BUILT HERITAGE IN POST-DISASTER SCENARIOS

IMPROVING RESILIENCE AND AWARENESS TOWARDS PRESERVATION, RISK MITIGATION AND GOVERNANCE STRATEGIES

EDITED BY
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CRC Press
Taylor & Francis Group

BUILT HERITAGE IN POST-DISASTER SCENARIOS

It is assumed that the impact of natural and man-made hazards on society in terms of damage cannot be avoided. To reduce potential disaster levels and to assess which policies have had a positive outcome, a careful comparison should take place on the procedures implemented in the management of crises.

The experiences with the earthquakes in the Pianura Padana area and central regions of Italy in the last ten years have been incorporated in the 'After the Damages' advanced training project. This project aims to showcase recent innovations and advancements in post-disaster management, so as to take a more proactive role in post-disaster management, and to respond more effectively when disasters occur.

This volume provides insights into the dynamics and negative effects of natural and man-made hazards (i.e., earthquakes, fires, floods, droughts, volcanic eruptions, etc.), including more updated approaches to deal with post-disaster phases. The book also offers tools to deal with possible international crisis scenarios and mitigate the social impact of vulnerabilities through risk reduction.

Built Heritage in post-Disaster Scenarios aims at public administration managers, government agency representatives, international organizations, researchers, and professionals in architecture, engineering, and earth science.

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PROCEEDINGS OF THE 1ST EDITION OF THE INTERNATIONAL SUMMER SCHOOL "AFTER THE DAMAGES", FERRARA, ITALY, 1-15 JULY 2020

Built Heritage in post-Disaster Scenarios

Improving Resilience and Awareness Towards Preservation, Risk Mitigation and Governance Strategies

Edited by

Marcello Balzani, Federica Maietti, Manlio Montuori & Fabiana Raco

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CRC Press
Taylor & Francis Group
Boca Raton London New York Leiden

CRC Press is an imprint of the
Taylor & Francis Group, an **informa** business
A BALKEMA BOOK

The International Academy "After the Damages" project has received funding from the Emilia Romagna Region in the scope of the three-year higher education projects in the cultural, economic and technological fields pursuant to art. 2 of the regional law n. 25/2018 approved by resolution of the Regional Council n. 1251/2019.

Front Cover Image: Finale Emilia, Modena, Italy. The parish church, commonly known as the Duomo, and its belltower seen from Via Del Monte on November 19, 2012 (©Manlio Montuori).

First published 2024
by CRC Press/Balkema
4 Park Square, Milton Park, Abingdon, Oxon, OX14 4RN
e-mail: enquiries@taylorandfrancis.com
www.routledge.com – www.taylorandfrancis.com

CRC Press/Balkema is an imprint of the Taylor & Francis Group, an informa business

Typeset by Integra Software Services Pvt. Ltd., Pondicherry, India

Design, composition and editorial coordination by Manlio Montuori

Library of Congress Cataloging-in-Publication Data

A catalog record has been requested for this book

ISBN: 978-1-032-18274-2 (hbk)
ISBN: 978-1-032-18275-9 (pbk)
ISBN: 978-1-003-25373-0 (ebk)
DOI: 10.1201/9781003253730

Built Heritage in post-Disaster Scenarios – Balzani et al. (Eds)
© 2024 The Editor(s), ISBN 978-1-032-18274-2
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Table of contents

Part 3: Multiscale application and simulation Workshop

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Welcome Message

The Emilia-Romagna Post Seismic Experience

The 20th and 29th May 2012 are dates that will be etched into Emilians' memories forever. On those days, terrible earthquakes killed 28 and wounded 300, with 45 thousand people evacuated and 12.2 billion euros of damage, affecting 59 municipalities in the provinces of Modena, Ferrara, Bologna and Reggio Emilia. The efforts made to restore services, schools, jobs, places, piazzas, and social opportunities to those communities have never stopped, continuously supported by the achievement of goals set by the Emilia-Romagna Region from the beginning: reopening schools in time for the beginning of the school year, continuity of and attention to public services, support for work and industrial and agricultural production, "no to new towns", and plans for interventions on the huge amount of cultural heritage damaged. A commitment sustained by the desire to start again, and the courage to do so immediately, has consistently distinguished the communities hit. Right from the beginning they expressed the need to not give up, the will to help each other, the hope to come out of this stronger than before, this time too.

Today, the reconstruction work is 90% complete - private reconstructions (homes and companies) are almost finished, and the reconstruction of public spaces and the historical-artistic heritage is underway, and it is this that we are concentrating on the most, in order to bring it to completion.

Along with the reconstruction, for a few years the Emilia-Romagna Region has also been focusing on the promotion of a culture of seismic prevention and risk management - topics that need to inspire great interest through widespread campaigns from all institutions, in collaboration with universities and research institutes.

For this purpose, a permanent collaboration has been established with the universities of the area and the "Clusters" of the regional economic system, and taking place in this context is the international summer school, "After the Damages", which has the goal of addressing topics in the area of risk management relating to natural disasters, starting from the experience gained following the seismic events of May 2012, and training students, graduates, and directors in public administration, governing bodies and international organisations, as well as researchers, specialists and professionals.

A unique opportunity to bring many different professional views to the same table, both public and private, so that they can address topics that are essential for the future of our territory and our communities with an interdisciplinary approach. This occasion, as the records collected in this volume demonstrate, continues to open up results and best practices from the reconstruction in Emilia to opportunities for diffusion and discussion, also with the international academic and scientific worlds, which yet again guarantee the quality of the work carried out and the integrity of the routes taken.

Stefano Bonaccini
President of the Emilia-Romagna Region and
Deputy Commissioner for the Reconstruction

Built Heritage in post-Disaster Scenarios – Balzani et al. (Eds)
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Foreword

Taking Advantage of the Experience Gained

The first edition of After the Damages compiled in this publication aims to return the value of an advanced training project, which, thanks to the intensity and quality of what has been produced with everyone's contributions, has laid the foundation for the creation of a vibrant interdisciplinary community projected towards encouraging developments.

In a year marked by the difficulties of the pandemic, the Summer School made its debut, offering up an example of a solid methodological system and a rare capacity for organisational adaptation. The interdisciplinary, integrative approach at the foundation of this educational programme for international experts, technicians and policymakers on the management and reduction of the risk related to the impacts of natural and man-made disasters on cultural heritage and existing buildings is supported by the multi-faceted structure of the institutions involved in the course. These include the Architecture Department of the University of Ferrara, the research centres DIAPReM, LaboRA and LEM and the industrial research laboratory TekneHub, in collaboration with the Engineering and Architecture Department of the University of Parma and the Enzo Ferrari Engineering Department of the University of Modena and Reggio Emilia, along with the Regional Agency for Reconstruction - 2012 Earthquake, the Emilia-Romagna Regional Institute for Artistic, Cultural and Natural Assets (IBACN) - now the Cultural Heritage Service - and the Archeology, Fine Arts and Landscape Superintendence for the Metropolitan City of Bologna and the provinces of Modena, Reggio Emilia and Ferrara.

From this we can see the growing, pronounced need to promote and support spaces for genuine in-depth study and exchange on an international scale, and these aspects, along with a highly qualified teaching body, have made it possible to trace an effective path to gradually acquiring the right cross-disciplinary skills and behaviours to manage the complex decision-making processes related to the crises arising from catastrophic events, whether natural or caused by the actions of mankind.

The positive results of the first edition of the Summer School, starting from the number of participants coming from four different continents and the quality of the interventions and final work from the attendees, have come with a confirmation of the interest generated at an international level by the project carried out by the institutions representing businesses from Emilia-Romagna in the administrative, conservation, research and innovation sectors, with the aim of taking advantage of the experience gained, not only in terms of best practices, but also the failures and missed opportunities in the almost ten years of reconstruction after the 2012 Emilia earthquake.

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Preface

The Emilia-Romagna Regional Agency for the Reconstruction - 2012 Earthquake

Enrico Cocchi
Regional Agency for Reconstruction - 2012 Earthquake

ABSTRACT: The organisational model that has characterised the reconstruction after the 2012 earthquake is an extraordinary example of managing the consequences of natural disasters, developed through a collaborative approach that has seen the creation of an institutional management model shared with the state and regional levels of government. The reconstruction was designed and carried out using participatory methods, with the involvement of local authorities and citizens. The premise is that the overall vision, common rules and goals must be built together with civil society and its democratic representatives, with the assumption that consensus is also an influencing factor in efficiency, transparency and control.

Today, in the later stages of the reconstruction, the complexity of the process set out by the Emilia-Romagna Region, the extent of the data, and the best practices tested in the field, make it possible to share and collaborate with the academic world. This experience will be the subject of further scientific, technical and regulatory debate, in order to form an administration that is ever more prepared and effective when facing the challenge of protecting our economic, social and historical testimonial heritage, and better able govern the region, as well as contributing to the prevention and management of possible future natural disasters.

Keywords: Joint Technical Commission, Minimum Intervention Units, Joint Technical Panel

1 INTRODUCTION

The earthquakes of the 20th and 29th May 2012 affected a large area of territory that was highly industrialised, with a population of around 1.24 million inhabitants. 59 municipalities were hit in a highly productive area of Emilia, characterised by small and large farms, a very high concentration of industrial and artisan activity, and manufacturing districts of international significance, such as the biomedical sector.

The area hardest hit was the northern part of the Emilian Po Valley, comprising the provinces of Reggio Emilia, Modena, Ferrara and Bologna. The destruction, in some cases causing collapse or serious damage, affected both historical city centres - involving public and private buildings and also buildings of historical and cultural value - and industrial and artisan warehouses in suburban and industrial areas, with 28 victims and around 300 people injured.

There were almost 21 thousand homes damaged, with 45 thousand people having to leave their homes, some temporarily. 489 churches and religious buildings were damaged, along with 35 town halls, 28 libraries, and 39 theatres, of which 31 were protected buildings that suffered serious damage. Similarly striking are the figures relating to work - at the time of the earthquake, Emilia produced 2% of the national GDP. There were several thousand businesses affected in the area, and 3,748 of these were forced to resort to the furlough scheme for over 40 thousand workers. The total estimate for the damage exceeds 13 billion euros.

2 THE RECONSTRUCTION: A SYSTEM OF GOVERNANCE

A characterising element of the reconstruction after the earthquake was then Prime Minister Mario Monti's decision not to assign a Government Commissioner as a representative of the Prime Minister's Office who would be foreign to the territory, and an organisational model that was based on its extraordinary facilities and exceptions to current legislation, including local building and zoning regulations, which were fast and efficient.

Indeed, the selection of the presidents of the three regions affected as the representatives of the central government solidified the process of reconstruction with involvement from the communities, and allowed full coordination between regional administrative offices, state agencies and local institutions: Regions, provinces, municipalities and the agencies related to them. The first act of the president of Emilia-Romagna, as Deputy Commissioner for the reconstruction[1], was the creation of the Institutional Committee[2], chaired by the Deputy Commissioner himself: a place of exchange and participation for public entities working on the reconstruction (President of the Region/Deputy Commissioner, Presidents of the Provinces, Mayors); this authority fulfills the role of an anchor for the governance of the system, ensuring decision-making capacity and continuity of policies. The regional government therefore plays a central role in terms of subsidiarity, as an intermediary body between the local government level (municipalities and provinces) and the National and European governments. The Region is the institution with the best possibilities for dialogue with the territory, as it is sufficiently close to understand its peculiarities and receive its requests, but also has enough "critical mass" to interact and cooperate with superordinate institutional levels, using its unique expertise.

The effort to guarantee full continuity of public services to support citizens affected by the event, as well as support for the continued activity of the economic and manufacturing system, were the main goals of the Emilia-Romagna Region and the entire institutional and social system of the territory hit by the earthquakes. A concrete example of this initiative was the action taken for the school and education system, with the aim of reopening schools for the beginning of the school year in September 2012: this meant that the education system took on even more of a role as a community space, with libraries, theatres and other public spaces within the red zones no longer able to do so. The reconstruction was designed and carried out using participatory methods, with the involvement of local authorities and citizens. The premise is that the overall vision, common rules and goals must be built together with civil society and its democratic representatives, with the assumption that consensus is also an influencing factor in efficiency, transparency and control. Governance conceived in this way is also a prerequisite for saving the territory's roots and historical identity, moving simultaneously in the direction of innovation and the improvement of safety, the environment and the wellbeing of individuals and communities.

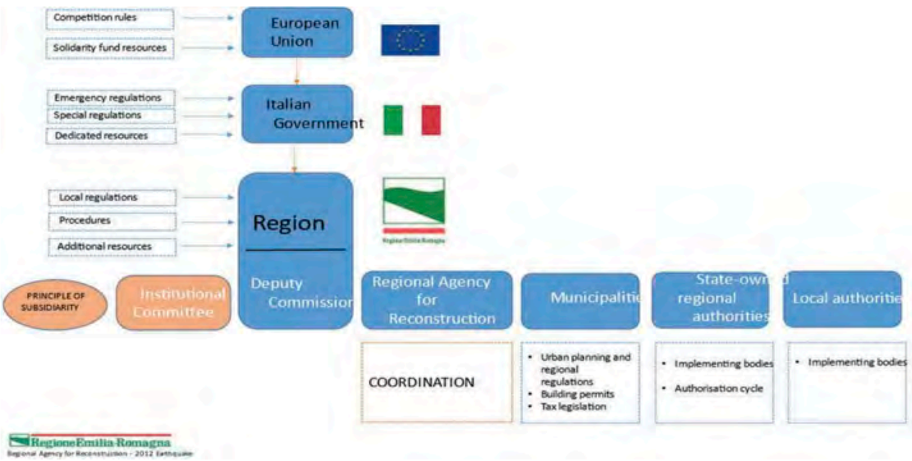

Figure 1. The principle of subsidiarity applied to the governance of the 2012 earthquake in Emilia.

3 REGULATORY FRAMEWORK

The national legislation and orders of the Commissioner are inspired by three fundamental principles: legality, transparency and equity - to impede organised crime's access to the territory and public funding, to ensure that nobody speculates on the reconstruction, and to guarantee that all those entitled have access to help, with nobody excluded.

In the absence of a regulatory framework that governs reconstruction processes after large-scale natural disasters, the laws for the reconstruction of Emilia, with funds to help families, businesses and the reconstruction of buildings and public services, were drafted by the government, parliament and the regional assembly during the emergency. They are not designed as a stable system, and provisions still continue to be issued today to supplement and improve the legislation. The national regulations, which are carried out through orders of the Deputy Commissioner, have allowed for prompt action in many areas. These are grouped into various overarching areas of action: assistance to the population, provisional or urgent operations of early intervention, reconstruction of residential buildings and productive activities, and the environment (disposal of rubble, securing the territory). Emilia-Romagna adopted a regional law already in 2012, Law 16/2012, which was complementary to the orders of the Commissioner aimed at the operational management of the reconstruction, ensuring a wide range of action that focused on public interventions in two areas: the qualification of urban planning and construction facilities, and the relocation and redevelopment of spaces and buildings. The first aspect took shape through the provision of joint projects that reduced the vulnerability of the urban fabric with the identification of the Minimum Intervention Units (UMI); the second became an opportunity to plan redevelopment that would be configured according to new functional, social and economic requirements.

4 ORGANISATIONAL MODELS

In order to demonstrate a few intervention models consistent with the organisational system adopted by the regional administration, we will now cite a few examples. The presence of hundreds of historical buildings in the urban and rural territory, important both for their historical-architectural value and for their function for identity, has led to an awareness of the need to pay particular attention to this aspect of the reconstruction: these are buildings and architectural complexes of particular importance, which are part of a system of relationships that forms the connective-historical fabric of the place and daily life that was interrupted by the trauma of the earthquake. The Region's actions, with the purpose of fulfilling its mandate to restore the physical integrity of protected monuments and buildings, aim to preserve and enhance the distinctive elements of the architectural space and the cultural and urban landmarks that belong to it. In order to respond to this complex goal of reconstruction and restoration, the Deputy Commissioner, with order 53/2013, established the Joint Technical Commission[3], with the aim of carrying out prior analysis on the preliminary projects related to the buildings protected by Legislative Decree 42/2004 and its later modifications. The commission is chaired by the Director of the Regional Agency for Reconstruction - 2012 Earthquake, and made up of the Superintendent for archeology, fine arts and landscape for the metropolitan city of Bologna and the provinces of Modena, Reggio Emilia and Ferrara, from the MIC; the Service Manager for the technical management of reconstruction operations and management of contracts and disputes for the Regional Agency for Reconstruction - 2012 Earthquake; and a director from the geological-seismic and soil service for the Emilia-Romagna Region. The details of the procedure followed by this agency in the analysis of practices are the following. As interventions on cultural assets, planning proposals must follow the operating guidelines "Guidelines for the evaluation and reduction of seismic risk for protected cultural heritage", according to the provisions of the "Technical regulations for construction" approved by the Ministerial Decree of the 17th January 2018. The officials in charge of the investigation from the competent authorities participate in the work of the Commission, according to the evaluation carried out for areas relating to their competence, with the aim of providing a shared overview of opinions on the planning proposal. Therefore, the Commission performs a joint examination and expresses a preliminary opinion involving the members' respective fields, providing a joint indication on aspects relating to the structural work and the cultural interest of the asset.

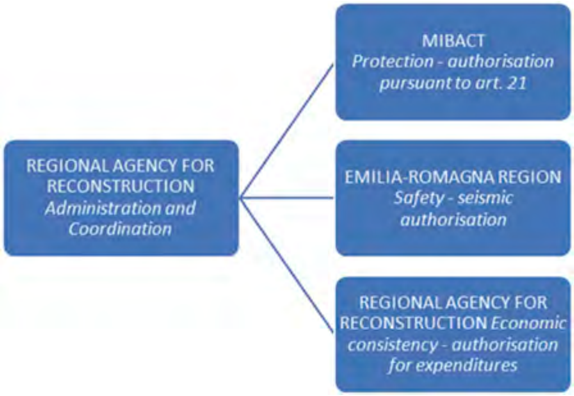

Figure 2. Structure of the Joint Technical Commission.

Another vitally important authority for the reconstruction process is the Joint Technical Panel, formed by representatives from professional associations, unions of municipalities, the Regional Agency for Reconstruction, ANCI Emilia-Romagna and trade associations. The coordination of the panel falls within the commissarial structure, and it meets approximately once a month. All the participants in the panel have the important task of publicising the decisions made within it, so that they can be applied consistently by both municipal engineers and professionals. The goals of the Joint Technical Panel are: to facilitate the reconstruction process; to understand what the difficulties are in the administrative procedures for the granting and allocation of funds; to address general problems that slow down the reconstruction; to find useful, shared operational solutions to improve the efficiency of the regulations; to create a place for debate between municipal engineers and professionals. This collaboration between institutions with different objectives and skills therefore has the goal of preserving the cultural assets affected, rebuilding them and providing the minimum and sufficient structural supports to make them safe and restore them to the community.

5 BEYOND RECONSTRUCTION: A PROJECT TO SPREAD TECHNICAL AND SCIENTIFIC INFORMATION

Today, in the later stages of the reconstruction, the complexity of the process set out by the Emilia- Romagna Region, the extent of the data, and the best practices tested in the field, make it possible to share and collaborate with the academic world. This experience will be the subject of further scientific, technical and regulatory debate, in order to form an administration that is ever more prepared and effective when facing the challenge of protecting our economic, social and historical testimonial heritage, and better able govern the region, as well as contributing to the prevention and management of possible future natural disasters. In particular, this field involves many collaborations with the world of academia and research, with the aim of pursuing numerous projects in post-disaster management. In this context, the Agency for Reconstruction promotes all actions with the goal of preventing and mitigating the damage caused by earthquakes and other natural disasters, as well as improving, reinforcing and spreading institutional and operational skills in the area of prevention and management of the consequences of natural disasters.

The Regional Agency for Reconstruction - 2012 Earthquake therefore maintains that it is necessary to capitalise on the experience gained in the definition and application of innovative methodologies in territorial governance for the physical and socio-economic reconstruction after this disastrous event, carrying out many development, communication and collaboration projects with the world of academia and research.

An example of such projects is the collaboration with the University of Ferrara, and in particular with the Architecture Department, which in 2018 came out of an idea shared with Professor Marcello Balzani[4]: the need to look beyond the purely physical dimension of the reconstruction in Emilia. The 2012 earthquake was a terrible loss, a tragedy that was obviously unwanted, which forced an entire system to react and face endless challenges, many of which involved and still involve the world of science and technology. As a public entity with technical, administrative and supervisory responsibilities, it is therefore natural to share part of this journey with those institutions whose natural expertise is in the development of skills, knowledge, research and modelling relating to the operations carried out, in order to submit them for in-depth discussion and make them reproducible, and available to other entities, for other needs. The need for this shared process is also linked to the nature of the emergency management model, which in Italy is expressed through the Civil Protection system. This is a structured system, regulated and managed throughout the territory, which has been able to address and respond impeccably to everything the initial emergency involved, as is the case for all the unfortunately frequent emergencies in Italy. However, the capacity of the country's system to take on what comes afterwards - the reconstruction - is quite a different matter. There is no "reconstruction system" - every case has been addressed differently, with entirely different laws and organisational models, so it seemed appropriate to make the experience of the institutional system in Emilia available to institutional decision-makers, the Government and the parliamentary chambers.

It is from this premise that the idea of sharing the project for the Advanced Training Academy "After the Damages" came about, in particular directing focus towards the topic of Cultural Heritage, as it is clear that when it affects monuments, churches and historical buildings, an earthquake is damaging not only physical elements, but also the memory and identity of a community. It is therefore indispensable, at least in the reconstruction process, to take special care and ensure a level of technical and administrative sensitivity that takes account of the community's timelines and needs. Instead, the initial emergency is addressed using completely different methods, as they must guarantee the continuity of the best possible living conditions for citizens, along with conditions of safety.

The creation of a link and an opening up of conditions that favour the transfer of experience and knowledge, and also technology, between these two phases - the initial emergency and the reconstruction - therefore becomes fundamental. For the system of cultural assets affected by the 2012 earthquake, right from the first days this translated into emergency relief operations that were not focused separately either on protecting people or protecting assets, but instead on making an effort to use imagination. From this fact emerges the need to develop solid skills, in order to form a united front using the experience gained, so that even so-called temporary projects would already involve a level of attention that could guarantee, in later stages, their full use and the full opportunity to intervene in the reconstruction process. It is also for this reason that the 2012 earthquake response involves experience that must be in part consolidated and in part transmitted. So this is a school that can simultaneously be a place for sharing experience, spreading best practices and describing their successes, and also, for an institutional entity Emergency management: awareness, knowledge and communication after the Emilia earthquake in 2012 such as the Agency for Reconstruction, for interacting with someone who could eventually also provide a critical analysis of their work. This is all with the goal of verifying whether what has been carried out during the emergency in terms of actions and needs is found to be effective and correct after more in-depth, careful study and discussion involving statistical analysis[5]. Along with this requirement, there is also the need to further study the areas relating to methods of technical intervention, in order to understand how to operate, with what technologies, and which types of diagnostic analysis to use for the conditions and behaviours of the materials and buildings under stress.

Just as we envisaged technical and administrative actions in the first phases of the emergency in 2012, today we envisage the search for a way to represent and pass on the planning and technological experience gained due to the 2012 earthquake. This poses the question not only of how to describe such experience, but also how to consolidate and make available the experience and skills developed in this territory, famous for its expertise, so that this event can become an asset available to the wider scientific world, and other communities unfortunate enough to be united by catastrophic events.

4 CONCLUSIONS

In this period, when the experience of the reconstruction of Emilia is showing all of its potential - if we hadn't recovered so quickly, maybe we wouldn't have been able to make use of the extraordinary contribution that the companies in the biomedical sector are providing today in the battle against the health emergency caused by Covid-19 - it has become essential for the Agency for Reconstruction to activate the scientific collaboration with the Architecture Department of the University of Ferrara and the Advanced Training Academy "After the Damages", in the knowledge that the emergencies that communities and institutions find themselves facing - such as the 2012 earthquake and the Covid-19 pandemic - are not isolated phenomena, but instead produce effects with widespread interconnections and repercussions throughout the territory, which we must transform into common, shared assets and knowledge.

NOTES

1 The path chosen by the Deputy Commissioner for the management of the emergency and the transition phase, and for the launch of the first phase of reconstruction, was that of cooperation with the system of local governments, in compliance with the provisions of Legislative Decree 74/2012, converted into Law 122/2012. This acted to make the various levels of government co-responsible, with the aim of making decisions and operating in the territory in the most effective ways possible.
2 Established by Commissarial Order no. 1 of the 8th June 2012. https://www.regione.emilia-romagna.it/terremoto/gli-atti-per-la-ricostruzione/2012/Ordinanza_1.pdf/view
3 https://www.regione.emilia-romagna.it/terremoto/gli-atti-per-la-ricostruzione/2013/ordinanza-n-53-del-30-aprile-2013/view
4 Former President of Clust-ER Build in Emilia-Romagna. Clust-ER Build is a private association of businesses, research centres and training institutions that share skills, ideas and resources to support competition in the building and construction sector, which has great value for the development of the sector in the region. https://build.clust-er.it/
5 Over 2,000 important cultural assets were affected by the earthquake, and of all the public assets, 79% are subject to primary constraints from the authorities, meaning that they are recognised as deserving of particular attention from the Italian State, as well as being considered to be communal property and part of the identity of the entire community.

Built Heritage in post-Disaster Scenarios – Balzani et al. (Eds)
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Introductions

Prevention and Safety Solutions Through Design and Practice on Built Environment

It is assumed that natural and anthropic hazards, their consequences, and, most of all, their impact on society in terms of damage cannot be removed. However, the limits of tolerance to their effects should be increased, thus reducing the level of potential disaster. Pursuing this aim, a careful comparison should take place on the procedures adopted in the management of crises, such as those that affected the Pianura Padana and the central regions of Italy in the last ten years, to assess which policies have had a positive outcome and which constraints characterized any inefficiencies. This is the objective of the After the Damages high training project, carried out through a wide international participation on different contexts, different kinds of risk and different approaches to mitigation.

A higher education project on the management of calamitous events. Capitalizing on the experience gained in recent post-disaster reconstruction by the involved partners and the experience of disaster management, the project brings together an interdisciplinary team of Italian and international experts. The aim is to highlight recent innovations and advancements in the post-disaster management by providing the most up-to-date expertise to enable participants to play a proactive role in disaster risk management and respond more effectively through mitigation strategies.

An international academy. After the Damages is the three-year advanced training project promoted by the Department of Architecture of the University of Ferrara, the Department of Engineering and architecture of the University of Parma and the Enzo Ferrari Engineering Department of the University of Modena and Reggio Emilia.

The project is developed in cooperation with the Regional Agency for Reconstruction – Sisma 2012, the Authority for Archaeology, Fine Arts and Landscape for the metropolitan city of Bologna and the provinces of Modena, Reggio Emilia and Ferrara, and the Institute for Artistic, Cultural and Natural Heritage of the Emilia-Romagna Region (i.e., IBACN). Funded by the Emilia-Romagna Region, Direzione Economia della conoscenza, del Lavoro e dell'Impresa, Servizio programmazione delle politiche dell'istruzione, della formazione, del lavoro e della conoscenza, as part of the Call for three-year advanced training projects in the cultural, economic and technological fields pursuant to art. 2 of the Regional Law 25/2018, the Summer.

School After the Damages deals with issues related to risk management starting from the experience gained in the Emilia-Romagna Region following the seismic events of May 2012. The project is part of the Emilia-Romagna Smart Specialization Strategy, is implemented in collaboration with the High Technology.

Network, the Clust-ER Build, the Tecnopoli of Ferrara, Parma and Modena. The advanced training project is part of an international partnership of universities, institutions, research centres and Higher Education.

Institutes represented in the Technical Scientific Committee by experts coming from Italy, Morocco, Brazil, France, Ecuador, China, Armenia, Spain, Greece, Belgium, Germany, Denmark, Turkey, India and Slovenia, with also the support of Consiglio Nazionale degli Architetti,

Pianificatori, Paesaggisti e Conservatori, Green Building Council Italia, Clust-ER Build – Edilizia e Costruzioni, Istituto Italiano per il Disegno and ICOMOS Italia. The first edition of the Summer School (1st-15th July 2020), the School received 114 applications and saw the participation of 62 students from 18 countries and 4 continents.

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Rationalising the Emergency

The earthquake that struck Emilia in 2012, causing damage estimated at around 13 billion euros, has completely transformed the territory of the provinces of Modena, Ferrara, Bologna and Reggio Emilia. Now, ten years on from the earthquake, it is possible to observe how extraordinary the regional system's capacity for reaction and transformation was, and how it was also characterised by the desire to make it replicable and applicable in other similar situations. Regional, national and international organisations, professionals, technicians, universities, research bodies and representatives from the local business sector have been involved not only with the process of reconstruction, but, especially, in transformations and innovations that have changed the institutional and productive system.

The rationalisation of decision-making mechanisms, the involvement of the main stakeholders and an increase in the level of participation are maybe the three main parameters we can use to evaluate the improved response that some innovative transformations in local governments have helped provide to the regional system. With particular reference to the preservation of buildings of cultural heritage, it is clear that the direct involvement of the research sector, and in particular universities located in the area, has allowed us to achieve significant results, both scientifically and in the field of advanced technical training.

In the field of training, the initiatives developed at university level with the support of the Region have involved many different groups of users. In the immediate aftermath of the earthquake, many advanced training courses were organised, specially designated for sector operators (officials, technicians, specialists, procedural managers, etc), with the aim of gradually improving knowledge and skills in the region's technical organisations which would need to start working shortly afterwards on the architectural heritage compromised by the earthquake. At the same time, in secondary education, degree courses, and in particular in the field of specialised workshops, issues relating to the restoration of specialised buildings affected by the earthquake were addressed, with the aim of leading students through a course with direct professional outcomes. Later, taking advantage of the significant experience gained in the field of reconstruction and the involvement of some of the most important academics and professionals in the country, post-graduate training courses specifically dedicated to the topic were also developed. In particular, the two-year Master's Degree in seismic improvement, restoration and consolidation of historical and monumental buildings offered at the University of Ferrara, now in its 8th year, has become a point of reference at the national level.

Finally, important initiatives such as the International Summer School "After the Damages", entirely funded by the regional government and founded even later on, provide the opportunity to share essential cultural heritage at an international level through the consolidation of local operating practices and the sedimentation of knowledge and skills in the discipline.

From a scientific point of view, the issues around restoration introduced by the earthquake have ended up providing an important sounding board for testing both theoretical convictions and operational models on different scales, from the architectural to the urban.

At the city level, the involvement of this field of study has been a decisive factor in the preparatory operations of surveying and representation leading to the identification of the Minimum Intervention Units (UMI), and more generally to planning for the reconstruction. A further level of analysis performed on behalf of the Department for Civil Protection regarded an examination of the structural characteristics of the housing in Ferrara's historical centre, with the purpose of evaluating its vulnerability in order to carry out preparations and risk prevention. The working group, which was able to make good use of previous studies on the formative and transformative phases of the city of Ferrara, managed to construct interesting relationships between the phenomena of urban mutation and the vulnerability index. Finally, scientific support in the analysis of the Limit Condition for Emergency (CLE), used to plan the municipal civil protection carried out on behalf of the Emilia Romagna Region in the towns hardest hit, has allowed the department to refine and optimise this tool, which at the time was still in its experimentation phase.

In terms of the process of reconstruction, the cases of architectural restoration have involved many academics at various levels in the main relevant disciplinary areas: from science to construction techniques for restoration, from history of architecture to design. There has been constant commitment from the very first hours after the earthquake: from the survey campaigns prior to the demolition of architectural structures to guarantee the safety of residential areas, to collaboration with contracting authorities in the field of preparation of documents for project guidelines, from technical-specialist consulting in the professional field to the involvement of tender commissions for the awarding of services and works. In the context of this scientific support for the reconstruction process and the many opportunities for exchange (conferences, technical meetings, contributions etc.) that have resulted from it, it has been possible to propose and at the same time test a methodological system that I have defined as "post-critical". This puts the "resolution" of the architectural context at the centre of the project, and dispenses with all forms of falsified restoration on one hand, and on the other, any easy concessions to ruinism. Indeed, it falls to us to evaluate how much of the architectural landscape has survived this extreme event and establish its real "enforceability". The documentation that can be found, primarily photographic, but also occasionally iconographic, can only give us an indication of the "values" lost, and never constitute the basis for an analogical, restorative reconstruction. It will be the historical building itself, or rather what remains of it, that indicates to us the paths to be taken by the project. These are never univocal, and lead to a "restoration of values", not a "material or formal reconstruction". Such "values" will end up being "changed" in a way that is directly proportional to the extent of the damage suffered. The operation, therefore, is entirely contained within the discipline of restoration, even where it may be necessary to attempt overtly modern solutions in the process of reconstruction, both in terms of materials and in formal terms.

If, at the local level, the progressive sharing of goals has led to a general consolidation of disciplinary knowledge and skills provided by the technical organisations in the territory, the important occasion of the International Summer School "After the Damages", which still sees us committed several years after the traumatic event, constitutes an essential opportunity for the sharing of unique experiences at an international level, so that they can be of help in similar situations and trigger further developments in the field.

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Existing Built and Cultural Heritage: Risk Prevention, Conservation and Management

The materials collected in the Proceedings of the first edition of the International Summer School "After the Damages" document the quality of the results achieved and the fact that they certainly met expectations.

The interdisciplinary nature of the topics was a structural component of the school's programme, and the development of the contents and their adherence to the most recent international experiences, best practices and current research in the field of risk analysis, forecasting and management, gave substance to this approach by providing participants with a broad and, above all, up-to-date picture of the complexity of the topic.

The programme of lectures, presented by various experts from academia, applied research, public administration and the professions, provided a detailed picture of the multiplicity of problems facing the plans and strategies for the prevention and management of the risks to which the built heritage is exposed and, in particular, its most fragile component: architectural and monumental heritage sites.

In addition to the lectures, there were testimonies from the protagonists (Agency for Reconstruction, administrators, designers, companies, etc.) involved in the reconstruction of four sites affected by the 2012 earthquake, where the planned inspections were carried out in virtual form.

Finally, in the final workshop that concluded the course, the candidates, divided into 12 groups, tried their hand at a design exercise in which they were able to experiment, in different scenarios, the methodologies and tools for designing interventions "after the damages".

The workshop, in particular, fostered the start of a very interesting ground for comparison between the themes of the Summer School and those on which the laboratories and research groups operating in the Department of Architecture work.

But, above all, it put into practice one of the founding principles on which the Summer School is based: the close connection between research and education.

The main topics of the Summer School programme reflect and are based on the outcomes of the latest research projects carried out in the Department, achieving that transfer of the results and outcomes of these projects which is a crucial aspect of our concept of undergraduate and postgraduate training.

Risk prevention, conservation and management of the existing built and cultural heritage are the main focus of several important research projects conducted by our scientific community. The school's training programme has therefore seen the results of the 'Inception project', research on river deltas and coastlines, the 'Crater project', studies carried out as part of the PhD programme and field investigations carried out after the 2012 earthquake, come together in the various stages of its development.

Bringing the results of this research to the centre of the activities of the Summer School certainly contributed to giving the workshop concreteness and adherence to the themes that are really at the centre of studies in the field. However, it also provided the After the Damages.

Academy, the Department of Architecture of Ferrara and the entire scientific community working in these institutions with essential feedback for the work of the coming years and, certainly, for the planning of the 2021/2022 Summer School, which we hope will be able to match if not improve on the results of this first edition.

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Part 1

Invited lectures

Built Heritage in post-Disaster Scenarios – Balzani et al. (Eds)

Built heritage, natural hazards and climate change

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ABSTRACT: Understanding the transformation is the problem. The Anthropocene represents the most intense image of climate change, structured through the idea of super-control over the environment or the attempt to impose a development model that is still too interested in dominating nature. It is also necessary to realise that a "project of amnesia" is taking place globally, which we need to contrast with a "project of memory" where the pairings of identity/ sustainability, security/ loyalty and resilience/sustainability must be used to broaden cultural and technological categories. Every disaster transforms lived experience into an ever more concrete future where transversal skills, techniques and new knowledge can continuously be integrated. The transparency of the change highlights how the affective and "symbolic memory" of territories and communities can become part of the participatory experience of every transformation; whether in terms of the governance of reconstruction, regeneration, or a new, adaptive method of risk assessment. Conservation processes, which operate on the landscape in a historical context, are at the foundation of the inclusive development of an ever-more widespread idea of cultural heritage; they need technologies to document "geometric memory", and new design models and skills to find the solutions necessary to manage and work with complexity. Because it is already generally evident that every conscious, aware act of conservation can trigger a virtuous process of conflict resolution. This is why, after the experience of the 2012 earthquake, the Emilia-Romagna Region, with an active role taken by universities and territorial authorities, proposed an international Summer School on "After the Damages".

Keywords: *Alhambra*, *earthquake*, *explosion*, *fire*, *restoration*

1 "AFTER" OR "BEFORE"

We should ask ourselves whether the term "after" should not include within it the concept "before": because there is never only an "after". The misunderstanding is on the threshold: intersections, borders, and therefore thresholds, belong to the domain that "After the Damages" aims to discuss. The term "after" implies a dynamic attitude. There must be a "before" in order for the "after" not to take place in "disaster mode". The "after", if it takes place, must be in some way tollerable. We would like to believe in and work towards a "before", to already be able to believe in action and activity, but it is not yet possible. So it is understandable that damage and disaster (which we are all too often faced with) are a *condition*. A human condition that in some way must continuously be addressed. A condition that requires a *new way of thinking*, that can represent a different way of seeing reality. This is a topic that is being addressed today from many perspectives. Perceiving reality requires new points of view, but also hybrid models that can correlate individual opportunities for choice with collective opportunities to interact with our own existence on the planet. Everything that has happened over these months of the Covid-19 pandemic has made it even more obvious how the human race can be considered to be an *invasive species*.

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DOI: 10.1201/9781003253730-1

Ronald Wright said as much in his “A Short History of Progress” (2004), when he addressed the age-old topic of homo sapiens, which started to domesticate every species during the Neolithic Revolution, setting the foundations for an entirely different hierarchy of values. A pervasive, incessant “dominant dimension”, which has only started to partially change in the last hundred years, since ecological culture has made it possible to establish a different perspective with new topics of discussion. The first twenty years of this new millennium have shown an even faster global progression in which the pandemic is demonstrating that many individual behaviours constitute the basis of every social relationship. The urban landscape everywhere changed profoundly, in just a few months. We seemed to be watching the planet’s *invasive species* hiding in their *nests*. Observing how they renounced life in context, the connective fabric, the uncontained, the space that makes every interactive reality possible; very different from the digitally interactive space. What did other living species think of this temporary submission? A defensive retreat after millennia of tireless expansion, day and night, reaching every “limb” (or limbo, which after all is still etymologically an edge) of territory? With astonishing speed, an exceptional, relentless *global reset* took place, which had never been predicted, even in the best science fiction films, despite often being declared among other describable (im)possibilities. In “The University of Disaster” (2007), Paul Virilio foresaw and summarised how vibrationist practices, hyperactive temperaments, delocalising functions and individualist optimisation would pervade every “Space & Society” (to put it à la Giancarlo De Carlo) with active and passive logic in accordance with every sociological imagination (Zygmunt Bauman): “all exiled in a mass externalisation” that requires a higher critical awareness. Nobody, however, was interested in subjecting the system to a *preventative ultrasound*, even though we knew that the right *antibodies* weren’t being produced in global society. Now that proxemics has become a safety science, and Edward T. Hall’s “hidden dimension” has become clear, revealing new types of intimacy and taboos, “the art of traceability” has emerged from the *underlayers of the anthroposphere* as an approximate solution that no longer defines space, but instead behaviour.

We moved from the geometry of quiet to that of movement: domestic inertia conflicts with the need to extend our own spatial body. And the urban landscape, plunged into *global quarantine*, seemed to share a never-ending (and unsettling) freeze frame. The *violence of the global* (to quote Byung-Chul Han) lifted up the triple jaws of Cerberus in Dante’s circle of (obese) gluttons and proposed the obligation of transparency and hyper-communication: everything close, no refuge, all steps in an ever-more transitory global society, in constant digital overexposure. In this *transparent hell*, with the progressive arrival of more and more new *Apps for smartphones* (a metonym for each individual), somebody was implementing a terrible “law of movement” (Hanna Arendt) that would fight a Blitzkrieg with the invisible, the uncertain and the changeable. Something mythological was appearing in the background.

2 THE “PROJECT OF MEMORY” AGAINST THE “PROJECT OF AMNESIA”

The development model in these years, especially in the area of the planet that has been operating based on market decisions (successful), has brought together many individual roles in a collective goal of progress, GDP, and targeted and efficient (exclusive) productivity. This model seems to include a *distorted* perspective that, as it grows, contaminates even its own foundations, as if a (proclaimed) *disaster* seems to be always just around the corner. Even without considering Renè Thom’s *catastrophe theory*, when we started to identify catastrophic processes through a structur- alist view as conditions of an almost obligatory dynamic in human reality, the current ongoing *transitory condition* in which our development model is applied also shows how *conflicts* seem to be constantly just below the surface. For example, with an analogy offered by conservation processes, we have realised, especially in Italy, how activities and acts of conservation can some-times also constitute the foundations for *conflict resolution*. Deciding to preserve a cultural asset is never a trivial act. Contrary to commonly-held views, it can represent the *resolution of a conflict*. A conflict over our vision of the future, over the idea that a cultural asset identifies a collective memory, over the idea that it can express economic sustainability, and even a real opportunity to carry out a *function* as a *place*, as part of the *landscape*, as *architecture*. Because the *project of amnesia* is always present, and constantly being fed into. The world of globalisation, which we have been catapulted into with the pandemic, seems to be *embedded* in the project of amnesia. Amnesia is seductive, inviting, simple, *easy* and *smart*. It is simpler to forget things than to remember them. The world of consumerism, productivity and growth is also a world of *silent destruction*. As a quantitative indication, today our active generation is destroying more cultural heritage than any other previous generation, including during the Second World War. This comparative estimate helps us to understand how, for example, the project of memory (which represents a different vision and point of view) can offer the opportunity to place different values at the centre, even in contrast with what is happening. Memory is not an easy term. Science tells us that memory is not storage, and not an archive. Human memory is a dynamic tool that serves for the future; it structures images, thoughts and solutions designed for a "Future" (Marc Augé 2012) that is be- coming ever more concrete. Our synapses change. Memories do not stay the same. The transfer of experiences down through the generations is an extraordinary human goal, and it is this that we are trying to achieve through critical discussion, such as the discussion that takes place at the Summer School "After the Damages". It creates the possibility of preserving the value of memory, by addressing the topic of identity.

Figure 1. The approach to assessing the appropriateness of expenditure in reconstruction projects.

2.1 *Identity and sustainability*

Identity is another difficult word, because identity can represent a violent concept with the expec- tation of recognition. But identity can also be interpreted in the role of tradition, of understand- ing those processes that have resolved conflicts in order to preserve the values of context and community. So we can imagine how every topic at "After the Damages" appears much richer if we interpret it beyond its material boundaries and address it in a dimension that may be able to intersect the complexity of the adaptation and development of our species, opening up a much broader scenario of integrated concepts. Never before has the role played by the project (in all its forms), in interpreting transformations and allowing us to define models through which to catalyse the aspects of a concrete future, seemed to be articulated through such an intersection of the meanings and values acquired by identity and sustainability. Meanings and values desired as being unambiguously determined by cultural interpretations, but which are difficult to establish and constrain within the frameworks of models and structures.

These too are destined to become floating signifiers of that globalised mindset created by convention, rather than being analysed through a critical approach. It should also not be forgotten that it is probably the context that creates the passe-partout of these components. This context coincides less and less with a place or an environment, even though appearances may be deceptive, or rather, the interpretative con- ditions of traditional models may require it. An expansive, continuous context, defined by the lowest common denominator that tends towards standardisation and reductive simplification. A context in which it is not only biology that creates boundaries and determinations, but rather experiential and environmental modelling, in which protection and threat, wealth and poverty, and methods and criteria for visualising the social with regard to the individual (and viceversa) take prominence.

2.2 *Resilience and sustainability*

One of these concepts is *resilience*, which is a term that today is frequently used and highly effective. A few decades ago, the term *sustainability* seemed to be the technological and procedural solution for many transformation processes. In an urban context, *resilience* defines a system of relationships (cognitive and project-based) that are not limited to just adapting to change. This process searches, especially in the community, for innovative social, economic and environmental responses that allow us to increase our *ductility* and *resistance* to the stresses of the environment, history and processes that constantly present themselves (in new forms). It is important to remember that resilience training models human beings and transforms traumatic experiences into new catalysts. But we must also remember that passivity towards suffering creates an *algophobic* society. Fear of pain is pervasive and widespread, while spirit and even pain may have the capacity to preserve themselves through this contradiction. The Meaninglessness of Pain. The Cunning of Pain. Pain as Truth. The Poetics of Pain. The Dialectic of Pain. The Ontology of Pain. The Ethics of Pain. These are some of the titles from the latest essay by Byung-Chul Han, “The Palliative Society” (2020), which reminds us how “the pandemic behaves like the terrorism that hurls naked death onto naked life, generating a powerful immunological reaction”. These are not simple topics. The 2012 earthquake in Emilia, whose management and reconstruction work by the Emilia-Romagna Region was the inspiration for organising the international Sum- mer School “After the Damages”, made the physical loss of immaterial values tangible. The 2012 earthquake was the first industrial earthquake in Italy, because it had the power to alter GDP: the gross domestic product of a whole country was drastically reduced in just a few months. And now, measuring how the pandemic has radically changed the GDP of many countries around the world, we can see that this period of industrial crisis has almost overtaken that generated by an earthquake. These factors require a perception of the role of communities in adaptation, and also a concrete perception of how to act with security.

2.3 *Security and loyalty*

Security is another complex term that needs to be made technically comprehensible. People (and communities) want to feel secure, and they try to be secure, even in their affections. The first step is always security. Security requires (in the built environment, just as it does in body and spirit) a strong dose of *loyalty*: the loyalty of the community, loyalty to a secure vision of what the com- munity is investing. The meanings of these terms (resilience, security, loyalty) find a relationship between the deep nature of human beings, and the vision of acceptance of a forced transforma- tion of reality, because disaster is always close by, and this impending catastrophe must be per- ceived with a completely different vision. Historical city centres, for example, demonstrate how resilience is actually possible. There are historical contexts that have resisted violent processes of transformation. Some of these find themselves in “latency curves”, where they seem on the point of either collapse or regeneration: they hover on the brink. What will happen to these places that are so incredibly layered with forms of humanity? To these special *nests of our species* that have been consolidated over time? It is no trivial issue. We attribute historical value and meaning to contexts (both physical and social) that appear *expansive* and *porous*, beyond their simple chrono- logical age, which is an important

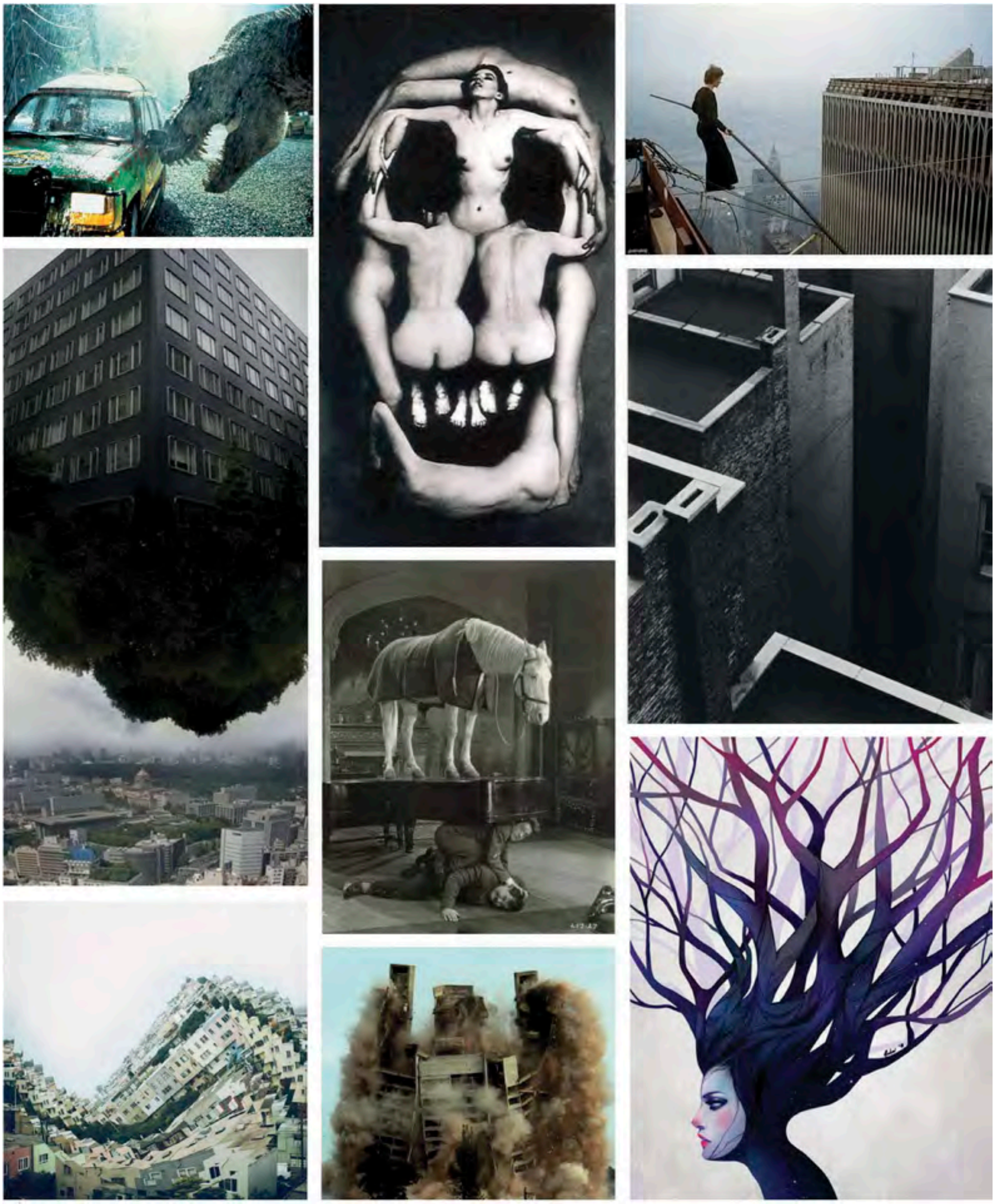

Figure 2. The approach to assessing the appropriateness of expenditure in reconstruction projects.

part, but not the only one. We can imagine how urban contexts undergo and have to incorporate changes, also from a methodological perspective. This is a sign of adapting to change, depending on the type of disaster: it happened five-hundred years ago in Ferrara, and then the *project of amnesia* won due to the long period of time between events. Then the recent event of 2012 brought to light (with all its violence) an already-lived experience. But earthquakes are not the only problem. If we look at a map of Italy showing the levels of risk and instability, it is interesting to note the connection with other events: floods and landslides. Wide- spread weaknesses that form part of that fundamental factor we tried to make sense of a few lines above: existing in continuity, the capacity to *persist* (suddenly overturned), and therefore *adapted*. The risk of floods unites many more countries across the world than earthquakes. In

Europe, earthquakes happen mainly in the Mediterranean area. Central and Northern Europe do not suf- fer from this problem. In the Americas, we know that there are parts of the great continent that do not face such a risk, but they are extremely vulnerable to flooding, for example, which due to climate change is now hitting areas all over the world. We are faced with urban models that will have to change their systems for claiming territory, their sewer systems, the very idea of areas of relevance and unenclosed space. In the urbanisation process, we will no longer be able to block the imbibition of large surface areas and remove their capacity to absorb water. We will have to find other strategies, such as those for water conservation, because water will demonstrably be the most important topic of international discussion. The conflict, because tragically there will be conflict, will probably be much more based around water than energy.

2.4 *The anthropocene and transparency of change*

When we pay attention to changes on a wider scale, we realise how much the living spaces of our species have radically changed in the last one hundred years. Such a profound, intense transforma- tion may never have happened before on this planet. From here we can start to define the idea of the *anthroposphere* and the *anthropocene*. Until a few years ago, it was inadmissible to imagine that the human race could have an effect on a *planetary scale*: the dominant species, but not to the point of changing the conservation process at the level of geological eras. Today, certain important indi- cators of the contamination of the planet's crust are starting to prove that claims of such an appar- ently irreversible scenario are more justified and admissible. Citing the research of paleontologists, we can find an interesting parallel with the evolutionist metaphor of the Cambrian *explosion*. Be- fore, the water was dense, the air impossible, full of fumes from volcanoes; it was impossible to see anything. It was a world undergoing huge dynamic change, and the living species were immersed a context that did not even require the morphological evolution of organs to look at themselves. Eyes had not yet developed in living species. Then the planet became *transparent*: clearer water and air. At that point the species developed eyes, but they also simultaneously developed armour: because when you can recognise yourself (in your own identity), you also want to defend yourself.

D. C. Dennett and D. Roy, who study complex systems, find a parallel in the current transforma- tion generated by globalisation and web development, as if it were living through the Cambrian explosion. Everything taking place online (a higher demand for *transparency*) is producing totally different models of resistance and defence, because the *aggressions* have completely changed. The responses needed to understand new models of transparency and sharing, in safety and with pro- tection, are still to be reached, especially with the creation and development of big data usage.

2.5 *Diverse strategies for diverse contexts with integrated approaches and behaviours*

At "After the Damages", our colleagues from Nepal illustrate what has taken place between 2015 and today, after their earthquake. This is not only a construction problem related to models for the construction of buildings, because strategies for development and regeneration of the pro- cesses in historical town centres, in terms of their resilient capacity to preserve memories and identity, are the most important part of the response in order to find a solution for the future. Likewise with the morphological characteristics of a continent, its structure: because, for exam- ple, Brazil (where there are no earthquakes) has a noticeable problem with flooding, involving the dimensions of the quantitative aspects (both social and environmental) at play, also in terms of the structures and relationships of its demographics and urban sprawl. But all this is also true of India, or in other densely populated countries, which choose to apply strategic approaches to limit or reduce damage. Water, therefore, can be overabundant or in scarce supply. Our col- leagues at CEPT University illustrate the Indian models where the capacity for resilience has always been connected to conservation, and not to the capacity for imbibition or dispersion. This is a logic of conservation that determines strategies to resist, to absorb, to trigger new behaviours, apparently contrary to those in which water is an image of flooding or instability. We should ask ourselves how certain models and construction techniques, or certain aspects of architectural logic, can instead follow more similar behaviours. The Summer School “After the Damages”, by creating groups of students during the workshop, allows us to stimulate the search for the lowest common denominator. Finding what unites us and brings us together: because today, asking the right questions is probably more important than finding solutions. Defining the problems, because problems unite us in finding models for responses and adaptive solutions.

3 SYMBOLIC MEMORY, EXPERIENCE AND RISK GOVERNANCE

Like all problems connected to cultural heritage. What happens when in a territory with a Catholic culture like Emilia, after the 2012 earthquake, four-hundred parish churches (in other words, centres of the religious community) are damaged? And in a city like Ferrara, only two churches remain open for worship? What is the loss of value in terms of symbolic memory? And how can we reconstruct places that have lost even their outlines, or elements of religious symbolism (bell towers) or secular symbols (such as a town hall)? This is not just architecture. All of this is not an exclusively architectural problem. “After the Damages” tries to understand these other aspects too, which make the requirements of memory and identity comparable all over the world; be- cause Kathmandu and Emilia are similar. But it is just as important to have the capacity to look forward. An example, still within the Emilia-Romagna Region, could be the Romagna Coast. It is a tourist coastline running for hundreds of kilometres that was built mainly in the 1960s and 1970s. When it was developed, a little like the great tourist coastlines of Brazil or California, it was an example of the integrated industrialisation of tourism. But in those years, the issue of the en- vironment’s vulnerability and the danger of its impact was not yet evident. Approximately every hundred years, in this Northern area of the Adriatic Sea, there is a relatively violent earthquake. When it happened in the early years of the last century, of course, the extensive, continuous *line of cities* facing the Adriatic Sea was not there. So the

Figure 3. Mirabello, Ferrara. The Oratory of the Beata Vergine di San Luca, safety procedures and reconstruction.

question we must ask is: the danger is medium-high, the vulnerability is high, the exposure for this type of community in terms of its tourist-industrial value is very high, so what is the current risk? An extremely high risk. There are three components that, if analysed, change the overall value and meaning to assign to this context. Through the Emilia-Romagna Region's Build Clust_ER, we are trying to transfer the know-how from the experience of the 2012 earthquake, because significant *governance* developed *in wartime* can help the process of regeneration *in peacetime*, when the possible *war* triggered by the earthquake has not yet happened: this is still the *before*. And it comes out of skills developed in the same region, but in a different industrial context. In the area of the Emilian earthquake, the economic and industrial value was based in biotechnologies, whereas in Romagna there is an industrial tourism sector that brings in an incredible quantity of people over the summer period, and provides resources to the inland area of the region and the Italian industrial system in general, not only in Emilia-Romagna. It is a scenario that needs to be addressed, and involves many different aspects.

3.1 *Where it was but not how it was: Solutions for complexity*

It is then necessary to define topics of approach that make the cycle of disaster, mitigation, preparation, response and recovery more conscious. How did Emilia-Romagna manage, in the seven years after the 2012 earthquake, to implement what other Italian regions have probably not managed to carry out? They provided a significant amount of capital, also with help from the EU, and managed to create a strategy not only to reconstruct and reduce risk, but also to deal with the region's transformation, which triggered a regeneration of the area. The territories involved were not only secured, but also connected to a new vision for the use of energy, for example, and the use of public space. At this point, they are completing the phase of reconstruction of cultural assets, which is the final, maybe most complex phase, trying to understand how the conservation of cultural heritage has been handled. Does *"where it was, as it was"* make sense? If we reconstruct it exactly *as it was*, it will collapse again… Do we have to reconstruct it *where it was*? Sometimes it is not possible *where it was*, partly due to the safety of the context. But if I can reconstruct it *where it was*, *how*? Or recreating *as it was*, but safer and restored - but in what way? "After the Damages" visits worksites to understand what *"where it was but not as it was"* means in Emilia-Romagna, all with great critical attention; because these are difficult topics, and not only in a technological sense. They are difficult because they are complex - woven together - in the original sense of the word *complex*. When difficulty transforms into complexity, it is translated into relational and cor- related complexity. So is it possible to control the damage? Yes, of course it is possible - humans have always demonstrated this, with different levels of necessity. For the Greeks, that necessity was Ananke, an extremely powerful goddess who controlled the Moirai (as recorded by Aeschy- lus in "Prometheus Bound"), who cut the thread of life. Otherwise, necessity is separated out: the needs of the Indian population, the needs of Brazilian mega-cities, the needs of the Turkish population and their context, the needs of the African continent - what are the needs of so many communities? Because we start from here; always from a matter of necessity, in order to then gen- erate the resulting evaluations. These consequences are generated primarily by the behaviour of the *invasive species,* because if we look carefully at 99% of disasters (such as Coronavirus), we find that humans are responsible. And we understand how the impact on society, in terms of damage, cannot be eliminated, but only limited, made tollerable, with effects that reduce the potential di- saster. This is a fundamental process that humanity has always carried out. Nevertheless, in the present-day, it seems that our condition is that of *amnesiac beings*, individuals who do not remem- ber. Whatever frame a *slide* presents (historical memory of equipment, roots and feet, travel as a journey, mega-cities in *lockdown*), as is easily perceivable, the subject is always the same - there is nothing else, it is always just us.

3.2 *Against the fear of the "White Whale"*

Why is it important to have strategies? So that we don't find ourselves drowning in the idea that Moby Dick exists, which, in fact, yet again represents us. Melville's extraordinary novel is fun- damentally a representation of our fears. Strategies define a topic that is continuously

Figure 4. Mirabello, Ferrara. The Oratory of the Beata Vergine di San Luca, safety procedures and reconstruction.

evolving, because the post-disaster phase can have different effects. This is why research, scientific and cultural exchange, the need to analyse in depth, and a critical approach to intervention meth- ods make “After the Damages” an opportunity to stop finding ourselves here, under the white whale, creating the condition to not generate this condition. The processes can be truly incred- ible, because there are many different strategies and they use landscapes

Figure 5. Mirabello, Ferrara. The Oratory of the Beata Vergine di San Luca, safety procedures and reconstruction.

as their models. How to address the transformation of the landscape in terms of city models, and processes of sharing and participation. The quality of the landscape will be an important indicator, much more than it has been until now. Maybe the *key* to the landscape will be one of the *most interpretative keys* to reconstruction. But equally important are higher levels of expertise on the models. Because, for example, the Italian urban centres extensively studied and analysed during and after the earth- quake have demonstrated new levels of expertise in interpreting types of buildings and smaller aggregate forms. It is not only the large church, the cathedral or the castle, but homes that contain living memories and values of the community, of the group, which need to be kept safe. So they must be assigned a new capacity for resilience.

3.3 *The importance of "geometric memory"*

"After the Damages" allows us to see the worksites, the building processes, the logic of reinter- preting models with new technologies, which interpret forms, preserve identity, and also secure, for example, a place of worship. But with a correct interpretative approach. As needs to be the case for all the technological problems of integrated surveys with laser scanner and drones, and Building Information Modelling, in order to understand how these models can become the basis for the acceleration of documentation processes. We need to document first. A documented, sur- veyed building has more chance of existing than an unsurveyed building, because it has geomet- ric data available, which we can define as "geometric memory". This opportunity increases the resilience of the community. A community that makes documented descriptive content available has more chance of existing in the future. An unknown, forgotten building, like the one in J. L. Borges's wonderful story in "Fictions" (1955) about the ruins whose existence in the desert only a few birds remember, will lose every chance of being preserved once it is forgotten by those birds. This is why these technologies are, first and foremost, fast (with precision), and allow us to doc- ument at speed much more heritage than ever before. Satellite images, drones and laser scanners enter the knowledge-gathering process, which still requires interpretation, however: between data acquired and information transferred, interpretation is needed - data (from a laser scanner or another source) is not yet interpreted, so to become information it must be interpreted. So a critical approach is necessary: a *doctor's report*, specific expertise, often also interdisciplinary. This is not and should never be a method of investigation that is unthinking (because it is delegated to the "powers" of tools) or over-simplified (in terms of accuracy and return of information), but the opportunities created by the technological innovation of digital techniques allow us to develop better strategies to mitigate risk in documentation, conservation and reconstruction.

4 FROM LIVED EXPERIENCE TO THE FUTURE: TRANSVERSAL TECHNOLOGY, TECHNICAL SKILLS AND NEW INTEGRABLE KNOWLEDGE

Lived experience is always valuable support. The image chosen for the front cover of the 2020 Summer School "After the Damages" is a little ironic. It is a drawing created by a large design studio called Superstudio, during the famous flood in Florence in 1966: it shows the plain of Flor- ence submerged in water. The image still has a strong psychological impact, and helps us to un- derstand how we need to do everything possible to avoid being in the same situation somewhere else. This is why "best practices" are so important. Documentation case studies made available as learning tools are an extraordinary, valuable resource. A valuable resource that is, as it were, consistent with the many technical experts, now all around the globe, who have requested ad- vanced training at "After the Damages". It must be a transversal acquisition of skills completely different from anything that has happened until now. Until today, these skills were transversal primarily in a technological sense: integrable technical skills. But today it is recognised that be- yond the technical, there are interpretations to implement from a social or economic perspective, or something else, such as a legal perspective: which laws do we need? Emilia-Romagna has proposed regulations, codes of conduct, what to write when events of this type occur, and how to set everything up so that it is already prepared. Because if another earthquake happens - even a small one - we cannot always start again from scratch. Is it important to have a hospital for artistic heritage, for intangible assets? At a certain point, the pandemic showed us that we did not have enough beds in the hospitals or places in intensive care, but we didn't have them when works of art were collapsing, either. In Emilia, after the 2012 earthquake, hospitals, sick beds were built for the soul and for culture. These masterpieces need places in intensive care too. What does this mean? What is the identity value of uniqueness? It is very important to put all the elements to- gether - this is no trivial matter.

4.1 *Models and skills for "charismatic forms" and "connective fabric"*

"After the Damages" aims to offer the opportunity, through inspections, guided visits and discussions, for the experience developed through the reconstruction after the 2012 earthquake not to be lost, but to instead become *active knowledge capital*. Because comparing models for intervention and management, first in the Emilia-Romagna region and then in Italy, can be truly useful. We are testing technologies for survey and intervention, materials and building techniques, and documentation processes. We are learning how to prototype damage to castles, cemeteries, theatres, and specialised, very complex buildings, which do not fall into the classic categories of church or palace, but are equally important because they are also considered *charismatic forms*. When we look at the sea, we naturally look for dolphins, whales, but it is more difficult to understand the richness of the ecosystem in its entirety. The same thing happens on land: we immediately try to identify the whales, the dolphins, the large, *charismatic forms of humanity*: the places designated to represent the cultural, social and productive history of a territory. But everything needs to be saved: just as we save the jellyfish and the plankton. What is essential is a vision able to inte- grate large complexes with connective fabrics, with different systems of relationships. Therefore, we need many skills, and the expanded international technical-scientific committee at "After the Damages" demonstrates a base of relationships and dozens of international collaborations, many of whom are also teachers, and have collaborated in developing the *case studies*. Over the years, we would like to strengthen these resources, because "After the Damages" aims to become an inclusive model that brings together many different profiles. This is something that has already been simulated in the technical-scientific committee and the international scientific committee, which brings together a truly rich variety of personalities and institutions at a global level. But this is not enough. It is little - too little; it is a starting point. It is a newborn baby; it is something that is still very young. We need to keep it alive. So this is how we have decided to structure it, through the coordination of research centres, starting with the University of Ferrara, integrated with research centres at other universities, institutional partnerships, and how these have become active, open people. "After the Damages" is currently primarily university-based: this is the first level of the network. This is the case all over the world. However, we are already working on expanding it: there are now institutions such as IPHAN Brazil and ICOMOS Italy, and also private organisations, so the network is beginning to grow. We would also like to build up an industrial network of Clusters at a global level, which can interconnect the networks of technological platforms, because we also need these types of collaborations. Then there are the sponsorships: the National Council of Architects, including councillor Walter Baricchi, who has helped us a lot with the Civil Protection; but also GBC Italy, which opens up the possibility of a sustainable vision applied to resilience with LEED and CAM protocols; as well as the UID Association (Italian Union of Design), which has offered a significant starting contribution, helping us to address topics fundamental for surveying and documentation, also at the scale of smaller towns around the world: Latin-American, Russian, Asian experiences in comparison, where operational workshops have considerably broadened the models of knowledge. But also the Faculty Members: from China to Turkey, from Ecuador to Armenia, from Spain to Brazil. This is intense, integrated research that needs to be kept active. The three universities involved in the Emilia-Romagna Region have created focused operating units, also connected to spin-offs and linked to European projects and research laboratories. There are many people who have collaborated in the creation of what "After the Damages" represents. But we would like to create task units in other countries too. "After the Damages" can collaborate in the creation of models. If colleagues or institutions from other countries are interested in developing "After the Damages" task units to activate and keep up this idea of comparison, "After the Damages" can come, organise an event, simulate a discussion, and leave the resources to spread the roots of a mindset that is very different from other ideas that seem to be winning around the world today.

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Built Heritage in post-Disaster Scenarios – Balzani et al. (Eds)

The aesthetics of landscape and the intervention on the historic city centers: The study of granada

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ABSTRACT: The city of Granada, Spain located in the south of the Iberian Peninsula. The monumental complex of the Alhambra has been present in all periods of the city. Through its architectural styles it narrates history across the common reference element of its "genius loci". In the 13th century, Muhammad I established his reign in this city due to its geographical characteristics and also the existence of important fortified buildings. This being the legacy of the Islamic period in the city. The case study of interventions in historic centers after damage is focused on four areas within the Alhmabra: Tower of Vela, Tower of Comares, Hall of the Barca, Palace and garden of the Generalife where damage occurred due to fires, earthquakes, lighting and/or explosions. The interventions carried out after these events in order to conserve and restore the space, such as the works carried out by Torres Balbas and Prieto Moreno.

Keywords: Alhambra, earthquake, explosion, fire, restoration

1 INTRODUCTION

The city of Granada, Spain responds to the historical model of city-hill, surrounded by mountains and watered by the Darro and Genil rivers, the first specifically divides the territory into two opposing fronts that conditioned the construction of the medieval city. The hills around the Darro river are S. Cristóbal (760 m) on the right bank of the river and Sabika (790 m) on the left bank. The Alhambra sits on the left bank. (Figure 1).

The Alhambra from a certain moment, has accompanied, almost as a constant, the different phases of the city's history. It is important to try to understand the Alhambra in its meaning and temporal relationship with the city of Granada. Let us try, therefore, to understand the Alhambra in its genesis and its different architectural performances. Its magnificent relationship between landscape and architecture is the common reference element of its "genius loci" (the spirit of the place).

The mitification of the landscape UNESCO world heritage was occurred on 1984 to The Alhambra and 1994 Albaicín. Under the following standards:

I. To represent a masterpiece of human creative genius.
II. To provide a unique or at least exceptional testimony of a cultural tradition or of a civilization that is still alive or that disappeared.
III. To be an outstanding example of a type of building or architectural or technological ensemble, or landscape that illustrates a significant stage or significant stages in the history of humanity.

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DOI: 10.1201/9781003253730-2

Figure 1. Map of granada in 1657 by anthon vanden wyngaerde.

2 HISTORY OF GRANADA, ISLAMIC PERIOD

Granada was founded when the great lords of Spain became independent (early 11th century). The province's capital was formerly Elvira, whose inhabitants emigrated and settled in Granada. Abu-Zenetan made of it a villa, fortifying it, surrounding it with walls and building a castle, succeeding Badis, his son. He finished the constructions begun by his father and the establishment of the population that still subsists. His town is crossed by a river called Darro. In the middle runs the Río de la Nieve, which is called Genil and which has its origin in the chain of mountains called Solair or mountains of Snow. This chain extends in the space of two days; their height is very considerable and the snows cover them perpetually. Guadix and Granada are to the north of these mountains, and the part of mountains that extends to the South can be seen from the sea at a distance of about 100 miles.

It is not causal that Muhammad I (1237-1273) chose such a privileged place due to its geographical conditions, also taking into account the existence of important previous fortified buildings. The high places of cities have special peculiarities and respond to a geopolitical type decision very consistent with the medieval mind. The supremacy of the place and the control of the territory were everything in the organization of a kingdom in the 13th century, in which both the military power and the administrative organization required an enclave that ensured the physical presence of power over the city, to the time he kept clear of it.

The settlement of the second population that it shared with Ilíberis was Garnata or Granata, rather a neighborhood occupied by a large colony of Jews, for what it was called "Garnatat al- yahud", that is, Granada of the Jews.

In the current Granada area, there were three important cities:

– Ilíberis. Roman-goth "urbs". This one the last one gave its name to the whole region
– Castilia, another ancient Roman (and perhaps Iberian) city at the foot of Sierra Elvira
– Garnata, Jewish suburb of Eliberis, at the foot of Torres Bermejas.

2.1 *Chronological events*

Habus (1019-1037)
Transferring the zirí court to Granada, offering lands and tax reliefs. The population of Elvira left the city and settled in the plain at the bottom of the Qadima Alcazaba. The old Garnatha alyehud to the Qadima Alcazaba.

Badis (1037-1073)
The Berber tribe of the Zenetes occupies the intermediate land between the Alcazaba and Elvira street. The primitive nucleus of the Alcazaba overflows the limits and reaches the Darro river in 1155. The Cauracha Baja and Los Renegados neighborhoods emerged. The Hazariz neighborhood was born at the end of the 11th century, between San Pedro, Cuesta del Chapiz and San Juan de los Reyes.

Garnatha Alehud
Nucleus of important growth of the city. The Jews abandoned the Bermejas towers refuge due to the arrival of new emigrants and gained ground along the left bank of the Darro river. At the bottom of the Alhambra, the Almanzora neighborhood was founded, which was related to Garnatha through the Mauror. Cisterns and baths (bañuelo) were built.

Almoravide period (1090)
The new dynasty preferred the old Garnatha alyehud to the Alcazaba Qadima, building palaces and recreational estates.

Almohad period (1149-1238)
Internal renovation of the city especially in the religious and administrative field. Beautification of the border zone of La Vega.

Alhamar (1238)
The settlement of the area outside the walls to the Alcazaba Qadima begins. Towards Xarea (San Cristobal) and called Albaicin. Fortification and population of the Alhambra, from the Alcazaba Yidida.

3 CASE OF STUDY AFTER DAMAGES AT THE ALHAMBRA

Below are four case inside the Alhambra (Figure 2), where damage occurred due to fires, earthquakes, lighting and/or explosions. And how was processed after these events.

3.1 *Tower of the vela: After damages*

The Alcabaza is located the tower of the Vela. Its plant measures 16 meters on one side and is 26.80m high. The base is solid and has four floors with arches lowered by pillars that determine galleries covered with several vaults.

Figure 2. View of the alhambra 1913-1919. photo by: Vega kurt heilscher.

Chronology events

1522. Damage caused by the earthquake. 1590. Explosion of the San Pedro powder keg.

1840. Lightning destroyed the bulrush rebuilt in 1882.

After damage

Some parts were rebuilt, he continued to close the arches on the second and third floors, completely defaced, to this is added a modern staircase and other accessories to make the tower habitable. (Gómez-Moreno Martínez, 1973)

3.2 *Tower of comares: After damages*

Its height (45 meters) makes it the most powerful in the Alhambra and its name comes from the stained-glass windows that closed the nine balconies that open into the great room that occupies the interior of this tower. These stained-glass windows are still called "comarías" in the East.

The interior of the tower is occupied by the room known as the Hall of Ambassadors, as it was intended for official receptions (Figure 3).

The dome is supported by a rich cornice. The dome is a masterpiece of Granada carpentry, placed under the primitive dodged brick vault that protected the room. The vault skipped due its excessive push forced to reinforce the wall corresponding to the Barca room in 1672-1674.

From 1688 to 1691 it was finally removed, some of the windows in the living room were solidified and the pillars between the balconies of the living room were rebuilt. The vault was then replaced by an armor that intercepted the passage to the tower platform, which has been restored by removing that armor in the repair carried out in 1933. (Casares López,1973).

Chronology events

1522. Damage caused by the earthquake. 1590. Explosion of the San Pedro powder keg.

1686-1687. Recognition of Juan de Rueda. The skimmed brick vault, which covered the wood, was dismantled and the terrace was replaced by a hipped roof and the southern area was used as a basement and main floor to avoid collapse, the works lasted until 1691.

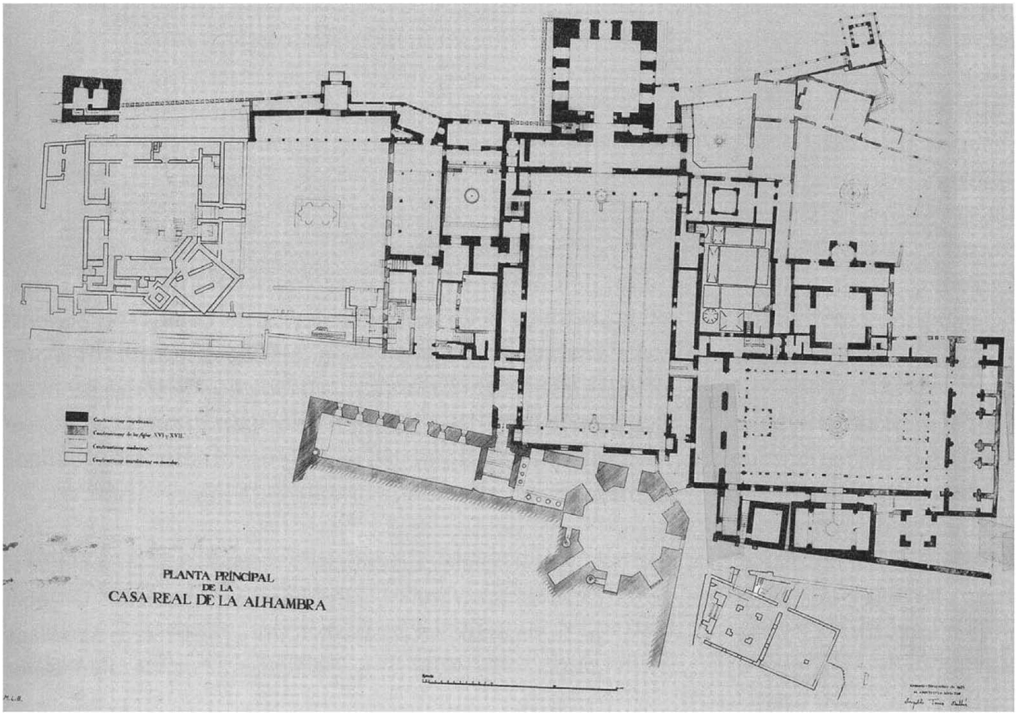

Figure 3. Plan of the casa real of the alhambra. by L. Torres Balbás (1923).

After damage

While the other three walls of the Tower are almost three meters thick and solid, the southern wall to which the Sala de la Barca adheres, had inside and throughout its height a series of small rooms and passageways that diminished Considerably its resistance to the thrust of the vault. For this reason, when it was found in an advanced state of ruin, a complicated shoring had to be made, emptying the exterior wall (that is, the one that closes the Barca Room, in almost the entire line of the Tower), and redoing it with ashlars with Alfacar stone up to a height of seven meters.

At the same time, the passageway was massified with the same material and up to that level, losing for it the underground plant. This considerable consolidation work was carried out between 1672 and 1674, and since the part on the left of the passageway served as the entrance to the staircase leading to the upper rooms and the terrace, a new door was opened in the Sala de la Barca. A careful examination made us see that there was no danger to the stability of the Tower in removing the ashlars that filled the passage, which, in addition to restoring the old arrangement of access to the staircase, would allow us to know the destination from the part of the corridor corresponding to the other side, which, was supposed to be another staircase to go down to the underground floor. The ashlars began to be removed in the last days of May 1923. (Torres Balbás 1934)

3.3 *Hall of the barca: After damages*

The anteroom of the most important space of the Comares Palace, its name may derive from the shape of its semi-cylindrical vault, similar to the hull of an inverted ship, or perhaps from the Arabic word al-baraka (the blessing), repeated repeatedly in plasterwork. of its walls.

Figure 4. View general of the patio de las arrayanes after the fire on september 1890.

Cronology

1890- Fire on September 15

1965- Restoration the ceiling as of drawings, photographs, and salvaged pieces. After damage

At the end of the 16th century, it was necessary to repaint the ceiling, so it was also known until recent times as the Golden Room. The shape and dimensions of the ceiling make it a strange and unique example. The original was almost totally destroyed as a result of a fire on September 15, 1890 (Figure 4-6), completing its restoration in June 1965, based on drawings, photographs, and salvaged pieces.

The armor, with a coffered bow, is made of pine wood. Its ends are quarter sphere with 12 loop decoration. The central axis combines wheels of 12 and stars of 8, combining them successively.

3.4 *Palace and Garden of the generalife: After damages*

The Generalife Palace and gardens: The Generalife Palace and gardens occupy the slopes of the Cerro del Sol, from which the entire city and the Genil and Darro valleys are encompassed. Ibn al-Jatib called it Yannat al-`arif, which has been variously interpreted, giving it the meaning of the garden of the Mayor, of the architect (alarife) or as that of the sublime garden, “the noblest and highest of all the orchards. As Hernando de Baeza did.

The Patio de la Acequia (48.70 meters by 12.80) is the most important part of the Generalife, but its appearance has changed since Arab times. At this times it was without the buildings added by the Christians, and more attached to the surrounding gardens. It is an example of an oriental garden closed, but that was opened in the Christian era, becoming an Italian garden, with a façade to the Tívoli villa.

Cronology

1958- Fire in December at Patio de la Acequia

Figure 5. View of barca room after the fire on september 1890.

Figure 6. View general of the patio los Arrayanes after restauration. photo by: Garzón.

Figure 7. View of fire on december 1958 at Patio de la Acequia.

Figure 8. View of fire on december 1958 at Patio de la Acequia.

After damage
1958 was a key year for the Generalife. Because of a fatal fire (Figure 6-7) destroyed important aspects of it, but at the same time, it was able to carry out a series of explorations and excavations for later reconstruction. In the Generalife, the Christian restorations and reforms altered its layout and disfigured many of its aspects. (Bermudez Pareja, 1965)

The most important intervention in this phase was focused on the Patio de las Acequia, which represented an outstanding example of the "riad" with its composition obeying the axis of the canal that ran between the pavilions. Prieto Moreno will rebuild in its cruise layout with the two longitudinal and transverse axes, with a central fountain and mochavados at the angles. (Prieto Moreno,1973)

The concern for gardening aspects, it would decisively influence in the layout of the new Generalife gardens (1951), which will be realized, connected with the open-air theater (1952). Inspired by the layout of the classic "riad". Due to, the stage of Prieto Moreno is characterized fundamentally for this inclination of the conservation of the monument (Figure 8), towards the aspects of gardening and landscape. (Prieto Moreno, 1973)

4 CONCLUSION

The different interventions carried out after damages caused by fires, earthquakes, lightning and/or explosions. In the areas of the Alhambra: Tower of the Vela, Tower of the Comares, Hall of the Barca, Palace and garden of the Generalife. In order to preserve and restore the space without losing the monument's history, such as the work carried out by Torres Balbás and Prieto Moreno. The conservative criterion has been imposed, and that today it is a general rule in the old countries of greater culture. For example, in Italy, the "Consejo superior de Antigüedades y Bellas Artes"("Superior Council of Antiquities and Fine Arts") issued, under the title "Schema di norme per il restauro dei monumenti", instructions that are usually called "Carta del restauro". These instructions order that all complementary or renovation works are excluded in the restorations, as well as adding elements that are not strictly necessary for the stability, conservation and understanding of the building. The old

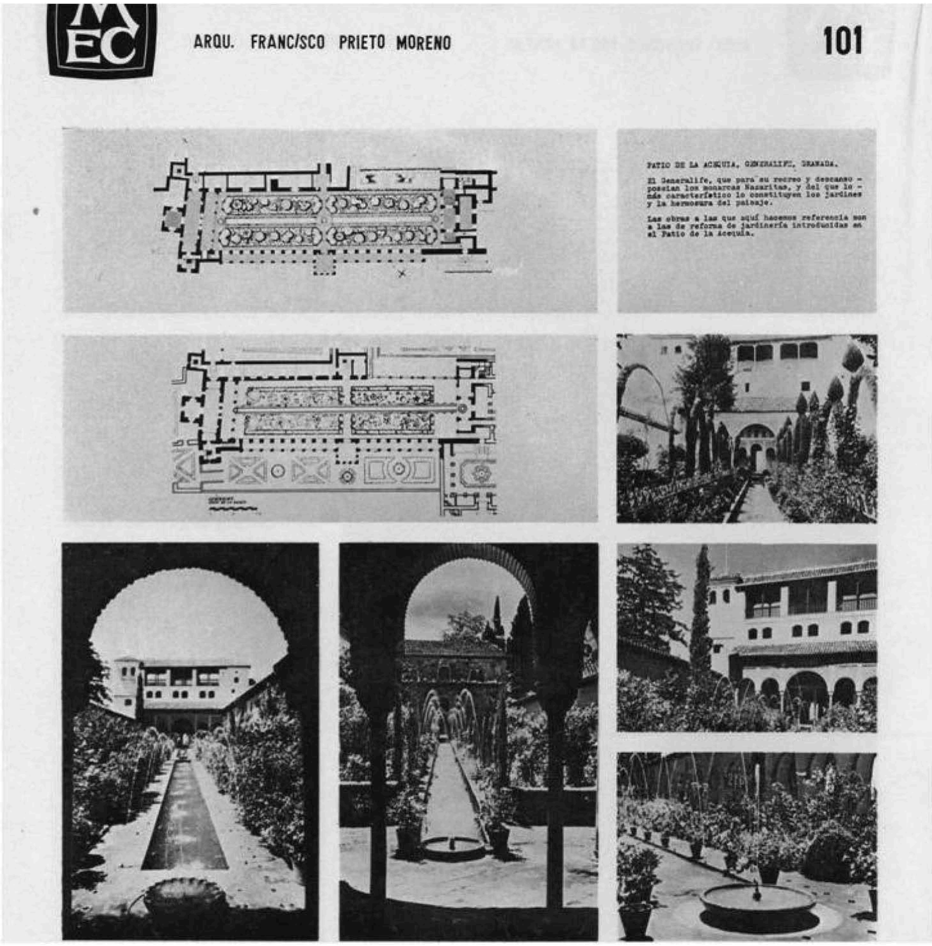

Figure 9. Monumental heritage of spain: An exhibition on its conservation and revitalization. plan and view general of restoration the architect Francisco Prieto Moreno at Patio de la Acequia. by Prieto Moreno (1973).

integrations and additions, when they have artistic interest or constitute a significant document for its history, will be preserved; the restoration should not be inspired in any way by abstract concepts of stylistic unity or reduced to hypothetical practices about the original form of the work, even if they are supported by graphic or literary evidence.

AUTHORS CONTRIBUTION

Conceptualization, resources, writing-review and supervision, F. Gallego Roca. Writing, review and editing original draft preparation, S. Bonilla-Correa. All authors have read and agreed to the published version of the manuscript.

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Built Heritage in post-Disaster Scenarios – Balzani et al. (Eds)

Public building restoration after earthquakes: A strategic overview of the funding process

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ABSTRACT: The contribution explores the peculiarities of the Emilia-Romagna territory of the Po Delta, tracing the main issues afficting this fragile coastal systems today, and outlining the necessary future challenges to take up in order to rethink its land/water structural balance, adapting to climate change and guiding territorial transformations towards more resilient confgurations. The effects of climate change, together with contemporary socio-economic dynamics, are creating new pressures on the territory and its population, exposing the latter to new conditions of risk and undermining an already delicate equilibrium, forcing the investigation of new resilient design strategies and solutions, at different scales, to achieve greater sustainability. Moreover, these invented and artifcial landscapes, mainly based on a constant control over the water regime, are also subject to an idea of heritage and cultural landscape as a static system that must be brought back to a previous "natural" state, freezing in time its features and characteristics to a specifc evolutionary phase. This attitude is triggering expensive and counterproductive processes – both at the governance and operational levels – that are not proving capable of consciously driving the necessary change. Today more than ever, the coasts and deltaic territories represent an extraordinary feld of testing and experimentation for design research and, with this aim, the CITER Research Lab (Architecture Department of the University of Ferrara) has been working on the EmiliaRomagna territory of the Po Delta, integrating scientifc research projects with educational paths involving university students, training events for professionals and public technicians, and experiences of participatory design involving local communities, some of which are briefy illustrated in this paper.

Keywords: Po Delta , territorial resilience, cultural heritage

1 INTRODUCTION

Post-earthquake reconstruction is an extremely complex, long and costly process, even only in its most immediately visible aspect of reconstructing or materially repairing the damaged buildings; therefore it is essential to have an idea of its evolution over time, in the various phases of activity planning, design and execution, on a territorial scale and on the scale of individual site.

In particular, one of the most complex issues is the reconstruction of buildings owned or otherwise used for public purposes. This is due on one hand to the sensitive nature of the functions they host, and, on the other, to the great and even symbolic importance that these public buildings have within the urban fabric: they often constitute the most powerful places where people come together, as well as more generally they represent the places of the greatest historical, artistic and testimonial value. Public buildings means both buildings in public ownership in the strict sense of the term, and more broadly all buildings which, for historical, financial, economic, legal or other reasons, are used by the public even though they are not owned by

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DOI: 10.1201/9781003253730-3

the public: this refers in particular to churches or places of worship in general which, as experienced with earthquakes in Italy and elsewhere in the world, usually are the most vulnerable buildings during seismic events. In economic terms, the Emilia earthquake of 20 and 29 May 2012 caused enormous damage, even though it was not an event of extremely high magnitude, because it occurred in an area that was intensely exploited in terms of productive activity. The Italian government after the event sent to the European Commission an early estimate for a 13 billion euros' worth of reported damage, in order to request the classification of the event as a disaster: in detail, a damage of about 3 billion was reported to residential property, and a further 5 billion euro to businesses (an assessment that in this case was not limited to property, but also included the economic losses caused by stoppage of activity, loss of stock, destruction of machinery and equipment, etc.). Focusing on the public sector, in the broadest sense, some 700 million euros were needed for the initial phase of the emergency and the first relief operations (assistance to the population, setting up of emergency camps, removal of rubble, rapid securing, etc.); the estimated cost to restore the large set of public buildings was estimated approximately in 3 billion euros, of which 2 billion related to cultural heritage and religious buildings, and a much smaller amount (around 1 billion euros) for non-historic public property, services and infrastructure. In the immediate aftermath of an earthquake, assistance is provided to the displaced population with progressively less uncomfortable solutions; at the same time, for local government, it is urgent to both make the surviving buildings safe, prioritising those with the least damage, and to provide temporary buildings or emergency facilities for the allocation of the services housed in those buildings that will take longer to make secure or to reconstruct. Only after this first phase of "restoration of functions", the efforts of the government authorities, businesses and professional bodies can focus on the actual building reconstruction. Nine years after the earthquakes the private sector reconstruction (business and residential) is 95% completed, while in the public sector, resources of 1.4 billion euros have been allocated to over 1,700 sites, with work in progress or already completed in over 1,200 and around 500 projects still to be drawn up or approved.

Thus, there is more inertia in the reconstruction of public property. Even the raising of funds for public reconstruction, and the planning of these works over the years, represent parts of a step by step process. In Emilia, as in the other areas of Italy affected by the most dramatic earthquakes of the post-war period, this process evolves over time, often with the accumulation of legislative measures along the years; in the case of the Emilia region, considered here, the initially estimated costs aren't yet entirely covered, 9 years after the event. To the date, approximately 930 million euros in funding has been made available from the earthquake emergency funds for public reconstruction in Emilia Romagna, plus a further 460 million euros in co-financing made available to local bodies (of which insurance payments constitute a major part, but which also includes donations and budgetary resources): a huge commitment, bearing in mind that the earthquake crater covers a total of sixty municipalities, many of which small or medium-sized.

The reconstruction phase is thus characterised by an initial inertia. This does not mean, however, that there was no public reconstruction activity in the first months or years after the earthquake, but rather that efforts in that phase were inevitably more concentrated on removing the rubble, on the first initiatives to make buildings safe, on demolishing non-recoverable parts, on the construction of temporary buildings for the emergency phase: hundreds of construction sites were activated within a few weeks or months. At the moment, at full capacity, more than 100 construction sites are being opened per year.

2 THE APPROACH TO PLANNING THE RECONSTRUCTION OF PUBLIC PROPERTY AFTER A SEISMIC EVENT

Reconstruction is a process that is extraordinarily extensive and complex in terms of both time and space, and it consequently involves great uncertainties, unexpected events and reassessments. This is why it is indispensable to plan carefully, with a clear understanding from the outset of what the priorities should be, and what possibilities must be granted to each of the categories that will benefit in the short or long term. Focusing on the reconstruction of public property, one might think, since it is a matter of allocating resources to buildings public through ownership or use, that the total expenditure is an independent variable, or in any event a fictitious limit that can always be exceeded. In reality, it is not quite like that: the fact that the assets are public does not mean that due attention should not be paid to the correct allocation of available resources, so that all damaged objects can be repaired, restored and returned to their functions in a reasonable time. It is therefore important that the planning never loses sight of the basic objective of a postearthquake repair or reconstruction initiative: to make the buildings safe and earthquake-proof. As we all know, an earthquake is an event that repeats in cycles, in a way that is totally unpredictable in terms of where and when; so, we cannot afford to spend resources on building repair work without at the same time improving their safety, in terms of their capacity to withstand similar shocks in the future.

Thus we deal with a resources optimization problem of in the context of a more or less limiting constraint on expenditure. The resources that can be used are scarce by definition: those are not just financial resources (which, strictly speaking, are at most the instrument, the lever through which reconstruction is encouraged and supported); an earthquake almost instantaneously creates a great need for activity, over an area that usually is too weak to sustain alone the effort without external contributions.

This need certainly applies to the financial requirements, which have to be supported with transfer policies that should be adequate in size and timing (in relation to the spending capacity of the local government bodies that will then put the compensation and repair measures into practice); but the point of view should be extended, at least to the economic aspects in a broader sense, given that the issue is not just the financial power deployed, but also includes the productive capacity of the area subject to intervention. It may happen, for example, that there is little response to a call for tenders for a repair site because, at local level, the construction companies, collectively, do not have the capacity to absorb, on their own, an organisational effort of the magnitude required in a reconstruction process. The economic and productive strength of an area, which has, moreover, been hit hard by a sudden and often unexpected event, is therefore independent from the resources made available by government, which may eventually trigger a virtuous circle of growth, but not in the short term. On the other hand, the productive capacity of the territory, with its key sectors of activity (such as agriculture, tourism or, in the case of the Emilia earthquake, the industrial enterprises in the various districts that are well integrated into the international economy), must also be put in a position to restart soon. It is only when the economy in the broadest sense is restarted, that a process of reconstruction can take place leading to the reactivation of society, the population and the productive fabric, which gives meaning to the investments made on the buildings.

Finally, a seismic event is also a shock to society; this aspect was perhaps less felt in Emilia, whose territory is today relatively dynamic in terms of population numbers and density, as it was on the day of the earthquake, although it is composed of many small municipalities. For example, a different situation seems to be emerging for parts of the area affected by the 2016-2017 seismic shocks in central Italy, where the earthquake hit some particularly isolated communities, at an advanced stage of depopulation; in such a condition, irrespective of the resources made available, it is difficult to incentivise a reconstruction process for communities with a very high proportion of buildings that are uninhabited or abandoned, even if of great historical-testimonial value.

Returning to the broader theme of limited resources, an extreme but not entirely inappropriate comparison might be made to the ideal example not affected by this problem: the cathedral of Notre Dame in Paris, partially destroyed by fire in April 2019. Donations worth over a billion euros were collected in a few hours: certainly, for a building unique in the world, it was no problem to secure the expertise, the professional skills, the necessary agreement of the institutions and the impetus from society needed to carry out a rapid and complete restoration.

However, the reality of post-earthquake reconstruction in Italy is quite different: just think of the historic Messina earthquake of 1908, for which, more than a century later, the problem of dismantling the agglomerations of “shacks” housing part of the population comes up again and again. The comparison with the public reconstruction in Emilia Romagna is also cruel: compared to the one billion euro in funds raised by donations for just one building that burned down, Notre Dame, around sixty million euro in donations were raised here, for more than 1,700 buildings (and that is only the public ones) damaged by the earthquake. However, this is a large sum of money, absolutely invaluable both in the emergency phase and in the actual reconstruction phase, as it makes it possible to overcome the not always very elastic limits of public funding (just think of the Italy’s financial situation in 2012).

Insurance settlements also played a key role in triggering the reconstruction process, with more than 200 million received in compensation for public property alone. It should be borne in mind that in the area of the Emilian crater, the most recent earthquakes, which constituted the local “memory” on the subject, had all been of limited magnitude and impact: the last disastrous earthquake had occurred in 1574 (438 years earlier). From the regulation perspective, prior to 2005 (only 7 years before the earthquake) there were no specific obligations to design new buildings, or to plan interventions to transform existing ones, using anti-seismic methods. As a result, even from an insurance point of view, “all risks” policies were often taken out, which were mainly calibrated on different types of risks (floods, fires, etc.), and at most included earthquake risk as a secondary and almost optional risk: hence the overall compensation was an order of magnitude lower than the estimated damages.

2.1 *Optimisation of the available resources: planning, design, execution*

The issue of the scarcity of resources in dealing with a reconstruction process has been introduced. The need to optimise their use, not only in financial terms is now considered. This applies from the micro-scale of the individual building or group of buildings to the macro-scale of the territory. Establishing the perimeter of the affected area, for example, is an extremely delicate initial process involving a number of issues, and it is generally carried out “in the heat of the moment”, even before the damage surveys have been completed: in the presence of a spending constraint, enlarging too much the perimeter of the “earthquake crater” may entail the risk that there will not be enough resources, and that perhaps, with clumsy prioritisation and resource allocation mechanisms, very badly damaged buildings will in the end be excluded.

The planning phase therefore becomes decisive, as it is a moment that identifies the priorities of a territory, starting from the distribution of available resources among the various macro-sectors (housing, productive sector, public property, etc.), which is, moreover, taking place in a situation in which there is great uncertainty about how much is actually needed.

In the case of public property, careful planning should prevent the efforts made in the first months or years after earthquakes to carry out temporary works, first emergency works, shoring, demolition, removal, etc., from being ephemeral as they are purely for temporary use: this because they represent not only a huge expense, but also a considerable effort for the authorities.

Even in the individual project design phase, choices must be optimised, not only financially, but also in terms of respecting the peculiarities of the building, such as above all its historical and architectural characteristics, which must not be altered or at least compromised. Every project, like every public building, especially if of architectural importance, is a unique case, and it is not possible to direct the design in a binding way a priori, because, especially for protected assets, the design can pursue a great variety of solutions, since it can rely on a broad range of techniques, materials and criteria.

Optimising the use of resources does not stop with planning and design but must then be safeguarded by a corresponding attention to the works execution phase: naturally there may be contingencies, unexpected situations due to an unavoidable imperfect knowledge of the existing buildings, especially if they are historic, or unforeseeable conditions imposed by external factors (just think of the stoppage of construction sites during the first phase of the Covid-19 pandemic). Inevitably, given that the reconstruction process takes a long time, changes in the local community’s demand regarding the use of a building are also foreseeable: for example, depopulation of a community or reorganisation of the school network will mean that a building used as a school at the time of the earthquake will have to be converted to other types of uses. In general, the execution phase can sound a sour note, nationally: it cannot in any way be assumed that a construction project will be completed within the initial budget, especially for large-scale works. In this respect, the reconstruction of Emilia Romagna can be defined as virtuous, since more than 90% of the works have been completed without exceeding the funding allocated with the approval of the project, even if this implies a particularly careful phase of analysis and discussion around the project itself. In order to better understand the reasoning behind the planning of resources in a reconstruction process, it is useful to recall some basic principles of economics, first of all the concept of marginal utility: it is defined as an increase in the level of utility, i.e. of the satisfaction that an individual derives from the consumption of a good, which can be linked to marginal increases in the consumption of the good, with consumption of all other goods constant. This concept translates the common experience that, if a good is available in a limited quantity (a typical case would be water resources), the supply of minimum threshold levels is certainly considered vital and indispensable (very high utility), while, as the quantity supplied increases, needs of increasingly lower priority will be satisfied, and consequently the utility of the good is progressively decreasing.

An immediate application of the concept of marginal utility can be found for typical reconstruction issues, articulated on several levels:

– At the level of territorial planning, this translates into a prioritisation of lines of action according to the needs of the population, in terms of allocation of resources but above all in terms of the time frame of activities: this means to assess first of all the primary needs (accommodation of displaced persons, restoration of homes), then to facilitate the restarting of productive activities to safeguard employment, and so on, with decreasing urgency, the restoration of public services (here too, with a scale of priorities that can be revised from time to time according to the specific features of the territory).

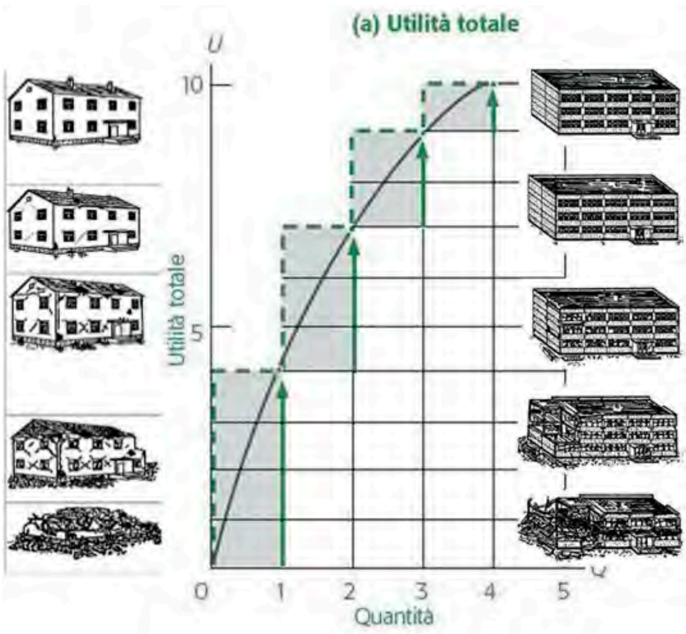

Figure 1. The concept of marginal utility in terms of the cost-benefit ratio of the seismic security of a building: minimal interventions and few resources are sufficient to ensure that a building can reasonably withstand another major earthquake without collapsing, but works with progressively greater impact are needed to ensure that it can also sustain damage that is limited or negligible and remain operational in a seismic crisis.

– At the design level, and therefore with reference to the individual building or artefact to be restored, assessing, depending on the financial resources available, which needs are a priority, because they meet users needs that cannot be ignored (in a post-earthquake reconstruction, certainly the restoration of structural safety and fitness for use), which additional needs are to be taken into account, and in what order (fire safety, removal of architectural barriers, plant upgrades, energy efficiency, restoration of decorative features, etc.).
– Even at the design level, although limited to just one aspect, the structural safety, the concept of marginal utility translates into the dual objective of, on the one hand, containing the intervention, in its multiple impacts (financial cost, but also duration of the works with interruption of the building's operations), and, on the other, increasing structural safety (in addition to repairing damage), with gradually increasing levels of seismic capacity up to potential retrofitting of the construction.

Naturally, different solutions can be pursued, both in planning and in design, with a plurality of choices, all of which can be considered optimal and legitimate, although different from each other.

A further concept extrapolated from economics that helps to clarify the subject is that of the Pareto front, i.e. the locus of the points of the solutions that are the most effective, in a multi-objective problem, with respect to all the parameters considered, because they are "nondominated": that means there are no other solutions that are simultaneously better for all the parameters considered, with respect to those on the front.

For example, applying the Pareto front concept to the topic of the relationship between the cost of an intervention and the seismic safety achieved, all the solutions that provide the best compromise between the two objectives will be considered optimal: that is, there will be no other possible design choices that at the same time, guarantee lower costs and achieve the same seismic safety. Consequently, solutions involving minimal, low-cost restoration and safety work, seismic reinforcement or improvement at gradually increasing cost, or upgrading and reconstruction at a higher cost will be equally "legitimate" and "optimal".

If it is then accepted that structural safety is not the only objective of a vast and complex reconstruction initiative, there will be a multiplication of Pareto fronts. It could be the case, for example, that a solution which is optimal from a structural point of view is not optimal for

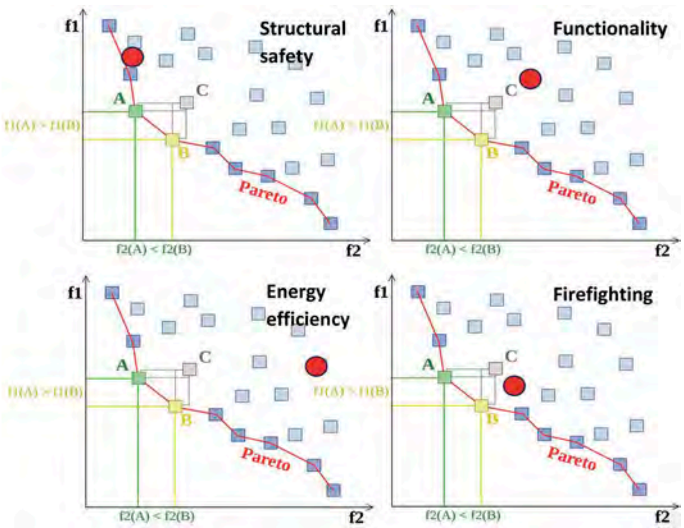

Figure 2. The multiplication of Pareto cost-benefit fronts for a multi-objective problem: the same design solution may be optimal with respect to seismic or fire safety, while simultaneously being ineffective with respect to building functionality or energy efficiency.

the functionality of a building, or with regard to fire safety requirements, and is even less optimal with regard to energy efficiency. The project will therefore have to reach a sound compromise between all these needs, representing the needs of the building's users and the wider local community; on a larger scale, a similar compromise solution at territorial level becomes the aim of reconstruction planning for the whole territory.

2.2 *Criteria underpinning the processes of financing the reconstruction of the built heritage: The specific features of the public property*

The criteria that normally lead the financing of reconstruction interventions can be synthetised in three categories, irrespective of the object of the intervention to be implemented:

- Objective: the basic principle, always emphasised in the legal instruments that regulate the emergency at the highest levels, is the correlation between the damage to the building and the seismic events, and the proportionality between the proposed interventions and the damage. This ensures uniformity of treatment among the various entities or bodies that are beneficiaries of the possible funding, with respect to the central structure of the government commissioner who has to allocate and justify these transfers.
- Subjective: related to the use of the building, because the uses are decisive in determining the needs that will be translated into design choices, and consequently in determining their costs.
- Design: guidelines are established which, while maintaining everyone's design freedom, enable a certain uniformity of treatment to be maintained. This refers, in particular, to the sector technical regulations that may apply, to the performance standards that are prescribed such as seismic safety levels or energy efficiency; other uniformity criteria may derive from the indication of reference price lists.

The process that leads to the determination of the contribution for a building to be reconstructed always starts from a planning process, based on laws, ordinances, calls for tenders, which makes it clear what the objectives are (e.g. the damage grids which can be used to frame the type of intervention and its eligibility). With this input data, the design phase can start. This is a phase of dialogue between the beneficiary and the authority that allocates the resources; at the end of this process, the contribution that can be granted for the restoration of the building is determined. After the 2012 earthquake in Emilia, three main lines of funding were activated, with varying degrees of detail within them: one for residential construction, one for industrial construction and one for public reconstruction.

With reference to the reconstruction of industrial warehouses, it was possible, for example, to provide mathematical formulas which, starting from damage assessment grids, assign a conventional parametric cost, which is compared with the cost actually envisaged by the project and, taking into account the possible presence of insurance compensation, makes it possible to determine the contribution to be granted as the lower of the two. Within this albeit schematic evaluation process, numerous variables can be considered, since for greater adherence to actual needs, the parametric cost is remodelled according to the size of the building, the structural type, the sector of activity, the type of intervention (which must be linked to the damage), the specific characteristics of the building or its intended use.

Similarly, for the reconstruction of residential buildings, damage and vulnerability grids have been created which make it possible to determine the so-called "operational level" for each individual building.

This in some way represents the margin of design freedom in terms of type of intervention and cost; it is combined with the ownership structure (if it is a condominium), the intended use, any historical, zoning or landscape constraints and special conditions to finally arrive at a parametric cost for the entire building. Once this limit cost has been defined, the design process can begin, providing an estimate of the actual cost needed for the specific building. The project is further guided by broad criteria in terms of structural safety, energy efficiency, removal of architectural barriers, and criteria of proportionality between different types of expenditure (repairs, installations, finishes, etc.).

When estimating the costs of public reconstruction, automatisms such as those described above are not applicable: the objectives can also be extended beyond mere compensation for damage as, in this case, we are dealing with the reconstruction of public buildings with public funds; it isn't then a mere compensation, but an investment. It is unthinkable to apply parametric costs or damage grids, due to the extreme variety of construction types and building types that cannot be summarised in a table: it is enough to just think of the damage surveys, which for cultural heritage saw the survey sheets for buildings and churches as operational tools.

However, these were not found to be applicable to theatres, historic cemeteries, chimney stacks, etc. Another element of specificity is that the eligibility of interventions must necessarily disregard whether the building is still in use or not. In the case of a residential building, for example, during the reconstruction in Emilia Romagna, the rules dictated by the national regulatory framework on emergencies meant that the law only applied if the house was declared uninhabitable and the residents evacuated, whereas in the case of a public building, perhaps precisely because of emergency requirements, the issue is reversed: for example, a town hall, if recoverable, must continue to operate, even if it is propped up. Moreover, purely numerical criteria of proportionality between structural works and plant works, finishes, decorations or restorations are inapplicable. There is therefore a need to focus, even more, in public reconstruction, on the project and its objectives.

3 THE PROCESS OF TECHNICAL AND ECONOMIC EVALUATION OF PUBLIC BUILDING RECONSTRUCTION PROJECTS: THE EXPERIENCE IN EMILIA

In order to understand the approach followed in the technical-economic evaluation of the projects for the restoration of public property in the post 2012 earthquake reconstruction in EmiliaRomagna, it is essential to always take into account the principle of scarcity of available resources, introduced earlier.

The criteria for the allocation of funding and the identification of priorities must already be clear in the planning phase; this is carried out at an early stage of the emergency, and it is based on the data available, at that time, on the amount of public property assets and on the damage suffered; therefore, one must rely mainly on the results of expeditious damage surveys and in the most fortunate cases, for some buildings, with the support of studies or vulnerability analyses carried out before the seismic event, which can provide more substantiated information on the expenditure and needs of the specific object.

In any case, the resource allocation process starts with a very rough first approximation estimate; it therefore needs to be continuously checked and updated based on the intervention projects, with iterative cycles for successive approximations.

In the experience of the 2012 Emilia Romagna earthquake, this initial estimate was combined with the resources actually available for an initial draft of the financial planning, together with the indication of some criteria for priority and reasonable uniform distribution among the various types of entities (with priority, once again, to school buildings): those were defined in Regional Law no. 16 of 21 December 2012, which provided the regional regulatory framework for reconstruction.

Once the implementation of the programme has begun, attention shifts to individual projects, in respect of which it is possible to verify the actual compatibility of the first approximation estimate with the resources assessed as necessary, obviously setting guidelines for the design, and rules of engagement not on the techniques or materials to be used, but on the methodology of approach.

The project, which represents the instrument of comparison between the bodies implementing the interventions and the central coordination structure that allocates the resources, must therefore start from surveys, measurements, damage assessment and vulnerability analysis, which lead to the identification of the structural works required; starting from these, the design process can then identify which works are strictly correlated or cannot be postponed (plant engineering, restoration, energy efficiency, finishes, etc.). Obviously, the design approach is not always so

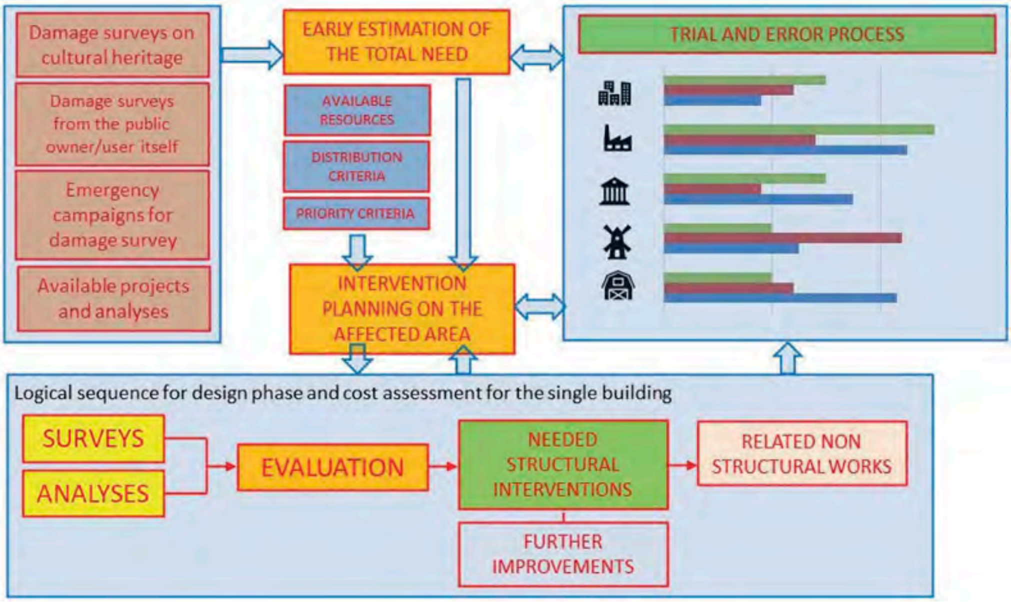

Figure 3. The iterative process of programming the resources for funding the reconstruction of public planning: the estimation of resource allocation proceeds in successive approximations, fed by progressive feedback from the projects submitted.

linear: it may happen, for example, that, for the most disparate reasons, the design reverses this path and starts, perhaps, from different objectives, such as the possible refurbishment or redevelopment of a building, making it difficult to objectively assess the costs strictly related to the damage, and therefore to correctly allocate the resources.

A realistic estimate is thus obtained from the comparison of individual projects; as the process of examining and approving projects, awarding contracts and carrying out works progresses, and as the financial planning coverage hopefully expands, resources are redistributed.

3.1 *The approach to project evaluation: from the general to the particular*

It should first be stated that the technical and economic assessment of the adequacy of projects is a process that is not regulated and cannot be regulated, other than through general indications and principles.

In the public reconstruction after the 2012 earthquake in Emilia, a top-down approach is adopted, with an apparently simple and linear process going from the general to the particular: there is an initial technical check that concerns the specific solutions proposed by the project (what works are proposed against the objectives to be achieved), and downstream of this a more specifically economic check, which means the way in which the individual works are measured, the price applied, the construction of the overall economic framework, which includes not only the cost of the works but also the costs for investigations, surveys, control of materials, technical expenses, land occupation, removals, etc.

In the case of projects for which parametric costs are applicable, such as those for private residential reconstruction, a technical assessment of the project is always necessary to check compliance with the regulations, objectives and costs; yet, an assessment of the appropriateness of the works, or of their justification in terms of cost-benefit ratio, is reduced to a standard check that what is proposed falls within the global parameters established in the conventional cost. When assessing projects for intervention on public property, especially if of architectural importance, instead, an initial check should be made to ensure that the project

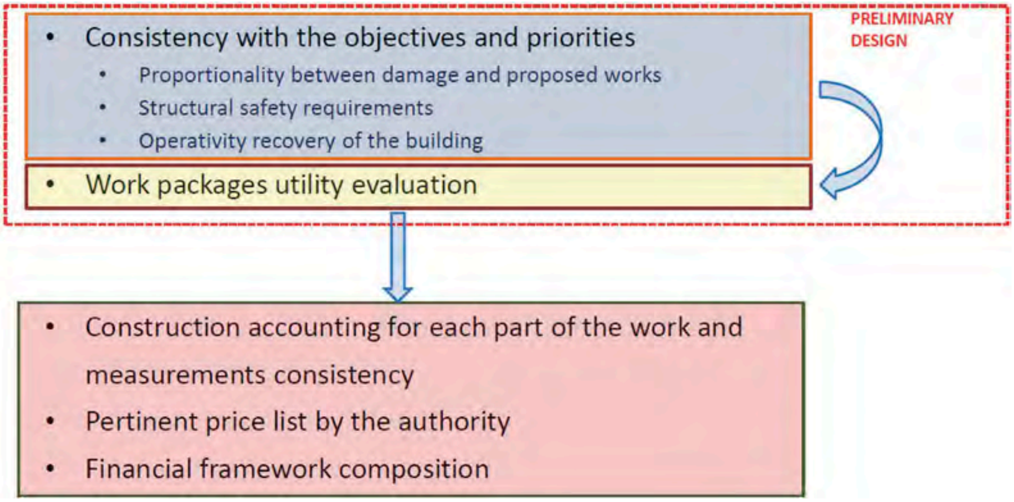

Figure 4. The approach to assessing the appropriateness of expenditure in reconstruction projects: a general outline of the progressive in-depth development from the general to the particular.

actually pursues the objectives, i.e. that there is a causal link between the damage and the seismic events, that the building can recover its usability and functionality, and that the proposed works are proportionate to the damage.

The specific solutions proposed by the project to repair the damage and consolidate the building by means of the proposed works are analysed in more detail: the actual necessity and coherence with respect to the objectives set (marginal utility of the various design solutions) is verified for aggregate "blocks" of works (structural work, finishes and related systems, corresponding temporary installations, related restorations, etc.).

These assessments can be carried out at a preliminary design level (technical and economic feasibility), so that the executive design can then be developed on a shared basis. Obviously, this is not always possible, often some assessments are inevitably postponed to the executive project: for example in the case of strengthening interventions of load-bearing walls in masonry, which in some way depend on the mechanical characteristics of the masonry itself, possibly not thoroughly investigated in the initial levels of the design process.

This first, more strictly technical, phase of evaluation is the most complex and decisive phase in the project assessment: this is the toll that the funding coordinating structure reserves for itself to verify the implementation of the programming objectives.

Once the strictly necessary works have been determined, the next steps in the check of the appropriateness of the expenditure can take place. These are more immediate and involve checks of the measurements, so that the works are correctly accounted for, of the prices applied, which must respect the official lists specified by the central coordination structure, and, finally, of the respect of the requirements of proportionality and financial sustainability on the overall economic framework.

Once again, it is useful to remember that the reconstruction of public property does not only concern the structures, but aims also to give back to the community a building that works to provide the services for which it was designed, that can be visited by its users: how it is visited, and its use, constitute the basic conditions for its future maintenance, as they make it sustainable to plan interventions going forward that will preserve its performance for a long time. Consequently, it is advisable that a restoration project, especially in the case of condemned buildings with extensive damage, should indicate the finishes connected with the repair works, the anticipated restorations, and the interventions on plant and equipment, furnishings and safety features that go beyond the merely structural.

3.2 *Reconstruction objectives for public property in Emilia*

The planning of public reconstruction after the 2012 earthquake in Emilia, which should be seen in the context of the historical squeeze on public finances during which it took place, imposed itself a quantitatively limited but qualitatively important set of objectives from the outset:

1. Damage repair and structural reinforcement.
2. Rehabilitation of finishes and plant related to structural works.

The primary objective is therefore structural safety, for which a criterion of proportionality has been established by identifying a necessary correlation between the seismic damage suffered by the building and the proposed category of intervention (Technical Standards for Buildings, Chapter 8.4). In the case of buildings with very minor damage, which may not affect the structures, simple repairs and local reinforcement will be carried out, while in the case of more damaged buildings, seismic improvement will take place, and in the case of non-historic buildings demolition and reconstruction will be permitted in the event of very serious damage.

In the case of buildings characterised by significant damage, in addition to mere repair, seismic upgrading is therefore required as a simple investment protection and cost-benefit criterion. These investments normally would have a great impact, for which it is particularly opportune and economically advantageous (consider, for example, the installation of scaffolding) to grasp the opportunity to undertake works that update a building also in other respects, alongside the structural work: in fact, it would be a bad investment to start long and laborious building works that would improve only the seismic behaviour of the structure, but would result in a building that is not functional and cannot be adequately used by users. In such cases, the two basic objectives are supplemented by three subordinate ones, namely:

1. Energy efficiency
2. Breaking down architectural barriers
3. Adaptation to various safety regulations (fire prevention, electrical installations, asbestos disposal, etc.)

Obviously, the pursuit of these “added” objectives is to be understood, in turn, as related to the actual use of the building, both at the time of the earthquake and in the future planning of the body that owns or manages it, and to the functional, social, architectural and artistic value of the building.

3.3 *Calibrating structural intervention as the key to the reconstruction project*

The centrality of the objective of seismic structural consolidation as a way of guaranteeing the long-term investment, in the face of future repetition of events of the same type, has been mentioned.

This centrality is expressed in the generalised application, on all public reconstruction projects, of certain performance requirements, regardless of the type of intervention (local strengthening or seismic improvement): in essence, the safety of the occupants must always be guaranteed, all damage must be repaired, the most evident seismic vulnerabilities must be resolved, particularly if the earthquake has made them manifest by activating the corresponding damage kinematics; moreover, in the case of seismic improvement, a minimum quantitative threshold is set for the overall seismic capacity of the building.

In Italy, the main post-war seismic reconstruction initiatives have never imposed, on seismic improvement works, safety levels equal to those of new buildings; the required levels were in every case limited to threshold values considered reliable and acceptable: in Emilia the level achieved must be 60% of safety compared to a new building (in acceleration terms). This threshold approach was subsequently codified in the Technical Standards for Buildings, from the 2018 update onwards (Ministerial Decree of 17 January 2018). For listed historical buildings, which are normatively exempt from reaching specific thresholds, a level of safety appropriate to their use is still required, since the structural safety of the building is a fundamental requirement for the protection of its values: vulnerabilities that may lead to damage to elements of architectural and artistic value must be removed or mitigated too.

Even when the choice is for local intervention, it will be advisable to not limit such work to only the repair of the damage, or damage mechanisms that have actually been involved, but to extend attention to the more typical damage mechanisms of the structural type of the building in question as well, even if such mechanisms were not triggered, perhaps because the seismic acceleration experienced was particularly low at the site: the typical connection deficiencies of industrial buildings with large spans, or the uncompensated thrusts of arches and vaults in historic buildings are examples of this.

Repair projects with local strengthening must thus in any case balance, albeit with limited interventions, the divergent requirements of consolidation, cost containment, minimum impact of the works on the operational continuity of the building, and complete restoration of its functionality. In the case of seismic improvement projects, that regard the most damaged buildings, the funding will certainly be higher, then the design must guarantee, even more, the resolution of possible conflicts with aspects of protection of the architectural and artistic values of the building: the interventions necessary to pursue a high level of safety, in accordance with the intended use of the building may in facts not be compatible with its protection, or with respect to its functionality. In general, a post-earthquake structural repair or rehabilitation project can be considered adequately calibrated when the solutions proposed clearly derive from the combination of the damages detected and the vulnerabilities identified, supported by surveys and investigations, while also respecting the characteristic elements of the building, especially if it is of historic interest: those include its structural design, when this has passed the test of the earthquake. The selection of typical and thoroughly tested traditional building techniques with a high cost-benefit ratio completes the picture.

On the other side, it is particularly difficult to share, discuss and, if necessary, amend projects which, to guarantee the numerical threshold of seismic improvement, are clearly guided not by the real building and its behaviour, tested, concrete and verifiable, but by a virtual building produced by modelling; a virtual model, it should be recalled, always involves great uncertainties, however sophisticated the modelling might be, which only comparison with the actual seismic response in terms of damage can validate.

4 MULTI-OBJECTIVE DESIGN: SOME EXAMPLES

The approach to the assessment of public reconstruction projects has been described above as a multi-objective problem, which has to balance different needs, not only linked to the cost and the achievable safety level, but also to all the requirements expressed by the present and future users of the building, which have to be taken into due consideration.

This paper then set out the approach followed in the experience of reconstruction after the 2012 earthquake in Emilia, both in the planning of interventions, which defined the objectives to be pursued, and in the approach to individual projects, with a logical path to guide the design, and a methodology for evaluating them in progressive in-depth steps.

In this paragraph we would like to provide a few examples of attention to multi-objective design, to illustrate in concrete terms the approach to the project by the central coordination structure, over and above the focus on individual cases, and to set out more clearly the substance of some evaluations.

As earlier discussed, for design solutions that need to be assessed against a plurality of objectives, ideally, we look at solutions on the various Pareto fronts. For an intuitive rendering of this subject, polar diagrams can be used, in which each solution is characterised by "scores" for the performance it guarantees in relation to the various objectives of the project.

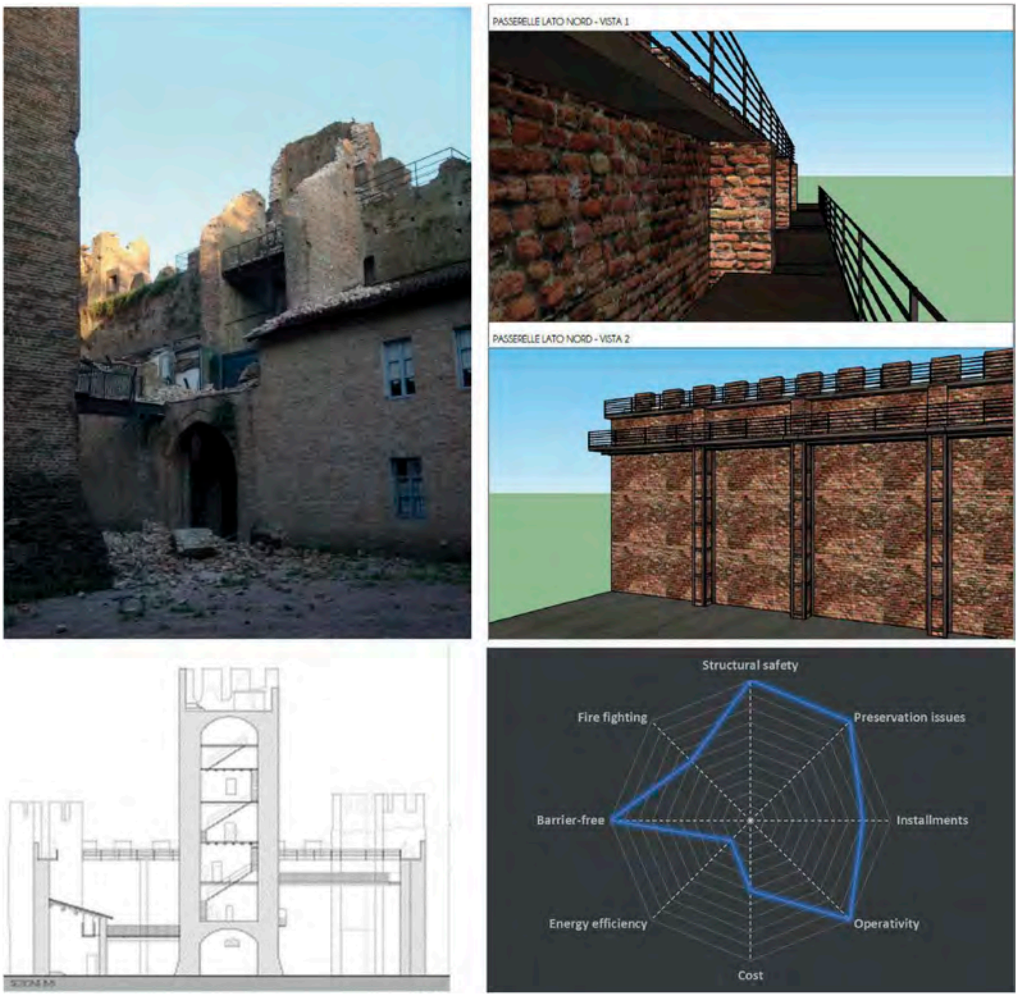

Figure 5. Rocca di Reggiolo (RE). In view of the general collapse of the battlements and walls surrounding the central donjon, the solution proposed was to intervene with "anti-seismic footbridges" made of steel, which act as bracing, provide access and remove architectural barriers. This intervention effectively meets the need for structural reinforcement, but also respects its listed status, because the historic building is not altered (the wall can be rebuilt, the battlement can be repositioned). For plant engineering purposes it can be used to carry ducts or support lighting equipment, operationally it is a particularly clever solution because it opens up new pathway to ensure that the historic building is more accessible, more open to visitors, and from the point of view of architectural barriers it is an excellent choice; it may not be the best solution for fire safety, as the material proposed is among the most vulnerable to heat sources, but on the other hand it can provide an escape route in case of fire. Compared to other objectives such as energy efficiency, it does not constitute a significant improvement, but in this situation, this does not appear to be a decisive drawback. Finally, it may not be the cheapest intervention, in financial terms, but it is an intervention that meets several different needs: it can be said that this intervention is on several Pareto fronts, and certainly a positive assessment can be made.

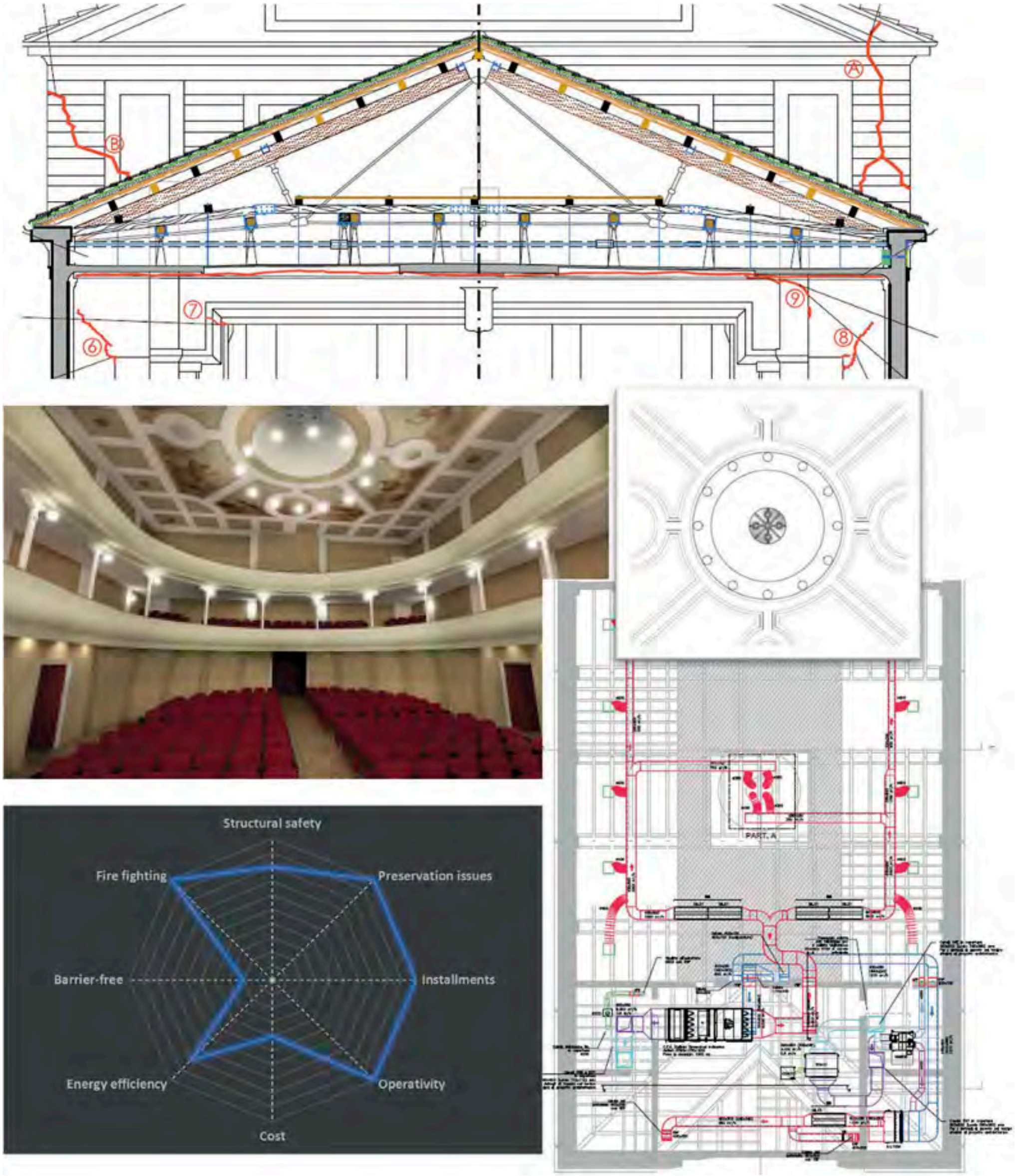

Figure 6. Teatro del Popolo in Concordia sulla Secchia (MO). The object of the intervention is the Perret-type ceiling, a very fragile and badly damaged structure, with collapsing frescoed plasterwork. The design proposal is to work from above, uncovering a roof that itself has clear vulnerabilities highlighted by the severe damage that has occurred; it is also necessary to create pathways in the roof space to carry out the necessary maintenance of the structures and systems, and to resolve fire safety issues, which are very tricky in public entertainment venues. The proposed solution, an intervention on the outer surface of the arch, addresses all these problems, and also makes it possible to provide fire protection for the wooden structures on the roof, to make safe the Perret false ceiling, and to walkways that will serve both for maintenance and for the passage of plant, allowing more efficient channelling of the air.

Figure 7 . Industrial prefabricated structure. The proposed seismic improvement solution can be considered optimal in terms of safety, as the creation of a system of external metal bracing system can, if properly sized, potentially allow the seismic safety of the structure to be updated, but at the price of creating thermal bridges and reducing the functionality of the building due to the size of the braces. There are also no benefits in terms of fire protection, since the material used is steel, which is very sensitive to high temperatures unless treated expensively, and there is no improvement in terms of plant, for which it may even be an obstacle, or with which it could interfere. Such a solution can therefore ideally fall on the Pareto side, which is concerned only with the costs and benefits in terms of seismic consolidation, not with other aspects.

5 CONCLUSIONS

The process of planning post-earthquake reconstruction, and in particular the reconstruction of public buildings, does not end with a first early planning draft. It must certainly start with a meticulous survey of the existing damage, a careful assessment of the resources currently available and the resources that will become available in future years, aiming to use the funding lever to mobilise technical and human resources as well as economic ones. Design is also a delicate and demanding process, in which there has to be investment in both the training of operators and in the dialogue between the designers, owners and building users, and the central coordination structure: that will have to ensure that the objectives figured at the beginning of the planning phase are actually met, and will lead to reciprocal growth of the professional bodies and public administrations.

In Emilia, this has been pursued by setting up a “joint commission”, where the objectives set out in the planning are assessed in joint meetings of the bodies responsible for checking different aspects of the planning. Specifically, this means the Ministry of Culture for issues around the protection of historic buildings, the regional Geological, Seismic and Land Service, responsible for the structural safety of buildings, and the Regional Agency for Reconstruction, which assesses the economic appropriateness of the interventions.

The efficiency of expenditure in a reconstruction process must therefore be carefully planned and based on the data available from the outset, but, above all, it must be accompanied and confirmed over the years through the tools of planning, programming, design and execution.

Built Heritage in post-Disaster Scenarios – Balzani et al. (Eds)

Temporary, non-invasive works

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ABSTRACT: In 2012 and 2016, two of the most disastrous earthquakes in Italy in the last century took place, the first in the area of the Emilian Po Valley, affecting the provinces of Modena, Ferrara and Bologna, and the other in the heart of central Italy, along the Apennine ridge, affecting the regions of Umbria, Marche and Lazio. These areas are very different from each other, beyond simply their geographical position, due to their physical and orographical features, their geology and landscape, their history, and the organisation of their urban settlements. This article presents two case studies taken from two seismic events: these exemplify the characteristics of the architectural assets of the respective areas studied, highlighting the differences in use of materials and local building traditions, as well as the different strategies adopted for temporary interventions. Indeed, in general, the first action to carry out on historical buildings - constructed using pre-modern materials and techniques - is to save, through a diversified series of protections, the parts of the buildings that are still present and have not collapsed, but have been reduced to a precarious state of stability by the seismic shocks.

Keywords: Temporary interventions, safety measures, palimpsest

1 EMILIA 2012

The epicentre of the 2012 earthquake was between the cities of Mirandola, Cento, Carpi, Finale Emilia and San Felice sul Panaro, with the effects of the damage stretching as far as Ferrara, Bologna, Modena and Mantua. In this area, starting in the 1950s, businesses of significant value have developed, such as industries in the biomedical sector, making it one of the most important regions for the national economy. For this reason, the Emilian earthquake has become known as "the warehouse earthquake" due to the amount of damage, and its economic effects, on the industrial sector. Just as important, as in any seismic event on Italian territory, is the damage to monumental landmarks, both in terms of the number of buildings damaged (counted at 2200) and the level of damage observed, in particular to churches and bell towers, castles and fortresses, palaces and towers.

The damage to historical monuments directly correlates with the planimetric and dimensional characteristics of these ancient architectural structures, and their age, as well as the quality of the materials and the installation techniques used. Indeed, the historical buildings in this area of Emilia-Romagna are built with thin brick masonry walls, mortar often containing low levels of lime, and wooden levels and roofs not connected to the walls; this made them unable to stand up against the horizontal stress caused by the earthquake. This vulnerability is particularly clear when it comes to the churches, which, due to their height and lack of intermediate floors, are already without a doubt the type of building most at risk.

1.1 *Temporary interventions*

One of the most serious, urgent problems that presents itself in the aftermath of an earthquake is the need to prevent damaged buildings from collapsing, even partially, and causing more damage.

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DOI: 10.1201/9781003253730-4

To deal with the emergency, it was decided from the first day after the Emilian earthquake that there would be a streamlined organisation of operations, carried out by specialised teams of engineers, architects from the Superintendencies and technicians from the National Fire Brigade. These teams were able to independently evaluate, directly onsite, the level of damage, the risks, and the temporary interventions that would be possible to perform within a few days[1].

Interventions to secure the buildings were therefore carried out immediately, directly by the Fire Brigade. These included hoop reinforcement, temporary anchors and frames, to help the structures to stay standing pending larger-scale, more long-term interventions.

Following this phase was a phase of more extensive temporary interventions, aiming for more long-term results, based on designs by structural engineers and architects; this was a particularly delicate phase, which, despite the temporary nature of the works designed to support the wall structures, entailed attention to detail and a long-term vision for the buildings involved: as well as the walls and horizontal elements, the conservation of the remains also included decorations, existing flooring, altars, and anything else significant in terms of architecture.

With this in mind, we should consider that in the area worst hit, the majority of architectural assets of historical or artistic interest present formal and decorative features dating from the 17th to 19th centuries. However, most of them have older origins: this means it is not unusual for collapses to have revealed decorations or structures from earlier periods, which had been covered up by transformations (for example the addition of chapels, enlargements of apses, facade modifications, attics, etc.), highly important for understanding the history of the building. These were valuable discoveries for gaining more in-depth knowledge of the building they are part of, testifying to its earlier origins.

Figure 1. Mirabello, Ferrara. The Oratory of the Beata Vergine di San Luca, safety procedures and reconstruction in a single phase.

Where these elements emerged, it was considered necessary to include them in the plans for the temporary works; and sometimes, given the delicate nature of the remains and their precarious position close to the collapsed areas they emerged from, they were removed and placed safely in storage.

Before proceeding with the planning for temporary interventions, it is always necessary to have an idea of the possible future of the building: are there plans for reconstruction? Or will it be left as a ruin, with all the damage caused by the earthquake? The answer to this simple but essential question can lead even the initial operations to secure the building in a different direction, even though the purpose in both cases is to preserve the residual wall structures and consolidate them.

In smaller buildings affected by the Emilian earthquake, the above has led to the two traditional steps - temporary interventions and reconstruction - being merged into one operation, as was the case for the Oratory of the Blessed Virgin of San Luca di Mirabello. In effect, it is a reconstruction, carried out in a reasonably short timeframe, with traditional techniques, of the external walls, leaving all of the finishings and complementary works for a future project.

1.2 *A case study: The church of San Felice*

But of course the most widespread case studies are churches with extensive collapses, which involve large-scale interventions of varying levels of complexity, starting from the work to secure the buildings. A particularly significant example is the parish church of San Felice sul Panaro, the main church in a small town in the province of Modena, which is recorded as far back as the year 551. The current architectural structure started as a simple hall in the 15th century, but in the following centuries (between the 17^{th} and 19^{th}), on several occasions, the side walls were opened up by a series of chapels, and finally the nave was raised up and given a great barrel-vaulted ceiling.

The earthquake caused the church to collapse almost entirely, saving only the lower order of the facade, part of the side chapels and a small part of the apse, while the bell tower, entirely lost apart from a fragment at the base, collapsed into the nave. Clues to the disastrous event can be seen in photographs, which clearly show how the higher walls were built with very weak, unresistant mortar, and they lacked the correct interweaving and restraints. The enormous amount of rubble is also noticeable, measured at 1690 cu. m^2.

Figure 2. San Felice sul Panaro, Modena. The parish church of before the earthquake.

In order to secure and guarantee the possibility of reusing the little that remained of this church, for which reconstruction was planned, a strategy was prepared for coordinated, gradual interventions spread out over time. In the days immediately after the earthquake on the 29th May, actions were taken to carry out the interventions needed to prevent the right-hand chapel walls and the facade from collapsing outwards into public space.

In order to proceed with a more structured phase of interventions, it was necessary first to address the issue of the rubble scattered around outside, especially in the piazza, where a large number of the buildings facing the church had also collapsed, and above all inside the church, where the floor was covered in layers of bricks ranging from one to three metres high. This work was carried out, partly due to the precarious state of the remaining structures, by a specialised group from the National Fire Brigade, with the assistance of archeologists to

Figure 3. The parish church of San Felice sul Panaro following the 2012 earthquake.

Figure 4. The first phase of securing the Church of San Felice: the scaffolding framework to prevent the overturningof the walls.

Figure 5. The second phase of the provisional works in the church of San Felice sul Panaro: removal of rubble, shoring of the collapsing walls, partial coverings to protect the decorated areas.

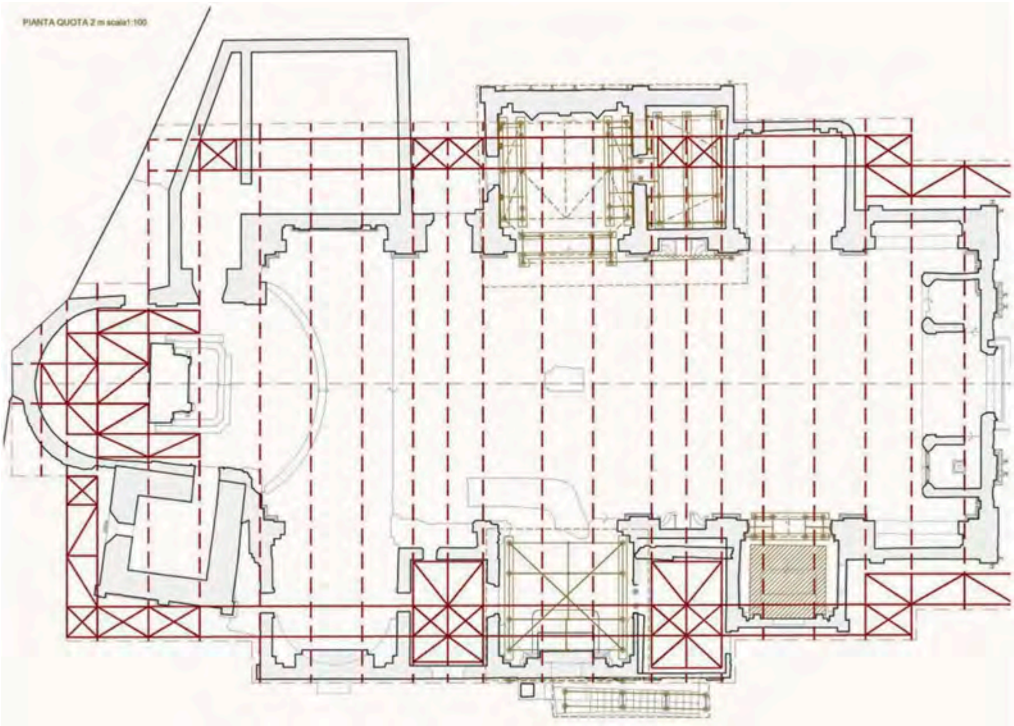

Figure 6. Third phase of the provisional works in the church of San Felice sul Panaro, project of the provisional roofing.

examine the materials moved, and recover stone architectural elements and valuable parts of the altars and flooring. Gradually, as the rubble was removed, the localised protection aimed at supporting what was left of the building was carried out. Gradual work and containment measures developed with great care for each part freed from the rubble were the key concepts in this highly delicate phase of the project, which also involved temporary coverings for two chapels and the remains of the central altar, in order to protect the remains of wall decorations, stucco and elements of value.

Figure 7. Third phase of the provisional works in the church of San Felice sul Panaro, project of the provision.

Figure 8. Church of San Felice sul Panaro: thorough operations of masonry walls consolidation.

The disastrous level of damage meant that the reconstruction of the church could not be completed in a short timeframe, so a third, final phase of temporary interventions was planned[3] to fully protect the remains of the hall from the elements, and at the same time consolidate the walls that were still standing. One of the purposes of the covering was to make the space visitable, so the main support structures, made from metal framework, were only placed along the sides of the nave and in the exterior spaces between the chapels, with the covering itself positioned along the slopes of the clerestories. The valuable natural stone flooring, which re-emerged from the rubble with many holes, cracks and deformities and will have to be restored, was protected with rigid panels. Meanwhile, on all the wall structures, which were in a precarious state because of both the original low construction quality and the disconnections and damage caused by the earthquake, an extensive intervention of consolidation was carried out through an integrated series of injections of liquid mortar, small wall reconstructions, and resolidification of some sections with fibre-reinforced mortar.

2 CENTRAL ITALY 2016

The Central Italian earthquake took place on the 24th August 2016, with an initial 6.2 magnitude tremor whose epicentre was in Accumoli, a town located in the heart of the mountain area between Lazio, Umbria and Marche. A second tremor with a magnitude of 6.5 happened on the 30th October, with its epicentre between Norcia and Sant'Angelo sul Nera.

The damage was enormous, especially in terms of cultural heritage, and in general on buildings from before the mid-20th century, which were built according to local tradition, with walls that were very thick, but made with mixed, not very homogeneous materials, held together using earthy mortar with very little binding agent. These traditional building techniques, along with continued modifications and repairs to damage caused by previous earthquakes, show the complexity of the construction history in this area, making the buildings very vulnerable to dynamic stress.

2.1 *A case study: The Basilica of San Benedetto in Norcia*

The present-day Basilica of San Benedetto is the result of a long process of construction, extensions, modifications and reconstructions carried out since the 14th century, partly as

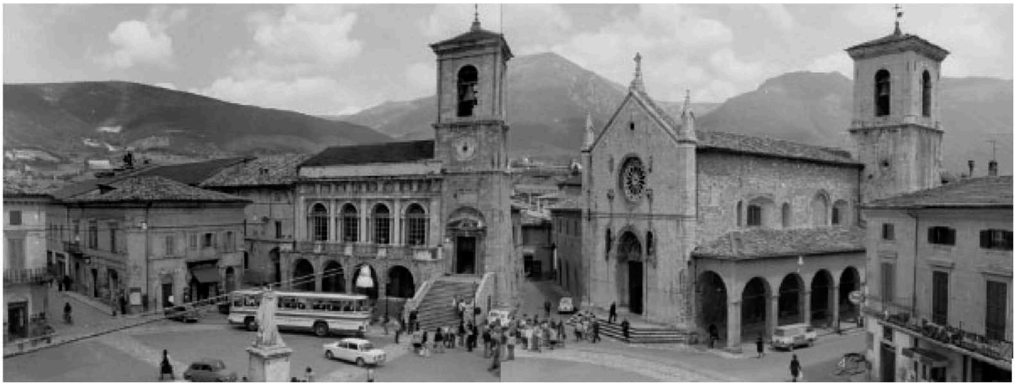

Figure 9. Norcia, Perugia. The Basilica of San Benedetto before the 2016 earthquake.

Figure 10. The Basilica of San Benedetto in Norcia following the 2016 earthquake.

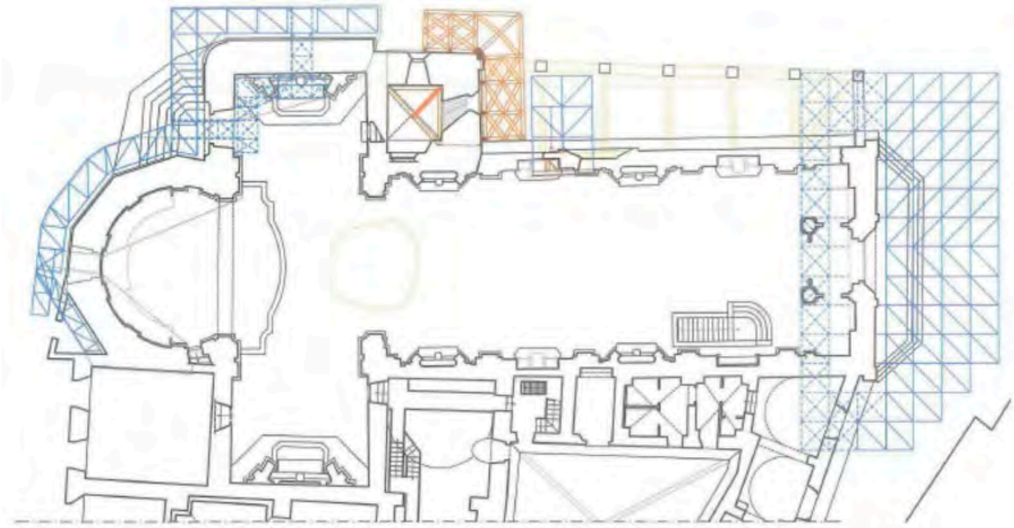

Figure 11. Project for securing the Basilica with metal scaffolding framework made assembling pipes through joints (clamps).

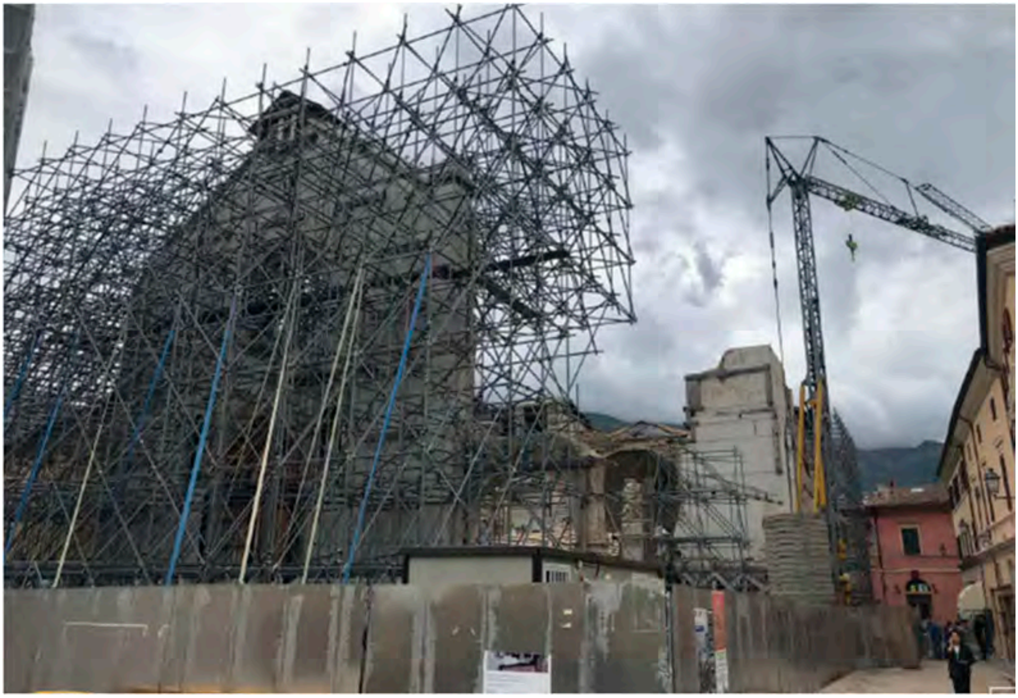

Figure 12. The metal scaffolding framework of the Basilica of San Benedetto.

a consequence of collapses and serious damage caused by earthquakes in more recent centuries. This is how the church arrived at the 2016 earthquake as a palimpsest of many historical construction phases, which contributed substantially to the weakening of the structures that suffered the most serious collapses. The wooden roof, the vaults of the transept, the bell tower, and the right wall with its attached Portico delle Misure all collapsed.

In this case, the temporary interventions, despite being carried out at different times, followed the logic of an overall project to secure the building, drawn up over the first few months after the earthquake[4]. This was in the context of the clear desire of the Diocese and all the authorities involved, starting from the Ministry of Culture, to aim for the quickest reconstruction possible. The rubble-collection phase was particularly complex, as mixed with the huge quantity of loose material were square blocks of stone material, both smooth and decorated in relief, and sculpted materials that were carefully examined and catalogued by specialists and then put in storage pending their use for the reconstruction.

With a view to making every effort to carry out a rapid reconstruction, no temporary covering was planned, but instead the remains of the altars and decorated areas were protected by custom-built boxes. The procedures for the reconstruction of the basilica were accelerated as much as possible, so as of today the worksite is already fully operational.

NOTES

1. The organisation for the emergency and the initial methods of intervention are described in A sei mesi dal sisma, rapporto sui beni culturali in Emilia, conference proceedings, Carpi, 20th November 2012, edited by C. Di Francesco. Bologna, Minerva Editore, 2014.
2. In surveys carried out by the IUAV, in agreement with the former Regional Direction for Cultural and Landscape Heritage in Emilia Romagna, Ministry of Culture. Studies, research and analysis in the degree thesis Il Duomo di San Felice sul Panaro dopo il terremoto: strumenti di conoscenza e riflessioni per una possibile ricostruzione by Claudia Cassai e Daniele Manzato, supervised by Prof. Francesco Doglioni, with co-supervisors Prof. Francesco Guerra and Arch. Andrea Sardo
3. Funding from the Ministry of Culture and Arcus Spa. Design by Ing. Alberto Lionello, (Superintendency of Architectural Assets Venice), Arch. Gabriele Botti and Lisa Stacul, RUP Arch. Paola Ruggieri.
4. Metal tube and joint structures, with wooden shoring, designed by Claudio Modena. Funded by the Ministry of Culture. The overall project to secure the building included contributions from Elena Simonato, Elvis Cescatti, Paolo Iannelli, Marica Mercalli, Mauro Caciolai, Vanessa Squadroni, Giuseppe La Cava, Mirko Sgaravato, Roberto Minelli.

Built Heritage in post-Disaster Scenarios – Balzani et al. (Eds)

3D digital cultural heritage for resilience, recovery and sustainability. The inception project

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ABSTRACT: Today, we are experiencing growing evidence of severe and accelerated climate impacts on cultural heritage worldwide and the need to reduce the increasingly urgent risk conditions for heritage and associated tourism economies. Together with risk reduction strategies, research activities developed the targeted use of technologies for the digitisation of the cultural heritage. In fact, the European Commission promoted several initiatives focused on digitisation and digital preservation, starting from the Research and Innovation programme Horizon 2020, investing in the development of digital tools and cutting-edge technologies to support cultural heritage. Among funded projects on digital cultural heritage, there is the INCEPTION project - Inclusive Cultural Heritage in Europe through 3D semantic modelling - that has been also recently mentioned in the "Declaration of cooperation on advancing digitisation of cultural heritage". INCEPTION focuses on efficient 3D digitization methods, enriched semantic modeling and, web-based solutions to ensure wide access of heritage contents to experts and non-experts. The project, coordinated by the Department of Architecture - University of Ferrara, has resulted in an innovative start-up company, INCEPTION Srl, accredited as a spin-off of the University of Ferrara, providing different actors with software solutions based upon the INCEPTION Core Engine for managing, visualising and archiving 3D or BIM models and all the related digital documents, aggregated by semantic technologies. Latest results and developments, including a collaboration with the Central Institute for Catalogues and Documentation, are presented in this paper with the aim of exploring further possibilities opened by technologies developed within the project.

Keywords: *3D survey*, *3D semantic modeling*, *BIM modelling*, *semantic web technologies*, *web-based solutions*

1 INTRODUCTION

"Natural and man-made hazards, anthropogenic effects and extreme climate change events, are persistently putting the cultural heritage of Europe under pressure, with a daily incremental frequency. In addition, such disasters and catastrophes compound the conservation challenges and needs of the heritage assets. These events also menace the assets' social, cultural, historic and artistic values, the safety of citizens, and have an impact on local economies linked to tourism. Consequently, research on adaptation strategies, methodologies and other

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DOI: 10.1201/9781003253730-5

remedial tools is crucial, in order to safeguard Europe's cultural heritage from the continuous pressures it faces and the related decay-inducing consequences" (Bonazza et al., 2018). As stated in the European Commission document entitled "Safeguarding Cultural Heritage from Natural and Man-Made Disasters. A comparative analysis of risk management in the EU", mentioned above, we are experiencing growing evidence of severe and accelerated climate impacts on cultural heritage worldwide and the need to reduce the increasingly urgent risk conditions for heritage and associated tourism economies.

In this direction, two international agreements on climate change and sustainable development have been signed. The Paris Agreement on Climate Change (United Nations Framework Convention on Climate Change, 2015), adopted by 195 nations in December 2015 at the 21st Conference of the Parties to the United Nations Framework Convention on Climate Change, and the 2030 Agenda for Sustainable Development signed in September 2015 by the governments of the 193 UN member countries. Together, these two international agreements provide a new framework to guide governments in responding to climate change towards sustainable development.

Moreover, the Sendai Framework for Disaster Risk Reduction 2015-2030 (Web-1), adopted by the United Nations in 2015, includes among its priorities the protection of cultural heritage, and invites national authorities to cooperate in increasing an awareness of cultural heritage impacts in the context of exposure to hazards.

The 2030 Agenda (Web-2), mentions, under "Goal 11. Make cities and human settlements inclusive, safe, resilient and sustainable", to strengthen efforts to protect and safeguard the world's cultural and natural heritage. Moreover, it is mentioned that "the spread of information and communications technology and global interconnectedness has great potential to accelerate human progress, to bridge the digital divide and to develop knowledge societies, as does scientific and technological innovation across areas [. . .]".

At the same time as risk reduction strategies have increased, more and more research avenues have developed for the targeted use of technologies for the digitisation of the cultural heritage.

"Immovable cultural heritage such as monuments, historical buildings and archaeological sites are particularly vulnerable to threats difficult to predict or prevent. The recent fire at Notre Dame that broke out on 15 April 2019 served as a reminder of this fact. Threats such as accidental damage, as well as natural disasters, pollution, mass tourism and erosion due to exposure over time can put Europe's historical sites at risk. In this context, it is an important new trend to highlight that eleven Member States reported funding programmes for digitisation of immovable cultural heritage, four of which reported 3D digitisation in particular. This new trend not only signals that Member States are increasingly working to make the most of digital technologies to record, document and preserve Europe's cultural heritage and make it available online, but that immovable cultural heritage is an important part of Europe's cultural resources that requires national and EU level attention" (Web-3).

The European Commission promoted several initiatives focused on digitisation and digital preservation, starting from the Research and Innovation programme Horizon 2020, investing in the development of digital tools and cutting-edge technologies to support cultural heritage. One of the major initiatives in this direction, is the "Declaration of cooperation on advancing digitisation of cultural heritage" (Web-4), signed in 2019 during the Digital Day by 27 European countries. The main aim of the Declaration is to better use state-of-the-art digital technologies in addressing risks that Europe's rich cultural heritage is facing, enhancing its use and visibility, improving citizen engagement, and supporting spillovers in other sectors. Within this document, 3D technologies are mentioned as especially promising, providing new ways of advancing scientific understanding, handling and restoring damaged or fragile heritage and ensuring digital preservation that reflects the uniqueness and multidimensionality of our heritage.

Among projects on digital cultural heritage funded by the European Union mentioned as a relevant background for the vision opened up by the Declaration, the INCEPTION project is featured. The project has been applied in 2014 under the Work Programme Europe in a changing world – inclusive, innovative and reflective Societies (Call - Reflective Societies: Cultural Heritage and European Identities, Reflective-7-2014, Advanced 3D modeling for accessing and understanding European cultural assets) within the European Union's H2020 Framework Programme. The project was developed between 2015 and 2019 as one of the reference projects on the topic of digitisation and inclusive accessibility of cultural heritage.

2 3D DIGITISATION: THE INCEPTION PROJECT AND BEYOND

The INCEPTION project, "Inclusive Cultural Heritage in Europe through 3D Semantic Modelling", started in June 2015 and lasted four years, aimed at developing advanced 3D modelling for accessing and understanding European cultural assets. One of the main challenges of the project was to close the gap between effective user experiences of Cultural Heritage via digital tools and representations, and the enrichment of scientific knowledge. The project activities were gathered in three continuously interrelated in-depth areas: 3D data capturing (digital data acquisition), 3D data processing and model sharing. All project development steps started from the latest State of the Art in the above mentioned fields. 3D surveying is a fast changing scenario, but lacks devices and software integration and targeted processes in the field of Cultural Heritage. Point cloud management in BIM environment was (and still is) an area in need of experimentation (Hichri et al., 2013; Teruggi et al., 2020), mainly in setting up semantic ontologies for Cultural Heritage buildings in order to share cross-disciplines data in an interoperable way. In the field of model sharing, more and more projects and activities are focused on the digitization of heritage and the setting up of webbased platforms and user-oriented applications; the main aim of the project was to develop a web platform for accessing and understanding digital Cultural Heritage buildings, together with the possibility of collecting and explore time upgradable 3D models.

Therefore, the project faced different challenging actions starting from advancement in 3D data capturing and holistic digital documentation, under interdisciplinary and cross-cutting fields of knowledge. One of the first steps at the beginning of the project was focused on the development of strategies aiming at the optimization of a 3D Data Acquisition Protocol able to guide the processes of digitization of cultural heritage, respecting the needs, requirements and specificities, and innovation strategies to the three-dimensional modelling.

Then, a new approach and methodology for semantic organization and data management toward H-BIM modelling was developed. The identification of the Cultural Heritage buildings semantic ontology and data structure for information catalogue allowed the integration of semantic attributes with hierarchically and mutually aggregated 3D digital geometric models for management of heritage information (Parisi et al., 2019).

In the end, the knowledge organized bridging the gap between 3D and semantic information has allowed to develop several outputs consistent with the main goal of inclusiveness in the Cultural Heritage sector (Empler et al., 2018). In fact, the INCEPTION technologies allow seamlessly retrieving the same data sources for different applications. From an online web platform open to the general public to specific apps for building assessment and asset management, from Virtual Reality environments for engaging off-site experiences virtually recreating an archaeological site to Augmented Reality apps assisting technicians on field (Bekele et al. 2018), just to mention a few of them (Brusaporci et al., 2021).

In order to test and validate the proposed advancements and methodologies, the project developed nine case studies, starting from the recognition of the specific needs and requirements of each building or site. This enabled the implementation of several digital acquisition systems and the development of specific three-dimensional modelling operations making the digital models usable by different categories of interdisciplinary users, and populating the INCEPTION platform.

2.1 *The INCEPTION protocol*

Integrated digital documentation under INCEPTION was conceived according to a holistic approach. According to "Principles for the recording of monuments, groups of buildings and sites" (ICOMOS 1996) holistic documentation needs to cover assets of critical information

Figure 1. The overall INCEPTION approach: from the data capturing to the 3D BIM modeling and data access and re-use in VR&AR app for different users. The approach is made possible by INCEPTION semantic technologies for managing, visualizing and archiving 3D Building Information Models (BIM), together with all the related digital documents.

regarding a monument's main attributes and characteristics, able to define it as a whole and to identify its significance and main needs. "Today the world is losing its architectural and archaeological cultural heritage faster than it can be documented. Human caused disasters, such as war and uncontrolled development, are major culprits. Natural disasters, neglect, and inappropriate conservation are also among the reasons that this heritage is vanishing. Although we should strive to preserve as much as possible of our architectural and archaeological cultural heritage, we cannot save everything. One of the options available to heritage managers and decision makers is to document this heritage before it is lost" (Letellier, 2007).

This statement is now more than ever well founded, as pointed out in the aforementioned "Declaration of cooperation on advancing digitisation of cultural heritage" (Web-4). "Increasing threats to cultural heritage due to natural disasters, pollution, mass tourism, deterioration over time, terrorism and vandalism, create an urgent need to make the most of digital technologies to record, document and preserve Europe's cultural heritage and foster their accessibility to European citizens".

Documentation of heritage at risk is increasingly urgent, and the adoption of protocols for the effective use of digital technologies can be a powerful strategy to save cultural assets, cultural memories, tangible and intangible heritage.

Nevertheless, documenting is a complex task, for which an interdisciplinary study of a monument and an enhanced methodology are needed. The overall approach has to comprise the documentation, analysis and management of all the different data, visualization, protection and preservation issues. The first step to creating a protocol consistent with the main actions of the project was the analysis of existing guidelines and procedures, from technical specifications (Andrews et al, 2015) to the many European projects, organizations and scientific committees that have investigated the acquisition, processing, archiving and exchange of 3D Cultural Heritage assets and information.

In order to set up the 3D Data Acquisition Protocol, during the project development a matrix of requirements was created considering the different possible purposes of digitization and data management (Maietti et al., 2018), from documentation purposes up to the development of Heritage Building Information Models consistent with the INCEPTION platform. This protocol was conceived according to a flexible structure, capable of incorporating the rapid evolutions within the digitisation field (in terms of tools, technologies, data management software, etc.).

The main direction toward INCEPTION moved was the setting up a methodology able to break through the barriers caused by segmentation in collecting documentation data by establishing a common framework through 3D documentation of Cultural Heritage buildings and sites.

The INCEPTION protocol includes different parameters depending on the procedure and the objectives of the digital documentation, including reliability, usability and effectiveness of the process as added value to the check of a set of technical indicators (Balzani & Maietti, 2017).

2.2 *Basic principles for 3D digitisation of cultural heritage*

Since the efforts towards the 3D digitization of Cultural Heritage are involving the main institutions and professionals working in this field, the INCEPTION project couldn't provide an only and unique answer to the topic. Rather, it significantly contributed to a trending topic in this sector, providing some of the main indication that has been then inherited in further documents, keeping the project results constantly up-to-date. INCEPTION has been indeed mentioned in the "Declaration of cooperation on advancing digitisation of cultural heritage", as previously stated, but the efforts and the contribution for the achievement of guidelines defining the basic principles for 3D digitization has continued even after the end of the project in 2019. Among these contributions, some results are worth to be mentioned. INCEPTION results contributed to the report titled "3D Content in Europeana" (Web-5), recently produced by a Task Force established for the purpose. The Task Force analyzed valuable content

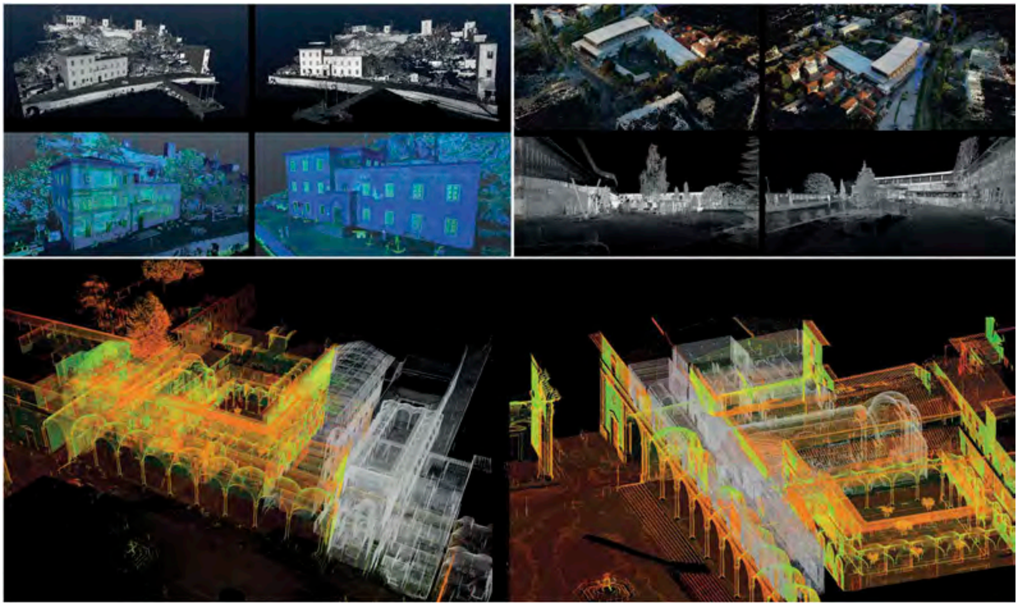

Figure 2. Examples of 3D digital documentation with advanced technologies (i.e., laser scanners and drones) following the INCEPTION protocol for ensure the best quality for the purpose. In the figure, on the top left, the HAMH museum in Hydra (Greece), on the top right, the Tesla Museum in Zagreb (Croatia). On the bottom, the Istituto degli Innocenti in Florence (Italy). The three buildings were among the INCEPTION case studies.

on 3D digitization of cultural artefacts at large, in the perspective of their integration in Europeana, also discussing a number of related issues such as, for example, data formats, standards and storage of the models. After reviewing the Europeana Publishing Framework and Publishing Guide (with particular reference to 3D content), the Task Force collected details of file formats, viewers and methods of publishing 3D content online amongst the network of Europeana data providers. The reconnaissance showed how modern browsers can exploit embeddable viewers and/or formats for directly playing 3D content and making them more accessible on Europeana collections. Among those, the viewer developed within INCEPTION was listed as the only solution for accessing 3D BIM data together with the related semantic information. In the end, the Task Force developed guidance and recommendations for Europeana, CH institutions and 3D content creators on publishing 3D content and making it accessible via Europeana Collections.

Even if the report "3D Content in Europeana" aimed at ensuring a higher quality of Cultural Heritage 3D content accessed online, the results provided indications mainly focused on the enjoyment of the 3D content, while the digitization itself was still out of the scope. However, too many times some iconic monuments have been digitized adopting approaches (e.g. measuring the quality of the model by the number of points or the scanning resolution) far from the holistic approach that is now required for documenting the Cultural Heritage. For this reason, the European Commission tasked an Expert Group on Digital Cultural Heritage and Europeana, where again representatives from the INCEPTION project have been involved, to the development of guidelines on 3D cultural heritage assets. Thus, the Expert Group elaborated a list of 10 basic principles and a number of related tips for each of them geared toward cultural heritage professionals, institutions and regional authorities in charge of Europe's precious cultural heritage. "The list of basic principles and tips below is especially for cultural heritage professionals and institutions, and other custodians of tangible cultural heritage, including local and regional authorities, who are in charge of cultural heritage buildings, monuments, or sites, who do not have any experience with 3D digitisation yet, neither directly nor via an external service provider. At the same time, it is also for all other such professionals, institutions and authorities, who may find here useful new principles or tips to help them in achieving the best results in 3D digitisation projects." (Web-6)

1. Consider the value of and need for 3D digitisation
2. Select what to digitise and for what use cases or user groups
3. Decide whether to digitise in-house or outsource
4. Clarify copyright aspects and plan for open and broad access
5. Determine the minimum quality needed, but aim for the highest affordable
6. Identify the different versions and formats needed for the different use cases targeted
7. Plan for long-term preservation of all data acquired
8. Use the right equipment, methods and workflows
9. Protect the assets both during and after digitisation
10. Invest in knowledge of 3D technologies, processes and content

Of course, these basic principles cannot be considered exhaustive and they need to be actually applied in concrete case studies, together with specific technologies, in order to provide best practices to the whole sector. Furthermore, the field is still far to be completely investigated and several research activities are ongoing as demonstrated by some of the last calls of the H2020 framework program (Web-7).

3 THE INCEPTION TECHNOLOGIES

Further than the methodological framework, the INCEPTION project developed core technologies for managing, visualizing and archiving 3D Building Information Models (BIM), together with all the related digital documents, based on semantic technologies, allowing a consistent adoption of BIM technology (Empler et al., 2021) even in the Cultural Heritage sector. Based on that core technologies the INCEPTION platform was launched as a beta version during the project. This approach was aimed at the adoption of new digital technologies from a wide audience, without barriers of specific skills or age.

The innovative core of the innovation lies in semantically breaking down a building or a monument in its single constituent parts (Iadanza et al. 2019). Each element, be it physical or functional, is treated with the same approach. The asset is therefore discomposed in elements provided with properties and relations with other elements (physical and/or functional). Hence, the whole building is modelled as a collection of these entities. The heart of this semantic approach is also the unicity of this solution: everything is represented as semantic triples, where two elements (namely "subject" and "object") are linked through a relationship ("predicate") between them. The properties of each element can be either tangible (e.g. material, dimensions, thermal properties, etc.) or intangible (e.g. space allocation, departments, users, etc.). According to this approach, each building element can be linked to other entities, such as documents, photos, and videos, using the same logic: subject -> predicate -> object (Bonsma et al., 2018).

The technological challenge is natively making use of public standards such as IFC (Industry Foundation Classes) for BIM modeling, RDF (Resource Description Framework) as data model for semantic triples and WebGL for 3D representation. The INCEPTION core technology consists of a framework of software tools and a set of APIs able to transform each element on an IFC BIM model into semantic triples, described according to an RDF data model, store them in dedicated a semantic triple store and link them to metadata, documents and other linked data using standards from semantic web. The whole site, or part of it, is then reassembled in a 3D model, navigable by means of a simple modern web browser (HTML5 + WebGL). In order to keep these technological advancements on the edge and provide them on the market, after the end of the project, INCEPTION has been established as spin-off company, an innovative start-up company incubated at the University of Ferrara. The spin-off offers support in the process of digitization, management, dissemination, enhancement of cultural heritage and built heritage, through products and services using BIM-based technologies and semantic-web platforms (Quattrini et al. 2017; Russo and De Luca, 2021).

3.1 *Data re-use and semantic enrichment for new synergies*

The validity of the INCEPTION technologies has been also recently confirmed by the collaboration established between the Central Institute for Catalogues and Documentation (ICCD) of the Italian Ministry of Cultural Heritage and the Spin-off with an agreement to cooperate on 3D digitization (Web-8). The collaboration will generate valuable knowledge relating to benchmarks, methodologies and guidelines for 3D digitisation of cultural heritage monuments and sites. The process of running pilot projects itself will also be documented, as a source of best practices for other subsequent similar projects in Italy or in other countries.

\The technical and practical knowledge made available this way will contribute to boosting both the number and the quality of 3D models of European cultural heritage, which would be extremely important especially with respect to cultural heritage at risk.

Currently, two pilot projects are under development, aimed at defining the standard for monument digitization: the church of Santa Maria delle Vergini in Macerata and the underwater archaeological site of “Gran Carro” at Bolsena Lake. The latter is particularly significant since re-use the technological core of INCEPTION, adapting it to underwater archaeological sites (Menna et al., 2021) rather than historical buildings.

The starting point of the 3D documentation are, in this case, 3D models realized with Structure-from-Motion (SfM) technologies. Models from SfM are usually complex meshes (Remondino et al., 2017). They could perfectly describe the shape of an element, like the basin of the lake or findings from the excavation activities, and the texture gives the extraordinary possibility of recognizing elements but, differently from BIM models, information can hardly fit in there. While the downside of switching to a technical depiction provided by BIM technologies, it’s to totally lose textures using standard formats (i.e., IFC). And here is where INCEPTION technologies provided a first solution: allowing to overlap in the 3D web viewer both representations, in order to navigate one and interrogate the other.

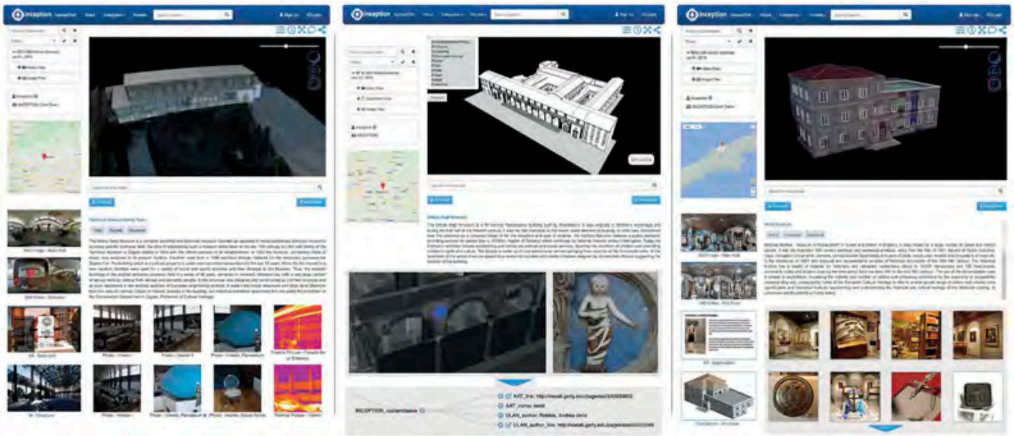

Figure 3. The INCEPTION platform, powered by the core technologies developed within the project, allow explore in a web environment both the shape of a building and the history related to that. Here, each element tells you a story, like the 10 tondos by Andrea Della Robbia on the façade of the Istituto degli Innocenti in Florence (in the center), all different and documented with hi-res pictures. On the left, the Tesla Museum in Zagreb (Croatia). On the right, the HAMH museum in Hydra (Greece). The three buildings were among the INCEPTION case studies.

Furthermore, must be noticed that 3D models of the findings, as mentioned before, are themselves among the information that could be attached to a 3D model of an excavation. From the perspective of technicians or researchers, having access to such models can help you to better understand the excavation process, where artifacts were found and their value. Even in this sense INCEPTION technologies provided a solution for hosting 3D models of artifacts, directly linked to the position where they were found.

Last but not least, based on the name given to each single object of the 3D information model, a live query has been developed for retrieving all the pieces of information on the ICCD catalogue directly within the platform. This was feasible only because of the Semantic Web technologies used by both systems and opened up to a still unexplored enrichment exploiting external data source.

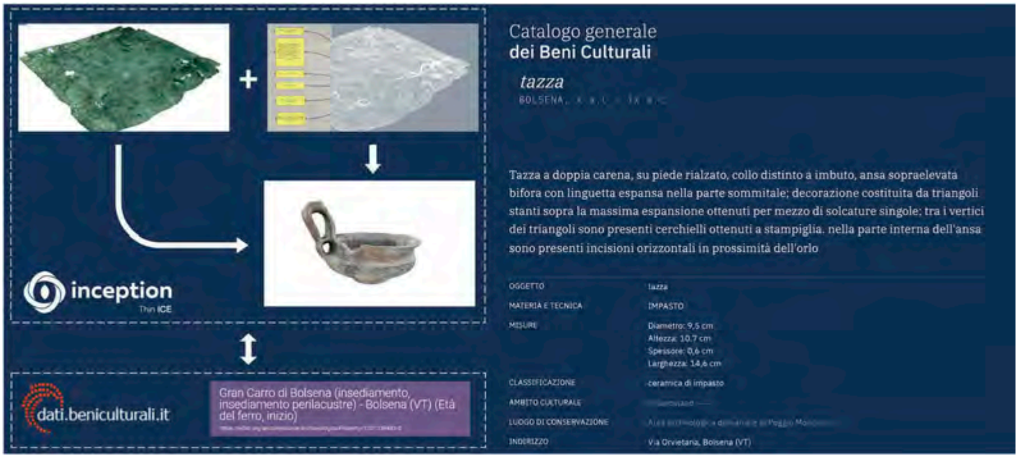

Figure 4. A schema of the re-use of INCEPTION technologies for the archaeological site of the Gran Carro at the Bolsena Lake. Textured Mesh Models and Information Models are merged together for allowing the users to access engaging 3D models while at the same time having also access to cataloguing information stored in the ICCD archive.

4 DISCUSSION

The paper outlines the results of the European project INCEPTION and some of its most recent follow-ups in the field of digital documentation of cultural heritage and in the management and use of acquired data for knowledge, preservation and dissemination purposes.

The main project outcomes can be summarized in a method for semantic modelling of Cultural Heritage buildings using BIM, and the INCEPTION platform for advanced deployment and valorisation of enriched 3D models, for a better knowledge sharing and enhancement of European Cultural Heritage. By pursuing the holistic digitization, INCEPTION met crucial needs related to conservation, management and preventive maintenance of heritage at risk, in addition to a wide accessibility and social inclusion. At this time, when several forms of accessibility are changing due to the pandemic outbreak, digitization is an effective solution to making monuments and sites virtually accessible for citizens.

The project demonstrated an effective exploitation and uptake of its results starting from the creation of an innovative start-up company, the INCEPTION Spin-off. The impact on the scientific and cultural community is spread through several collaborations with national and international bodies, including heritage agencies and associations, that are applying protocols, tools and platform to improve their policies and services, and as a best practice for 3D digitization and use of semantic contents. Moreover, the involvement of the INCEPTION team in the activities of the “3D Content in Europeana” task force has proved how the use of 3D for

Cultural Heritage is a short-term objective for the community. In the report, the INCEPTION technologies are listed as a unique solution for managing and accessing online Heritage 3D models using BIM.

Within the overall framework related to 3D digital cultural heritage for resilience, recovery and sustainability, the Priority 2 among recommendations framed in accordance with the Sendai Four Priorities for Action [web-9] must be emphasized. "Strengthening disaster risk governance to manage disaster risk" foresees documentation also by using IT tools, such as the digitalization of archival records and on-site laser scanning, ensuring easy access to required information.

Moreover, heritage fruition scenarios post pandemic condition revealed long-term impacts, putting a great emphasis on the use of digital technologies for the documentation, preservation and enhancement of Cultural Heritage due the restrictions on access to heritage sites. This condition gives new meanings to technologies for virtual tourism, accessibility of heritage sites at risk and remote accessibility, and this is largely addressed as a priority in the calls under the new Horizon Europe programme [web-10].

As an overall result of the project, in addition to specific outcomes and achievements released during the four years development, the main issues addressed by INCEPTION proved to be in line with the most current research avenues. The project has become a reference point for the new actions that the European Commission has launched on the digitisation of cultural heritage in combination with the major issue of heritage at risk of loss.

New collaborations established between the INCEPTION Spin-off and cultural institutions highlight the need for continued commitment to improve and implement the tools developed and to cooperate on 3D digitization in an interdisciplinary way.

AUTHORS CONTRIBUTION

Paper conceptualization, F.M. and M.M.; Introduction and overall framework, F.M.; Inception protocol development, F.M., M.M. and F.F.; 3D BIM modeling, F.F. and M.M.; Inception technologies development E.I. and M.M.; writing and editing, F.M. and M.M.; images, F.F. and M.M. All authors have read and agreed to the published version of the manuscript.

ACKNOWLEDGMENTS

The INCEPTION project has been developed within 2015 and 2019 by a consortium of fourteen partners from ten European countries led by the Department of Architecture of the University of Ferrara. Academic partners of the Consortium, in addition to the Department of Architecture of the University of Ferrara, include the University of Ljubljana (Slovenia), the National Technical University of Athens (Greece), the Cyprus University of Technology (Cyprus), the University of Zagreb (Croatia), the research centers Consorzio Futuro in Ricerca (Italy) and Cartif (Spain). The clustering of small medium enterprises includes DEMO Consultants BV (The Netherlands), 3L Architects (Germany), Nemoris (Italy), RDF (Bulgaria), 13BIS Consulting (France), Z + F (Germany), Vision and Business Consultants (Greece).

The INCEPTION project has been applied under the Work Programme Europe in a changing world – inclusive, innovative and reflective Societies (Call - Reflective Societies: Cultural Heritage and European Identities, Reflective-7-2014, Advanced 3D modeling for accessing and understanding European cultural assets).

This research project has received funding from the European Union's H2020 Framework Programme for research and innovation under Grant agreement no 665220.

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Built Heritage in post-Disaster Scenarios – Balzani et al. (Eds)

Survey methods for the heritage and vulnerability values in a block of mexico city historic centre

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ABSTRACT: This paper constitutes an updated report of the work carried out on the urban block of the historic center of Mexico City, in particular the urban survey of a block between the Plaza Major and the archaeological site of the Templo Major, a site arranged where it once stood, up to the Spanish conquest, the ancient Aztec capital of Tenochtitlan, built over the Texcoco lake with piling structures. The paper analyzes the opportunities offered by integrated digital surveys, made with different methodologies, mainly 3D laser scanners and photographic shots with SFM processing, for documentation and diagnostics aimed mainly at the conservation and restoration of architectures. At the urban scale, the survey focuses on the documentation of the urban facades and pays particular attention to the analysis of the plastic deformations and of the masonry walls, in order to evaluate the misalignment value of the fronts of the buildings from the vertical plane and the interactions between the walls of different building units. Going down from the scale of detail to the architectural detail, the restitution and analysis of individual building units was also studied, closely linked to the asset value of the area; attention was focused on the survey for the documentation, the analysis of the state of structural conservation, reaching as far as the identification and classification of the lesions, the verification of the main failures of the structures and any states of risk of collapse.

Keywords: Mexico City, Unesco, Urban Survey, Laser scanning, Vulnerability

1 INTRODUCTION

The earthquake of 19 September 2017 in Mexico mainly affected the historic heritage of cities and villages in the state of Morelos, but at the same time affected the surrounding areas, having been consistently felt up to Mexico City. The Mexican institution for the protection of monuments, Instituto Nacional de Antropología e Historia (INAH), has started a laser scanner survey of the heritage at risk; the digital scanning of Mexican monuments is configured as a first innovative step for the collection of digital information useful for the conservation of architectures of patrimonial interest. The Survey Lab. of the Department of Architecture of Florence for years has accumulated experience both in the field of architectural survey of monuments at risk or damaged by seismic events (Bertocci, 2013) (Bertocci, Minutoli, 2012); the Survey Lab. offered itself through the Italian embassy in Mexico City, in collaboration with UNAM of Mexico City, to document some case studies of patrimonial buildings damaged by the earthquake, to contribute to the reconstruction process implemented by the local government. In March 2018, two different digital survey campaigns were conducted which concerned two sample cases: a block in the historic center of Mexico City, located on the edge of the Zocalo between the Cathedral and the archaeological site of the Templo Mayor (Bertocci et al., 2020), and the Monasterio de San Guillermo Abad in Totolapan in the state of Morelos (Bertocci et al., 2021). This paper

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DOI: 10.1201/9781003253730-6

constitutes an updated report of the work carried out on the urban block of the historic center of Mexico City, in particular the urban survey of a block between the Plaza Major and the archaeological site of the Templo Major, a site arranged where it once stood, up to the Spanish conquest, the ancient Aztec capital of Tenochtitlan, built over the Texcoco lake with piling structures. Its altimetric position on the plateau, located around 2,000 meters above sea level surrounded by mountains and volcanoes, is characterized by a strong seismic risk; the geological characteristics of the place, which is built on an area of lake origin above the remains of the foundations of the pre-existing Aztec buildings and temples, make the constructions of this area of the city very vulnerable. The research explores an isolated block of the analyzed urban fabric, deepening up to the study of one of its buildings with the aim of verifying, through a significant sample belonging to the category of colonial-era buildings, which are most at risk, the reliability of the observations conducted by observing and documenting only the facades on the streets of the block. The building was made available for study by the Authority of the Historic Center of the city and has recently undergone renovation and consolidation interventions. The survey of all the internal spaces of the chosen building unit was integrated and the structural conservation status was analyzed following seismic events and changes to the urban space around it due to its position: it was arranged contiguously with the excavation of the site archaeological site of the Templo Major, and was close to a recently demolished building unit, both due to the precarious conditions and to possibly continue the archaeological research in the area.

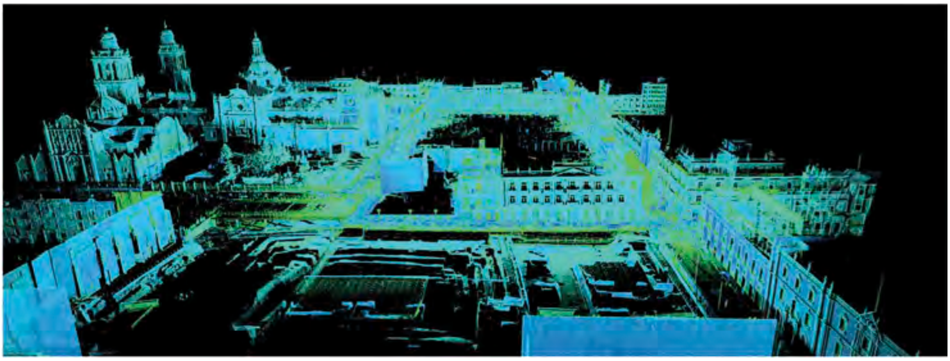

Figure 1. Point Cloud obtained from the laser scanner survey, showing both the block analyzed and the monuments urrounding it: The Cathedral and the excavation of the main Atzec Temple.

The paper analyzes the opportunities offered by integrated digital surveys, made with different methodologies, mainly 3D laser scanners and photographic shots with SFM processing, for documentation and diagnostics aimed mainly at the conservation and restoration of architectures. At the urban scale, the survey focuses on the documentation of the urban facades and pays particular attention to the analysis of the plastic deformations and of the masonry walls, in order to evaluate the misalignment value of the fronts of the buildings from the vertical plane and the interactions between the walls of different building units. Going down from the scale of detail to the architectural detail, the restitution and analysis of individual building units was also studied, closely linked to the asset value of the area; attention was focused on the survey for the documentation, the analysis of the state of structural conservation, reaching as far as the identification and classification of the lesions, the verification of the main failures of the structures and any states of risk of collapse.

2 SECTIONS

2.1 *The historic center of Mexico City: heritage protection*

The historic center of Mexico City was included in the World Heritage List in 1987, for the indisputable cultural value of its Aztec and Novo-Hispanic architecture. Part of the pre-Hispanic

Figure 2. Point Cloud obtained from the SfM process: all the photos were aligned in order to reconstruct the 3D digital model of the building's facades that form the block.

Figure 3. 2D drawing of the buildings' facades along Guatemala street: the orthoimages obtained from the photogrammetric model are applied to the drawing.

Figure 4. DEM analysis of the facades, obtained from the elevation map of the point cloud, showing every centimeter of deformation of the vertical plane.

architectural heritage has recently been rediscovered in the fabric of the twentieth century city thanks to the archaeological finds that took place during the excavations for the construction of the underground network; only portions of the most impressive religious buildings of the ancient Aztec city remain, which had so amazed the eyes of the conquistadores, as Cortes' own words report.

The city of Montezuma was founded entirely on a lake surface that has gradually dried up today: an urban organization similar to Venice, with buildings built on large rafts that were based on the bottom of the lake; a portion of the lake's original environment and landscape remains visible, also an integral part of the UNESCO site of Mexico City, in the Xochimilco area.

The arrival of the Spaniards caused the rapid fall of the Aztec empire and the disposal of all the buildings that were the symbols of an indigenous culture not accepted by the Christian invaders: the temples were destroyed and the new capital of the kingdom of Spain began to rise. The urban layout of the new city gave a regular shape with large blocks of rectangular buildings to replace the large platforms of the Aztec monumental area.

The high seismicity of the Mexican territory led to the reuse of the foundations of the ancient buildings to support the new buildings: churches replaced the temples that were gradually hidden under the new city, awaiting the recent rediscovery.

2.2 *The current asset classification systems*

In order to create a useful tool for the classification of the asset and vulnerability value of the building units present in the area, it was first necessary to evaluate the classification systems currently in force. Since the 1980s, the activities of classification and protection of the architectural heritage of Mexico City have had as their starting point an important phase of research and analysis of data on the buildings in the historic center. These data have been collected in an open access GIS platform where you can see the urban and architectural protection placed above each building in the city, and has the function of simplifying for the citizen the understanding of the degree of protection of the buildings. Especially in the historic center of the city it is common to find buildings that are subjected to multiple protections: the three main bodies set up to protect the heritage are the two Federal Superintendencies, INAH and ISBA, which respectively protect the historical and artistic value, and SEDUVI which protects the cultural heritage.

Over time, each of these bodies has had to list the architectural assets included in their respective protection lists, and therefore has drawn up a classification system that highlights the reasons for protection. For this reason there are numerous catalogs of the buildings of the city carried out by the superintendencies, often repetitive in general concepts, constantly updated over time. The historical heritage lists drawn up by INAH are probably the most detailed: they have been created since 1988, following the UNESCO declaration, verifying and updating the data over time. The databases are freely accessible and can be consulted online, and form an important knowledge base of the building: the census files contain information related to the location, construction period and maintenance interventions; the intended use of the building, the ownership regime and other legal aspects are also classified, such as belonging to the heritage lists or the reference to the 1980 classification form; a good part of the sheet is dedicated to the architectural description of the property, enriched with references to construction techniques, if identified, of all horizontal and vertical structures.

2.3 *The digital survey of the block*

The digital morphological survey operations of the historic center of Mexico City involved the block between the Templo Mayor archaeological site and the Cathedral. The rapid acquisition of this information and the need to obtain high accuracy and data density on the facades of buildings, in order to be able to conduct accurate morphological and deformation analyzes, have forced to design the measurement operations on the basis of modern range acquisition methodologies based: through the use of laser scanners and integrating the morphological data with the aid of three-dimensional models of the buildings obtained with SfM photographic acquisitions (Pancani, Bigongiari, 2019). As has now been experimented for several years in many research projects, from the image based data it is possible to extract information regarding the color, materiality and surface conservation of the facades, while to be able to obtain high morphological precision, necessary for the evaluation of the possible presence of structural deformations on an architectural scale, the use of range-based and closed-range instrumentation, or laser scanner instruments at a fixed location, is still essential today. The reduction scale chosen for the final reports, mainly for the purpose of collecting diagnostic information, is 1:50: this choice has influenced the entire survey procedure, from data acquisition to restitution, because it has imposed compliance with precise parameters of definition and accuracy. (Pancani, 2017)

In order to better conduct the operations, a Faro Focus X330 laser scanner instrument was used, whose characteristics are extremely effective for precision surveying. The not excessive dimensions of the block have led to the belief that the support of topographic instruments is superfluous to control the accumulation of errors in the scan registration process, moreover the ideal path to be performed with the scanner, which had to follow and resume the rectangular geometry of the block, would in any case have made it possible to verify, through a closed path of scans comparable as a concept to a closed polygon measured by the topographic station, the error obtained with the rototranslations of the individual scans. (Bertocci et al., 2015) 60 laser scanner stations were created, with a definition that guaranteed the mesh to the centimeter on the facades, and which consequently resulted in a distance always less than 15 meters between one location and the next. The process of acquiring the exterior of the block lasted less than 2 days, and created a database of morphological information of considerable size, around 50 Gigabytes. In the same way, the acquisitions inside the building of the block chosen as an in-depth analysis of the morphological analyzes were designed: the scale to be respected for the restitution of the entire building corresponds to that chosen for the analysis of the urban fronts; for these reasons, the resolution of the grid of points necessary to describe the architectural forms of the building, with particular attention to structural elements such as floors and roofs, has remained unchanged with respect to the urban survey. The high overlap between the scans led to experimenting with self-alignment procedures: the © Leica Cyclone 9.2 software was used, through which it was possible to suggest between which scans to try to make links, in order to speed up the process of identification of overlapping points. Since the link system creates a closed polygon, it was possible to directly verify that the alignment error of the scan group was acceptable. Although the results were comforting, vertical and horizontal sectional planes were performed on the model to verify that the misalignment of the clouds was less than 1cm, a condition that was largely satisfied. The scans relating to the building also studied in its internal components were instead linked through visual alignment procedures due to the complicated internal distribution space. In the same way, checks were carried out on the section lines which reported results similar to those found in the block registration process. (Bigongiari, 2020)

To complete the morphological database relating to the facades of the Mexico City block by adding information relating to the color of the surfaces, a photographic acquisition campaign was designed in order to reconstruct the three-dimensionality of the elevations thanks to SfM processes (De Luca, 2011). The need to create textured three-dimensional models of the facades is closely linked to the documentation and analysis of the buildings in the block of the historic center: rather than in support of the reconstruction of the morphology of the buildings, they were actually functional to the elaboration of accurate orthoimages of the facades. The data of the textures obtained from the models is strictly necessary both for the verification of the rules relating to the color plans of the historic center, and for the mapping of the pathologies that afflict the surfaces of historic buildings, both of a superficial and structural conservative nature. The photographic survey has been conceived and designed to allow you to create accurate orthoimages at a scale of 1:50 to integrate the color data. Thanks to the support of an accurate laser scanner survey, it was possible to proceed with the photographic acquisitions easily, with the certainty of always being able to refer to the models reconstructed from the shots on the morphological basis of the point cloud.

The © Reality Capture software was used for the three-dimensional reconstruction of the photogrammetric models; The shooting technique used, from the ground, led to obtaining very well defined textures for the 1:50 restitution scale, with the limit of not being able to complete the data where there were balconies, due to the obvious problems related to the cones of 'shadow: to solve this problem it was necessary to integrate the textures in post production, using portions of frames with adequate definition made at a greater distance, where it was possible or from higher positions, such as the views of buildings on the street opposite the isolated in analysis.

The vectorization of the survey data has followed procedures that have been consolidated for years in the panorama of research on digital survey systems (Parrinello, De Marco, 2018). For the realization of the elevations of the buildings, accurate rectified images were extracted from the point cloud management software and then polished on the CAD platform; the rasterization process of the point cloud was carried out taking into account the maximum definition level reached by the point cloud and the reduction scale necessary for the drawing of the drawings: each image extracted from the point cloud therefore had to maintain a minimum quality standard of 2 pixels for every centimeter of framed architecture, in such a way as to obtain a definition useful for respecting the errors allowed by the 1:50 scale. The drawing was made on normalized CAD sheets, with subdivisions in layers that distinguish the lines between: 1) lines for setting the drawing sheet; 2) section lines; 3) projection lines; object projection lines; 4) insertion of ortho-images; 5) insertion of orthoimages. The drawing was first made on the basis of the point cloud images, then the general drawing together with the ortho-images of the cloud were used to calibrate the orthoimages obtained from the photogrammetric models; the final design envisaged the use of orthoimages to integrate the more complex surfaces. The final restitutions were carried out at different scales: in order to be able to define the urban characteristics of the historic center, general sections were made on a scale of 1: 200 that described the relationships between the buildings, i.e. the heights, the colors, the materials, the slopes of the land and many other things; instead, to describe the single cadastral unit, wire drawings and orthoimages on a scale of 1:50 have been drawn up.

2.4 *The study of buildings in relation to seismic events*

The data collected for the historic center of Mexico City have the function of increasing and cataloging the information for the knowledge of the buildings with two intentions: on the one hand to increase and verify the data describing the asset value of the buildings, deepening the architectural surveys of all the facades, on the other hand with the aim of extracting information related to the structural vulnerability of the structural units and of the entire aggregate, considering the severe seismic and geological conditions that characterize Mexico City. The research carried out in Mexico City aimed to develop the use of digital survey products to investigate the seismic vulnerability of buildings: the analyzes were performed on the basis of complex and informationdense databases that were able to provide many indications on the buildings (Centauro, Francini, 2017). The result of this research was aimed at identifying discriminating factors that expressed a risk index for each building, and that was useful for planning experts to direct subsequent interventions for the protection of the Heritage following an order of priority established in based on the evidence provided by the survey.

The assessment of the structural vulnerability of the facades of the block required the design of a classification sheet of the multiple risk factors that can adversely affect the conservation of the buildings. Evaluating the structural behavior of a building from the analysis of the facades facing the street alone does not allow to fully understand a whole complex of mechanisms that can be implemented in the structures; it is possible to extract a lot of information that can highlight some points at risk, which need further investigation. In order to be able to extract the data useful for assessing the risk of the seismic vulnerability of the facades of the block of the historic center of Mexico City analyzed by this research, it was essential to summarize the knowledge deriving from the research carried out on historic centers in the past years, in in such a way as to have clear how to deepen the actual state of the places. As has been highlighted, the determination of vulnerability contributes to multiple factors of different nature, which can be easily highlighted in the buildings themselves.

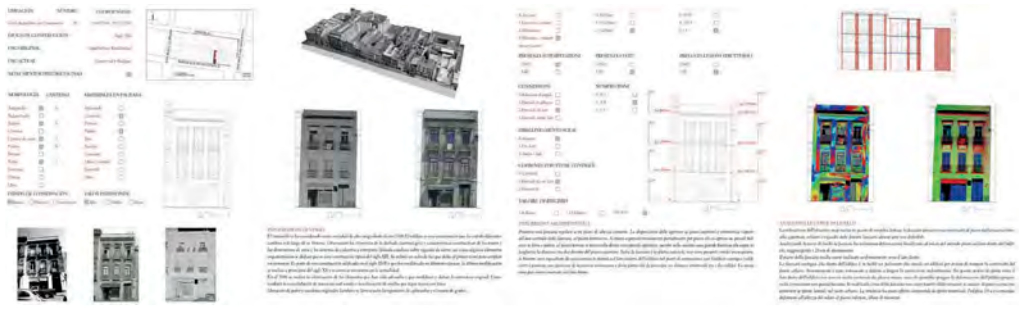

Figure 5. On the left, the first part of the census data sheet of a buildings showing the Heritage value and architectural design of the façade. On the right, the second part of the census data sheet of a buildings showing the Structural Vulnerability of the building.

In the first place, it must be taken into account that the horizontal stresses, unlike the static ones, place the individual buildings in direct contact with the adjoining buildings: precisely for this reason, research on earthquakes in central Italy has highlighted the behavior that is not so much of the single building as well as that of the urban aggregate, in this case of the block, which is affected by numerous situations not due to its structural behavior but from how the

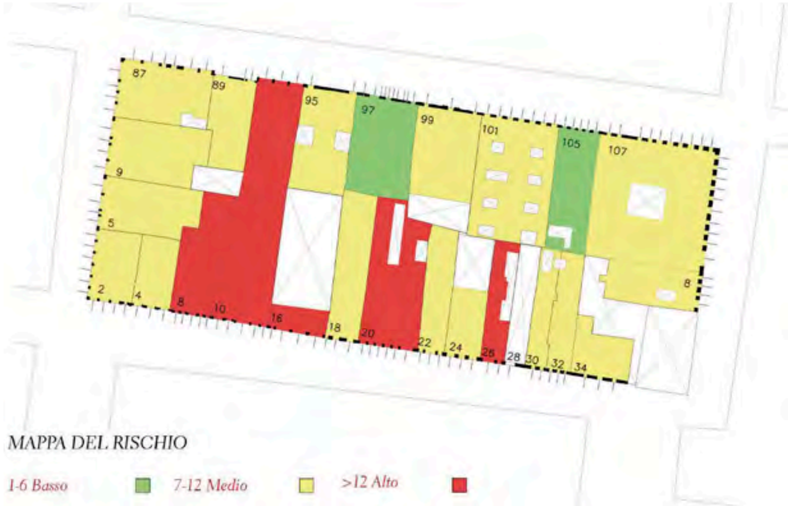

Figure 6. Final vulnerability risk scheme of all the building unit.

set of all buildings behaves (Minutoli, 2017a). It was important to take into account, in choosing the parameters useful for assessing vulnerability, a series of overall factors that put the single building in relation to the conditions it finds around it, such as the presence of internal courtyards (structural voids) within the block; the way in which the buildings flank each other (and therefore the horizontal stresses are supported and transmitted) and the ratio between the heights of the floors between the buildings. In the same way it was important to keep in mind all the data coming from the threedimensional survey and therefore the plastic deformations of the facades (the inclinations coming from the elevation maps) and the angular deformations that the elevations have accumulated in their history studded with numerous seismic events. Other data were instead deduced from the direct analysis of the buildings and were able to bring out considerations related to the materiality and the state of conservation of the facades and buildings which finally made it possible to carry out a rapid analysis but which took into consideration a sphere of aspects very different from each other. To evaluate the structural conservation status of the facades of the historic center, it was necessary to take into consideration a certain number of factors, which could be identified in all the elevations analyzed both thanks to the morphological data coming from the architectural survey and from the direct observation of the buildings. These factors were collected by fields, the values of which were categorized in order of danger; the sum of the values attributed to the fields made it possible to attribute to each card a vulnerability value which expressed the risk to which the building is subjected. The final risk value was divided into three macro-groups, which express a high, medium or low value (Minutoli, 2017b).

3 CONCLUSION

The project presents interesting ideas for the assessment and classification of risk in historic centers and in environments of patrimonial value. The documents produced have two different purposes: on the one hand, to provide local administrations with a document through which to be able to establish the actual asset value of the building units in order to guide the phases of recovery and possible compatible regeneration of the buildings and consequently of the urban fabric that it contains, and on the other hand, reliably define the degree of risk that buildings suffer in relation to the preventive analyzes on the study of deformations. The studies carried out and collected at the end in a sort of master plan a reasoned guide with the current destinations of use, the levels of asset value and the degrees of risk of the same building units identified finally constitutes, also with regard to the architectural scale, a document of fundamental knowledge, a study on the methodological definition also of the morphological and cognitive basis necessary for future in-depth studies relating to structural consolidation projects and the necessary architectural restoration and redevelopment of individual buildings.

AUTHORS CONTRIBUTION

"Conceptualization, S.B. and M.B.; methodology, S.B., M.B.; investigation, M.B.; resources, M.B.; writing— original draft preparation, M.B. and G.D.; writing-review and editing, M.B. and G.D; supervision, S.B.; In detail S.B. wrote 1. Introduction; G.D wrote 2.3 The digital survey of the block; M.B. wrote 2.1 The historic center of Mexico City: Heritage protection, 2.2 The current asset classification systems. and 2.4 The study of buildings in relation to seismic events. All authors have read and agreed to the published version of the manuscript."

ACKNOWLEDGMENTS

We would like to thank prof. Reynaldo Esperanza, UNAM, and its team for the opportunity to work together in CdMX; A great thank to INAH and Autoridad del Centro Historico CdMX for the support during the survey operations.

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Built Heritage in post-Disaster Scenarios – Balzani et al. (Eds)

DISS/Delta international sustainable strategies. An educational and research project for the Emilia-Romagna territory of the po delta

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ABSTRACT: The contribution explores the peculiarities of the Emilia-Romagna territory of the Po Delta, tracing the main issues affícting this fragile coastal system today, and outlining the necessary future challenges to take up in order to rethink its land/water structural balance, adapting to climate change and guiding territorial transformations towards more resilient configurations. The effects of climate change, together with contemporary socio-economic dynamics, are creating new pressures on the territory and its population, exposing the latter to new conditions of risk and undermining an already delicate equilibrium, forcing the investigation of new resilient design strategies and solutions, at different scales, to achieve greater sustainability. Moreover, these invented and artifcial landscapes, mainly based on a constant control over the water regime, are also subject to an idea of heritage and cultural landscape as a static system that must be brought back to a previous "natural" state, freezing in time its features and characteristics to a specifc evolutionary phase. This attitude is triggering expensive and counterproductive processes – both at the governance and operational levels – that are not proving capable of consciously driving the necessary change. Today more than ever, the coasts and deltaic territories represent an extraordinary field of testing and experimentation for design research and, with this aim, the CITER Research Lab (Architecture Department of the University of Ferrara) has been working on the Emilia- Romagna territory of the Po delta, integrating scientifc research projects with educational paths involving university students, training events for professionals and public technicians, and experiences of participatory design involving local communities, some of which are briefy illustrated in this paper.

Keywords: Po delta, territorial resilience, cultural heritage

1 INTRODUCTION

A large portion of the world's urban settlements have developed on water. Rivers, deltas, estuaries, lagoons, coasts and lakes, with their multifaceted geomorphology, have allowed the growth of cities in sheltered and defensible sites, rich in water to be used at the same time as a source of energy, nourishment and as communication route. Throughout time, the relationships between cities and water have followed some recurring trends, first of all the original conditions posed by water sites to the needs of human beings to build cities and safe places to live and trade. Since the nineteenth century, a sort of utilitarian shift occurred, transforming water into a necessary infrastructure for the start of industrialization processes. As a consequence, coasts and rivers became indicators of degradation and urban pollution, often sacrificed to the needs of expanding cities. Human settlements along river and coastal sites are the most variable in shape and features, rich in traces, sediments, ancient riverbeds, relicts of dunes and forests that, still today, allow us to grasp the secular processes of modification of these peculiar geographical sites (Farinella, 2020).

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DOI: 10.1201/9781003253730-7

If, on the one hand, we continue to look at the history of cities and entire territories through the relationships they have established with the element of water in its various forms, today we also wonder greatly about the present and future forms of these relationships (Farinella, 2013). Water as an element of first necessity, an urban and territorial resource, a source of energy and supply for agriculture, mobility infrastructure and, more recently, water as a factor of resilience and an element to be (re)discovered for possible interventions of regeneration, transformation, creation of new polarities and new landscapes, or for the restructuring of ecological corridors and green/blue networks. Finally, "water as heritage" in a perspective of the territory as palimpsest (Corboz, 2011) which, over the centuries, writes and rewrites the structure of places and re- signifies them through projects and policies that intend the complexity of history as a material of urban and territorial design, as widely discussed by Chastel (2012).

Historically, life on deltas has always been largely subject to uncertainty (Syvitzki, 2008) and, without human intervention, many delta areas would be rapidly submerged by fast marine transgression (Overeem, Syvitzki, 2009). However, today at a global level, water territories – first of all, deltaic and coastal systems – and the populations that inhabit them are experiencing unprecedented conditions of risk, pressure and exposure due primarily to the combined action of climate change, both in frequency and aggressiveness of the phenomena.

As reminded by the experts speaking at the international seminar "Dwelling the Risk. Urbanization, river deltas and coasts[1]", in the world today river deltas represent by extension 5% of all coastal systems, yet they are home to a population of about 600 million people who live in evident conditions of risk and vulnerability – although estimates of the number of people living on deltas vary widely, mainly because there is no agreed definition of a "deltaic area" (Tessler et al, 2015; Ericson et al., 2006) – directly related to the increasing vulnerability of deltaic systems themselves. Indeed, people living on river deltas are vulnerable to hazards, such as flooding, because physical stressors intersect with multiple socioeconomic and environmental stressors in these areas and, in addition, low-lying delta areas that are prone to storm flooding are globally often occupied by low-income residents, as discussed by Edmonds and colleagues (2020).

In a combined action between climate change and modifications induced by human action on the territories, many are the dynamics becoming chronic, such as: a significant reduction in the downstream transport of sediments, increasingly extreme subsidence; coastal erosion linked to the rise in sea level and the destruction of dune systems; ingression of the saline wedge (which makes agricultural practice difficult and increasingly less profitable); violent and increasingly frequent foods that are devastating entire cities and territories, with very serious consequences on the health and quality of life of the resident populations. In recent years, these phenomena have also led Italy to implement the so-called "Floods Directive" (2007/60/EC13) in order to establish a homogeneous reference framework at European scale for the management of flooding phenomena and/or inundations, with the aim of reducing the risks to life and human health, the environment, cultural heritage, economic activity and infrastructures.

As proposed by Ciavola and colleagues (2018), the impact of weather-marine events on deltaic and coastal systems can be divided and consequently estimated on the basis of six categories: economy, population, buildings and private properties, environment, infrastructure, and cultural heritage. This last category takes on particular relevance, especially in a territory like the Emilia-Romagna Po delta. If, as Françoise Choay (1992) reminds us, the concept of heritage is a relatively recent acquisition, the concept of cultural heritage/landscape (introduced in 1992 by the UNESCO World Heritage Convention) has allowed the debate to be further broadened, bringing the landscape and territorial asset within wider, long-term strategies. Cultural landscapes, product of the interaction between man and territory, are able to generate a stable balance over

1. The seminar, coordinated by Elena Dorato, was held within the first edition of the international Summer School "After the Damages" (LR 25/2018 art.2, project approved and funded by the Emilia-Romagna Region n.1251/2019), with the participation of Professor Romeo Farinella, urban planner expert in design in deltaic and fluvial contexts, Professor Paolo Ciavola, coastal geomorphologist at the University of Ferrara, and Professor Edward Anthony, geographer expert in deltaic systems at the University of Aix-Marseille, France.

time, producing environments of particular ecological and aesthetic value. However, the profound changes induced by climatic, social and economic phenomena now represent a threat to these territories and their communities: a challenge to understand how to drive their evolution in the sense of a renewed correspondence between forms of human activity and landscape production (Dorato, 2020). In this global framework, the Po River delta and its related coastal territories in Emilia- Romagna are no exception: these are ever-changing and fragile landscapes, made up of valleys, lagoons, coastal settlements, relicts of woods and dune systems, where widespread poverty and wealth concentrated in the powers that exploited its resources have always coexisted. A highly anthropic and "invented" territory, thanks to the important land reclamation works that have alternated with contrasting outcomes for at least four centuries (Gadda, 1939). With the economic boom after the Second World War, the delta was partially freed from its condition of poverty (also symbolized by the diffusion of malaria in the countryside) although it remains today one of the structurally weakest territories of the Region and of the entire country[2].

The documentaries shot by Adolfo Baruffl and Florestano Vancini or Michelangelo Antonioni (Farinella, 2015) in the 1950s show us the effects of the "economy of misery" that, at the beginning of the twentieth century, was widespread throughout the Po delta (Isenburg, 1971). Afer the war, the delta was subject to planning hypotheses that, if realized, would have devastated it far beyond what happened with coastal urbanizations (Corna Pellegrini, 1973), with heated discussions between "developmentalists" and "conservationists". The debate also fostered the idea of creating a Po delta Park, mainly thanks to the work of Giorgio Bassani (2005), although the national park was not established – despite the mobilization of many exponents of Italian culture – and the current regional parks were the result of political and administrative compromises that did not allow to transform this process into a complex territorial strategy (Aa.Vv., 1975).

2 THE PO DELTA OF EMILIA-ROMAGNA: A TERRITORY AT RISK

The Emilia-Romagna Po river delta, as already mentioned, is a strongly anthropic territory: an artificial landscape, shaped by the work of man who, over the centuries and through the control of the water system and the reclamation of the soil, has made it fertile and habitable.

However, contemporary conditions and dynamics – first of all, the effects of climate change – are creating new pressures on the territory and its population, exposing the latter to new conditions of risk, while undermining an already delicate balance, forcing to investigate new strategies and resilient design solutions, at different scales, creating greater sustainability. In such perspective, territorial planning and design, together with landscape architecture, can contribute to articulate this dynamic nature of the cultural heritage concept into planning and development frameworks, by operating on the spatial implications associated with the construction of exploratory scenarios and adaptive strategies to climate change (Lobosco, 2020).

More and more authors, internationally, are fostering a rich discussion on the role of climate change in redefining and improving the notion of heritage. Especially over the last few years, an intense debate on the need to liberate heritage from the conventional notion of being somehow prefigured has been fuelled by a vast multidisciplinary literature that has highlighted the impacts of environmental transformations on both its material and immaterial qualities. Among these reflections, David Harvey and Jim Perry (2015) discussed how the heritage-climate change nexus must be approached according to an operational attitude that should "reject the traditional view of heritage conservation that transports a valuable past into a well-understood and insecure future" (p.3). Thence, a new vision of heritage, serving society in times of rapid climate change, should embrace loss, alternative forms of knowledge, and uncertain futures, in order to "make decisions about the values and ways in which heritage assets have passed through time" (ibid.).

2. According to the National Strategy for Inland Areas (SNAI 2014-2020), of the 72 "fragile" territories identified throughout Italy due to distance from main centers, lack of services, geographic and demographic disadvantages, only 2 are coastal areas: the "Basso Ferrarese" and the "Contratto di Foce Delta del Po", i.e. the two large areas of Emilia-Romagna and Veneto that make up the largest portion of the Po Delta territory.

According to the European Commission (2012), the coast of the Po delta is second in Europe for the degree of “artificialization” (equal to 70% of the whole territory), a condition directly related to the high hydraulic risk to which the area is subject (Figure 1). Moreover, the provinces of Ferrara and Ravenna are characterized by the presence of more than 160,000 hectares of land with heights 3 to 4 meters below sea level, a condition for which several morpho dynamic factors make the shore and the back-shore unstable. With the increasingly frequent and extreme weather- marine events, the combined action of sea level rise, coastal erosion, saline intrusion (Perini et al., 2011), subsidence (Perini et al., 2017), and alternating periods of drought and violent rainfall, is further fragilizing this territory making it the most at risk in the Italian peninsula (Trigila et al., 2018).

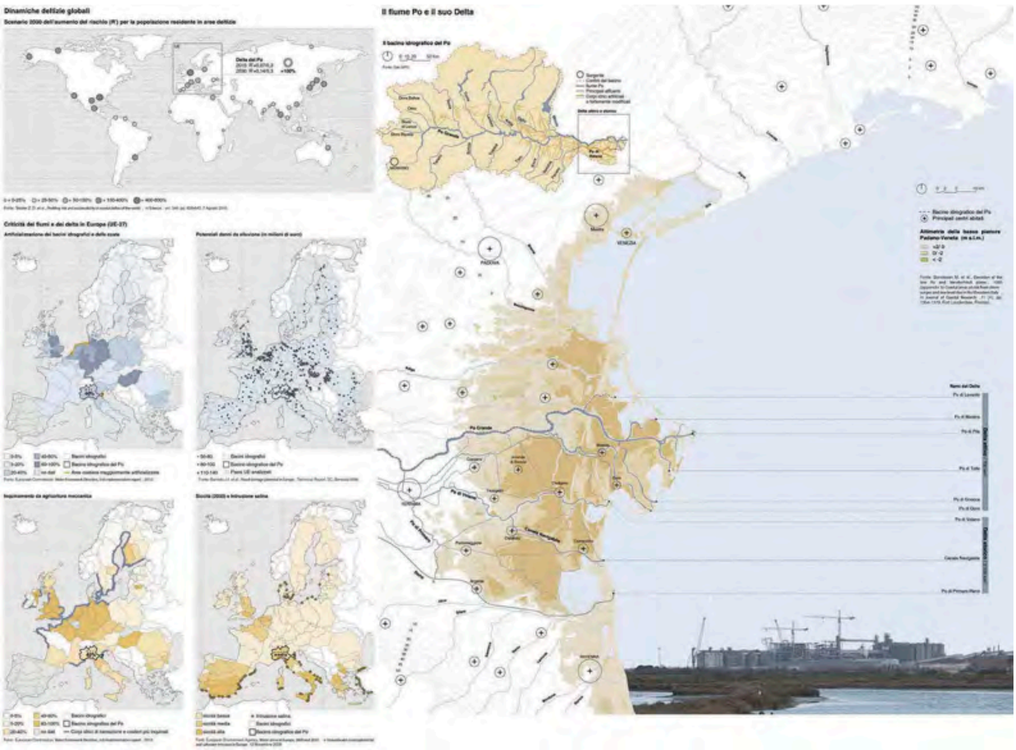

Figure 1. Main characteristics of European fuvial deltas and the Emilia-Romagna Po river delta (source: Master’s thesis by P. Lisotti, E. Seconi “Il Confne dell’Acqua”, DA UniFE a.a. 2017-18, tutor Prof. R. Farinella, co-tutor Prof. P. Ciavola).

According to the Emilia Romagna Climate Atlas 1961-2015 (Antolini et al., 2017), climate change at the local level is not just a projection or a scenario with a high degree of probability, but a fact, a documented phenomenon and already of relevant magnitude. During the next decade, the combined effects of land subsidence and sea level rise are expected to lead to increased coastal instability, resulting in a loss of beaches and, thus, heavy damage to the region’s touristic economy. Moreover, climate change is already causing an increase in irrigation needs and thermal stress for crops and livestock, as well as the anticipation of crop cycles and the spread of phyto-pathologies and new pests, damaging the local agricultural system which, at the same time, contributes greatly to the drainage of water resources and the emission of those climate-altering gases that are the main culprits of climate change.

In such a framework, the Emilia-Romagna coast of the Po delta is, as already mentioned, particularly subject to erosive processes, accelerated by the elimination of dune systems as a consequence of hydraulic reclamation and exacerbated, in more recent times, by the urbanization of the entire coastal area, even close to the beaches. Also, the construction of rigid structures to protect the coast (Perini et al., 2007), the realization of port works and the reduction of the spaces of action of coastal processes have contributed to such phenomena. Moreover, with the regulation of river basins and the excavation in the riverbed, the sedimentary supply of the beaches has been lacking (Simeoni et al., 2007), as well as the extraction of fluids (water and hydrocarbons) from the subsoil, near the coast, has led to an increase in the rate of subsidence, producing what in terms of coastal erosion translates into loss of volume at the expense of the beach. The impact of these dynamics is as much environmental as social and economic – for example, among the works of ordinary maintenance, only the beach nourishment carried out by the Region costs more more than 2.5 million euros/year – (Figure 2).

Acknowledging the extreme urgency of these dynamics is not enough, however, to ensure the effectiveness of contingent and strongly mono-disciplinary policies and solutions, which still struggle to take a process dimension and to understand the design of landscape and territory also as a device capable of counteracting the risks to which the area is exposed, offering integrated solutions and better responding to changing local needs. Especially in recent years, public investments on the territory have been relevant, also in terms of soil protection, but more complex strategies and a qualified governance are still lacking (Farinella, Seconi, 2021). In the Emilia- Romagna territory of the delta, different forces are concentrated, with different roles: territorial authorities (Region, Municipalities and two Unions of Municipalities), the Regional Authority of the Po delta Park, comprising the provinces of Ferrara and Ravenna, several Agencies such as the Consorzio di Bonifca Pianura di Ferrara and the public-private consortium GAL Delta 2000. Nonetheless, this structure does not seem yet able to define a solid, bold strategy and a unified vision for the territory, taking charge of the problems that make the delta still marginal and fragile, despite its potential.

At the same time, the tourist-cultural attention paid today to the Delta and its Park is still focused on monumental emergencies, naturalistic and historical excellences, ignoring those ordinary landscapes, heritage of everyday life, which describe the whole territory with its conflicts and contradictions. Situations of diffuse quality made up of relicts of vegetation, dune tracks, wetlands or areas of potential recharge, rural routes, abandoned railway stations, hydraulic structures, rural buildings and small villages no longer connected within the territorial system that, if integrated, could contribute to a broader strategy of enhancement of this extraordinary cultural landscape, no longer understood as a static heritage, crystallized in time, but as a dynamic heritage system, able to adapt and respond to the changing needs imposed by the contemporary world.

Figure 2. Coastal defense works with wooden stilts and sand bags trying to prevent beach erosion in Lido di Volano, Ferrara. In the background, dune and pine forest relicts (source: photo by R. Frainella, 2019).

3 NEW VISIONS AND DESIGN RESEARCHES

Today more than ever, coastal and deltaic territories represent an extraordinary field of testing and experimentation for design research; an opportunity to rethink cities, landscapes and territories in the perspective of complexity, taking into account key aspects such as the adaptation to climate change and the processes of transition and adaptation of communities and territories, the contrast to the vulnerability of urban and territorial socio-ecological systems, the planning and implementation of new processes and projects of urban and landscape regeneration aimed at a higher physical and aesthetic quality of places.

Especially in recent years, there has been a growing ambiguity regarding the planning and design processes of deltaic and coastal areas. Scientific researches and planning procedures for river deltas have mainly focused on environmental remediation, ecological restoration and the so-called "re-naturalization" processes, thus understanding landscape as a static system that must be brought back to a previous "natural" state, freezing its features and characteristics in time to a specific evolutionary phase. Moreover, the importance given to environmental values over cultural ones is exposing these peculiar territories to a number of additional threats, despite the fact that the preservation of natural systems is not per se the main cause of the decay of cultural landscapes (Agnoleti et al., 2015).

Rapidly changing contexts such as deltas have often been considered and managed as if their dynamic attitudes were something to be fixed or erased, rather than included in planning policies. In this prevailing logic, both European and Italian regulatory frameworks identify protected areas and areas of high environmental interest (i.e. "Natura 2000" sites, according to the "Habitat" Directive 92/43/EEC) as permanent in time and space: a conception that has been adopted also for the Po delta and that stands in stark contrast to the highly mobile nature of deltaic systems (Figure 3). Litoral zones, dune systems, wetlands – and therefore all other cultural heritage elements found on or near them – need to be identified and protected through more flexible tools, assuming also their mobility and the possibility of being relocated elsewhere (Di Giulio et al., 2017). Probably, in the near future, delta planning authorities will no longer be able to effectively manage environmental changes without making more radical and faster decisions, thus updating and adapting existing environmental protection tools, and participating in the creation of bolder visions for the evolution of these territories.

In order to contribute to the creation of such consciousness, also supporting future decision-making processes, scientific and educational works carried out by the Universities and research centers operating on the area acquire a particular relevance, being able to also involve local populations and institutions while raising awareness about the complex and multifaceted risks and ongoing dynamics affecting the delta. Understanding the importance of reflecting and acting on the ongoing phenomena, for many years now the CITER Research Lab (Architecture Department of the University of Ferrara) works on the Emilia-Romagna territory of the Po delta, integrating scientific research projects with educational paths involving university students, training events for professionals and public technicians, and experiences of participatory design involving local communities.

In this framework, a number of master's theses[3] have recently been developed on the coastal areas of the two provinces of Ferrara and Ravenna, imagining innovative strategies and meta-design configurations for the evolution of these landscapes, largely based on international multidisciplinary research and the study of virtuous case studies. All these works have been developed pursuing a necessarily adaptive and dynamic idea of landscape and heritage. Some students worked on the coastal areas of the province of Ferrara, rethinking its land/water structural balance to adapt to climate change and guide territorial transformation towards more resilient configurations (Figure 4). Design strategies include, among others, the selective flooding of degraded agricultural land (creating new and innovative

3. Annual studio class "Laboratorio di Sintesi Finale in Urbanistica", Architecture Department of the University of Ferrara (2016-2021).

Figure 3. The environmental system around the Pialassa Baiona, north of the city of Ravenna, and the many local protected areas (source: Master's thesis by G. Lazzarini, A. Montanari "Sistemi in Evoluzione", DA Uni- FE a.a. 2019-20, tutor Prof. E. Dorato, co-tutor Prof. R. Farinella and B. Giambastiani).

production chains, as well as new amphibious landscapes), the enhancement of environmental and heritage emergencies, the transformation of existing infrastructure into resilient and protective systems, the creation of new connective networks that enhance territorial mobility and support more sustainable forms of tourism. Similarly, some other theses have worked and are still working on the southern coastal areas, north of the city of Ravenna, safeguarding the vitality and richness of its ecosystems by guiding adaptive changes in the creation of new territorial and urban scenarios (Figure 5).

In order to promote an interdisciplinary approach to the study and elaboration of new proposals and strategies for the rich and yet fragile territory of the Emilia-Romagna Delta – similarly to the valuable interdisciplinary and international work started with the first edition of the Summer School After the Damages – the multi-year experience of the Delta International Summer School[4] (DISS 2018-2021) has set as its primary aim to foster the comparison between different traditions, methods and tools regarding the policies of enhancement of rural and water heritage landscapes, mainly following the approach proposed by delta Urbanism (Meyer, Bobbink, Nihuis, 2010). The Summer School has hosted for three years 50 non-paying participants from the Leader territory of the Emilia-Romagna delta, divided between technicians working in local public institutions, professionals working in the fields of design (e.g. architects, engineers, agronomists, geologists, biologists, archaeologists), university and PhD students, young researchers and recent graduates in disciplines related to the subjects covered by the event.

4. Progetto a convenzione DISS, Misura 19.2.02.10 Progetto Pilota per Aumentare la Cultura e la Conoscenza del Paesaggio, PAL Leader per il Delta emiliano-romagnolo 2014-2020". Benefciary institution: Department of Architecture UniFE (scientifc director Prof. R. Farinella, coordinator Dr. E. Dorato) with SSSCT UniBO, funding institution: GAL Delta2000 soc. cons. ar.l. More info at: https://drtlne.wixsite.com/ilmiosito

Through the comparison of national and international experiences and working together with the main public actors of the territory, the DISS wanted to promote a design experimentation intended also as a process of understanding the historical transformations of the territory, offering new tools for knowledge, reading and interpretation of landscape phenomena, spreading a complex and global approach to design, consolidating a culture of landscape through different activities dedicated also to local communities and promoting processes of identification of these communities with their own territories. Each year, interdisciplinary groups have worked on five different areas, characterized and selected each time according to the specific main topic.

Figure 4. A vision for the selective fooding of the areas around Lido delle Nazioni, Ferrara, and the creation of a new wetland recreational park (source: Master's thesis by I. Biondi "La Città del Delta", DA UniFE a.a. 2019- 20, tutor Prof. R. Farinella and Prof. E. Dorato, co-tutor Prof. G. Lobosco).

The objective of the Summer School has been the definition of strategic guidelines for a conscious and sustainable evolution of these territories, thanks to the multidisciplinary contribution of Italian and foreign professors and experts. The first edition of the DISS (held in Ravenna in June 2018) addressed issues related to the impact of climate change and the effects of coastal resilience in rural areas. The second edition (Comacchio, 2019) focused on the dichotomy designed/managed heritage, deepening these aspects according to a vision of material and immaterial heritage that is never static, and working on the definition of new systems and new territorial networks. The third and last edition (held in June 2021 via e-learning platform, due to the pandemic of Covid-19) worked on the close and increasingly relevant interrelationships between agricultural production and its supply chains, which still strongly characterize these territories, and the creation of landscape.

In the belief that the challenges of an increasingly complex and global world must be addressed in an integrated and interdisciplinary way, the training and collaboration paths proposed through international events such as the Delta International Summer School and the

Figure 5. Possible new morphological structure for the north coast of Ravenna: reconfguration of the protection dune system and creation of a sand motor for a dynamic conservation of the coast (source: Master's thesis by G. Lazzarini, A. Montanari "Sistemi in Evoluzione", DA UniFE a.a. 2019-20, tutor Prof. E. Dorato, co-tutor Prof. R. Farinella and B. Giambastiani).

Summer School After the Damages represent valuable contributions to the construction of a dynamic idea of heritage and territory. In order to be able to innovate and move to the future, it is necessary to be fully aware of the present, conscious of the processes that have generated this particular context and those communities that here are settled (Farinella, Dorato, 2020), in a global refection on sustainable cities, resilient territories and the prospects associated with climate change, trying to relate desires and opportunities for regeneration with the means available for action.

AUTHORS CONTRIBUTION

This paper is the result of a shared work between the authors. Conceptualization, investigation, drafting, and Paragraph 3: E. Dorato and R. Farinella; Paragraph 1: R. Farinella; Paragraph 2: E. Dorato. All authors have read and agreed to the published version of the manuscript.

ACKNOWLEDGMENTS

We want to thank GAL Delta 2000 for believing in the DISS project, supporting it financially for three editions. A special thanks also goes to all the lecturers and participants who, in these years, have given life to the Summer School, teaching us a lot and feeding a fruitful interdisciplinary exchange.

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Built Heritage in post-Disaster Scenarios – Balzani et al. (Eds)

Overview several EU countries action versus pandemic emergency

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ABSTRACT: The article summarizes the main contents of two reports prepared in June 2020 for the "After the Damages" summer school. This chronological clarification is relevant to appropriately contextualize the reflections with respect to a calamity different from the others dealt with in the cycle of seminars, both for the nature of the event itself and for the damages still to be assessed, not attributable to limited places and moments as in the case of earthquakes or floods.

Keywords: Health measures, operational indications, shared solutions, recovery

1 INTRODUCTION

The same theme of the interventions, "Overview several EU countries action versus pandemic emergency", takes note of this difference, making no sense to generalize a mosaic of COVID-19 situations nor to talk about consolidated post-event conditions because, despite the scanning in phases defined by international and state organizations, it is not possible to place oneself with confidence. At the end of June, the world epidemic is on the rise: an estimated 10 million infections, 500,000 deaths, 180,000 cases in a single day - statistics likely underestimated and where improving countries risk being sucked into the emergency.

In Emilia-Romagna the COVID-19 crisis also offers an example of the intersection with the post of other calamitous events, as it was with the reconstruction from the 2012 earthquake if only for the aspect deriving from the closure of construction sites established by the DPCM 22/3/2020 and lasted at least until 4 May. A secondary effect but one that reminds us of how disasters can overlap (imagine if the epidemic had occurred eight years ago . . .).

It is therefore difficult to address the assigned topic with an "After the damages" approach, for the increasing victims, due to the non-strictly destructive physical effect of the event still in progress, of the enormous amounts of damage caused and foreseeable in terms of lack of production, of the feared recurrence of the disease as well as of the breadth and complexity of the impacts on local and international structures, of the complex relationships between social and health measures (in particular the lockdown, with suspension of civil rights) and economic-employment (in balance between business interruption and income and business support).

How can we not get lost in a fragmentation of case studies (several countries: how many and which?) And futurological scenarios (moreover to be considered), in the concatenation of options taken in the months of February and March, revised in April and May and which appear continuously and prudent verification, waiting to know the political choices of the European Union?

2 THE PO DELTA OF EMILIA-ROMAGNA: A TERRITORY AT RISK

With minimalism, a particular perspective is proposed, capable of interpreting socio-health and economic decisions by looking at operational variations and production criticalities, of observing their interactions with the eye of subjects accustomed to intervening precisely in

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DOI: 10.1201/9781003253730-8

the event of calamitous events on behalf of people, productive activities and directly damaged public administrations. We will therefore take the point of view of the construction and plant installation sector, a fundamental production branch in terms of employment, which has citizens, businesses, public bodies as private customers and is involved in the restoration of real estate (homes, factories, commercial structures, urbanization, etc.), in maintenance and emergency interventions and which must therefore continue to operate even during emergencies.

By modifying the exposition of the first report, opened with the analysis of the general and specific conditions for some EU member countries thanks to a framework of the European Federation of the Construction Industry FIEC, here it seems preferable to start with the forecasts presented at the 89th conference Euroconstruct of 12/6/2020. A very differentiated reduction in 2020 is estimated for the EC-19 countries: a collapse in the United Kingdom and Ireland (between 33 and 38%) also compared to the collapse of GDP against the limited decline in Finland and Switzerland (within 2%); it is also estimated that construction could see a recovery of around 6% in 2021 and 3% the following year, reaching a level of production like that of 2018. Among the "big" only Germany would show levels of resistance (-2.4%) while France, Italy, Spain will face a fall between 12 and 20%. The widespread rebound will not fill the crisis, there are indeed risks of further downside and the most significant concerns the effective ability to containment of the coronavirus.

These projections, assessed against previous expectations of a small increase, are an authoritative measure of the effects of the pandemic. However, they do not say anything about the state of stress and difficulties that affected the countries at the same time as the spread of the infection, the numerous deaths, the fear of the health systems' stability, the discussed political options, how these are correlated with each other and the perception of gravity of the phenomenon. For this reason, the picture taken from the FIEC version updated to 6 May is integrated with references to the lockdown choices of the previous month and the contextual number of victims. It should be remembered that the article is not specific research on a complex issue such as COVID-19 and that uses sources not verified in detail but a reflection on what the construction sector has had to face in recent months.

In this regard, it should be emphasized that the countries have neither closed the activities of the construction sector nor resorted to defense measures in a homogeneous way. The synoptic table shows the cases of Spain, Italy, Germany, France, Belgium, the Netherlands and Hungary, in a list ordered by number of infections as of April 17. The closure of construction sites was less restrictive in Germany and the Netherlands (which have agreements to support demand) and in Spain and Belgium (limits on inhabited sites) while it reached particularly intense levels in Italy and France; the distance provided in the workplace varies from 2 meters in Spain to the meter in France and Italy (with the exception of Tuscany) and there are reports of critical issues with respect to territorial regulations in Italy and Germany; finally, the need to see recognized guidelines for construction sites appears different (Hungary and the Netherlands seem the least formalistic).

Cases of particular interest are the positions also taken by other countries outside the EU such as Switzerland and the United Kingdom. In Switzerland, SUVA has published a checklist for construction sites. Among the 13 questions, the request is whether a distance of at least 2 m is maintained. in the workplace, if people at risk are sufficiently protected, if hygienic practices are guaranteed at work and breaks, if all employees are encouraged to wash their hands and there are opportunities. A set of questions to be answered YES or NO. If NO, the measures described must be implemented immediately. The UK is a point of reference for setting standards and for management. Also, in this case the documentation is of considerable interest in terms of structure and proposition. The assessment of risks, their management through mitigation in compliance with other aspects such as parity are central to the government mandate to encourage smart working but to allow those who work on site to continue to go to work.

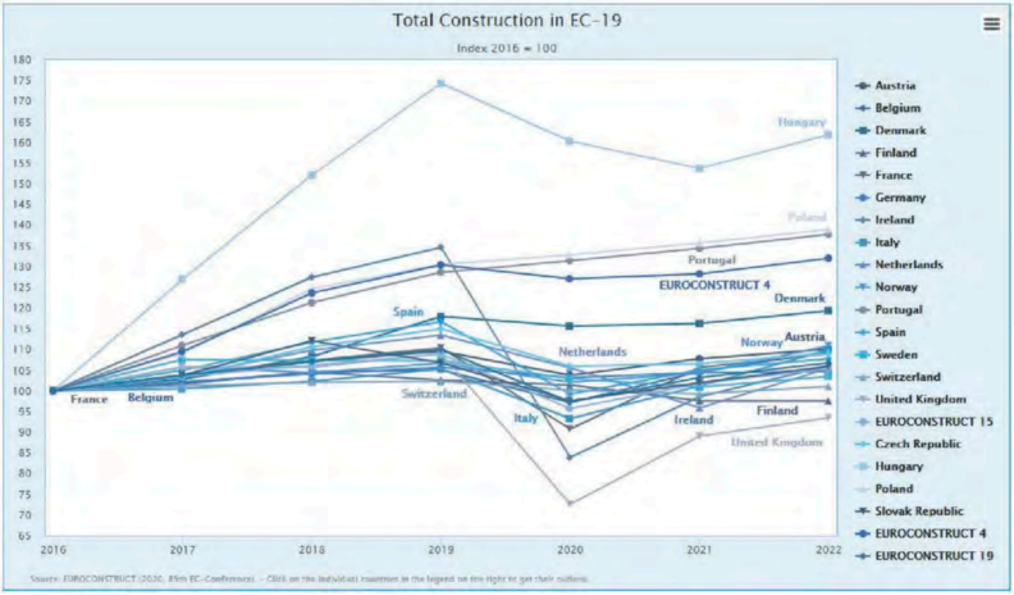

Figure 1. Economic national trends in the construction sector in Europe, Index numbers, 2016 = 100.

Within the EU, France is another country that makes methodology a boast: in fact, the documents attest to consistency. The guide approved by the ministries and published by OPPBTP opens on the preliminary and systematic agreement with the Client, bringing the whole in the field of the Construction Site Directive. It is on these roles that a process that goes from the project manager to the workers through the coordinator is grafted: meetings, setting up general plans, updating and harmonization of operational plans, suspensions. In addition, a COVID contact person must be designated for each construction site.

In Italy, where some aspects appear like those in France, a relevant issue was that of poor coordination in a situation of rapid spread of the disease and fragmentation of competences between national and regional levels, particularly on the health front. Beyond the proliferation of technical documents and checklists (by sector representatives, professional organizations, public administrations, supervisory bodies) it should be noted that the ITACA institute has produced operational indications (adopted by the Conference of Regions and autonomous provinces) for the application of workers' health measures in the case of contracts, including the division of costs between:

1. the costs of security, analytical and quantified according to the PSC and not subject to auction discounts;
2. company safety charges, necessary for carrying out the business activity and therefore included in overheads, of which they constitute a portion on which, at the time of the award, consistency is verified. This is a very delicate issue because, beyond the coverage issue, it deals with the issue of which ones can be recognized and how much remains to be borne by companies in the case of public contracts.

In closing, it should be noted that Annex 13 to DPCM 17/5/20, "protocol", identifies the formalized measures that have been taken and declined in the numerous checklists by several construction subjects for their different purposes:

1. Information
2. Access procedures for external suppliers to construction sites
3. Cleaning and sanitizing of the construction site
4. General Personal Precautions
5. Personal protective equipment

6. Management of common areas (canteen, changing room)
7. Organization of the construction site (shifts, remodeling of the work schedule)
8. Management of a symptomatic person on site
9. Competent physician health surveillance/RLS or RLST
10. Update of the regulatory protocol

Table 1. Overview on EU national measures against COVID crisis in April/May 2020.

Country	Social health measures on 14 April	Generals (rev 6/5)	Distance and Construction Site	Guidelines and others
Spain *Restrictions from 14/3 to 26/4* Cases: 184.945 *(data updated to 17/4)*	14/03: State of emergency with general confinement order. Schools, non-essential activities, hotels and other tourist accomodation have been closed. Leaving home allowed only for emergency reasons and work. 28/03: measures have been lightened. All non-essential workers confined at home for two weeks, until the 11/04. Some rectrictions postponed until 26/04.	Royal Decree no. 7/20 on economic impact and state of emergency ("estado de alarma") 14/3. Piano 28/4.	2 meters (not in inhabited sites). Due to restrictions stated by RD 29/3, in force from 30/3 to 9/4.	8/4: released a Bilateral Guide. National Production fell by 10% compared to the previous quarter.
Italy *Restrictions from 9/3 to 3/5* Cases: 168.941, with 22.170 deaths	09/03: National Lockdown. People allowed to leave home only for precise circumnstancies. Schools and non-essential activities closed. Grocery stores, banks, post offices and pharmacies still open. Travels and even short movements forbidden, except for emergencies, health reasons and work. *The former deadline of the decree (3/4) has been postponed to 13/4 and, later, to 3/5. From the 14/4 the first reopening took place.*	Wide range of tax postponements, financial and job support.	1 meter (1,8 m in Tuscany). Legal restrictions due to DPCM 22/3, 26/4 and 4/3.	Protocols with sectorial guidelines. 24/3 Authorized Ateco Codes: 42, 43, 2, 94, 38. Markel in sharp decline: -13%. *(source: euroconstruct '20)*
Germany *Restrictions from 22/3 to 19/4* Cases: 136.569, with 3.943 deaths	Germany did not impose a strict lockdown but imposed strict social distancing rules (22/03). Excepting for families and peolple who live together, gatherings of more than 2 people are forbidden. restaurants and non-essential services are closed. Schools have been closed until Eaaster. The only area who have imposed to their residents a strict lockdown are bavaria and Saarland. Social distancing measures have been extended until April the 19th.	13/3: Protection for workers and companies. 25/3: Debt block has been suspended.	1,5 – 2 meters. Ministerial measures in favore of public workers.	13/3: ZDB, then IIDB. 23/3: Berafsgenossenschaft bau. Letter to the Minister about the prosecution of works in case of major force. IIDB stressed the importance of a whole guideline.

(*Continued*)

Table 1. (*Continued*)

Country	Social health measures on 14 April	Generals (rev 6/5)	Distance and Construction Site	Guidelines and others
France *Restrictions from 17/3 to 11/5* Cases: 108.847, with 17.920 deaths	17/03: National Lockdown: all public gatherings forbidden. Residents forced to stay at home, with the exception of emergencies (with a form to fill). All non-essential activities closed, included open-air markets. The lockdown has been extended from the 1st of April to the 15th and, due tu the sill increasing number of cases, postponed until the 11th of May.	Wide number of social measures and state of emergency until the B24/7.	1 meter. 17/3: associations asked to the Government 10 days to adapt to the rules.	March: best practices. 2/4: Bilateral Guide authorized by the Ministry. 17/4: 91% of companies has been suspended.
Belgium *Restrictions from 18/3 to 3/5* Cases: 34.809, with 4.857 deaths	Restrictions untile the 19th April, with a possible extension to 3/5. Residents are forced to stay at home and avoid as much as possible any contact with external, with an exception just for emergency. Walking and small training sessions outdoor are allowed. Travelling abroad is forbidden until the 19/4.	6/3: federal measures regarding mayor force, unemployment and postponement of public contracts.	1,5 meters. Construction sites open, with exceptions.	Constructive even to void the spread of the pandemic in France and Netherlands. 4/5 full re-opening.

Source: FIEC, DW and others.

3 FROM PARTICULAR TO GENERAL

Taking the construction sector point of view and the construction site has made it possible to highlight some differences in the behavior of countries and organizations accustomed to coordinating in Europe. The actions reflect similar measures (distancing, practices, devices) but differently articulated, sometimes even within national territories. In this regard, it should be emphasized that the guidelines defined by the OSHA Bilbao Agency for the return to work are not binding even in the case of the COVID-19 pandemic, providing guidance but not mandatory to employers and operators in about:

Risk assessment and appropriate measures

- minimize exposure to COVID-19
- resume work after a period of closure
- cope with a high absence rate
- manage workers who work from home Involve workers

Take care of workers who have been sick Planning and learning for the future Stay well informed Making available information and documents ranging, in addition to construction, from food to entertainment, from education to transport, from sales to hygiene and health services, etc.

Hence, from the constructions and with similar knowledge needs, it is possible to resume a broader reasoning, starting from the risk matrix produced by INAIL by adapting a model developed by the US Bureau of Labor of Statistics which, based on the dimensions of the exposure and proximity - integrated with specific attention to aggregation - identifies four levels of risk, from the “high” level of hairdressers and funeral homes to the “low” level of agricultural and manufacturing activities; passing through the medium-high intermediate cases (couriers, waiters) and medium-low, typical of ecological and construction operators. Needs that led to the production, in the end totally coordinated, of the guidelines for the safe reopening attached to the DPCM 11/6/20, putting order to a sea of previous indications and regulations. Among the annexes: the protocols on work environments, construction sites, transport and logistics, and precisely the guidelines for the reopening of the economic and productive activities of the Conference of Regions and Autonomous Provinces. But how much do coronavirus cases affect production activities compared to the total number of victims of the pandemic? In Italy the D.L. n. 18 of 17/3/20 established that in cases of confirmed infection for workers, the insurance service to protect the injured person is the responsibility of INAIL. With Circular 13 of April 3 and with the INAIL notes of May 15, it is clarified that the employer is liable criminally and civilly only if the responsibility for willful misconduct or negligence is ascertained.

As of May 31, the positive workers reported to INAIL are 47 thousand out of a total of 233 thousand infected in Italy (about 20% of the total), of the over 33 thousand deaths only 208 would be the cases reported to INAIL (0.6% of the deceased and 0, 4% of positive workers). A figure lower than that identified by the Higher Institute of Health and the representatives as there are no family doctors, freelancers and even pharmacists among the insured personnel.

Although paying an important toll in terms of infections and human lives, especially in the field of health (for which a separate examination must be carried out), it cannot be said that the victims are concentrated in the workplace but indeed, at least for now, between the elderly and retirees, with an average age according to the data of the Istituto Superiore di Sanità at 25/6/20 of 62 years for the diagnosed and 82 for the deaths: 33,532 deaths in total of which less than 1,500 under 60 years of age.

Yet safety at work can dictate priorities and force the social partners to find shared solutions, to look at the relations between workers and the population, between productive activities and their role for the country, both inside and outside the emergency.

In terms of employment, the ILO note “COVID-19 and the world of work: 2nd edition” highlights a widespread and massive loss of jobs and hours of work: the international labor organization estimates that 1.25 billion people, almost 38 % of the global workforce, are employed in sectors with severe production decline and high substitution risk: sectors such as retail trade, accommodation and food service and manufacturing

A dimension of enormous damage, with respect to which we must ask ourselves, what influenced our choices briefly recalled in the summary framework. In this regard, it is useful to look at the European COVID-19 map of 6 March 2020 and rethink the perception determined by what were “just” 7,423 cases at the time, for the most part concentrated in Italy but already consistent in France and Germany, not forgetting that the phenomenon was distributed in a different way on the territory, for example. in Italy where almost half of the deaths occurred in Lombardy, bringing about the collapse of a health system among the best considered in Europe.

The map in question is disturbing, not only for Italians, because it leads us to think of a rapid and devastating spread of the epidemic, even outside Europe without too much regard to the level of economic development of the various states because already in April the The United States is firmly at the top of the sad ranking of infected people and deaths: 660 thousand cases and 33,633 deaths as of 17/4. Between January and April, however, the set of economic estimates prepared by OCDE and FIM is reversed, the forecasts of the World Economic Outlook (FIM) pre-COVID, Lockdown-COVID and “Unparalleled Crisis” show the inversion of the world development process. From a global 2020 growth of 3.3% we pass to a reduction of similar intensity but in June it emerges that the crisis is estimated in the order of 5%.

The world economic scenario, taking up the titles of charts and tables of the FIM and OCDE Outlooks, can be summarized in the following points:

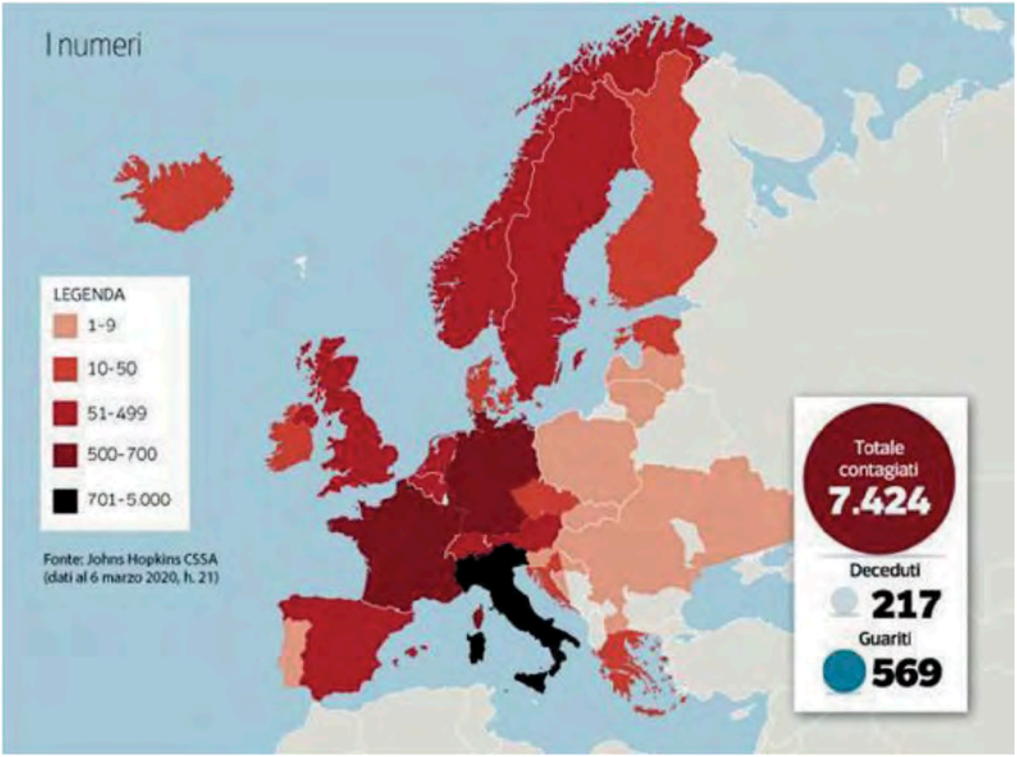

Figure 2. Spread of the COVID-19 epidemic in Europe in March 2020. (source: www.corriere.it).

Figure 3. On the left, Tentative Stabilization, Sluggish Recovery. (source: International Monetary Fund, World Economic Outlook, Jan 2020) On the right, The Great Lockdown. (source: International Monetary Fund, World Economic Outlook, Apr. 2020).

- Gdp from -3% to minus 4.9 in the new forecast of June 2020
- global business fell sharply in the first quarter of 2020
- exceptionally weak commercial activity
- collapsing world trade, with challenges for tourism-dependent economies
- increased tensions on the financial markets
- massive job losses and high unemployment
- tax positions destined to deteriorate drastically
- national currencies significantly weakened against the US dollar

Latest World Economic Outlook Growth Projections

(real GDP, annual percent change)	2019	PROJECTIONS 2020	PROJECTIONS 2021
World Output	2.9	-4.9	5.4
Advanced Economies	1.7	-8.0	4.8
United States	2.3	-8.0	4.5
Euro Area	1.3	-10.2	6.0
Germany	0.6	-7.8	5.4
France	1.5	-12.5	7.3
Italy	0.3	-12.8	6.3
Spain	2.0	-12.8	6.3
Japan	0.7	-5.8	2.4
United Kingdom	1.4	-10.2	6.3
Canada	1.7	-8.4	4.9
Other Advanced Economies	1.7	-4.8	4.2
Emerging Markets and Developing Economies	3.7	-3.0	5.9
Emerging and Developing Asia	5.5	-0.8	7.4
China	6.1	1.0	8.2
India	4.2	-4.5	6.0
ASEAN-5	4.9	-2.0	6.2
Emerging and Developing Europe	2.1	-5.8	4.3
Russia	1.3	-6.6	4.1
Latin America and the Caribbean	0.1	-9.4	3.7
Brazil	1.1	-9.1	3.6
Mexico	-0.3	-10.5	3.3
Middle East and Central Asia	1.0	-4.7	3.3
Saudi Arabia	0.3	-6.8	3.1
Sub-Saharan Africa	3.1	-3.2	3.4
Nigeria	2.2	-5.4	2.6
South Africa	0.2	-8.0	3.5
Low-Income Developing Countries	5.2	-1.0	5.2

Source: IMF, *World Economic Outlook Update*, June 2020

Note: For India, data and forecasts are presented on a fiscal year basis, with FY2020/2021 starting in April 2020. India's growth is -4.9 percent in 2020 based on the calendar year.

INTERNATIONAL MONETARY FUND IMF.org

Figure 4. A Crisis Like No Other, An Uncertain Recovery, IMF WEO. (source: International Monetary Fund, World Economic Outlook, June 2020).

- several central banks that have become dominant holders of domestic government bonds
- pandemic will leave lasting legacies.

The parallel world health scenario, on the other hand, appears to be characterized by.

- 10 million rapidly growing infections
- over 500 thousand deaths
- doubts about the production of a vaccine in 2020 but also, for a communication:
- ambiguous and not very authoritative
- opportunistic and not very fair
- with exchanges of accusations and offenses.

when instead it would have been necessary to invest more in collaboration, knowledge, coordination, even at a European level where there was no lack of irreverent behavior, hoarding of devices, selfishness.

Italy is an example of a controversial communication where too many times the levels of government have clashed and scientists have come into conflict with each other, but the Netherlands seems to have been not very transparent in the communication of deaths while cases of delay in supply some data appear to have concerned Belgium and Spain. Exchanges of accusations have had the US and China as leaders but also the United Kingdom, examples of offenses and irreverence have instead concerned German and French operators towards Italy. Finally, the case of Hungary has generated action at a European level due to the excessive reduction of democratic rights justified by the contrasting measures.

4 CONCLUSIONS

In addition to the damages mentioned, there are others that are really difficult to assess, from the loss of many lives to the possible redefinition of a global balance, to the consequent distribution of work and resources in a context of less movement of goods and people. As the pandemic continues to rise, the risk of a second wave materializes. Globally, it is estimated that a second wave could lead to a contraction of GDP from 6 to 7.6%, with a particularly strong fall in the euro area (11.5% against 9.1) and even worse for Italy (from minus 11.3% to minus 14%).

But just as the COVID-19 epidemic has shown greater lethality in people with previous diseases, similar risks must also be considered at the socio-economic level, ranging from the rating level to debt on the financial market, from dependence on particular production and financial activities. service to the efficiency in the management and investments of private companies and public affairs. The ability to contain illegality and prevent criminal organizations from receiving financing or acquiring control of companies in difficulty thanks to their availability of capital has in the experience of the earthquake in Emilia an example of how this objective can be pursued, in the AEMILIA process. evidence of risk.

The rating level already explains many of the differences that bind the countries indicated in the table with respect to their real usability, but it will be above all the quality and effectiveness of the general and specialized measures financed in deficit that will make the difference, together with the legality game, which is a an extremely broader problem in the world than one might think.

It is a widespread belief that after the pandemic it will be difficult to return to produce and live exactly as in the past.

It has been heard so often that it is forgotten that change would be the natural condition of dynamic societies, opportunities for exiting from this and other emergencies, that sectors such as construction can only lift themselves from moments of crisis with massive technological and organizational transformations, with a much more extensive smart evolution of agile and innovative work in terms of marketing: new products, processes and services also starting from the same covid experience.

Thinking about this and other scenarios allows us to remain operational and constructive even in difficult times, to study solutions for a complex world that we have learned can take unexpected directions and for which we need to decide whether we need more Europe or less

Europe but above all which European Union. Beyond the pandemic wall, there is in fact the landscape of objectives that we will be able to set and pursue: together and in individual countries and territories. Covid 19 that transported us to a science fiction scenario could prove to be an opportunity to trigger a turning point in our economies. However, the recovery must be guided in such a way as to create a new social and environmental balance, this is what authoritative researchers assert in a study that invites us not to waste this crisis: for sure we will have a lot of damage to repair and a lot of things to learn.

ACKNOWLEDGMENTS

Special thanks to AISM colleagues Franco Aniello for their contribution to setting up the final part, to Fabio Lazzarini from CRIBIS and Marco Mosti from GIMBE.

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Built Heritage in post-Disaster Scenarios – Balzani et al. (Eds)

Mind the_gap & Be Haz-Ior

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ABSTRACT: The project proposes a system composed of two solutions, one complementary to the other: The SOLUTION platform is the perfect solution (on SaaS platform) for Assessment Decision Takers; assesses the specific pandemic biological risk of the company, monitors the evolution of the emergency on a territorial basis, managing and activating the necessary action scenarios (specific prescriptions and operating procedures for the different Homogeneous Groups of workers exposed to risk) and the related pandemic emergency plans in the workplace (Production Emergency Plans). SOLUTION restits a report (certified by a trained professional) of the corporate pandemic risk expressed in five classes of growing risk declined in a colorimetric index of easy interpretation, supports (with a solid and rigorous metric) the decision-maker and the implementer in organizational choices, records the data and actions taken to future trace and protection against any legal actions or recourse (service cases). The APP APPLICATION, currently being marketed, is an application dedicated to Production Health Distancing; it works in full compliance with the stringent rules to protect privacy and is a useful tool to support compliance with social distancing and therefore increases the control of the spread of the pandemic influenza from Covid-19.

Keywords: Covid-19, Safety, Digital platform

1 INTRODUCTION

In the world of construction, the problems to be faced are numerous and often involve important responsibilities to which we cannot shirk:

- Safety
- Timing
- Correspondence between project and security plan

The technicians often have to face of with several biological problems, that belong to these sectors:

- Building general problem
- Idraulic system
- Water sewerage

Fungi, bacteria, bacterial endotoxins, virus and parasites can be found in mold of a wall during refurbishment, or when we decide to change the bathroom position moving toilet pipes. As a result, Covid-19 virus could be compared to biological problem in the construction

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DOI: 10.1201/9781003253730-9

Figure 1. Recommendations for the Covid-19 control on construction sites. Examples in Italy and Germany.

area except that the previous problem have a specific induced low risk and Covid-19 has e specific induced high risk.

The pandemic has therefore emphasized two main topics:

- Who is the responsible for employers' security?
- What the customer should do?

For answering to the first question we have to analyze the different country:

- IT: Covid-19 is not a professional risk, but the Security Coordinator is responsible for it
- Other Countries: a COVID-19 manager has been appointed for each yard

In the second case, only France has an answer: the customer himself is required to follow a specific protocol, wearing personal protective equipment himself or leaving the site.

2 THE SOLUTION

The project proposes a system composed of two solutions, one complementary to the other:

- The SOLUTION platform is the perfect solution (on SaaS platform) for Assessment Decision Takers; assesses the specific pandemic biological risk of the company, monitors the evolution of the emergency on a territorial basis, managing and activating the necessary action scenarios (specific prescriptions and operating procedures for the different Homogeneous Groups of workers exposed to risk) and the related pandemic emergency plans in the workplace (Production Emergency Plans).

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- The APP APPLICATION, currently being marketed, is an application dedicated to Production Health Distancing; it works in full compliance with the stringent rules to protect privacy and is a useful tool to support compliance with social distancing and therefore increases the control of the spread of the pandemic influenza from Covid-19.

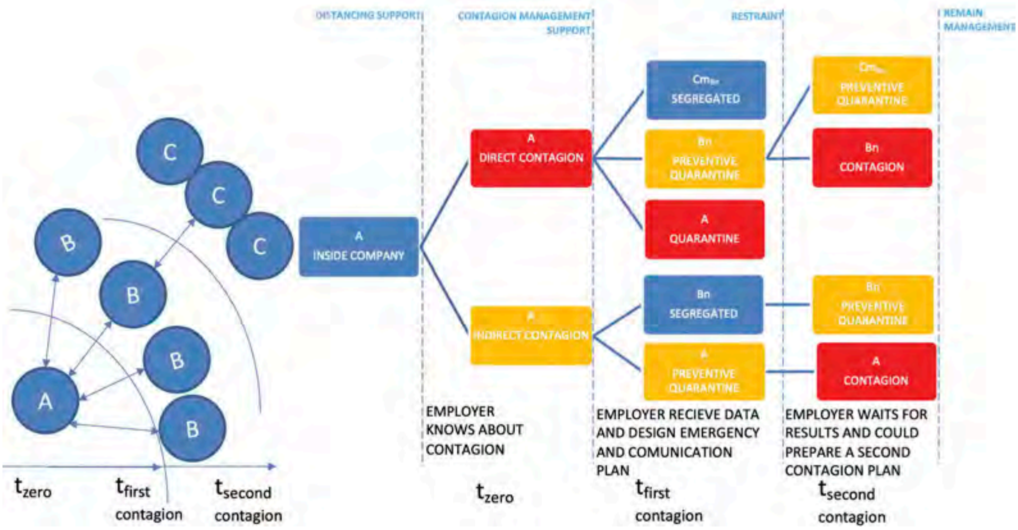

Figure 2. Distance and contagion management.

2.1 *Economic impact*

The construction site is, par excellence, the place of co-presence. For this reason, the application of contagion containment measures is bringing various difficulties in the management of shipbuilding activities, including the shifting of work teams to avoid gatherings, management and control of the use of D.P.I. for those processes that by their nature require working near other people. In addition, a sharp slowdown in processes is to be expected and being able to estimate them is essential in general economies and in the allocation of safety costs according to recent directives.

Greater attention will be paid in the development of the SOLUTION platform also to the management of suppliers and procurement and sub-contract contracts, to manage the staff assigned and registered within the construction site diary, as well as there will certainly be a new version of P.O.S. (Operational Plan For Security) and P.S.C. (Coordinating Plan For Security).

This solution is intended to monitor and support companies and the provision of services versus the productive risks of a company, the evolutionary state of the pandemic by supporting the decision-maker and the implementer to their prediction and organization.

2.2 *Sustainability*

The SOLUTION platform is the solution for Decision Takers (Employers, Line Managers, HSEQ Managers, Circular Economy Responsibles) who need to assess the risk of contagion during a pandemic situation. This solution aims to analyze the risks and the evolutionary state of the pandemic by returning a colorimetric index of 5 classes (from green to red) that define the state of emergency and activate the related plans. In addition, the platform has already been designed to accommodate a GREEN index to highlight the corporate delta footprint determined by organizational changes in pandemic and post-crisis (New Normal) set-up, giving the Decision Taker a measure of the positive impacts related to the options greener. (e.g. Smart working vs Working in situ).

2.3 *Innovative character*

With APPLICATION, the operator has a customized system for the construction site with respect to the work he must undertake. The operator will have access to Directives (what to do), how to do it (training) and with which PPE, periodically receiving notifications of the change based on the construction site where he is located (risk index), surveys to verify understanding and FAQ.

In addition, the operator can work safely, moving hands-free while the flow of data takes place in cloud mode and alerts directly from the smartphone, without having to check the device from time to time.

APPLICATION differs from other Distancing solutions because it is aimed specifically at companies and the implementation of emergency plans that each company is autonomously entrusted to implement on the basis of the specificity of the activities and risks, moreover its uniqueness lies in the fact that there is no need for dedicated expensive infrastructures. In addition, WITH SOLUZIONE the chrono-programming capacity will be renewed through a "smart" operation through analysis of the opportunities for overlap and time extension, also resorting to shifts and strategies aimed at mitigating the apparent limitations and slowdowns generated by the prescriptive measures.

2.4 *Covid response*

The problem we want to face and solve is the reopening of the production sectors in complete safety thanks to an increased awareness of the specific risks to be managed.

The APPLICATION responds to the needs dictated by the Prime Ministerial Decree of 10/04/2020, on the maintenance of the minimum required distances, alerting in real time and tracing the failure to respect the distances for a subsequent quarantine process, preventive quarantine and segregation in case of positivity of a worker (supplier, consultant, visitor) or potential positivity if you have come into contact with an established case.

SOLUTION will therefore serve as a navigation system (multidimensional dashboard) for decision-makers in the possible alternation of situations of a lock and sudden local lockdown, identifying for each construction site and/or production site the most appropriate measures to be taken.

Built Heritage in post-Disaster Scenarios – Balzani et al. (Eds)

Resilience of a legacy: Water harvesting in traditional settlements

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ABSTRACT: A dialectical view of the interaction between modernization and tradition has been revealed in extensive scholarship on the Indian social system, based on diverse case studies. Recent geopolitical narratives based on confidence have generated global interest in post-liberalization economies. There remains the question of whether traditional wisdom can withstand aggressive urbanization, growing inequality of wealth, and, perhaps most importantly, environmental vulnerability. Using a combination of studies from various disciplines and approaches within scholarship, we can map the shifts and changes in the relationship between modernization and tradition. Research on water infrastructure is one of these areas. Specifically, this paper explores traditional water systems in the arid region of Rajasthan, particularly Jodhpur. Despite paradigm shifts in management and procurement processes due to modernization, this study attempts to assess the resilience of traditional water harvesting systems. In the aquifer, the well is the smallest element. Despite crisis situations, well water is always available, unlike regulated water supplies. It is a daily ritual to worship the auspicious peepul tree by the well. It provides much-needed shade from the harsh sun. An otla (i. e., plinth) at the well is used by local men as a place to gather. Almost all households in the area are supplied with fruit and vegetables every day.

Keywords: traditional water infrastructures, resilience, well, auspicious peepul tree

1 INTRODUCTION

In 1965, in a conference held at the University of Chicago, on social structure and social change in India, papers were presented to review and analyze the adaptive processes in the Indian social system, concerned with the traditional patterns and modernization (Berland). Since then extensive scholarship on the subject, with diverse case studies have revealed a dialectical view of the processes of interaction between modernization and tradition. The post liberalization economy and the recent geo-political narrative built on the confidence of a fast-growing economy has ensured global interest. The question that persists is that of resilience of traditional wisdom in the face of aggressive urbanization, growing unequal distribution of the wealth, and most importantly environmental vulnerability. Synchronic empirical studies from diverse disciplines and approaches in the scholarship can help map the shifts and changes to assess the trajectory of this relation between modernization and tradition. One such research is related to the water infrastructure. This paper investigates the traditional water systems in the context of the arid region of Rajasthan, in particular Jodhpur to assess the resilience of traditional water harvesting systems despite the paradigm shifts in management and procurement processes due to modernization.

2 CONTEXT

Jodhpur, established in 1459 as a more secure alternative to Mandore, sits on the eastern edge of the Thar desert, amidst the Aravalli range. The transition region is composed of undulating

DOI: 10.1201/9781003253730-10

dry land with fragmented outcrops from the Aravallis, one of the oldest mountains in the world. In the pre-Harappan times, the area was green with adequate rainfall, and it was only from the 3rd millennium BC it acquired its present arid and semi-arid conditions (Misra). There is no perennial river in the region. The Luni which runs 30 km southwest of Jodhpur loses itself in the Rann of Kutch. The average summer high goes up to 46 °C with temperatures often touching 54 °C. It is characterized by high winds and sand storms. The winter evening temperatures can drop to 0 °C.

The annual rainfall is close to 300mm with an average of only 18 rainy days a year, resulting in droughts. The historic city lies mostly on the southern and western slopes of the Pachetiya hill overlooked by the daunting Mehrangarh Fort. Chowks punctuate narrow lanes that traverse the slopes, and the overall form of the city is an organic growth where "one can feel the absence of a complete story. It is a kind of open-ended play, in which characters and events can be added at will. The starting events are spatially influenced by topographical and geographical considerations..." (Jain and Jain 84). Courtyard houses abut streets with elements

Figure 1. Birdfeeder_Fatehpol well.

like jharookhas, oltas and verandahs. Being on the edge of a desert, ingenuous systems and techniques to capture and store rainwater were intrinsic to the city up until 1897, when the British introduced the public water system at which point "the phenomenon of constructing and developing water bodies came to a virtual halt" (Mohnot 44).

Evidences of rainwater harvesting can be traced back to Harappan times. Excavations at Dholavira have revealed a system of dams and 16 reservoirs of varying sizes and designs taking advantage of a 13m level difference in the overall topography. The town was placed strategically between two monsoon fed rivulets, Mandsar and Manhar. "[...] water structures and relevant and related activities accounts for 10 hectares of area, in other words 10% of the total area... Excavations show elements dedicated to water management like flight of steps, inlets, outlet channels, outside features like terraces, working platforms, tanks, drains and wells. All the tanks were interconnected with drains.

The surplus water flowed out through a masonry drain into another series of reservoirs. The citadel demonstrates an intricate network of storm water drains. These are connected to arterial drains with slopes, steps, cascades, manholes (air ducts / water relief ducts), paved flooring and capstones." (ASI). The weakening of the SW monsoon, and increasing aridity saw the appearance of simple bunds even in the pre-Harappan times as found by Pandey et al in their research on the 'correlation between heightened historical human efforts for construction of rainwater harvesting structures across cultural landscapes throughout the human history in response to aridity and drought conditions' (52).

The research on the 400+ water structures of Jodhpur, published as 'Spatial Ecology of Water' (Arya 2019) showed a tremendous range of type and tectonics like wells, stepwells, tanks, stepped tanks, reservoirs, channels, and aqueducts. These elements of managing water have a strong presence in the built fabric as well as the landscape, the architecture being evocative and deeply touching. They were called by a plethora of names like *sar, samand, vav, bavdi, sagar, talav, jhalara, kund, beri, bera, kuan or kuin.*

Figure 2. Ranisar.

3 RESILIENCE OF TYPE

The well is the smallest element and taps the aquifer. More than 200 wells existed in Jodhpur and brought water to *mohallas* (i.e., neighborhoods) and individuals ensuring that the citizens did not have to walk long distances to procure water. Though, since the early 19th century, households are supplied with piped water for 2 hours on a daily basis, the 2011 Census shows 2-3% of the population (about 3000 households, all within the historic city) still take water from the wells. Regulated water supply is often erratic, whereas the well water is constantly maintained, even at times of crisis, as is discussed later. Recent mapping showed wells like

Jetabera, Navchokiya, Satyanarayan Mandir ka bera, Ladji ka bera etc. continue to be extensively used daily. The street widens to accommodate the well and creates a public *chowk* (i.e., square). The auspicious peepul tree next to the well is worshipped every day. It provides much required shade from the harsh sun. The *otla* (i.e., plinth) of the well is a place for the men to gather, serviced by a nearby tea stall. A fruit and vegetable stall completes the daily requirement for most households in the vicinity. Small channels take spilled water to the street animals like dogs, cats, squirrels and birds. Many wells are located within religious precincts like temples and mosques. Their water, believed to be pure, is used for religious ceremonies. Apart from providing water, wells are the center of social activity. The collection of water being a gendered activity, the well was the meeting point for women. They could gossip, loiter and complete the drudgery of housework in the company of friends and family. The water elements have a presence that is tactile, haptic and contribute to a direct experience.

Wells have been excavated from Harappa and Mohenjo-Daro, with layers of time demonstrating the persistence of the type. Dug wells have been part of the story of human development across time and space. They differ in their making, scale and proportions from place to place. Their resilience speaks of the deep and sound knowledge of the historical process of adaptation and transmission. It is derived not as much from the 'supply of water' but from its deep embeddedness in the everyday lives and social structure of the urban fabric. Granovetter connected this embeddedness to institutional, explicit, 'rational' structures and social relations. His argument underlines the value of social relations in society's institutions also demonstrated by Regmi and Fawcett's field studies on the new water infrastructure in Nepal. They showed that "If the design and location of the new water systems is inappropriate, women are not likely to be interested in protecting them" (63). Modernization in management of water disregards this sociality of generations.

The resilience of a type can also be linked to its direct response to the physical geography of a region. Reservoirs, descendants of the pre-Harappan earth bunds, are particularly prolific in Jodhpur. The undulating terrain of the Aravallis made it relatively simple to build a wall across a narrow valley to stall the flow of water and collect it in a reservoir. The scale and size of the embankments depended on the location to maximize runoff. Larger reservoir had their catchment augmented by small bunds constructed on natural channels like the group of 6 bunds found upstream from Balsamand. The strategy controlled the surge of water in case of excessive rainfall, dissipating the energy of the gushing water. The larger embankment was protected from breaching. "The knowledge of the order in nature makes it possible to both predict and affect events permeating the daily lives of mortals" (Hahn 57). Percolation from the reservoirs recharged the aquifer which in turn replenished the wells, stepwells and tanks. A spatial ecosystem was built for sustenance linking social practices and the environment. Abutments, spillways, sluice gates and channels were added to the embankment depending on the capacity and function. Nagadari built in the 12th century, is the most complex, and provided water to Mandore, the previous capital. It helped irrigate the Mandore gardens. Today Kailana reservoir continues to provide water for the city, though it is now replenished by the Indira Gandhi Nahar (i.e. IGN) bringing water from the Bhakhra Nangal dam, 800kms away. A major project for modern India, for food security of a new nation, it, however, resulted in the alienation of water from its geocultural context and tactile experiences.

The type has been resilient through the test of time and change as it is also a resultant of closely observed climatic patterns. Irregular rainfall is one key characteristic of the climate of Jodhpur creating fluctuating water levels. From being empty to brimming full of water, the water structures undergo transformations across time. Water surplus during monsoon contributes to the ground water recharge, but also results in loss of water in the water bodies. Efforts were to maintain the equilibrium of the hydrological cycle, while extracting for anthropogenic uses. Its regularity and continuity provided assurance to the people. Steps along the edges of the water elements accommodated the flux. Landings, integrated with the steps, were places for rest and gathering. Niches, for oil lamps or local deities were a gesture of sanctity for water. It was a relationship that embodied the principles of the action to be taken, but manifested it according to highly localized conditions. Harvey and Fieldhouse define this way of knowing as "land(scapes) of mind" that "describes how we understand the character of an area of land, in a biophysical sense" (11). The

Figure 3. Ranisar beris.

number and pattern of the steps, the riser and treads, etc. were not predetermined. The transition between the natural and the humanmade is blurred, gradual and reflects the ambiguous edges resulting from varying rainfall. It was a relationship of negotiation, working with the uncertainties of nature.

The relationship of the built to the natural was not only of ambiguity, transition and adjacencies. There was also an expression of control and containment, particularly in the *jhalaras* (i.e., tanks). The architecture created an emphatic center with a strong boundary of crisscrossing steps. The built interface created tension between the dynamic sides and the deep center. The eye takes in the form, the movement of the steps leading to the water, but is also tempted to rest on the dramatic patterns of steps. The funnel to the water and the reflections in it brings a strong connection to the sky heightening the awareness of the water cycle. At one level, there is only the relation of the water, the sky, the built form and the individual. The water structures construct the relationship between a person and the landscape. It is this relationship that conveys a deep sense of being to the individual, of being deeply connected to the various elements of nature on the threshold of the humanmade and the natural.

4 ADAPTATIVE PROCESSES

Moving the capital from Mandore to Jodhpur brought a tactical shift in favour of smaller but more reservoirs that were closer to the settlement. The undulating topography implied smaller reservoirs rather than one large reservoir. The construction was simpler and speedier, enabling a faster development of the city while capturing a wide catchment. Ojhon ka talaab, Deo Kund, Padamsar, Lalsagar, Bhavani Kund, Takht Sagar, Swaroop Sagar, Akheraji ka talaab, Shekhavati talaab, Ravti ka talaab, Ranisar are some examples. There is, thus, a modification to the extant knowledge. New information is processed and inducted within the traditions of learning. Petruccioli analyses the development of the type with reference to its modification and suggests a similar process, where adaptation, or a new type or mutation occurs in the leading type in the context of an 'event' that causes the need for a reorientation. The new type continued to intimately respond to the geography. Its deeper inherent structure persisted with modification in the articulation, elements and scale. Since they had direct access to the source of water, to ensure the regularity and quality, the community was likely to be involved in regular upkeep. It shifted the onus of responsibility for maintenance from the state to the community.

Another adaptation to tackle the irregularity of the monsoon was to construct wells and stepwells in the beds of the reservoirs. The Luni Basin is traversed by lineaments like the Luni-Sukri lineament, Tonk-Raisinghnagar lineament etc. They contribute to the subterranean drainage giving water natural pathways within the earth. Water collected in the reservoirs during monsoon percolates into the smaller structures along the subterranean gradients with the reservoirs working like retention ponds. The rhyolite below the shale contains the water with its low permeability. When water in the reservoir dries up, the smaller structures are revealed with their store of clean water. Cleaning efforts in Ranisar in 2003 revealed 5 *beris* (i.e., wells) dug into its bed. A well is also dug into the abutments accessed on the top from within the fort. A stepwell is found in Golnadi. "It would not suffice to have the vision capable of seeing underground, patal water; the whole society, too had to have a special point of view, a point of view which combines the capacity of seeing, searching, drawings and obtaining underground water" (Mishra 93). Of the 125 small *beris* in Fateh Sagar, the late Dr. Naggar mentioned "In 1956, there was a severe drought in Jodhpur when all the reservoirs had dried up. People were able to collect drinking water from these *beris* and it became the primary source for survival".

5 TYPE: A GEO-CULTURAL RESPONSE

The traditional water structures are a geo-cultural response that have evolved into sophisticated, beautiful and diverse types. There is persistence of structural principles over 500 years in the construction of the water bodies due to their integration into the social, cultural and environmental aspects of the settlement. Identified by Petruccioli as apriori types, they are rooted within the society. "Since it is formed on the structure of the environment and on principles and structures of use as experienced, the apriori type is deeply tied to the place and is opposed to the conventionalism of standards, but to the atopic as well. It is always politically, culturally, and economically up to date" (26). The choice of type, its manner of making, its relations to the context all emerge from the norms and practices that constitute the "legacy of transmittable characteristics" (Petruccioli 26). Already, at the end of the 18th century, Quartmere de Quincy had introduced to type the idea of continuity and the means of maintaining connect with the past. "The antiquity of Indian tradition is, I think, less impressive than its extraordinary continuity…". (Das 85) Through variations the type is modified, but the relation to water and surrounding environment rarely changes. The change and transformations localized the type, giving it a contextual identity. The complete disappearance of the previous types occurs with the change in the power structure. This shift is embedded in the water structures through the abrupt break observed post colonization and subsequent modernization, which Petruccioli refers to as a crises (20). Post-Independence, the major addition to the Jodhpur water works is the IGN.

The awareness of the water, its path and quantity, was embedded in the making of the water elements. The artisans assessed the flow of water during the short monsoon through keen observations of the natural channels. This is considered difficult even with the availability of modern technology. As Laity says, "The majority of channels in drylands are ephemeral in nature… The relative infrequency and short duration of flow, the remoteness of many

Figure 4. Tapi bavdi.

channels, and the hazard and technical difficulty in measuring floods have made the study of channel runoff more complicated than in more humid regions"(86). The knowledge was used to locate the bunds, superimposing a network of spatial structures on the natural topography. By depending on the natural channels, the flow of water was not disrupted, and it continued to provide water to the people. Today, neglect of the natural channels has led to extensive urban flooding, disruption of the natural flow, and thus, loss of precious rainwater. The architecture was a reminder of the cyclical process and its transience encouraging a frugal use and careful distribution. "The problem of man and nature is not of one providing a decorative background for the human play, or even ameliorating the grim city: it is the necessity of sustaining nature as a source of life, milieu, teacher, sanctum, challenge and, most of all, of rediscovering nature's corollary of the unknown in the self, the source of meaning". (McHarg 19)

6 CHANGING PARADIGMS

In time, the sacredness and veneration that water had has waned. Most traditional systems are vulnerable to neglect, encroachment, incongruent later additions and lie unutilized. They become dumping yards and landfills. Others are defaced and vandalized without any regard for their architecture, their history or their value as social spaces. Some are preserved as monuments, arrested in time, detached from human engagement and evocative by their ruinous character or embellishments rather than as components of a system, managing a resource and providing a valuable life-giving element. New technology and contemporary need have displaced significant traditional resource management strategies and infrastructure. The divide was accentuated at the turn of the 19th century with industrialization and colonization that discouraged and disparaged traditional knowledge contributing to the deepening gulf. "Many of the European traders realized that if the dexterity of the hand was not curbed, it would be impossible for the cloth of the Manchester mills to survive and pervade the international market". (Vatsyayan 22) Large scale, centralized infrastructure brings water to homes through subterranean pipes via canals originating in dams located kilometers away from the destination. Shifting paradigms from community to individual in water policies makes the spatial occupancy of the spaces for water in the cities vulnerable to being usurped.

Figure 5. Woman at Navchokiya.

In more recent times, principles of impounding rainwater have undergone paradigm shifts. Transporting water over vast distances is being reviewed in the context of environmental impact and climate change. There is a rise in the interest on the 'local', traditional patterns. "The explosion of interest in traditional ecological knowledge in recent years reflects the need for ecological insights from indigenous practices of resource use, and the need to develop new ecological ethic based in part on indigenous wisdom" (Berkes 283). The turnaround reiterates the wisdom and resilience of traditional societies.

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Built Heritage in post-Disaster Scenarios – Balzani et al. (Eds)

Endangered heritage. The preservation of industrial artefacts in Abruzzo, through research and projects

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ABSTRACT: What remains of old water mills, paper mills, icehouses and country kilns is the ever more meagre residue of an industrial proto-history that was supplanted at the turn of the 20th century in Abruzzo by more modern, precise production equipment, which itself has become outdated and obsolete in the span of a few decades, by passing time and circumstance. Indeed, the route of the Adriatic railway, built soon after the Unification of Italy, shifted the axis of interest of a local economy that was once connected by rivers and drove roads, towards the coast, and started a new chapter of the region's history that would be decisive for the reorganisation of the territory and the redistribution of its resources.

This contribution aims to provide an account of the historical heritage that sustained Abruzzo's industry for a long period of time, focusing in particular on assets in a state of preservation that promises them a future, which is as possible as it is desirable for the assets themselves and the communities they belong to.

Keywords: slaughterhouses, disused railways, built cultural heritage

1 RESEARCH HORIZONS

Separating industry from proto-industry is a conventional operation that in regions such as Abruzzo can be confirmed not only by its history, but also by the circumstances relating to its geography. Located in the centre of the Italian peninsula and housing the highest, most rugged mountains in the Apennines, which themselves look over a vast area of hills and the narrow strip of coastline that runs from the border with the Marche in the north to Molise in the south, Abruzzo has become an economic intersection between different cultural realities, despite its difficult context marked by landslides and earthquakes.

The presence of a dense network of drove roads, which for centuries permitted the movement of animals, people and goods from L'Aquila as far as the Apulian plains, established a series of proto-industrial settlements that are considered as such only because of their remote origins, considering that they survived more or less intact until the second half of the 1900s, when the dismantling of the agro-pastoral economy and creation of new means of communication required by modernity led to a progressive, often unbalanced reorganisation of the territory.

The distinctive feature of many economic activities is their close ties with the geography of the place, thanks in part to the general conservation of the landscape, especially in the interior.

Directly linked to the herding economy, and therefore to the drove roads in the region, is L'Aquila's wool art, made famous by trade with Medicean Florence, along with the hatmaking and fabric businesses that were still fully active at the beginning of the 1900s. Similarly, the multitude of rivers and streams that structure the morphology of Abruzzo on their path from the mountains to the sea are the origin of many water mills and fulling mills, used for wool, paper and food industries. The manufacturing district in the Aventino Valley was one

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DOI: 10.1201/9781003253730-11

of the strengths of Abruzzo's premodern economy, an important symbol of the industrial history of the whole of southern Italy. In 1835, only along the River Sangro and its tributary, the Aventino, the existence of 130 active facilities is documented; they have not completely disappeared today, although the few that have survived are in ruins (Colanzi and Rossetti 2014). Many of these facilities would eventually become milling and pasta-making industries, such as along the Valle del Verde, at the foot of the Maiella massif, in Fara San Martino.

Thanks to the availability of clay in the region's coastal area and hills, there was a similarly dense network of brick kilns, some permanent, based on the vitruvian model, which can still be found near San Buono (Chieti), and others temporary, or "country style". The 310 quarries for the extraction of the raw material and 679 kilns present in the territory in 1890 were primarily the second of these two types, while the continuous-cycle kilns would be developed only later, for the opening of the Adriatic railway in 1863, mainly along the coastal strip (Felice 2008, 124). But of course the production facilities mentioned do not fully represent the variety and riches of the region's proto-industry: here too, "necessity (when it is produced by nature and not man) is the mother of industry" - according to the assertion of Abruzzese illuminist Giuseppe de Thomasis, quoted by Benedetto Croce in his *History of the Kingdom of Naples* (Felice 2010, 90) - and, at least in the first phase of product processing, this was primarily small-scale domestic production, carried out to supplement agricultural and pastoral work. The same is true of silk production, linked to the many mulberry tree cultivations documented since ancient times, especially in the province of Teramo, which only later reached the level of specialised factories dedicated to such purpose. From this business, a few "wormeries" remain, such as Santo Janni, in Pacentro, which is now unused and abandoned (Di Marco 2017). Among other examples is the Giammaria spinning mill in Pescara, built in 1900 from the transformation of an ancient Bourbon hunting lodge, and still standing, albeit in a precarious condition, until its demolition in the spring of 2015 (Varagnoli and Cecamore 2015, 75-84; Varagnoli and Cecamore 2019, 141-152).

Starting from the end of the 1800s, the gradual shift to a capitalist economy, along with the opening of railway lines both along the coast, as already mentioned, and inland, towards Rome and Naples, led to a concentration of large factories in strategic locations in the territory. This is how the "landscape" of Hoffmann kilns came about along the coast - from Martinsicuro to Vasto - as well as along the Pescara Valley in the fascist period. Adding to this picture are the sugar factories in Avezzano, Chieti Scalo and Giulianova, the mining facilities in Bussi and the electro-chemical plants in Piano d'Orta, at the foot of the Maiella massif (Fosco 2007;Marcucci 2015;Verazzo 2020, 3331-3369), managed by Italian and foreign companies with large profits (Benegiamo 2004, 155-186).

Despite its shorter history, more recent industry in Abruzzo has fared no better than older examples. The reason for this, more than technological progress, has been neglect, the destruction of the Second World War, speculation, and significant indifference to a heritage that still struggles to be recognised as an asset that provides values and qualities that benefit local communities.

The first text that bravely investigated the industrial heritage of the region was a contribution by Feliciani, La Spada and Pellegrini in 1985, which launched a highly fruitful line of research, even though this almost never had a real impact on plans for safeguarding and conservation (Feliciani,La Spada and Pellegrini 1985). Following that example were research studies carried out in the field of Architectural Restoration at the Architecture Department of the University of Pescara, which has been working for years to give recognition to the territory and denounce the state of dereliction and neglect of historical industrial remains, with the goal of raising awareness of the parts of the region's heritage that lie outside the sphere of interest of pure speculation.

Unlike the remains of the local proto-industry, which are generally far from the beaten track and therefore in some way at peace with nature, now an integral part of the evocative local landscapes, the factories built more recently have almost always been surrounded by the expansion of the built-up areas they were once on the edges of, and have therefore already been replaced by more profitable buildings, or are waiting to become so. A telling example can be seen in the Pescara kilns, which have been reduced to only one surviving example, the Forlani kiln - which, what is more, has been transformed into a residential complex and is now unrecognisable - of the twelve that used to exist(Serafini and Cecamore 2019, 49-64; Tontodonati 2019, 207-2016; Verazzo 2017, 199-210). Despite the opportunities offered by these large industrial facilities, administrations then struggle to put serious programmes in place for their requalification. This is why the Ciampoli kiln in San Vito Chietino is lying empty in an area with great possibilities for tourism (Cieri and Rubbio 2013); the same is true of the Roseto degli Abruzzi kiln (Amelii and Lucidi 2016), while the one in Martinsicuro (De Muzio and Cusato 2012) is at risk of demolition due to controversy over its designation of use, and the Staccioli kiln in Manoppello is overgrown with weeds (Geografo and Glieca 2015), as are many other factories in the region. Neglect and demolition are also feared for the facilities in Bussi sul Tirino, while even the large former sugar factories are still waiting to be reinserted into modern life, such as in the sensational case of Chieti Scalo (Silvestri 2013; Febbo 2019), where works have been started despite many uncertainties regarding the approach to the design. Then there is also the former brewery in Scontrone, a pioneering establishment in the region, with great architectural significance, and the former liquorice factory occupying the Convent of San Domenico ad Atri (Del Monaco 2010;Carletti 2019;De Santis 2011). The rushed, haphazard demolition of the former Milk Plant (Appignani, Di Biase and varagnoli 2011) and the former Giammaria spinning mill, both in Pescara, which have never been replaced with the new constructions for which it was claimed there was urgent need, is a telling sign of the inability to come up with investments and projects that are able to pick up the threads of an interrupted history in the interest of the community.

Working against the factories in question is often their size, and their condition as abandoned, empty shells, which makes it difficult to assign them any value beyond their land rent. However, it is precisely re-using them in a prudent, intelligent way that could invert the current process and trigger a more rational process of management and protection of the territory. This is the only way in which the question of sustainability and saving resources can stop being used as a term of convenience, and acquire real operational value in line with the requirements of the assets themselves and the communities they belong to.

2 NEW USES FOR OLD SLAUGHTERHOUSES. FROM THE MUNDA IN L'AQUILA TO THE MATTA IN PESCARA

The need to find a new function, almost always carried out using contemporary architectural language, seems to be the common denominator when we speak of the reconversion of industrial buildings, regardless of the aesthetic quality or testimonial value of the pre-existing building. The change is seen as a necessary transition, in the majority of cases played in favour of protecting only the outer shell, and adding elements and functions on the inside that are completely disconnected from the original use. This is an approach that descends from the same characteristics that are typical in industrial architecture, designed to create large vessels, characterised by serial static structures, supporting perimeter walls, and abundant, often overhead lighting, which lends itself well to housing new contents.

The central theme, therefore, is not the pre-existing artefact, but the modern addition inserted or superimposed, in the name of poetic reinterpretation, with the task of giving the building new meaning, reintroducing it into the life cycle of the established city (Dalla Negra 2017, 34-65). All this may indicate difficulty in considering even the recent past for what it is; that is, something that comes from a time with a different sensibility, with which we need to establish a dialectical relationship, avoiding interference or erasure. This means shifting our attention towards the pre- existing structure, and putting the disciplinary field of restoration right at the centre. In this way, when restoring a building with a new designation of use and appropriate requalification, the role of the added parts will be subordinate to the preservation of the original context.

The project for the former slaughterhouse of L'Aquila, in the context of a programme for restoration and conservation of the built environment and urban landscape, is a clear example of this approach. The architectural complex, donated under a thirty-year loan for use by the Municipality of L'Aquila, the owning entity, to the Ministry of Cultural Heritage and Tourism, has been designated to temporarily house a substantial collection of archeological remains and works of art from the Abruzzo National Museum (Arbace and Congeduti 2020), pending restoration works on the 16th century castle that has been the historical home of the collection since 1949. The project has been made possible by around 6 million euros of funding, allocated from the funds of the Mumex programme for the development of museums in the south of Italy, promoted by the ministry itself and the former Department for Development and Economic Cohesion.

The factory was built between 1881 and 1882, based on the design of engineer Alessandro Vastarini Cresi, in Borgo Rivera, next to the River Aterno and the 14th century city walls, on the site of the ancient Church of the Madonna del Rifugio and its attached Cistercian monastery, which collapsed after the catastrophic earthquake of the February 2, 1703. Changing requirements in terms of hygiene and health pushed the municipal administration to relocate the activities of butchery and the sale of meat to the southern area of the city, in line with what was taking place all over Europe starting from the first decades of the 1800s. Indeed, the distance from the city centre, where butchers' shops had been located since the Middle Ages - in the area between the market square and Piazza di San Francesco a Palazzo - the easy access for carts and other modes of transport, the good ventilation and abundant availability of water were all strong motivations for choosing the new location.

The city slaughterhouse, made up of three separate pavilions, designated respectively to the preparation of beef, pork and mutton, along with a few service areas, was opened on the 16th February 1883 and remained active for over a century, adapting over the years to improvements in the principles of hygiene and health, and technology and science in the fields of slaughter and meat preservation. At the beginning of the 1990s, the facility ceased operations, setting in motion a slow, inexorable process of dereliction that reached its peak in 2009. The earthquake of the 6th April compromised the already precarious conditions of the 19th century facility, but especially damaged the two buildings added in the 1940s, which were later demolished.

As mentioned, the restoration project for the former slaughterhouse is part of an ongoing broader programme for the requalification and development of both architectural structures in Borgo Rivera - the Church of San Vito, the fountain of the 99 spouts, and a few sections of the city walls - and features of the landscape and environment along the River Aterno.

The works, which started in 2012, included a thorough analysis of the level of damage suffered by the buildings of the former factory. The three pavilions, connected by two passageways cutting across them, presented damage along the perimeter walls, which were made from blocks of limestone. The gabled roof, supported by trusses, with wooden purlins and rafters, was also in a very deteriorated state. In line with the provisions of the Prime Minister's Directive of the February 9, 2011, regarding the "Evaluation and reduction of seismic risk on cultural heritage with reference to the technical standards for construction in the Decree of the Ministry of Infrastructure and Transport of the May 14, 2008", the project tried to reconcile the industrial building's requirements in terms of conservation with the need to improve and upgrade its seismic protection, through the use of the CAM system. The absence of high-quality plasterwork allowed stainless steel mesh to be inserted, positioned in three dimensions and attached together with joining elements, forming a box-shaped structure that was effective for both traction and compression.

Inside the three pavilions and the two passageways between them - all of which are dedicated to the theme of the exhibition, which leads visitors on the discovery of a series of archeological remains, wooden sculptures and paintings from between the 15th and 17th centuries that represent the variety and quality of the collection at the Abruzzo National Museum - new volumetric elements have been inserted. These are true architectural backdrops, extremely compact and clearly identifiable as added elements, which contain all the electrical equipment, such as the air-conditioning system, and most importantly, a system of supports equipped with advanced technology to guarantee stability in the constructions themselves in the event of possible earthquakes. The additions, which are of a strictly functional nature, are therefore clearly distinguishable and essentially reversible, allowing the character of the structure of the pavilions to be almost fully preserved, in particular with regard to all the pre-existing iron technical elements. The conservation work on these elements was carried out using fine sandblasting, an anti-corrosion treatment, a fireproof coating, and then a final layer of paint in the original colour. Rather than destroying the signs of the recent past that are present in the architectural complex, its current use encourages the contemplative enjoyment of both "archeologies" in a skilful play of contrast between the works representing the history and culture of the entire region, and the system of guideways for the transport of animals for slaughter. This is the context in which we can admire rare examples of funerary objects, such as the *Lid of a cinerary urn in the form of a snake* and the *Relief of a funeral procession*, both made from limestone and coming from Amiternum (end of the 1st century BC - early 1st century AD), but also the *Madonna of Lettopalena*, from the 12th- 13th century, and the *Madonna of Ambro*, from the first half of the 13th century, and masterpieces such as the *Beffi Triptych* (1410-1415) and *Christ and the Adulteress* by Mattia Preti. There are also many works displayed that, after being recovered from the rubble of the 2009 earthquake, have been brought back to life thanks to skilful restorations.

The flooring, which for technical reasons was not possible to preserve, has instead been faithfully recreated based on the original design and materials, changing only the slopes that were present before, for functional reasons due partly to the general quality of the space, and particularly to the technical and structural elements used.

The project to restore and redevelop the slaughterhouse also involved the construction of a new addition, formed by two overlapping buildings, designed to be able to accommodate various functions dedicated to the community[1]. The first, with an L-shaped plan, lines up with its longer side against the southern facade of the pre-existing building, and its shorter side against the northern facade; the second, cutting across the first, has an irregular, elongated pentagonal layout. The entire architectural structure, designed with the aim of reducing energy use, is built using a supporting steel structure with an alternating system of positive and negative spaces on the external facades, created respectively with weathering steel panels and large thermo- acoustic windows. It should however be noted that the self-referential character of the modern design seems to overshadow the pre-existing building, with which it is in stark contrast. The issue revolves around the effective recognition of the quality of the old premises, whose historical and documentary value is protected only through the preservation of the shell, which, having no pre-eminent aesthetic value, becomes a mere background for the contemporary addition. Consequently, the recovery and restoration of the slaughterhouse, despite being carried out with careful attention in terms of the construction, loses its significance as a testimonial to the activities of butchery and slaughter in the capital of Abruzzo when it comes to the modern addition.

Another example in the field of strategic plans for the reconversion and requalification of abandoned industrial buildings is the former Pescara slaughterhouse, which, after decades of neglect and deterioration following the relocation of the business starting in the late 1990s, seemed to become the object of care and attention from local citizens, and particularly the local administration. Indeed, the direct participation of cultural associations and citizen committees prompted wide debate on the future of not only the architectural complex, but the entire area, which had become a place of social exclusion and a makeshift homeless shelter. Appropriately, the restoration project was therefore orientated towards themes of socio-cultural development. Out of this came the idea for a project to redesign the former plant as a "factory of culture", to house socio-cultural, educational and theatrical workshops. This was in part related to the availability of large, permeable spaces thanks to the fact that the factory had been completely emptied, with all the old butchering machinery looted over the years, except for the guideway systems that were still present.

1. The project was carried out by the "NUSPAQ2010" group, an acronym for *New Space L'Aquila*, which was the winner of the contest for proposals for the temporary museum, announced by the professional associations for architects and engineers in the province of L'Aquila with patronage and sponsorship from the Municipal Department for Reconstruction in 2010. The group is a temporary coalition of professionals, consisting of architects Federica Di Vincenzo (coordinator), Giancarlo Di Vincenzo and Vincenzo Tattolo, and engineer Lisa Di Bartolomeo, with consultation from Professor Livio Sacchi (Calabrese, 2010).

The plan for the requalification and reconversion of the area, which still today has not yet achieved the results hoped for, primarily due to the unfavourable economic conditions, combined with problems related to the pandemic, was launched between 2009 and 2010 with the beginning of the works on the first of the three buildings that made up the old slaughterhouse. The large capacity of the pavilion was reinterpreted as a single space, simultaneously able to house actors and spectators and removing any division between the stage and the audience. This created a flexible structure that allows for different layouts - frontal, central and vertical - in which the flooring becomes the marker of the division between the areas: the stage in larch wood, and the audience in dark red industrial cement. All the service rooms are behind the stage wall on the lower level, housing the dressing rooms for the artists, while the upper floor contains both rehearsal rooms and temporary exhibition spaces.

The restoration of the second building was also aimed at the creation of a multifunctional space for both theatre and events and conferences, and it was supposed to involve the construction of tiered seating with space for 207 people. The project also envisioned the removal of the building sandwiched between the two pre-existing pavilions, in order to insert a new connective addition in steel and glass. This building would have housed a bar, a restaurant, a kitchen and some service rooms on the ground floor, while the upper floor would have contained accommodation for artists and conference guests.

Of the entire project for the requalification and regeneration of the area of the former slaughterhouse, only Spazio Matta, located in the first pavilion since 2010, is currently active with theatre workshops, artistic creations, exhibitions and debates, while the other two buildings are still in a state of neglect and dilapidation[2].

Despite the strategies for conservation of the built environment and regeneration of the areas on the outskirts of the established city, as seen in the cases analysed, project outcomes show choices informed by limited knowledge and understanding of the disused industrial buildings, using only their shells (Varagnoli 2007, 841-860; Verazzo 2014, 38-43). Even the pursuit of distinguishable or reversible options, which seem to find new opportunities for possible experimentation in the re-use of industrial assets, is not able to give substance to the projects created, which instead tend towards transformations with little consideration for the pre-existing structure. The cases analysed seem to lack a deeper reading of the architecture, which would be found in its specific features and inner workings. These are living bodies that are not just empty shells to fill, but interlocutors with which to open a dialogue. However, the modern additions diverge radically from the original elements, without even reinterpreting the value of the assets using a compatible language. We are not proposing here that we should adopt an allusive or citationist attitude, but rather that contemporary expressive forms should be able to fulfill the difficult task assigned to them; that is, to serve the pre-existing buildings, which this way will be given new meaning and be reinserted into modernity.

3 A NEW ARCHEOLOGY. DISUSED RAILWAYS

Due to the size of the phenomenon, today in Abruzzo the topic of disused railways occupies a significant position in the debate around the recovery of its heritage. As well as participating in a copious history of glorious events immediately after the Unification of Italy, linked to the area's release from the isolation it suffered for centuries, first with the Adriatic line, and later with the Apennine routes, the region's railways also endured a painful series of closures. These coincided with the betrayals of a vision of modernisation that certainly proved itself, especially after the Second World War, but also had many victims: not only stretches of track, but also stations, locomotive sheds, bridges and storage areas, which today are mostly destroyed or abandoned (Colapietra 1989, 9-10; Aristone and Bengiamo 1992, 25-62; Sabatini 1996; Vittorini 1996,30-33; Serafini 2020, 339-350).

2. There is little news of the continuation of the reconversion works for the former slaughterhouse, with the most recent information dating from 2019. (Cantadore, 2019).

The first turning point came about after the Second World War, when the destruction inflicted on the entire central Italian railway system due to its proximity and connection to the Gustav line led to a period of reconstruction that was progressively updated according to new demands put forward by industrialisation and the increasingly frequent movement of people and goods.

The first closures were suffered by the inland Apennine routes, which were shut down because they were little-used and decidedly unpopular. This was due in part to the winding track and length of the routes, and in part to the two motorways opened between Rome and the Adriatic (the A24 Rome-L'Aquila-Teramo and the A24 Avezzano-Sulmona-Pescara) to keep up with the booming economy and the mass motorisation of the country starting in the 1960s (De Panfilis 1996).

On the Adriatic line, the operations with the greatest impact, not only in quantitative terms, involved Pescara, and from there, the entire section leading to the new Vasto-San Salvo station on the border with Molise. The project launched at the end of the 1980s and completed in 2005 - moving the railway further uphill, upgrading the line and substituting and/or merging some stations - not only led to yet another reorganisation of the territory, but this time also produced a substantial amount of scrap and a large number of residual areas. Pending their transformation into cycle tracks and footpaths, in line with grandiose greenway projects that have been the subject of debate across Italy for years, the old tracks have been mostly covered by thick concrete casts, almost always functioning as parking areas used primarily in the summer months; the old brick bridges - true masterpieces of engineering and architecture, as well as being extraordinary points of contrast in the landscape due to their size and level of harmony with the region's resources - have been in need of maintenance for a long time, and have been seriously compromised not only by the rising damp on their robust pylons, but also by a large amount of vegetation that almost hides them from view; and the old stations, once the pride and glory of the new towns that grew around them, with their architecture, are closed and abandoned, often in very run-down environments, both physically and socially (Rovelli, Senes and Fumagalli 2004;Cortesi and Rovaldi 2011;Sulpizio 2019).

In Pescara, the construction of a new station in step with the times, which is able to accommodate not only the growth of the city, but also its ambitions for a metro, has first and foremost meant the closure of the original 19th century building and its redevelopment for use by the ICRAnet (International Center for Relativistic Astrophysics Network). In front of the reused building, which guarantees relatively continuous maintenance of the spaces, structure and facades, is the residual space once occupied by the platforms, which today is used as a car park, clashing with the context and offering itself in all its glory as a "non-place", to use the words of Marc Augé.

The very architectural characteristics of the facade, in the sober neo-Renaissance style proposed after the Unification for buildings with utilitarian purposes such as stations, increase the sense of disorientation when compared to the long glass frontage of the new building, with neither in a condition to be the gates to the city, but instead just sterile counterpoints of each other. Again in Pescara, the old line connecting with the port was closed down, and of the old Porta Nuova station, only the facade remains, cut from the old building in 1883 and inserted as part of the project to redevelop the area of the old De Cecco Mill.

On the line to the south of Pescara, closures affected the stretch between Ortona and Vasto-San Salvo. Here, the retreat inland of a railway line that ran along the sea and the Trabocchi Coast led to the opening of almost 30 km of tunnels, the merging of some stations, which were rebuilt on new sites, and the consequent dereliction of the remaining structures, which are now made invisible by the stretch of railway in tunnels. The case of the Torino di Sangro and Vasto stations along this line is of course only a small sample of the dereliction and closures affecting historical Italian railways. However, the circumstances affecting these stations seem to reflect a much more general discussion regarding all historical heritage, especially that which, as it is "more recent", still has very little chance of being recognised and appreciated, and therefore protected with interventions at the level of the values at play. Indeed, it is true that when compared to the tracks, which, as mentioned, have been the focus of a cycle/footpath project that, while progressing very slowly, is underway, it is the buildings that are suffering the most. These still have solid supporting structures, but their facades and decorative elements are seriously deteriorating.

In Torino di Sangro, a large amount of the plasterwork covering the facade of the two-story block building is crumbling and stained with salt from the sea, as are the liberty style decorations that embellish the series of openings running regularly and symmetrically around all four sides.

In Vasto, the characteristic three-story building, with the central section rising higher than the parts to the sides, shows even more obvious deterioration due to the badly-aged reinforced concrete projecting roof on the side of the old platforms, and its contrast with the brick veneer.

However, compared to the dignified architecture of these old stations, the new merged stations are anonymous buildings with no ambition other than to carry out their assigned function. The new Torino di Sangro-Fossacesia station is a reinforced concrete building with the mere function of a place to pass through, and the Vasto-San Salvo station is the same, with the aggravating circumstance of having to coexist with the expansion of the two cities' respective beach towns, which is now so pervasive and all-encompassing that it dwarfs the cities, taking away the prominence that they deserve, and not only in terms of size.

Just like the more general theme of the neglect of historical heritage, the topic of infrastructure is also complex, since in a period of economic crisis and lack of resources, it brings into play the opportunity to restore establishments conventionally assimilable into the industrial archeology sector, which have fallen out of favour because they are impossible or inconvenient from the point of view of technology and ease of use, but have remained at the centre of national and international debate for some time.

In Italy, the National Day of Forgotten Railways, which counted its 13th edition in March 2020, demonstrates the level of interest in the topic, partly due to the support of the literature, which in the meantime has registered around 6000 km of disused railway lines (Maggiorotti 2018).

Beyond the folklore of such events, however legitimate this may be, we need concrete actions supported by a multi-scale approach to the territory, to be reconsidered after the changes that have taken place, and leaving aside narrow responses that are limited to a case by case basis.

AUTHORS CONTRIBUTION

This paper is the result of a shared work between the authors. Research horizons: C. Varagnoli; New uses for old slaughterhouses. From the munda in L'Aquila to the Matta in Pescara: C. Verazzo; A new archeology. Disused railways: L. Serafini. All authors have read and agreed to the published version of the manuscript.

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Built Heritage in post-Disaster Scenarios – Balzani et al. (Eds)

Historic masonry building: From damage to first aid interventions

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ABSTRACT: Over centuries, the Italian territory has undergone several seismic events which caused deep injuries to existing buildings environment, especially to cultural heritage sites. The recurring of the same mechanisms of collapse in masonry structures allows the study of their seismic behaviour in order to define reinforcement interventions for their conservation. Thanks to recent researches, several tools are nowadays available to manage the preservation of historical buildings in face of seismic emergency but further studies are still necessary to optimize securing operations. In particular, the choice of first aid interventions seems to be disconnected from the damage survey and moreover the design and realization of temporary interventions rarely consider the following phases of definitive restoration with a consequent waste of resources. In light of these considerations, a research has been carried out within the PhD Programme at Parma University, in collaboration with Emilia Romagna regional offices for the post-seismic reconstruction. The study analysed the management of the emergency caused by the 2012 earthquake in the Emilia Romagna region in order to define a methodology to optimize the definition of first aid techniques and the cost assessment. The research focuses on religious buildings, one of the most vulnerable architectural typology to seismic actions. Several case studies have been investigated in order to identify the elements of vulnerability, the main securing actions, the advantages and disadvantages of each one and the aspects to care while preparing the emergency response. Moreover, statistical analyses have been carried out on the cost assessment, leading to a methodological proposal that allows to identify the most suitable first aid intervention for the specific case, optimize their operative application and evaluate restoration costs in an homogeneous way.

Keywords: cultural heritage, emergency management, first aid interventions, masonry buildings, seismic damage

1 INTRODUCTION

Italy is certainly the country that more than any other is characterized by the combination of a high number of historic buildings - mostly in load-bearing masonry - and earthquakes. In recent decades it has also become the country, among the most developed ones, in which the economic amount of the restoration and consolidation interventions on existing buildings, including post-earthquake reconstruction interventions, has been by far the majority compared to that of the interventions for new buildings. The technical and economic problems related to interventions on existing buildings have therefore become prevalent in the activity of building engineers and architects and the experiences and researches, both in the industrial and university fields, on the existing buildings have enormously developed: today the Italian experts in this field are among the most experienced and qualified in the world and the Italian regulations are extremely advanced. Among the problems of existing buildings, a particularly large sector is occupied by the stability of masonry constructions and particularly the ones that compose our precious cultural heritage. After about two centuries - starting from the introduction of steel in construction - in which the interest of the technicians has focused on the innovative structures of steel and reinforced concrete and on the calculations for predicting their behavior, the problems related to the stability of

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DOI: 10.1201/9781003253730-12

masonry buildings have become of widespread interest for their social relevance starting from the dramatic seismic events of the 60s-70s of the last century, with thousands of casualties and hundreds of historic buildings destroyed.

It became soon clear to the most attentive eyes (Di Pasquale et al., 1986; Giuffré, 1988) that the traditional masonry buildings showed typical, recurring seismic behaviours, related to the building typologies, that had to be studied in order to prevent future damages. Indeed, the masonry withstands little or no tensile stresses, therefore its stability is linked to issues of balance rather than resistance, and balance means shapes and proportions. A steel or rc element subjected to horizontal forces can stand the horizontal actions as long as the material strength is not reached at its base, so the stability of modern structures depend on the quality of the material and on their strength. On the contrary, for millenniums buildings were made in masonry, that subjected to horizontal forces, due to the lack of tensile strength, will lose their stability when losing their equilibrium, which is connected to the shape and dimensions of the elements: for this reason, for centuries the construction "project" was guided by proportional rules (Como et al., 2018), with reference to the quality of the materials but not specifically to their strength.

It is important to bear this in mind, because it has direct consequences that can be observed on historical masonry buildings. In Italy there were a lot of occasions to experience how these buildings react to earthquakes and it was possible to see that a lot of damages were recurring, repeated many times in similar buildings typologies. For example, the overturning of the top of the façade of churches was experienced in many earthquakes, in different times and areas (Figure 1). When you see basically the same damage repeating again and again in the same building typology, you start to realize that there is a strict relation between building typologies and features on one side and damage and collapse mechanisms on the other side.

Figure 1. The overturning of the façade is one of the most recurring damage mechanisms in masonry churches: here just some examples taken from different Italian earthquakes in the last century: from left to right, 1915 San Giovanni Church in Avezzano (AQ), 2012 Santa Maria Maggiore Church in Mirandola (MO), 2016 Church in Amatrice (RI).

2 RECURRING SEISMIC DAMAGES

2.1 *Relations between building typology and collapse mechanisms*

Due to our unfortunate experience with earthquakes and damages on cultural heritage, this awareness took progressively place, starting in particular with Friuli earthquake (1976), whose effects on churches were analysed by Doglioni et al. (1994): starting from the observation of damages, their modes and frequencies, for the first time the concept of macro-elements was introduced, as parts of the building characterized by similar damages when affected by seismic actions. The identification of these macroelements and the consequent damage mechanisms became official in the Italian Technical Code for the protection of enlisted buildings from seismic risk (DPCM 09/02/2011) which is a very important and edge cutting normative, that can be considered a reference also for non-enlisted traditional masonry buildings and that defines an approach, deriving from decades long Italian experience and studies, introducing a specific chart of typical collapse mechanisms for churches and bell towers (Figure 2). More recently, a similar chart has been developed for seismic damage mechanisms on palaces and the two of them are at the base of the official activity of damage survey on historical buildings after earthquakes. Given the strict relation between building typology and damage mechanisms, it is clear that churches and palaces are probably the most widespread historical buildings, but they are not the only ones. For this reason, the Emilia Romagna region has decided to fund some researches to adopt a similar approach also to castles, theatres and cemeteries (described in other chapters of the present book), in order to define their own damage charts.

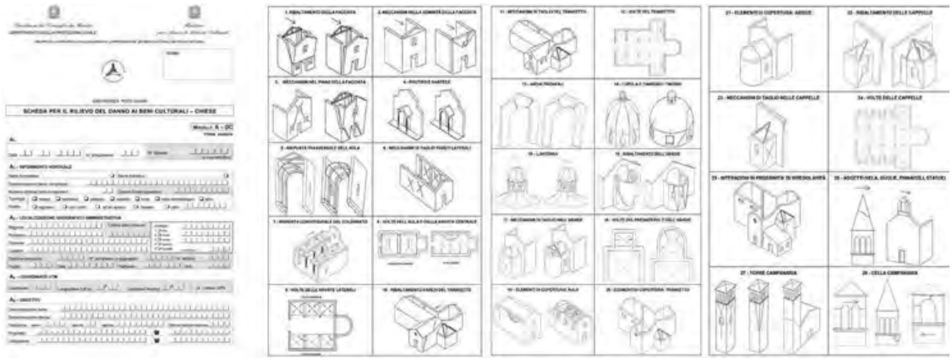

Figure 2. The inventory sheet adopted in Italy for the survey of the seismic damage on churches (A-DC model).

These charts are important for the damage survey but also for changing the way we look at things in “time of peace”: we must start thinking in a preventive way to which are the damages that are more prone to happen for that specific typology. The study of these charts can integrate the experience of direct observation of seismic damages, giving important indication to be aware of possible future risks and thus working on prevention and not only on the reconstruction.

2.2 *From the damage survey to the definition of the strengthening interventions*

The link between analysis and intervention is something that in restoration is a must, but not always this is respected when we deal with structural restoration. Indeed, the connection between damage analysis and intervention strategies from the structural point of view is sometimes disregarded, also because of the faith that many structural engineers pose on numerical models: in some cases the intervention strategies are more guided by numbers rather than from the damage analysis as it should be. Looking at a damage and understanding which is the cause, it should be straightforward to find the best solution to hinder this problem also for the future. It is nonetheless difficult to maintain this connection and define first aid interventions in such a way to keep it strictly related to the damage analysis during the emergency management, because there are other priorities: ensuring public safety, resuming socio-economic activities, preventing the progress of damage, ensuring the conservation of cultural values of the constructions. Sometimes the hurry in defining these interventions has led to uneven, ineffective and/or expensive solutions: it is therefore necessary to optimize strategies for emergency management and first aid interventions, defining tools that guide and speed up the work of professionals in order to have an operative impact.

In moderately seismic areas, like Emilia Romagna, usually a long time passes from one damaging earthquake to the next one: local professionals are not always ready and experienced enough to face these events and sometimes there is an impression that at each earthquake we start over, also because the situations are different in terms of damage level, building typologies, population density, infrastructures, technology evolution. Anyway, even in the less “experienced” areas, we never start from zero: the Italian know-how is long in terms of seismic hazard laws and emergency management. The tools developed for on-site damage and risk assessment and for securing damaged built cultural heritage are already existing and, as aforesaid, they gather the results of decades of researches on the seismic behavior of historical buildings (in particular churches and palaces). The inventory sheets adopted by the Civil Guard (filled in each time by a team composed by one expert of cultural heritage, one of structures, one fireworker for safety conditions) include the description and dimensions of the buildings, the type of damage with reference to the mechanisms chart, and at the end an indication about possible first aid interventions and an estimate of the costs for these interventions. The latter part is quite limited and generic: it is difficult to take these decisions and quantify them quickly on site, granting some level of homogeneity among the different cases and different teams. This last part is also somewhat disconnected form the damage assessment part, as there are no indications about how to choose the intervention depending on the type and level of damage surveyed. The professionals can refer to manuals and guidelines (AA.VV., 2010; Grimaz, 2010; Dolce et al., 2004) that look for a possible standardization of the interventions and introduce the possibility of finding definitive implications for these interventions. The damage assessment inventory sheet is important and dedicates a lot of time and space to the damage survey but it does not guide neither the choice of first aid techniques, nor the definition of recovery costs. To face this issue, the response system of the Emilia Romagna region (guided by a unified management under the president of the Region) introduced in the first emergency phase a validation group, with the aim to define comparable cost values, overcoming the problems of subjective views and assessment of cost values, which could cause problems in the reconstruction phase. A group of people with a broader view about damages and costs could guarantee a more homogeneous evaluation. Another innovative solution adopted by the regional office for reconstruction some months after the shocks was the joint commission for cultural heritage, to have the opinion of all the public bodies involved in the choices related to interventions on enlisted buildings, from a technical, cultural and economic point of view.

Considering these interesting innovations in facing the seismic emergency for cultural heritage, we tried to analyse what happened in the Emilia Romagna earthquakes, in order to focus on the weak parts and make proposals in view of possible future earthquakes, to improve the work of professionals in the emergency phase. Starting from a single building typology, connected to a specific type of damage, the constructive features and the consequent damages were analysed and put in relation, then the first aid and definitive interventions were studied both in terms of technical and economic features and the relation between the two was inspected. The building typology chosen was the one of churches, as they were widespread and very damaged, but also because the inventory sheet specific for this building typology was already existing and applied, so it constituted a base for the study, also in connection with the first aid intervention choices.

3 EMERGENCY RESPONSE AFTER THE 2012 EARTHQUAKE

The current first aid techniques have evolved over time (Bellizzi, 2001; Di Pasquale, Dolce, 1999) offering, nowadays, several possibilities of interventions. In the past, timber rakers were the mainly used first aid interventions (Dolce et al., 2004). Then, the progressive improvement of technologies has introduced hoops and structural scaffoldings (Grimaz, 2010). In the present days, the spread of new materials, new systems and new equipment offers many alternatives, among which it could be difficult to choose and design the optimal solution for the specific case. Actually, this choice should come from the analysis of damages occurred after the earthquake. However, as previously said, the current tools for damage assessment (in the specific, the A-DC model for churches) is very generic in this part, resulting in a disconnection between the damage and emergency action. Therefore, some interventions carried out after the 2012 earthquake on Emilian churches have been analysed in order to deepen the advantages and disadvantages of each techniques. In this way, methodological and operative recommendations for optimizing the intervention have been identified. Moreover, the architectural typology has been considered as composed by macro-elements (Doglioni et al., 1994). For each one, the most used techniques were identified and analysed in relation to the type and severity of damage. From this preliminary study some consideration arise.

3.1 *Securing actions for masonry walls*

The analysis shows that securing interventions on masonry walls often concern only the main façade or the walls in front of the main roads, that means the elements that generate the greater risk for public safety. To prevent the most dangerous mechanisms, the overturning out-of-plane,

Figure 3. San Michele Arcangelo Church in Bomporto (MO): on the left the wooden rakers installed in 2012, on the right the worsened conditions of the same interventions in 2019.

shoring systems with structural scaffoldings and timber rakers or hooping systems with steel wire ropes were the most used techniques. Against shear mechanisms, the main intervention consisted in the realization of timber frames for shoring the openings, sometimes followed by the cracks refill aimed at restoring the masonry structural continuity. Anyway, no particular correlation between the securing technique and the level of damage has been detected in the 19 analysed cases. Figure 3 shows an examples of timber rakers, mostly used by the Civil Defense and Fire Brigade Teams. This technique allows to quickly secure buildings with low costs but, on the other hand, it requires large spaces in front of the building and easily deteriorate under whether conditions, losing their effectiveness against new shocks. Moreover the material can't be reused.

Structural scaffoldings is another widespread solution for shoring damaged structures. The seventeenth-century Jesus Church, in Mirandola (MO), is an example of this kind of interventions (Figure 4, left). Immediately after the seismic event, a triple scaffolding has been installed around both the façade and the south transept. Dynamic tests carried out by the University of Venice showed the effectiveness of this system. Moreover, after 5 years, in-situ investigations was needed to design the final strengthening project: in this occasion, the scaffolding has become an useful support to investigate the building from a short distance. Anyway this structure could be very expensive. Hooping systems with steel strands, polyester bands or tie-rods are another technique frequently used in the Emilian emergency (Figure 4, right). This system is less cumbersome and less expensive with respect to the aforementioned techniques. Moreover, this devices could become definitive thanks to small adjustments (i.e. changing anchorages or re-tensioning rods

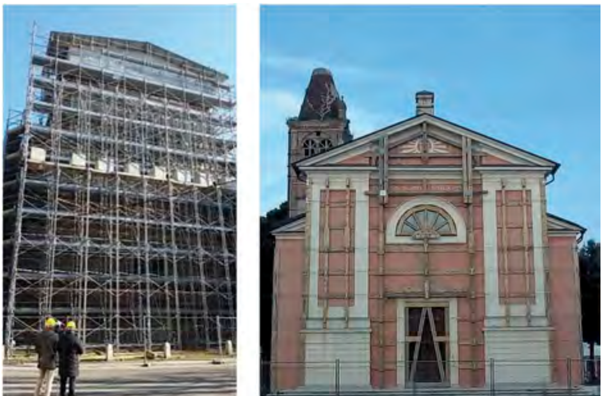

Figure 4. On the left, Jesus Church in Mirandola (MO): the structural scaffolding prevented the overturning of the façade damaged by the Emilian earthquake; on the right, Santa Caterina Church in Rovereto sulla Secchia (MO): the hooping system with steel strands prevented the overturning of perimetral walls.

according to current stress conditions). However, precarious safety conditions which prevent to operate close to or inside the structure, or irregularities in the architectural shape may hinder the application of this system.

3.2 *Securing actions for arched structures*

The study shows that, in most cases, no emergency action is provided for arches, vaults and domes, regardless of the severity of damage. The lack of intervention is due both to the precarious safety conditions of inner spaces and to the lower risk for public safety, as a possible collapse of vaulted structures would not usually involve the surrounding areas. However, the collapse of these elements causes the loss of its architectural and cultural value and creates rubbles which slow down the recovery operation, hindering the access to the building and requiring to be selected before the removal.

Figure 5a shows a structural scaffolding shoring a damaged vault. Because of the elements density, it has been a quite expensive solution but, on the other hand, it has been used to investigate the building for designing the recovery plan and to realise the final strengthening and restoration works. Moreover, it required low maintenance because, placed in the inner spaces,

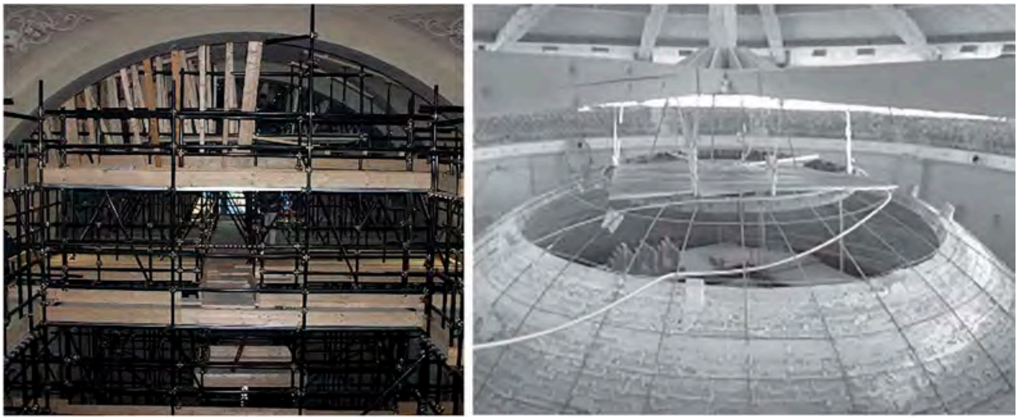

Figure 5. On the left, Santa Maria Assunta Church in Reggiolo (RE): the structural scaffolding, which first aim was the shoring of damaged vaults, allowed to deepen the knowledge of the damaged building and to carry out the final restoration works. On the right, Collegiata di Santa Maria Maggiore in Pieve di Cento (BO): the emergency hooping system of the damaged drum became a definitive element of strengthening whereas the shoring system with the scaffolding supported the reconstruction of the partially collapsed dome.

it was protected against degradation caused by weather conditions. This situation allowed to completely re-use the standard elements of the scaffolding in other building sites. This solutions is the most widespread for damaged arches, vaults and domes. However, in case of total or partial collapse the intervention is more complex. For instance, in the case-study of Collegiata di Santa Maria Maggiore in Pieve di Cento (BO) the collapsed domes required a temporary cover (Figure5b) to protect the inner spaces. Moreover, the damaged drum needed to be secured with a hooping system made of steel strands and a metal ring-beam on the top.

Note that this device became definitive in the final recovery whereas the inner shoring system of the dome has been used as a support during the reconstruction of the collapsed part. In the specific, it allowed to shape the dome masonry without the realisation of a traditional centina, a more complex and expensive shaped support.

3.3 *Securing actions for roofing systems*

The research highlighted that in most cases, especially for low levels of damage, the intervention usually consisted in an overhaul of the roof covering. The roofing structures that partially or totally collapsed instead required a temporary cover. In this regard, note that those realized in metal or timber structures can be integrated with the shoring systems whereas, for smaller collapses it is possible to use PVC membrane that is less expensive but short-lasting over time. However, in some cases, these intervention are postponed to the final recovery phase and no measures were taken to protect the inner spaces, causing their progressive deterioration because of the weathering very high cleaning costs, close to the restoration ones.

3.4 *Securing actions for bell towers*

After the 2012 earthquake, the danger of collapse of these constructions, besides representing a technical and structural problem, had also strong social implications, generating fear and uncertainty in the population. Indeed, the overturning of these high towers would have involved a large number of surrounding buildings, imposing the demarcation of wide off-limits areas. Nevertheless, the lack of a proper knowledge about how to face this kind of risk soon emerged. To deal with the many requests for demolition, the Regional Offices for cultural heritage decided to appoint a commission of experts with the aim of defining guidelines for fast interventions. These first-aid devices were rapidly designed, financed and realized (Di Francesco, 2012).

In such a situation, preliminary interventions are usually needed in order to improve safety conditions before getting close to the structure. Then, to prevent the most dangerous collapse mechanisms, the emergency intervention consisted in hooping with steel strands whereas, shoring with structural scaffoldings was mostly used to restore the vertical masonry continuity frequently injured by the horizontal cracks due to hammering phenomena. However, the emergency solution needs to be carefully planned according to the issues of the specific case. For instance, the first aid interventions adopted for the bell- tower of Sant'Anna Church, in Reno Centese (FE), was strongly influenced by the heaviness of damages that prevented from getting close to the structure (Figure 6, left). Because of the precarious safety conditions, a preliminary securing was carried out from distance using Spritz-Beton technology. This first action allowed to get near the masonry applying fiber-reinforced strips for restoring structural stability. However, the removal of this emergency reinforcement, foreseen by the final recovery, was quite invasive for the conservation of the historical surfaces: even if this technique is not expensive, its removal required about the same cost as its application. The first aid action adopted for the trunk strongly influences the technique for securing bell chambers. Hooping systems with polyester bands or steel strands, associated with timber shores for openings and crack refill to recover the structural continuity are usually preferred. For the most dangerous cases, in which the bell chambers is completely detached from the trunk, a scaffolding could be installed to connect the upper part with the lower one or, if the severity of damage is too high, it could be necessary to remove the entire macro-element, storing it for the future restoration (Figure 6, right).

Figure 6. On the left, Sant'Anna in Reno Centese (FE): the isolated bell tower was heavily damaged by horizontal cracks and requires emergency action for restore adequate safety conditions to get close to the building. On the right, Santi Senesio e Teopompo Church in Medolla (MO): in order to prevent the overturing of the bell chamber, the macro-element was removed and conserved in a storage area.

4 ECONOMIC ASSESSMENT OF FIRST AID AND RECOVERY INTERVENTIONS

From the analysis of first-aid techniques, some consideration about the relationship between safety and conservation issue arise. Securing actions are usually considered as something extremely contingent and temporary, but on the other hand, the same provisional nature makes these devices reversible, a particularly suitable feature for intervention on cultural heritage, in compliance with the principles of restoration, as also suggested by the guidelines (DPCM 09/02/2011) and other technical manuals.

However, this potential is often forgotten and the interventions that try to consider the first aid as a possible support for design and realization of final recovery or as a definitive element of strengthening are rare (Ferrari, 2020). Keeping this in mind when planning a first aid intervention could allow an optimization of the interventions and a reduction of costs, that is another big deal during a seismic emergency. In fact, the high frequency with which destructive seismic events affect the Italian territory generates significant extraordinary costs (Mariani, 2016).

The financing programme of first aid and recovery interventions is based on the damage assessment carried out in the emergency phase. Consequently, a correct and objective economic evaluation of the effects caused by the seismic event is essential for requiring an adequate funding for reconstruction. However, this assessment is as important as complex. The A-DC Model requires a fast evaluation of costs, but the lack of a guided path produces non-homogeneous and not immediate values. To improve this evaluation, the research analysed the costs of the 2012 earthquake with the aim of defining a methodology that simplifies the definition of a cost range for first aid and recovery. Searching for factors that influenced the costs, the analysis highlighted that neither the type of damage nor the type of macro-element affected clearly influenced the costs, whereas, the architectural value, the technique used for first aid and the volume of the building influenced the overall amount. Deepening this correlation, different expressions of cost have been defined according to the volume size, for both first aid and recovery. These formulations can be used by administrations for a preliminary cost assessment in order to obtain homogeneous and more accurate economic evaluations, at least for churches typologically similar to the ones analysed.

5 OPTIMIZATION OF FIRST AID TECHNIQUES

The first aid intervention has to be effective from different points of view: operational, structural, conservative and economic. In this regard, a procedure has been developed in order to find the most effective solution in consideration of all those aspects. Starting from an assessment of the effectiveness of each first aid technique, and considering the influence of external factors (such as the level of damage, site conditions and the architectural value) it is possible to define an order of efficiency among all the possible techniques in order to help the professional to choose the proper technique for the specific case. Moreover, it is important to follow some methodological and operational measures that allow a further optimization if applied from the beginning. Therefore, for each first aid technique, a specific document has been drafted, highlighting the main aspects to care during design and realization. For instance, different typologies of frame systems can be used against overturning mechanisms: each one has pros and cons and should be designed and realized in consideration of some aspects. For example, the shoring systems represented in Figure7 (left and centre) are both made of modular elements with their own foundation. This allows to reduce encumbrance so that these techniques are compatible with small spaces or with the need of preserving the passage in the nearby roads. Note that, differently form steel, wooden elements easily deteriorate if exposed to weathering so that it’s better to use timber frame in covered spaces. On the other side, steel frame could be very impactful, expensive and completely not reusable with a huge waste of material and money, whereas timber frame is more “light”, respectful of the context and reusable for the next stages. Indeed, it could become a definitive strengthening if integrated with the final restoration through appropriate finishes. Therefore, all these aspects need to be considered when choosing and designing the first aid.

Shoring systems with structural scaffoldings can also be optimized. This structure, made of small modular and standard elements (pipe and joints), are characterized by great easiness and speed of installation that allows to shore also the more complex architectural shapes in small operating spaces. On the other side, as previously highlighted, this shoring technique is rather expensive. It is therefore important to ascertain whether rental or purchase is more cost-effective, in consideration of the time foreseen before the final recovery. This assessment must consider different factors. First of all the maintenance costs: in general, after three years it is necessary to restore structural efficiency by integration and replacement of degraded parts. Moreover, it must be considered the possible economic advantage obtained by using the same structure to investigate the building for executive design and to realize the final works. To this aim, all the safety requirements should have been observed from the first stages (i.g. the scaffolding has to be installed at the correct distance from the building). Another aspect to consider is the possible recovery of purchasing costs obtained by selling the scaffolding. This structures indeed can be totally reused in other interventions ensuring the almost complete recovery of the material. Anyway, structural scaffoldings could have significant encumbrance that could prevent access or usability of spaces. Consequently, in order to ensure the passage, it could be convenient the integration with a metal frame, as shown in Figure 7c. In this case, the lower part is made of metal frame in order to reduce the dimensions, whereas the upper part is made of scaffoldings to encircle the building, becoming a useful support for subsequent operations.

Figure 7. On the left, San Luca Church in Medolla (MO) and, in the center, Santa Caterina Church in Novi di Modena (MO): shoring systems with timber frame and metal frame respectively. On the right, Beata Vergine del Rosario Church in Finale Emilia (MO): shoring systems with metal frame and structural scaffolding.

6 CONCLUSION

In the last decades, the dramatic experience of damaging earthquakes that hit the Italian cultural built heritage has developed a deep knowledge about the seismic behavior of traditional masonry constructions. Basically we understood that to prevent future damages we had to look backwards: looking at the way our ancestors built (based upon proportions rather than strength), understanding the building techniques, inspecting the technical details, analyzing the effects of traumatic events on the different building typologies is the most effective way to foresee the future damages and possibly act in a preventive way. This is valid also for first aid interventions, soon after the seismic events: the aforementioned examples showed the complexity of managing this kind of situations.

Even if there are many technical possibilities for securing damaged structures, in the past first-aid interventions have been often not optimized, generating waste of time, material and economic resources. Nevertheless, this experience can become a precious source of data and indications about how to start thinking about provisional works not as disposable elements, but something that can be reused also in the definitive intervention, in line with the concepts of economic and environmental sustainability. Moreover, in a post-earthquake emergency, it is extremely important to be immediately operative, to intervene as soon as possible, working together for making safe the damaged structures, also considering the possible definitive implication of first aid. To this aim, learning from previous experiences is also fundamental to be prepared for future emergencies, aware of all possible risks and consequent interventions, with their pros and cons, in order to define in "peace times" effective strategies of response.

AUTHORS CONTRIBUTION

The author of Sections 1 "Introduction" and 2 "Recurring seismic damages" is E.C.; the author of Sections 3 "Emergency response after the 2012 earthquake", 4 "Economic assessment of first aid and recovery interventions" and 5 "Optimization of first aid techniques" is L. F. Both authors contributed equally to Section 6 "Conclusions". Conceptualization, E.C. and L.F.; methodology, L.F.; investigation, L.F.; resources, E.C and L.F.; writing - original draft preparation, E.C. and L.F.; writing - review and editing, L.F.; supervision, E.C.; project administration, E.C..; funding acquisition, E.C.. All authors have read and agreed to the published version of the manuscript.

ACKNOWLEDGMENTS

The authors gratefully acknowledge Dott. Dir. Enrico Cocchi, Arch. Antonino Libro, Ing. Davide Parisi and all the working group of the Agenzia Regionale per la Ricostruzione Sisma 2012 for their contributions in terms of discussions and materials.

The authors are also grateful to the Soprintendenza Archeologica Belle Arti e Paesaggio per la città metropolitana di Bologna e le province di Modena, Reggio e Ferrara, il Segretariato Regionale del Ministero dei Beni e delle Attività Culturali e del Turismo per l'Emilia Romagna e l'Agenzia per la sicurezza territoriale e la protezione civile for the archival documentation and images. To this regards the authors would like to highlight that all the figures are property of MiBACT and belong to the "Sisma Photographic Archive" and from the "Soprintendenza Archeologica belle arti e paesaggio per la città metropolitana di Bologna e le province di Modena, Reggio Emilia e Ferrara Photographic Archive", located in via IV Novembre.

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Built Heritage in post-Disaster Scenarios – Balzani et al. (Eds)

Building resilience: Documentating, surveying, and representing the historical urban contexts

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ABSTRACT: The officially added symbolic dimension of intangible risk to the list of commonly shared dangers expanded the meanings related to the environmental, social and cultural sustainability and the recent growing recognition of the value of 'community resilience' approaches, focused on the interdependencies between the built environment and human systems, went in the same direction. Then, if new or adaptive reuse interventions are based on community cultural features the urban resilience grows. The subject of the paper is the interpretation of immaterial resilience aimed at critically reading the historical settlements with the scope to test if a knowledge management system and data workflow, conceived and designed to support the decision making process, allow to create balanced relationships between the stakeholders. The Identity survey methodology represented from the contexts survey to expliciting material and immaterial features of the places has been applied on three cases studies in Tuscany, Italy.

Results of the study is consisting of the outline of the urban Identity Atlas's model containing the cases studies outputs. Conclus are focusing on the use of ID survey as first step of the roadmap conducting to the urban historical contexts risk management update aiming to promote the awareness of immaterial features of places and practising the above described matching between cultural sustainability and community based urban resilience.

Keywords: Castelnuovo Garfagnana, genius loci, Gombitelli, identity survey, immaterial resilience

1 INTRODUCTION

Change is an archetypal motive that spontaneously constitutes the city, understood as a spatial system of systems that communities live and use on a daily basis, constantly adapting their behaviours with perennial creativity and planning, more or less intentional, both as an active strategy and in a more reactive sense, to face obvious risks and dangers unknowingly putting into practice the resilient approach to managing change as a manifestation of a "dynamic equilibrium" (Techne, 2018).

The explicit mention of the changes in 11 SDG declared in 2015 ("Making cities inclusive, safe, resistant and sustainable") has dealt with change not only as a danger but also as a necessary and positive factor for improvement.

The pandemic emergency that broke out in 2020, however, dramatically and quickly led to a sudden and traumatic updating of the changes to be put on the agenda as well as highlighted the need to combine new and different risks with the previous ones. The scenario that suddenly emerged in 2020 highlighted, in fact, that from now on it is also necessary to urgently pursue the changes necessary to mitigate the damage deriving from functional and social imbalances that burden, albeit with very different ways and intensities, on many urban realities in the world (UN HABITAT, 2021).

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DOI: 10.1201/9781003253730-13

Along with this enlargement, the meaning we previously attributed to the terms resilience and sustainability has also partly changed: the term "resilience" has a growing presence also in planning and governance and there is greater awareness of new vulnerabilities of the heritage represented by our living environments.

This debate has contributed to focusing attention on the need to create resilience also at an urban scale, as well as buildings, and on the urgent need to update it with the multidisciplinary theoretical and operational frameworks necessary to achieve an effectively complex notion of resilience by adding it with further consistency levels and systemic relationships. Only a holistic approach, in fact, can represent a driver for promoting a more balanced life in cities, greater environmental and social sustainability of built contexts, and growth in the regeneration of contexts "11.b By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015-2030, holistic disaster risk management at all levels" (United Nations, 2015). In this recent debate, the idea has been consolidated that in order to encourage the creation of more inclusive and sustainable places, it is therefore necessary to activate intangible resilience in the various settlement realities of all sizes - metropolises, small cities, villages - with other design components, such as the anthropological and social dimensions of the places and the involvement of different groups in the design and decision processes.

The paper intends to present a proposal for a critical interpretation of immaterial resilience aimed at reading historical settlement contexts with examples of application of the Identity Survey methodology to three Italian case studies.

2 BACKGROUND OF THE SUBJECT

Despite in the definition of urban resilience from SDG 11 the most consolidated meaning of "damage" has even gave strong prevalence to the case history of material damage deriving from disasters -understood almost exclusively as traumatic events caused by sudden natural events with victims and damage due to the material interaction between infrastructures, buildings and people- the profound repercussions of the covid19 emergency prevention measures on cities have everywhere acted as a marker of new vulnerabilities, suddenly making it clear for everyone how close the immaterial relationship between man and city is and how much the functions that take place there also have a physical impact on the places. It input the urgency to develop also a necessarily holistic and integrated immaterial resilience.

While in the past decades significant protection forms of historical urban heritage have also been developed, today we observe the occurrence of completely new risks affecting our ancient settlements and making them vulnerable contexts: there is a whole series of problems, which afflict in particular the historical settlements, deriving at times from slow changes in the general conditions of life and at times from rapid transformations of the character of the places, which in turn cause deterioration of the habitat and physical distancing or estrangement of the communities from these delicate contexts.

We are talking about the loss of identity, the "washout" of the urban fabric and social dispersion for the larger cities, depopulation and uprooting for the smaller ones; in both cases, the livability deficit due to imbalances in the distribution of functions which in turn induce transformations in the physical structure of the most fragile urban and architectural organisms.

To briefly frame the topic also in scientific regulatory terms, we mention the recent statutory framework about the protection of the architectural and urban heritage, which is based on the decades-long history traced by the documents issued by the most important international organizations (UNESCO, 1962; UNESCO, 1976; ICOMOS, 1987; UNESCO, 2005; UNESCO, 2009; ICOMOS, 2011; Conference of European Ministers of Culture, 2018). The "Recommendations on the Historic Urban Landscape" (UNESCO, 2011), that stressed the need to promote the protection, preservation, conservation and enhancement of the historical urban landscape, intended as the "historical stratification of cultural and natural values and attributes" while taking into account the related social and economic processes, is one of the main recent steps that confirm the transition from the protection of the urban and architectural heritage for their material and testimonial value to the protection due of its social value, the promotion of inclusive citizenship and balanced economic development. In this document also the intangible elements of the built heritage, prefigured by the Convention for the Safeguarding of the Intangible Cultural Heritage (UNESCO, 2003) and the Faro Convention (COE, 2005) and then fully focused in 2015 in the SDGs, are incorporated in this context.

The European Commission also works in this sense setting up a specific task force to develop circular economy models for the adaptive reuse (CLIC Consortium, 2020) and Horizon 2020 has dedicated a lot of attention and resources to the Built heritage for its intrinsic and social value. Furthermore in Horizon Europe 2027 the pillar II-cluster 5 "Climate, Energy and Mobility" dedicates to cities the entire intervention area "Communities and cities" focusing on the potential role that heritage buildings can play in improving environmental sustainability and urban regenerations.

This concept sees the definitive update conceiving the historical built heritage no longer just as an important legacy of our past and the object of static protection of the artefacts but as a driver of sustainable development. In improving urban sustainable regenerations the historical urban and architectural heritage, in fact, proved to be particularly significant in the mitigation of severe imbalances of urban functions and an important resource of social, economic and cultural resilience of the communities through the activation of the circular economy deriving from the enhancement and the adaptive reuse of heritage buildings (Throsby, 2002; Forlani et al., 2017; Shirvani Dastgerdi, De Luca, 2018; Foster, 2020; Sicignano et al. 2020).

3 THE HISTORICAL BUILDING HERITAGE IDENTITY AS DRIVER OF SUSTAINA- BILITY AND RESILIENCE THINKING

To promote the balanced life of cities, and ensure the environmental and social sustainability of built environments and launch urban regenerative processes based on a holistic vision, greater intangible resilience can become the driver not only for rehabilitation after disasters but also to prevent intangible damages following three main ways:

1. promoting the ability of communities to care for and regenerate their material habitat from an architectural point of view, through co-planning and co-management practices as models of participatory and adaptive governance;
2. promoting the ability to keep cities "alive" through the vitality of networks and interactions between individuals and groups;
3. preserving the socio-economic context and cultural identity, especially in the symbolic components of the townscape.

Going deeper into point 3, historical urban contexts show how one of the most powerful drivers of sustainability is the identity potential.

The paradigm of sustainability has so far generally paid little attention to the specificity of the intervention on historic buildings, an important Italian asset both in quantitative and qualitative terms, but the identity potential of historic buildings is also a consistent driver of sustainability for both the physical capitalization of architectural artifacts and urban contexts and for powerful cultural capitalization that the buildings and historic Italian cities represent for their inhabitants.

For these reasons, the historical architectural heritage has a role that is not only a testimony of identity, multiplicity and cultural richness, but it's also an element of social cohesion to be protected because it can contribute to making cities and towns inclusive, safe, resilient and sustainable human settlements as well as a key resource for building resilience to disasters (United Nations, 2015).

"The evolution of resilience in the buildings sector as described above –from asset-specific to community and systems-based thinking, from physical to human dimensions, in both developing and developed contexts– illustrates a continually broadening approach. However, there remains an opportunity to leverage investments in new building construction and improvements to the safety and performance of existing buildings not only to reduce risk and the potential for physical and economic loss from an acute shock, but also to create broader social, environmental, and economic benefits that lessen the impacts of everyday chronic stresses and allow communities to better handle all sorts of unanticipated shocks and stresses. … It also integrates disaster management objectives with sustainability objectives, which have traditionally been kept distinct." (100 Resilient Cities, 2019).

Among the peculiar characteristics of the Italian built heritage, the large-scale historicity certainly constitutes its most macroscopic feature, which on the one hand identifies it and conditions all intervention but on the other it has constituted its precondition of longevity thanks to the flexibility to allow the transformations that the historical built heritage presents, sometimes even more than the modern one.

It thus emerges that it has an added value in terms of sustainability of the refurbishments thanks to the possibility of perpetuating with new skin at each stage of life: is the historic building a resilient building?

The place attachment that binds the inhabitants with each other and with the place develops over time and gathers all the social dimensions of the life of a community and its culture.

Every day in the city a stratification of knowledge, traditions and rules takes place which constitutes it in a continuous, unique and irreplaceable way: it's a way to transmit and reflect cultural notions, associations and values on how a society thinks itself, which includes the material and immaterial features forming the physiognomy of a place and the value of places identity.

The stratification of historical contexts then produces "the perceived uniqueness of a place" (Norberg-Schulz, 1979), and the specificity of each context and the genius loci, expressed through its tangible and intangible elements and a combination of physical characteristics of the place, the activities that take place there, and the meaning that is attributed to that place by the inhabitants (Puma, Trombadore 2020). When this temporal and spatial continuity of the city cracks or a distorted situation becomes heavy and permanent, negatively affecting individual and collective identity, the harmony between people and city is lost and livability becomes critical. We refer here to changing demographics and imbalances in the presence and type of population, ranging in the opposite situations of too strong anthropic pressure or depopulation between the "too much" of mass tourism and the impoverishment of the functional and social mix in the art cities to the "too little" of abandoned villages. In short, imbalances that seriously question the sustainability of life in many historical urban contexts.

Moreover, "The identifying components of a building, a neighbourhood, a place or even an entire territory, their recognition on behalf of communities and the shared prospect of new identifying values still to be formed all key aspects for resilient planning, for growing the necessary social awareness and cultural responsibility to take on an active role in managing the constructed environment's transformations" (Faroldi, 2018).

4 THE IDENTITY SURVEY METHODOLOGY

"Although the term mostly identifies critical and/or risk situations, resilience can also represent an opportunity: not only intervention in emergency, but also the starter of processes of transformation of the built environment through the knowledge of the critical and vulnerability of that context, which considers the resilient attitude of the analyzed system." (Lucarelli, 2018). Multidimensional knowledge plans need to support politics decisions that are sustainable for communities and citizens in social, economic, environmental but also cultural and anthropological terms.

Regarding the architectural survey as the first phase of the building process (Brusaporci, 2015), an important update is required today to target every transformation of the existing buildings in the frame of sustainable intervention, a vision in which the traditional instrumental and methodological variables of the architectural survey must be further added by information capable of accounting not only for the physical characteristics but also for its aptitudes and/or carrying capacity, the size of its resilience, its dimensions of social value.

Basing on these premises in 2015 the research group coordinated by the author started to conceive and work on a methodology, still actually in progress, designed to understand and represent the complexity of the places in their integrity and syncretic perception normally experienced in everyday life (Puma, 2020). In short, the method tries to adapt the data representation in more pertinent way in respect of the multidimensional analyzed system; in our opinion a deep understanding of urban environments could be communicated only using a more integrated representation able to inform both about the material data (in their visible characteristics of size, shape, materials) and the immaterial features of their genius loci (in the characteristics that define in such a peculiar way the character of a place: from its function to the chronological dimension that connotes its rhythm of life in the day or in the seasons, to the social typology of its inhabitants), both indestructible factors of the identity of a place (Figure 1).

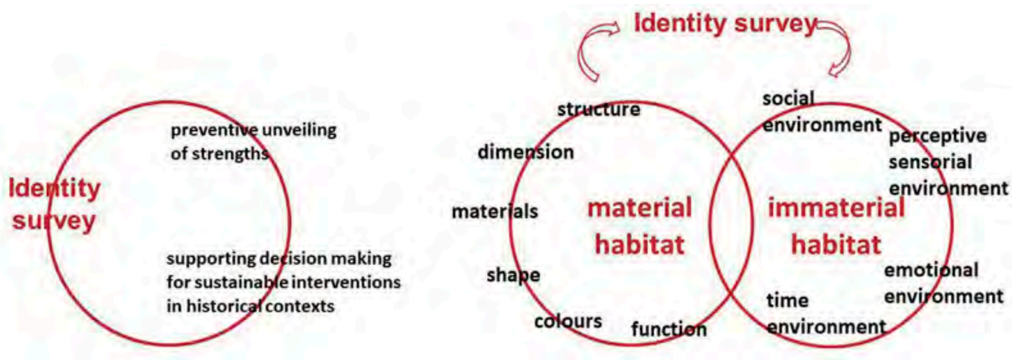

Figure 1. Conceptual schemes of the Identity survey.

The identity survey implements the architectural and urban survey with the identification of the main characteristics of intangible heritage of the places described in their characteristics of interaction between people and the place, therefore aims to be a method of analysis and reading of contexts centered on the specificity and implicit material and immaterial potentialities with a preparatory function for the project of sustainable intervention on historic contexts.

Then the architectural survey can also take on the function of a tool for the unveiling all the potentialities, to be activated for:

– preventive monitoring of historical contexts for risk reduction;
– framing the decision-making and authorization process in a framework of sustainable transformations and better resilience of the physical and social structures that over the centuries have layered a so unique identity heritage.

The ID Survey workflow is therefore splitted as follows:

a. data acquisition of information on urban and architectural heritage;
b. production of numeric, graphic and textual materials;
c. production of interactive maps for the description of the immaterial characteristics of the place: soundmap, chronomaps, olfactory maps;
d. production of documentary repertoires with multi-scalar basic and critical contents for marking and assessment of the vulnerabilities and the resilience gradient.

5 RESULTS OF THE STUDY

Based on these premises, some campaigns of identity survey have been conducted on sample cases located in Tuscany, whose crucial phase is constituted by the interactive representation, interpreted as the convergence between traditional survey data and 3D representations to obtain advanced visualization models evolving to dynamic data creating in real-time identity maps.

Figure 2. Sinopsys of the three case studies: on the top of the previous page, the square of San Pier Maggiore in Florence; on the bottom, the Gombitelli village; above. Here above, the midtown of Castelnuovo Garfagnana.

The three case studies were selected to sample the settlement scales which are also exemplary of critical issues deriving from the imbalances described above of excessive anthropic load, the square of San Pier Maggiore in Florence, a depopulated Apennine village, Gombitelli, and a small touristic town that decided to start the transition towards a slow tourism and circular economic model (Figure 2).

5.1 *Overtourism in san pier maggiore square in florence*

Few cities in the world are bearers of such a widespread and powerful tourist imagery as Florence. The image, even literary, of a city that still presents itself to the visitor today as an "integral" scene of history and as a city universally associated with the values of art has for decades represented the constitutive essence of the social, economic and cultural identity of its inhabitants in a long and slow sedimentation of architectural and urban events with an apparently perennial artistic reputation over time.

Tourism has always been an integral part of a very strong city identity. Although the historic center of Florence has been included in the Unesco list of world heritage since 1982, this model has recently shown signs of crisis due to too rapid transformations for a place with all the fragility of historical centers. The beginning of the 21st century also marks the beginning of new travel habits that trigger ever more rapid and profound transformations of the urban fabric and which today show all the risks of an unstoppable loss of the genius loci of the city: urban transformations that Florence shares with many other cities and metropolises with high tourist consumption.

The case study is focused on the square of San Pier Maggiore, which is located in the heartof the historic center of Florence at the confluence of the territorial lines of the ancient city and is therefore the knot of urban signs that have come down to us in all their symbolic and spatial density.

The square San Pier Maggiore has always been a lively and attractive place in Florence: it is located a few steps from the Cathedral, but in the direction that opens up to an urban quadrant until a few years ago not interested by the large tourist flows and today heavily affected by "airification" phenomena. The square is now at the center of tourism activities that have replaced the inhabitants shops and services: restaurants and cheap souvenir shops have supplanted the shops groceries, the neighborhood newstands, the historical textiles and clothing shops, the artisans; on the upper floors, the larger apartments have often been split up to maximize the income from short-term rentals, while a large part of the resident inhabitants have been replaced by the daily tourists turn over (Puma, 2018). The Survey, Representation and Communication segment of the documentary project carried out about the square is based on Digital Cultural Heritage as the pivot of the documentation and information communication chain deriving from the operational continuity between methods of access to knowledge and dissemination output, working on two axes:

- the knowledge axis: the production and interpretation of data by data acquisition-traditional urban survey and identity survey- and data post processing;
- the communication axis: the data dissemination of results by 2D graphics, and 3D models, and interactive maps.

5.2 *The depopulated village of Gombitelli*

The revitalization of the inland Apennines areas and villages has long been at the center of national Italian policies (ANCI Legge n. 158, 2017; SNAI, 2013; Italia Nostra, 2020) and has recently been included in various actions of the Next Generation EU Italian plan (PNRR, 2021), in order to activate here interventions that see the material heritage and immaterial valued as a driver of sustainable development.

The village of Gombitelli was founded in the early Middle Ages between the Versilian coast, which is only 12 kilometers away, and the first offshoots of the Apuan Alps and grows according to the typical settlement conditions of spontaneous architecture that arises from the close intertwining of natural and anthropic elements. The focus of the study is on two material and immaterial levels. Among the legacies of the past that make Gombitelli one of those unique, though not exceptional, contexts that art. 2 of the European Landscape Convention cites as "landscape of everyday life", there are the texture of the facades shining in the sun stands out for the plasters containing the waste of the past iron working and the mosaic of rural and built spaces generated by the orography, with geomorphological characters of the rocky outcrops from which the houses arise and from the green presence that surrounds and enters the village.

The tangible and intangible heritage of the village has many strengths: the being a linguistic island, an element that constitutes a powerful identity element defended by the about hundred people who still permanently inhabit the village; the near passage of the Via Francigena; the archaeological heritage to be museumized; the strong traditions of fine and renowned artisan pork butchery; the very strong memory of the ancient tradition of iron working (Anichini, Giannotti, 2011; Repetti, 1833).

Gombitelli therefore constitutes an indestructible continuum of material and immaterial culture that can find in the collective memory a decisive lever for activating the resilience of the territory and the community.

This very particular village constitutes the study sample of the survey carried out in preparation of the enhancement project for the emerging territorial project of Ecomuseo delle Seimiglia. In particular, the village was mapped through the survey -carried out with an integrated laser scanner and aerial and terrestrial SFM methodology- of 12 significant small sites that will constitute the relative visit points of the open air museum. The visual information contents coming from the survey will contain interactive descriptions developed on the basis of traditional representations and maps created as a result of the identity survey (Puma, 2021).

5.3 *The transition towards slow tourism in Castelnuovo di Garfagnana*

Although traces of the Etruscan and Roman periods indicate human presence since ancient times, true documentation of the town can only be dated from the Langobard period.

The town rises in the early Middle Ages at the confluence of the Serchio river and the Turrite secca torrent in a valley of the Apuan Alps and is well connected to Lucca, Florence and the Versilia coast, from whose it is distant about 50 km, 116 km and 40 km. The town, which now has about 6,000 inhabitants, soon became an important center of the trade routes connecting Emilia to Tuscany, while remaining protected by the mountainous crown that surrounds it and gives it a strong social and cultural physiognomy. This geographic condition conditioned the growth of the original settlement nucleus and directed its subsequent development forcing it beyond the waterway in various suburbs located radially going up the hill slopes. The presence of water significantly characterizes the townscape resulting from the intertwining of built fabric and natural textures perennially accompanied by the sound of the flowing river and the view of the woods immediately surrounding the town. The historic center is surrounded by a wall built between the XIV and XV centuries to complete the ancient medieval fortress, subsequently enlarged in the period between the Lucca and the Este domination, which in the period 1522-1525 saw the poet Ludovico Ariosto among the its governors for the Este dynasty. For its location, the richness of natural resources and the long history that has settled important monumental signs –including the Cathedral of SS. Pietro e Paolo, and the Rocca Ariostesca, and the imposing Mont'Alfonso Fortress-Castelnuovo Garfagnana is a renowned and very attractive tourist center without, however, having developed an adequate hotel offer (AA. VV., 1993; AA. VV., 2014).

In order to work on the material and intangible specificities of the place as a trigger for a sustainable tourist livability of the historic center, a series of survey campaigns were launched from 2020 with the aim of supporting enhancement interventions based on a green-circular economy perspective and the creation of the "albergo diffuso", a tourist solution already widely shared by the inhabitants.

The surveys carried out were set up in order to produce the urban mapping conceived for the description of the identity potential of the place. The traditional descriptive and critical 2D graphic representations are accompanied by 3D models of the main architectural nodes and landmarks of the townscape as well as a first data visualization platform designed as a virtual tour. The main results of the study are consisting of the outline of the urban Identity Atlas's model containing the cases studies outputs (Figure 3).

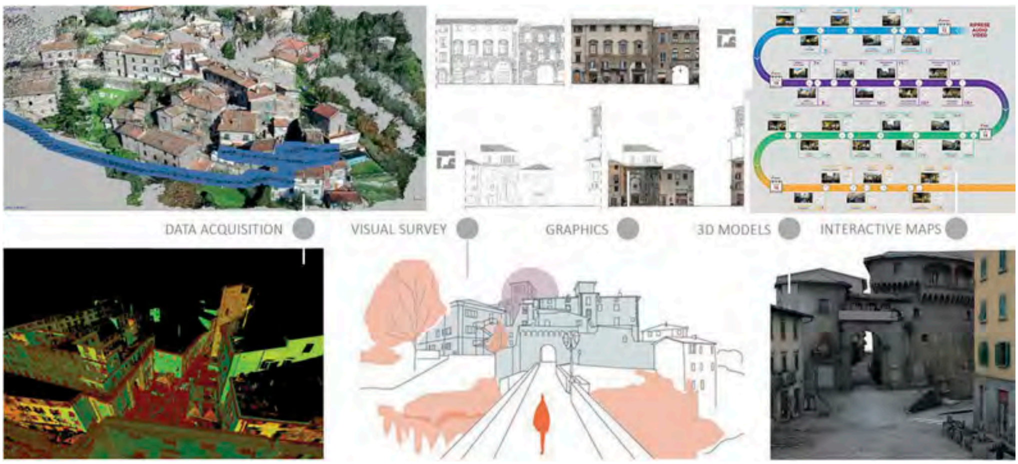

Figure 3. Conceptual schemes of the Identity survey.

6 CONCLUSIONS

The officially added symbolic dimension of intangible risk to the list of commonly defined dangers expanded the meanings related to the environmental, social and cultural sustainability. The recent growing recognition of the value of 'community resilience' approaches, focused on the interdependencies between the built environment and human systems, went in the same direction. Then, if new or adaptive reuse interventions are based on community and cultural features the urban resilience grows. Knowledge management systems conceived following a data workflow to supporting the decision making process constitutes a powerful resource allowing to create balanced relationships between the stakeholders (Faroldi, 2018).

Aiming to promote the awareness of immaterial features of places the ID survey methodology has been applied on three cases studies in Tuscany practising the above described matching between cultural sustainability and community based urban resilience.

ACKNOWLEDGMENTS

The general project "E sem a Gombetea" has been promoted by Municipality of Camaiore (Lucca, Italy) and coordinated by prof. Andrea Innocenzo Volpe- DiDA/University of Florence. The urban survey of Gombitelli has been carried out by the author in the framework of the scientific agreement between Municipality of Camaiore (Lucca, Italy) and DiDA/University of Florence coordinated by proff. Andrea Innocenzo Volpe and Paola Puma (DiDA/University of Florence), dr. Iacopo Menchetti (Municipality of Camaiore.)

The urban survey of Castelnuovo Garfagnana has been carried out in the framework of the general project coordinated by Antonella Trombadore- DiDA/University of Florence.

Author would like to thank Giuseppe Nicastro, Architect and PhD at Department of Architecture, University of Florence, Italy for his contribution in the survey campaigns and developing preliminary visual data. Author would like to thank: for their conducing the survey campaigns discussed in their final theses three graduate junior architects at the Department of Architecture, University of Florence, Italy as follows Chiara Francesconi and Carla Gaviano (Gombitelli), Elena Migliorati (San Pier Maggiore square); the preliminary researches provided from the students of the workshop "The historical contexts between memory and innovation: the identity survey and the responsive design for sustainable enhancement" in Castelnuovo Garfagnana.

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Built Heritage in post-Disaster Scenarios – Balzani et al. (Eds)

Basics of the resilience of cultural heritage assets

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ABSTRACT: The evidence of the human creation of environment through the millennia is preserved in what today is recognized as a cultural heritage asset, movable or immovable one. In invisible way it also contains a variety of intangible messages which are difficult to read and understand but they should be preserved for the next generations. Each asset is exposed to long-term and sudden environmental and man-made harmful impacts, which damage or erode asset's materials and components and lead to loosing of the incorporated intangible messages. The lack of knowledge and improper decisions of site managers significantly increase exposure of assets to all kinds of risks. Therefore, they are obligated to increase assets' resilience. Resilient asset is capable to respond on harmful impacts with less damage and has better recovery potential after environmental or man-made disastrous event. In present paper is explained the authors' view on the heritage resilience concept based on the protocols of data collection and significances of cultural heritage assets. The outline of cultural heritage resilience model is briefly presented and commented regarding its further development and its importance for development of related standards and protocols. The background of the chapter is authors' own research and experiences study of relevant literature.

Keywords: cultural heritage asset, data collections, significances, resilience model

1 INTRODUCTION

Current scientific discourse in the field of heritage preservation introduces holistic integrated approach, involving humanities and social sciences as well as natural sciences and engineering (Appelbaum, 2012). Even though each type of heritage should always be investigated and observed in its specific context, stakeholder participation and sustainable strategic planning, which aims to harmonize economic, environmental, and social aspects of development dimension should be an umbrella approach to address the common challenges of heritage preservation. Consequently, heritage preservation is marked above all by sustainable preventive conservation and regular maintenance. However, development of appropriate management strategies for preventive conservation and maintenance, as well as for informed decisions on interventions must be based on reliable data, supported by appropriate documentation methodology. In the recent decade the issue of resilience of cultural heritage as an important part of maintaining the resilient society, came in focus of interest in academic, research and professional environment. It resulted in decision of the EU Horizon 2020 Programme to launch several calls on that topic and probable continuation in the forthcoming EU Horizon Europe Programme.

2 CONCEPT OF RESILIENCE

As the term of "resilience" has been used in different disciplines with sometimes different variations of meanings and context its origins are also multiple. According to the Oxford English

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DOI: 10.1201/9781003253730-14

Dictionary, “resilience” comes from the post-classical Latin “resililentia” for the fact of avoiding. It also comes from the classical Latin resilient-, resiliens, present participle of resilire. It entered in English from *Sylva Sylvarum* (Bacon, 1627) where it is defined as ”t*he action or an act of rebounding or springing back; rebound, recoil*“.

The concept of resilience is still not enough understood by many professionals dealing with preservation of cultural heritage and management of heritage sites. The concept of resilient societies is defined by emergency preparedness and response as well as by systemic mitigation of damage. It is based on analysis of factors, which influence social and technological change in a way to comply society with a fast-changing environment. In modern times, the concept of resilience was first introduced in the 1950s in the natural sciences and later adopted by psychology and the educational sciences. Since the end of the 1990s the notion of resilience has been increasingly applied to corporate contexts.

There are four leading concepts of resilient society. The first originates from concern about the impact of natural and man-made risks and constant need for mitigation of consequences of unfavorable sudden, unexpected events. The second focuses on the risk adjustment and disaster transformation to harmonize society within a fast-changing environment. The third is based on the analytical approach of stocktaking trying to provide tools needed for transformation of ”natural“ social resilience into feasible criteria for action. The fourth, and the newest concept, is based on the innovative cognitive paradigms, which integrate technology, democracy, and society. Approach is particularly characterized by liberation technology and participatory technological innovation. Thus, everyone should be granted the basic right to use certain technologies such as computer, mobile phone and the internet as well as the knowledge of how to use them.

Yet, related more specific to cultural heritage, the definition of resilience according to the Intergovernmental Panel on Climate Change (Field et al., 2019) is: ”*the ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner, including through ensuring the preservation, restoration, or improvement of its essential basic structures and functions.*“

3 COMPONENTS OF THE CULTURAL HERITAGE RESILIENCE

The resilience of cultural heritage asset aggregate multifold aspects. In simplified way it can be observed as an aggregate of three important aspects, although some other can be added. These three are: managerial, societal, and technical (Figure 1). Managerial aspects include activities of stakeholders, who are in charge to cover organizational, legal, financial and all support activities needed for integral management of the asset. Societal aspects cover mostly intangible significances of asset, i.e., its role and value for local and wider society which also includes the importance for economic growth and well-being of population. The third, technical aspects are related to physical integrity, stability, and all over condition of asset assuring its resistance to long-term environmental and unintentional man-made impacts as well as environmental and intentional man-made disasters.

3.1 *Proper management*

One of the most important issues in increasing of resilience is high awareness, professionalism, and knowledge of stakeholders in charge, including the authorities responsible for heritage preservation. An illustrative example of decision making is reported in (Jigyasu et al., 2013) about the examination of the extent to which disaster risk reduction is considered within the management systems of various World Heritage sites. Those, which appear to be the most exposed to the disaster risks, are particularly targeted. The study surveyed 60 World Heritage sites and identified 41 properties in 18 countries as most at risk from natural and man-made hazards according to World Risk Index (Web-1). It appears, according to the study, that in management of World Heritage sites the Risk Preparedness Plan is not among the highest priorities. The problem is that many managers of heritage sites do not find enough time or motivation to read and use them in solving everyday problems. Especially, where comprehensive collection of texts on the conservation of art and architecture is published, can provide useful information (Price et al., 1996).

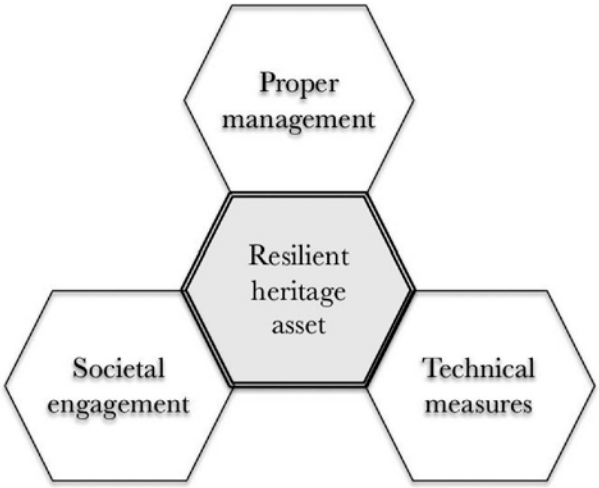

Figure 1. Components of establishing of resilience of cultural heritage asset.

3.2 *Societal engagement*

Resilience of societies in cultural heritage rich small towns and rural areas as an important issue was well addressed in European Regional Initiative Project in INTERREG IVc, HISTCAPE-Historic Assets and Related Landscape (Eppich et al., 2014). The Europe's 747 million population, of which 514 million inhabitants are joined together within the European Union, in great number lives in rural landscapes that are home to a scattered pattern of smaller historic towns and villages. The HISTCAPE project focused on the some 4500 small, heritage assets reach towns of under 20.000 population that have traditionally acted as community hubs – a focal point for economic activity and social cohesion. This role has, however, come under serious threat over recent decades with outmigration, particularly of young people as a direct consequence of changing patterns of economic activity - adversely affecting demographic balance and sustainability. The ensuing loss of facilities and services combined with a loss of economic activity has resulted in a lack of investment in these communities. The acceleration of this trend, exacerbated by the recession, directly threatens the existence of much of Europe's historic assets. The HISTCAPE project addresses this challenge by focusing on the sustainable management of historical assets in small rural towns.

3.3 *Technical measures*

Technical measures encompass two groups of activities: regular maintenance and structural rehabilitation. When it is decided to upgrade the physical resilience of building or other heritage object the series of activities are carried out. In Figure 2 redrawn from (Matulionis and Freitag, 1991) five possible conditions of asset are presented: normally eroded, having minor failures, occurrence of major failures, non-usable condition, and occurrence of structural failures. Regular preventive maintenance keeps asset in a good condition, enables normal use of asset and is cost effective.

In case of sudden events or due to neglecting, minor failures can develop on structural and non-structural parts of asset. Immediate measures after observation of minor failures prevents object from development of major failures. Costs of minor repairs are higher than preventive maintenance costs but still much lower than costs of major repair. Each repair contributes to increase of asset's resilience and with regular interventions the targeted resilience can be maintained.

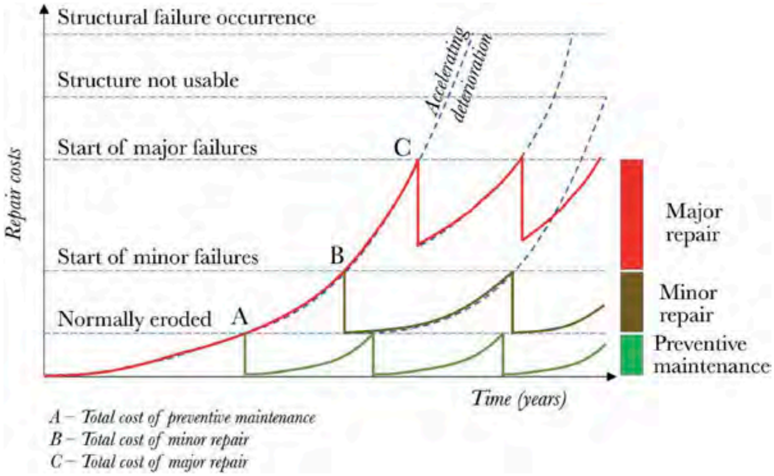

Figure 2. Comparison of preventive maintenance, minor and major repair costs (Matulionis and Freitag, 1991).

Conservation of monuments and heritage buildings is well developed scientific and professional discipline and there is several books and other publications that transfer theoretical and practical knowledge to professionals and researcher (Feilden, 2007; Young, 2008). These books comprehensively survey the fundamental principles of conservation in their application to historic buildings, and provides the basic information needed by architects, engineers, and surveyors for the solution of problems of architectural conservation in almost every climatic region of the world. They can help professionals in every day's heritage maintenance practice because presented reliable methods of intervention that has been proved to be efficient can serve as a source of solutions design.

Structural rehabilitation increases resistance of heritage asset to disastrous natural and man-made impacts. In this kind of intervention both major repair of asset and structural strengthening is performed. Because of sensitive nature of cultural heritage intervention must engage experts from different disciplines coordinated by experts having both high technical capacity and cultural sensibility. Within discipline of earthquake engineering the heritage building repair and strengthening is well developed and extensively published. Since the new knowledge develops and experiences are gained from earthquake response the literature is constantly updated although there are well established principles and methods of structural assessment and repair/strengthening design. International Council for Research and Innovation in Building and Construction (CIB) has published "Guide for the Structural Rehabilitation of Heritage Buildings" (Santos et al., 2010) that can serve not only for interventions in heritage buildings to increase their earthquake resistance but also to increase their resistance to other disastrous events.

4 RESILIENCE MODEL OF CULTURAL HERITAGE ASSETS

4.1 *Characteristics of the resilient system*

In the recent two decades the interest for the resilience of built heritage in context of its vulnerability is becoming the important issue of research and planning of long-term heritage protection. The high interest of European Union for protection and promoting importance of cultural heritage reflects also in its research policy since the early research programmes. It started in the 1st Framework Programme for Research & Technological Development (1984- 87) and continues into current HORIZON 2020 (2013-2020). In it, several calls on resilience of cultural heritage has been lunched, and selected projects are in course. In general, resilient system is one that shows:

– Reduced failure probabilities.
– Reduced consequences from failures, in terms of lives lost, damage, and negative economic and social consequences.
– Reduced time to recovery (restoration of a specific system or set of systems to their “normal” level of functional performance).

4.2 *Data based significances of cultural heritage assets*

Significances of cultural heritage are in focus of researchers and professionals more than a century and especially since Alois Rigel’s classic essay ”The Modern Cult of Monuments: Its Character and Origin“(1903). Fredheim and Khalaf (2016) give a critical discussion of value typologies for heritage conservation and management based on review of published literature on heritage values. Heritage significances, which are presented were first defined in the framework of the interdisciplinary PhD study of Vodopivec (2019). Result of the research was a multiple-criteria decision making (MCDM) methodology for assessment of architectural heritage properties (Vodopivec et al., 2014). The methodology can be, as the study confirmed, relevant and scientifically sound support for decision makers aiming to plan scientifically justified priorities of renovation and maintenance interventions, especially when public funds are limited. The methodology can be as well a basis to plan revitalization and integration of monuments into local environment and regional development (e.g., planning of management and function of object).

The proposed scheme of significances is organized in nine blocks, each further divided in three sub-blocks covering the large spectra of different aspects, properties and values of heritage assets following the idea of holistic approach to cultural heritage understanding and managing. Detailed description of significances is presented in (Žarnić et. al, 2017). Yet, in case of cultural heritage asset under observation, its properties organized following the scheme (Figure 3) can only be derived from the available data. Data collections are the key for understanding and learning about the asset.

Recognizing the importance of the reliable and as complete as possible data on various aspects related to cultural heritage, its properties and values, experts and authorities in many counties have been developing and use various systems and tools for inventory and

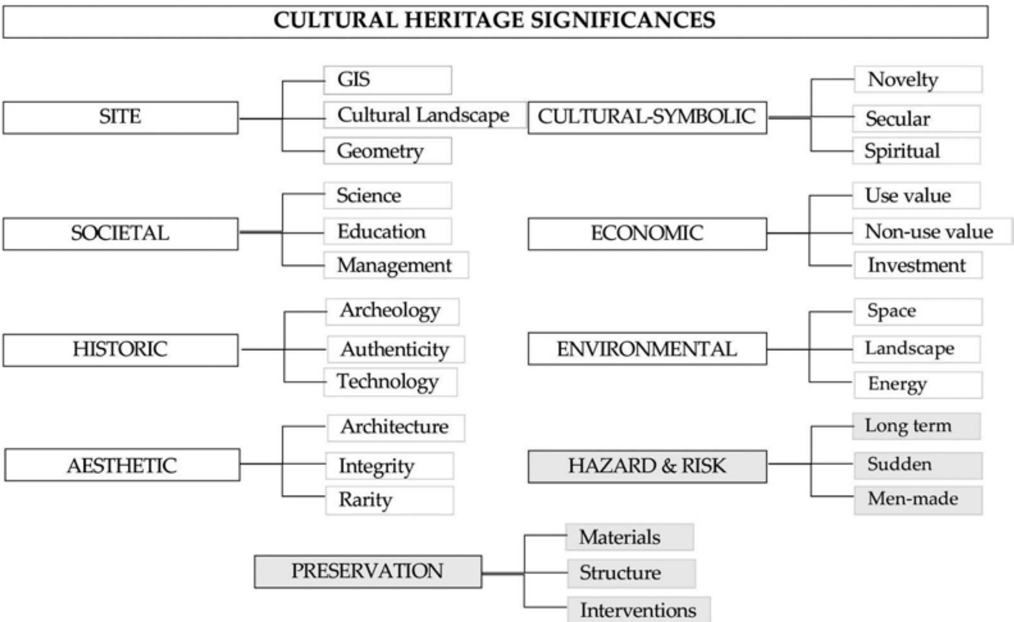

Figure 3. List of significances of cultural heritage assets as proposed by authors of this article.

documentation of cultural heritage. The whole tradition of care for cultural heritage is reflected in those systems, yet at the same time their approach to content stems from the local approaches and understandings.

The need for unified approach to collecting and organizing data on cultural heritage that can be compared on the European level lead to an action of researchers and experts from 15 Eu countries and Egypt which resulted in gaining the EU FP7 Coordinated Action "European Cultural Heritage Identity Card" (EUCHIC, 2009-2012). The main aim of the Action was to propose a strategy and most efficient methods and tools for harmonisation of criteria and indicators to be addressed for tracking environmental changes and human interventions on the tangible cultural heritage objects across European and neighbouring countries. The project demonstrates a significant cost-benefit advantage for all owners, managers, authorities, and conservators who are in charge to protect movable and immovable cultural assets and should monitor and systematically report all human and natural changes of state, to make the most appropriate knowledgeable and economic choice for an effective preventive conservation.

One of main objectives of the EUCHIC was to develop and test guidelines, needed for efficient compilation and storage of data, pertinent to each monument under observation. The system of EU-CHIC supports sustainable maintenance, preventive conservation and rehabilitation of historic sites and monuments.

The partners of EUCHIC developed a data collection protocol where data are divided in three groups. The first one named Level 1 contents the general data about heritage asset following the recommendations of the Council of Europe (Palmer and Bold, 2009). The template for data collection and Guidelines translated in 13 languages are available on (Web- 2). The second level of data is more detailed and can be collected by various approaches and organized following the above presented grouping by significances. The third level of data contains the aggregation of level 1 and level 2 data that they can serve for decision making on planning and execution of interventions (Figure 2), thus maintaining, and increasing resilience of the cultural heritage asset.

4.3 *Concept of the resilience model of cultural heritage assets*

In the case of contemporary systems where the operational condition and structural properties are known and well documented a broad measure of resilience that captures these key features can be mathematically expressed and thus calculated. Resilience depends on the quality of the asset. Performance can range from 0% to 100%, where 100% means no degradation in quality and 0% means total loss (Figure 4a). If a disastrous short-term event occurs, it could cause sufficient damage to the asset such that the quality measure is immediately reduced (from 100% to much lower percentage, or in the worst case of collapse to 0%). After post- event intervention the asset is entirely repaired and return in full function (indicated by a quality of 100%). In time

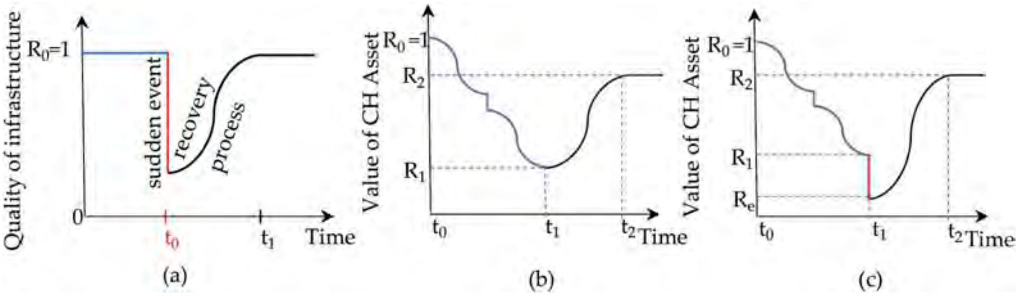

Figure 4. Schematic presentation of: (a) performance of contemporary infrastructure before and after disastrous event, (b) decreasing value of cultural heritage asset due to long-term influences and short-term impacts and increasing by the radical intervention during regular maintenance and (c) decreasing value of cultural heritage asset due to long-term influences and short-term impacts and increasing by the radical interven- tion following the disastrous event.

of occurrence (t0) of event the infrastructure is assumingly 100% resilient. Due to known and documented condition and functionality prior the event it can be restored by appropriate intervention in certain period (t1) to initial level of resilience (R=1, 100% performance level).

In the case of built heritage, the situation is more complex because value of heritage asset depends on state of its preservation regarding all its known significances (Figure 3), including condition of materials and structure, maintenance, and previous interventions. Because of this specific nature of cultural heritage asset here proposed concept of resilience model for cultural heritage assets differs from model for contemporary infrastructure. Heritage asset's value was 100% (R0 = 1) in time of creation. Various long-term and sudden impacts occurred during its lifetime that is measured by centuries or even millenniums. In the present time (t1) the resilience of asset is much lower than the initial one (R1 < R0). Asset practically cannot be completely restored to its original state (Figure 4b) but only to the best achievable ones (R1< R2< R0). Theoretically, it would be possible to reach the initial resilience (R0) only in cases where the complete documentation of the initial state would be available and reconstruction in its parts would be allowed. Documentation is complete only if contains both, data on tangible characteristics and intangible values of asset.

The solution of problem becomes even more demanding if in observed, present time (t1) in (Figure 4c) the additional sudden drop (Re) of value occurs due to the natural or man- made impact.

Because of its uniqueness detailed investigation, study and even research are needed to quantify resilience of each heritage asset. Due to variety of heritage assets, it is not likely to develop a universal resilience model. However, here presented concept can help in creation of basic rules of the model. The main idea is to preserve and with proper interventions mitigate further losing of inherited asset value.

Figure 5 schematically presents losing of value in past until the day of renewal, marked by circle in graph, and targeted situation after that day. Since creation, the heritage asset was exposed to different long- and short-term influences that gradually and/or instantly decrease its value. In some cases, some events, mainly sudden ones, and post-event interventions were recorded but many of those records have been lost.

Learning from the available documentation and data obtained by inspection and assessment of heritage asset the current value of heritage asset can be identified when a decision on renewal of asset is made. Based on collected data covering all tangible and intangible significances of asset (Figure 3) the resilience can be estimated in relation to the assumed resilience of the earliest documented date (Rinitial) This estimation can be also considered as a new (Rnew) initial resilience with which all future resiliencies will be compared. The purpose of the renewal intervention is to upgrade the heritage asset to highest possible level to recover as much as possible of the original value. Due to the lack of information about the asset's creation and due to alternation of use, function, or purpose of the asset certain part of original value cannot be recovered. However, the owner or responsible authority can assign another purpose and use to heritage asset, which is in line with its sustainable economic exploitation

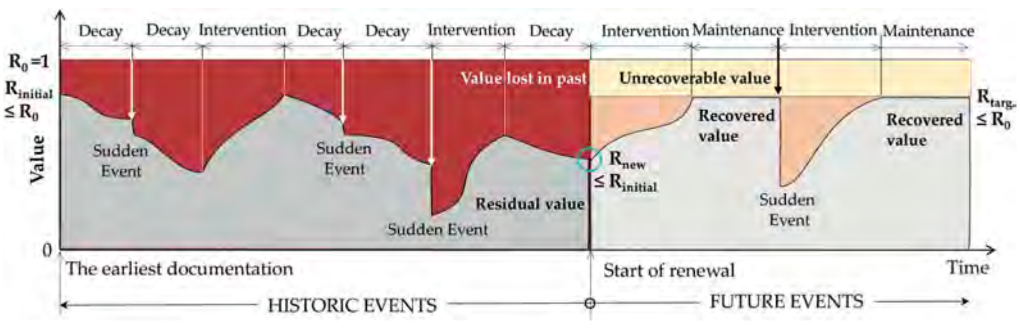

Figure 5. Schematic presentation of value's degradation during the past lifetime of heritage asset and recovering of value due to renovation and regular preventive maintenance.

what can enrich the original value. The result of renovation is a recovered value and asset in this stage can be validated to calculate its resilience as the targeted one (Rtarg). In this stage of asset life, the complete and holistic documentation should be created including its economic value and values expressed by all other significances.

After completing the renovation, the precise maintenance plan and its execution should be assured to keep resilience of asset on targeted level (Rtarg). Maintenance should be carried out regularly in a way that all long-term environmental and unintentional man-made impacts would be neutralized. The environmental and intentional man-made disastrous events cannot be avoided in the future life of renewed asset. But high level of resilience achieved by renovation and extensive documentation certainly can diminish risk of losing entire value of the asset and enable its faster recovery after unwanted event up to the targeted level of resilience.

5 DISCUSSION

The presented approach cannot serve only as a support to plan renovation and maintenance of monuments; it can also offer a profound and reach material to revitalize and integrate monuments in their environment and regional development, as well as to define their function. Thus, the concept of heritage resilience management, addresses also use of heritage objects, which is one of the most ardent challenges in heritage preservation. In addition, scheme of significances, supported by ICT tools, allows collecting, presenting, and storing data, which enable preservation and conservation, as well as reconstruction of heavily damaged objects. Scheme was originally defined for the architectural heritage but allows to be used also for other types of heritage. In such case, the structure needs to be re-considered and re-assessed prior to its use. Further, the user needs to be aware of the limitations of the approach, in particular the potential simplification of individual scientific disciplines and potentially dan- gerous generalization of results if applied without support of specific, in-depth case studies. Resilience concept brings together various concepts from heritage values and signifi- cances to risks, hazardous events and their mitigation. To this purpose the cultural heritage resilience model, designed especially for heritage assets, was developed through joint efforts of various disciplines, civil engineering being the leading one. Yet, it is evident need for standardization of data collecting, organizing, and processing on the global level (ICOMOS, UNESCO, ISO…) where system of approach from the general and global to particular and detail data would be introduced.

AUTHORS CONTRIBUTION

Conceptualization, R. Žarnić, methodology, R. Žarnić and B. Vodopivec, investigation, B. Vodopivec, writing—original draft preparation, R. Žarnić; writing-review and editing, B. Vodopivec, supervision, R. Žarnić project administration, B. Vodopivec; funding acquisition R. Žarnić. All authors have read and agreed to the published version of the manuscript.

ACKNOWLEDGMENTS

The research leading to these results has received funding from the European Union's Seventh Framework Programme FP7/2007-2013/ under grant agreement no° [226995], EUCHIC - European Cultural Heritage Identity Card (2009-2012) and from European Union's Horizon 2020 research and innovation Programme /2013-2020/ under grant agreement no° [665220] INCEPTION- Inclusive Cultural Heritage in Europe through 3D semantic modelling (2015-2019).

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Built Heritage in post-Disaster Scenarios – Balzani et al. (Eds)

Critical-comparative analysis of the historical theatres in Emilia damaged by the 2012 Earthquake

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ABSTRACT: This contribution aims to highlight the results of the critical-comparative analysis applied to the sample of theatres of the Emilia crater damaged by the 2012 earthquake. This aspect is a substantial part of the methodological framework of the PhD research conducted within the 34th cycle of the IDAUP program - International Doctorate in Architecture and Urban Planning - of the University of Ferrara and funded by the Emilia-Romagna Region program "Three- year high skills plan for research, technology transfer and entrepreneurship" according to Legislative Assembly and Representative Deliberation N. 38, 20/10/2015, ERDF ESF 2014/2020 thematic objective 10. Through the integrated documentation of the Historical Theatres of Emilia-Romagna affected by the 2012 earthquake, the research aims to elaborate on one hand a meta-form- expeditious protocol- for the survey of seismic damage for the specific architectural typology, intended as an implementation of the current MiC procedures, on the other hand, the development of the integrated protocol of seismic damage survey, specific for the analysed architectural typology. The integrated protocol starting from the systematization of data and metadata archived by the Agency for the reconstruction of the Emilia- Romagna Region proposes the digital implementation of the same within the H-BIM platform developed under the INCEPTION project, funded by the European Commission and coordinated by the Department of Architecture of the University of Ferrara, to ensure the mitigation and management of seismic risk in both emergency and routine programmatic maintenance.

Keywords: historic theatres, critical comparative analysis, integrated protocol

1 INTRODUCTION

The critical comparative analysis has organised on two overlapping levels of information. The first relates to the analysis of the data and information reported in the MiC forms - earthquake, sent by the Agency for the reconstruction, compiled in the immediate emergency phase, to survey the cultural heritage damaged by the earthquake. The forms are classified into two specific types: Model A- DC (churches) and Model B-DP (palaces) and have the main goals of identifying the damage index to grant the first economic contributions for the safeguarding of the damaged assets. Furthermore, they represent the basis for the documentation, the representation and the specific diagnostic analysis of the damage by the professionals in charge of the restoration and conservation project. Instead, the second level analyses the data coming from the competent R.U.Ps and related to the specialised investigations carried out by multidisciplinary teams of professionals in charge of the conservation of each historical theatre. Consequently, the comparative methodological framework had to consider first of all the macro-sample of damaged theatres - 25 surveyed through the MiC forms - and then go into detail on a sample of 11 theatres selected by the Agency for Reconstruction the R.U.P made their databases available (Figure 1).

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DOI: 10.1201/9781003253730-15

By comparing the MiC sheets and the specialised surveys submitted by professionals, some weaknesses emerged concerning the current procedures for the survey of seismic damage for the "Theater" typology. These weaknesses are due to the following factors: a) subjectivity of the surveyor, b) expeditious nature of the model, c) application of an adapted form. Factor c) is mainly considered. Most theatres have been surveyed using only the model B-DP - Palaces. Consequently, the damage survey for the specific typology needs a specific form to correctly analyse the correlations between the architectural structure in its articulated planimetric and altimetric configuration and the structural units and the damages found related to the macro-elements.

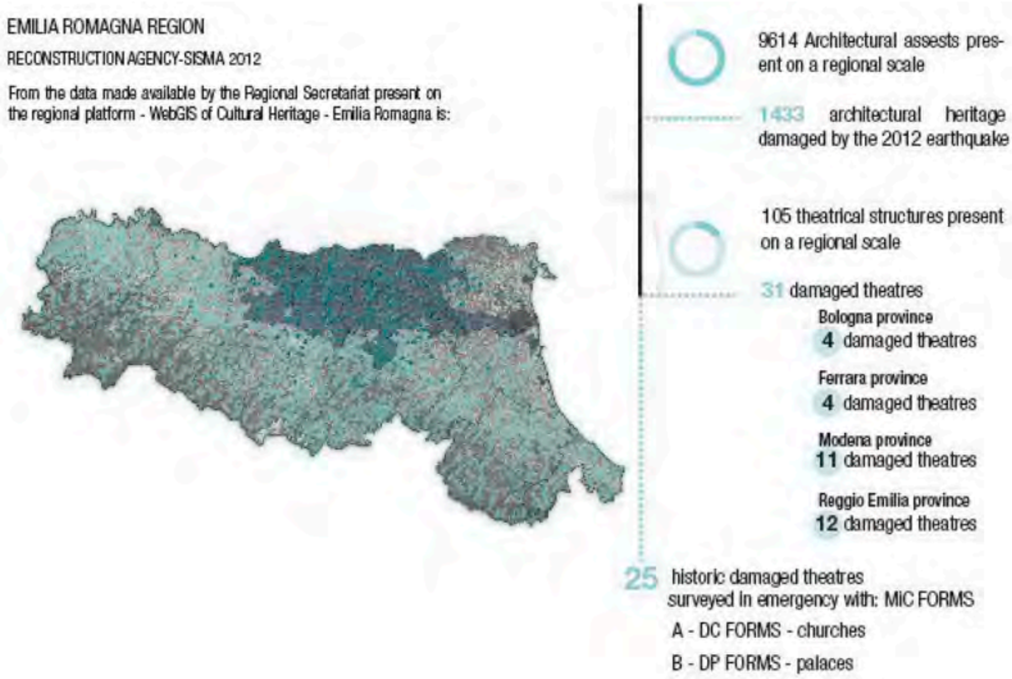

Figure 1. The map shows the 2012 earthquake damages about 80% of the protected regional heritage. In this range, the historical theatres account for 25% of the damaged regional assets.

2 CRITICAL-COMPARATIVE ANALYSIS: MACRO SAMPLE

To systematize and digitise the data collected from the damage forms, and the surveys of professionals have represented the first step to identify the criteria and standards to develop the matrix of the protocol meta-form, on which the integrated protocol of the optimized seismic damage has developed, to ensure an effective tool for the assessment of the seismic vulnerability of a listed asset. Therefore, this means digitising the extracted data and documental systematization within an integrated and interoperable platform. Thus, it is possible to operate and implement data and metadata to integrated seismic risk management for the regional cultural heritage.

Considering the macro-sample of 31 theatres damaged by the 2012 earthquake according to the survey of the Regional Secretariat of the MiC, in collaboration with the Office for the Coordination of post-seismic reconstruction interventions on heritage buildings of the Agency for the Reconstruction of the Emilia-Romagna Region, it has settled to analyse the 25 MiC form of the damaged historical theatres of Emilia-Romagna[1].

In this analytic phase, it has been observed that a majority of the theatres have been surveyed through the model B of the MiBACT forms[2] - model B-PD: Palaces -, while in only two cases - Town Hall and Theatre of Pieve di Cento and Ruggiero Ruggeri Municipal Theatre of Guastalla - the form B have been joined by the model A - DC: churches.

This data underlines the absence of a specific theatres' form gives the possibility of a subjective interpretation of the detectors concerning the architectural-structural space to the damage surveyed. The integration of the two scheduling templates highlights a coherent morphological-structural analysis of a historical theatre that, on the one hand, in the front areas and the dressing rooms are similar to a palace. On the other side, the cavea and stage areas have morphological and structural affinities with the environments of a church.

The experts' analysis supports this approach by optimizing the phases of damage assessment, site management and preliminary and executive interventions. In order to check and verify the static response of the macro-elements regarding the seismic action, four distinct structural units have identified: forepart-foyer (A); hall - stalls (B); stage and backstage (C); dressing room unit (D). This structural-morphological macro schematization shows how the extreme blocks, corresponding to the areas of the forecourt and foyer and the dressing room units, have behaved similarly to the structural scheme of a building under seismic action. Whereas the large free volumes of the hall - the stage and backstage - are schematically in assessment with the free volume of a church hall due to the seismic action.

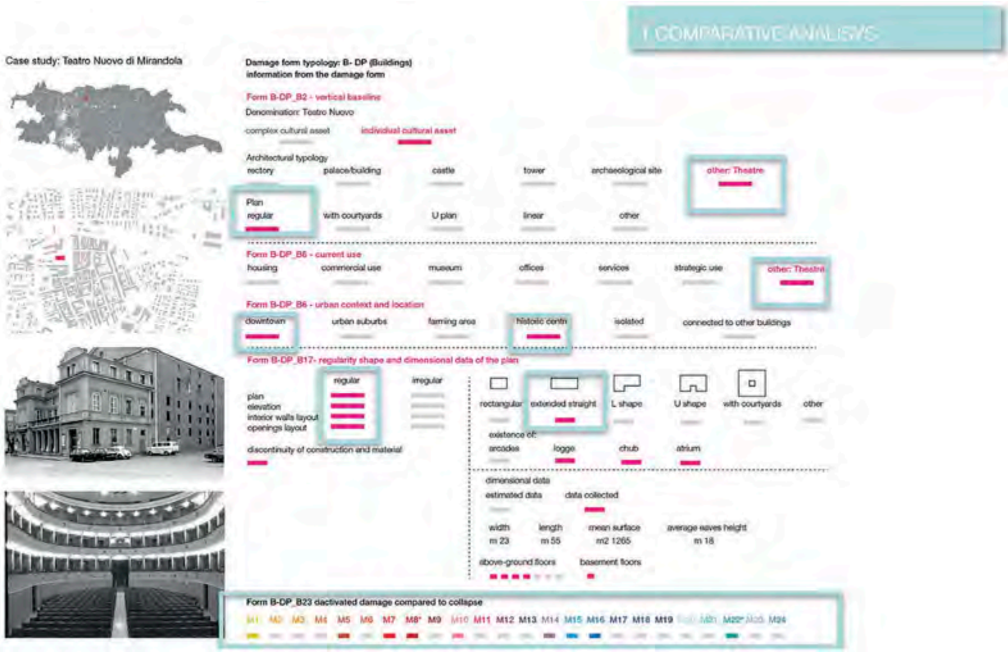

Figure 2. Critical aspects of the current B- DP board. Some fields in the form lack information, sometimes giving an inaccurate reading of the seismic damage.

This aspect allows a more coherent interpretation of the damage level in the emergency phase and an optimization of the subsequent phases aimed at securing the damaged asset and the conservation intervention. The critical comparative approach has shown some critical aspects of the quantitative, qualitative information in the forms (Figure 2).

Analysing the macro sample of 25 theatres and focusing on the field related to the "regularity" of the building (B17), it can be observed that the surveyors identified the theatre, in its interior spatial configuration, as a regular building in planimetric and altimetric aspects. This interpretation is too generic and simplified (Figure 3). Basing ourselves on the morphological-structural macro-schematization, we observe instead that while volumes A and D (reduced - foyer, dressing room block) are confined spaces characterized by planimetric and elevation regularity.

The B and C spaces (stalls, stage and backstage) are open and free volumes in which there are different altimetric levels. Moreover, the hinge nodes of the stairwells and the scenic arch are of great importance with the seismic action. The stairwells connecting the free volumes of the stalls with the box-shaped volumes of the reduced and dressing rooms represent one of the most critical nodes in the overall behaviour of the structure under seismic action. In correspondence with them, there are, in fact, lesions due to the effect of hammering. The section of the scenic arch is also a critical point connecting two free volumes -hall and stage- that under the seismic action influence its static behaviour. In correspondence with the scenic arch, there are phenomena of overturning and partial collapses.

These observations illustrate that the overall regularity described in the form prevents a correct and coherent evaluation of the seismic damage. Therefore this form item would have meaning if related to the single morphological-structural units. The critical study shows that the theatre's entire volume presents more geometric, dimensional, planimetric conformations and elevation variations. This group of variables influences the seismic response of the macro elements, belonging to the specific four individual macro-structural units, determining the consequent deformation and cracking framework on a global scale (Figure 4).

Figure 3. Analysis of field B17 relative to planimetric and elevation regularity.

The analysis of field B17 has followed by studying B23 relative to the collapse mechanisms activated by the earthquake. As the form has formulated, the collapse mechanisms are indicated on a global scale and then referred to the single macro-elements to indicate the damage index. Comparing the data deriving from the forms with the analytical reports and the diagnostic investigations of the professionals, it results again as expeditious survey the data and the information collected follow a subjective approach. In particular, this is clear in the

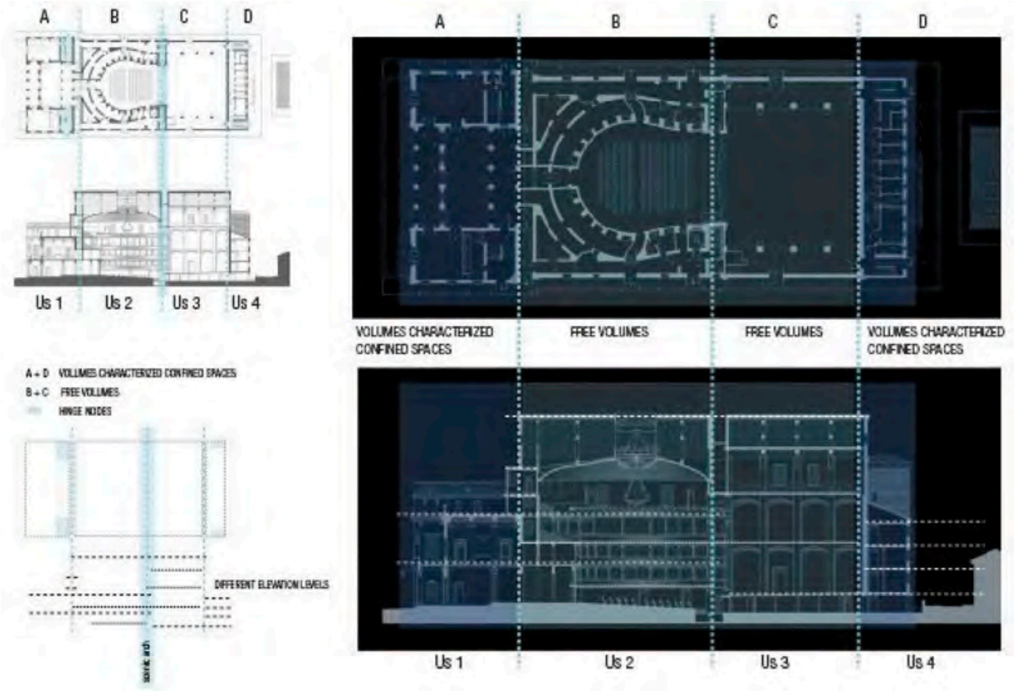

Figure 4. The diagram illustrates the structural, morphological schematization used for seismic damage analysis of theatres.

optimized forms, where a general synthesis of the mechanisms and a percentage estimation are not very accurate.

The information in the current forms misses several quantitative and qualitative information: the stratigraphic-evolutionary phases and the eventual restoration interventions that have taken place over time. This information is necessary for the evaluation of the effective damage index. The need to apply an integrated approach to the specific typology of historical theatres guarantees a coherent survey and assessment of seismic damage. Furthermore, the critical comparison of the analysed data has led to identifying a matrix for developing the meta protocol, which is to be implemented ad hoc for the theatres of the current procedures.

The metaprotocol that will have formulated based on what emerged from this analysis will also consider the standards defined for cultural heritage at the national level by the ICCD but will implement the criteria developed by the European project EU-chic identity card.

3 CRITICAL-COMPARATIVE ANALYSIS: MICRO SAMPLE

The second level of critical-comparative analysis involved the limited sample of 11 damaged theatres selected by the Agency for Reconstruction. The R.U.P of the respective municipalities provided historical reports, damage survey, specialist investigation and related technical elaborations. In particular, this analytical step focused on examining the integrated methodologies and techniques used by multidisciplinary teams of professionals aimed at the knowledge and survey of seismic damage. For each micro-sample theatre, four parameters have identified in order to survey, classify and represent the grade and the quality of the damage related to the architecture after the earthquake: a) overall damage level, methods and techniques for the metric and geometric survey, methods and techniques for the diagnostic survey, damage representation.

The assessment of these 4 indicators and comparing the results obtained concerning the case studies belonging to the restricted sample defined a quantitative and qualitative evaluation of the damage survey - Level of detail of the seismic damage analysis - applied to each theatre. The integrated survey methods and techniques have resulted in a coherent and comprehensive damage analysis that has informed the subsequent phases of the restoration and conservation project. What has been applied in this phase, therefore, has allowed proceeding to a first implementation for what concerns the research field of analysis and mitigation of seismic damage on the cultural heritage of historical tetri of the DAP (data acquisition protocol) defined within the INCEPTION project for the optimization of data acquisition. The results obtained from the analytical sample will be tested on the case study of the Social Theatre of Novi di Modena, for which the flow of the survey operations will be analysed according to specific requirements and indicators related to the planning of the survey project. The survey of the theatre will consist mainly of two phases: a photographic campaign and a survey campaign with Lidar technology and drone.

Therefore to the criteria defined in the DAP will be verified parameters such as the support of the topographic network, the scanning plan, the safety conditions, the technical characteristics of the instrumentation used, the resolution requirements, the accuracy, the mode of acquisition and recording up to control, verification and storage of the returned data.

4 CONCLUSION

Appling integrated methodology used in the critical-comparative analysis has allowed the systematization of the data collected during the emergency phase after the earthquake to document, classify, interpret and return the "significances" of the historic theatre. These data coherently identify the macro structural units and related macro elements against which to express an assessment and verification of seismic damage. Specifically, in the critical- comparative phase.

The double level of analysis carried out has led to the identification of new quantitative and qualitative parameters, standards, on which will be set of a criterial matrix that will

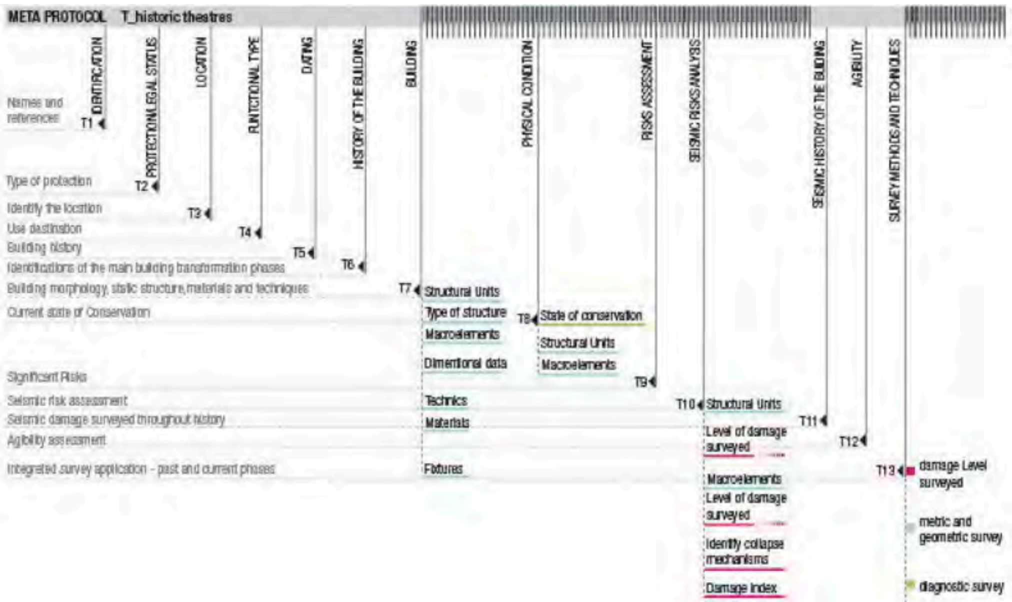

Figure 5. Structure of the meta-protocol for the expeditious survey of seismic damage for historic theatres. It' is a proposed implementation of the MIC sheet on the specific theatres typology -T.

inform the integrated protocol for the survey of seismic damage for the damaged historical theatres of Emilia. The multi-scalar and multi-criteria approach of the matrix will serve to develop, on the one hand, the implementation of the MIC earthquake forms for the specific architectural typology of historical theatres in order to have a more analytical tool –"metaprotocol" - in the emergency phase for a more objective evaluation of the seismic damage occurred.

On the other hand, the standards defined through the analysis conducted, suitably integrated with national and European standards and declined on the specificity of the case study, will be used to implement the DAP of INCEPTION. in order to achieve the integrated protocol of optimized survey of seismic damage. Therefore, within the research, the protocol of damage survey will be declined on the specific architectural typology analysed. However, having been structured based on a multi-criteria matrix modulating specific factors, diversified and declined for different architectural typologies, it will be adaptable and declined to other cultural heritage types to optimize the phases of the integrated survey of seismic damage.

Data and metadata collected in the emergency and post-earthquake phase will be digitized and systematized within the interoperable HBIM platform of INCEPTION. The goal is to develop a digital database through which, choosing different user profiles, an integrated and programmed management of seismic risk is possible in the emergency phase and for ordinary programmatic maintenance.

END NOTES

1 Of 31 damaged theatres, only 25 forms related to historic theatres under protection are analyzed. The remaining six forms concern theatres connected to parochial appurtenances. Therefore they have been left out because they cannot be identified with the intrinsic characteristics of historic theatres.

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Built Heritage in post-Disaster Scenarios – Balzani et al. (Eds)

The damaged cemetery of Emilia-Romagna: From type definition to recurrent collapse mechanism identification

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ABSTRACT: The Guidelines for the evaluation and reduction of seismic risk on Cultural Heritage and the Directive 12/12/2013 of MiBAC identify as first cognitive procedure the compilation of specific sheets to describe vulnerabilities and damage level on movable and immovable assets after an earthquake. Specifically, they refer to two important survey instruments: the A-Church and the B-Palaces sheets. These are the only two tools used between 2012 and 2013 for the damage level characterization of the Cultural Heritage caused by the "Emilia 2012" earthquake. The widespread use of these sheets has brought to light several problems that have negatively affected the successive economic assessment of the intervention.

In fact, if these sheets well describe the vulnerabilities of the specialized types Churches or Palaces, they are ill suited to types with different features, which, in the Emilia-Romagna case, represent about 30% of damage cultural heritage numerically and economically. In particular, the most relevant sample in this set is the cemetery type.

After the analysis of sheets produced for this type after 2012, the need to implementation of the already consolidated procedures has become clear. Starting from a knowledge of the cemetery and an in-depth analysis of the survey data collected on it, it will be possible outline a correct and conscious interpretation of the most critical points and define a new interpretative sheet, closer to a type that represents an important part of the local cultural identity.

Keywords: Cemetery type interpreting, Cultural Heritage, Damage survey tools , "Emilia 2012" earthquake, Macro-element definition

1 INTRODUCTION

Seven years after the earthquake in Emilia in 2012, we have been witnessing an extraordinary response capacity and transformation of the socio-economic system (Zuppiroli, 2019). Now that even the Architectural heritage - the last priority identified - are entering the construction process (Regione Emilia-Romagna, 2019), the key point in the reconstruction phase has been played by the "invariant factors" (Capriotti, 2014), which can be adjusted to other similar disaster areas. The ambitious project promoted by the Emilia-Romagna region, aiming at the capitalization of experiences, is the analysis of what has been achieved so far and the identification of both strong and weak points of the reconstruction process in order to implement the best policies. The project led to the activation of specific research projects. In the field of Cultural Heritage the earthquake made us more aware of the building evolution (Bartolomucci et al, 2012) but at the same time it puts to a test both its structures and its conservative principles (Dalla Negra, 2012). In this context, the damage survey is among the first operations to carry out in an emergency phase with the hard task of identifying all buildings requirements (structural, conservative and economic).

In Emilia-Romagna, almost the 80% of the damaged public buildings is under protection and the survey campaign has showed some peculiarities in the damage survey report. The significant change in the grants provided for the reconstruction represents a first evidence of this

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DOI: 10.1201/9781003253730-16

criticality nonetheless it shows the great potentialities in the evolution of the damage survey research started in the Seventies. One of the most challenging type of buildings is the cemetery, especially from an economic point of view and for a lack of efficacy in the survey tools. Only 35% of the cemeteries in the preliminary phases were economically well estimated, though their importance for the communities - both for cultural and hygienic-sanitary issues - demands new tools. After the 2012 earthquake 30% of the region's cemeteries were damaged but if we examine the crater area only, the percentage is significantly higher, up to 80%, representing a major damage in terms of numbers from a socio- cultural perspective (Figure 1).

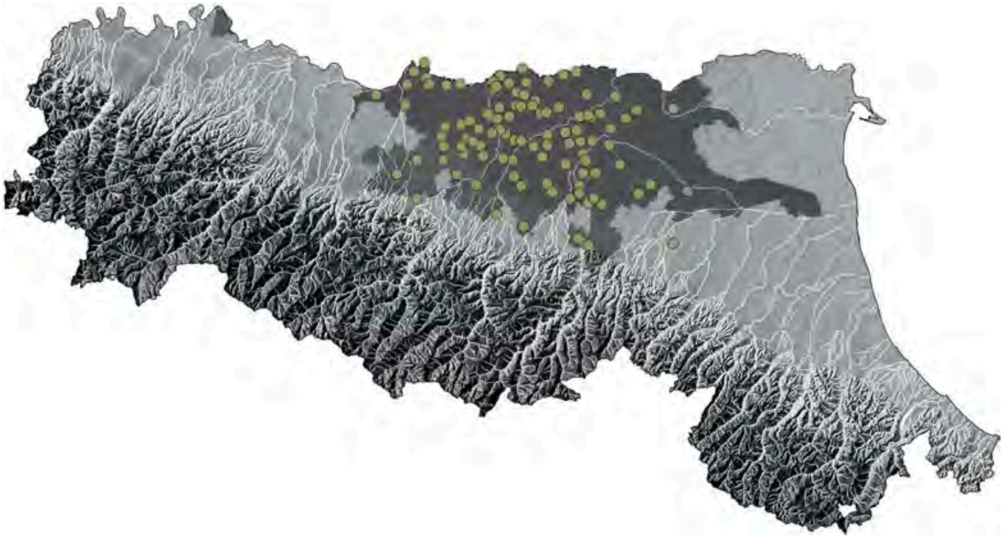

Figure 1. In red localization of Emilia-Romagna damaged cemetery inside the crater area (dark grey).

2 CEMETERIES DAMAGE SURVEY AFTER THE 2012 EARTHQUAKE

2.1 *Sheets for the damage survey on the architectural heritage*

The earthquakes occurred in the last 30 years have revealed the significant vulnerabilities of architectural heritage. These are strictly related to the building construction quality, the form and dimension of architectural components and anti-seismic devices which are connected to the seismic activity of the area and to the time distance between construction/renovation and the earthquake (Lagomarsino, Podestà, 2005). A proper identification both of the historic buildings' vulnerabilities and the related activation level of the collapse is a useful tool for prevention and for managing the after-earthquake reconstruction phase. With the aim of providing a support in the complex and delicate emergency management phase, in Italy a series of sheets of different levels have been studied, that through a guided procedure should eventually assess vulnerability, damage (Papa, Di Pasquale, 20113), practicability and lastly the intervention costs.

The sheets currently in use are the result of several studies and experiences. These range from studies of the research unit coordinated by Doglioni on all churches in the Friuli region damaged by the 1976 earthquake (Doglioni et al, 1994) to researches carried out by GNDT, INGV and the Department of Engineering of Genova coordinated by Lagomarsino (Lagomarsino, Podestà, 2004a, 2004b, 2004c), regarding religious buildings only. The fact that churches are more vulnerable compared to other historical buildings led in 1987 to a practical application of the first damage survey sheet, the GNDT-S3, which later would become the well-known "FORM A-DC church". This sheet was officially adopted for all religious buildings in 2001 (Presidenza del Consiglio dei Ministri, 2001), later modified and re-approved in 2006 (Presidenza del Consiglio dei Ministri, 2006). More sheets have been added over the years, related both to movable assets and to other buildings types. Therefore, it was created the "FORM B –DP palaces" for the most relevant historical buildings, which is quite recent and for this reason it is still object of discussion, improvement and optimization. All these sheets were then incorporated by the Italian Ministry of Cultural Heritage in the "*Guidelines for the evaluation and reduction of seismic risk on Cultural Heritage*" (Ministero per i Beni e le Attività Culturali, 2006) and in the Directive 12/12/2013 "*Procedures for management of activities for cultural heritage securing and safeguarding in the event of emergencies caused by natural disasters*" which, together with the NTC2018, represent the most relevant legal texts for any intervention on the architectural heritage damaged by earthquakes.

2.2 *The application of existing tools to cemeteries*

"FORM A-DC church" and "FORM B –DP palaces" are, therefore, the models applied in the 2012 earthquake in Emilia-Romagna. The use of these tools, strictly connected to the type they describe, even if they are the only ones currently available, has highlighted the need to intervene with appropriate adjustments, in particular with reference to types of a different nature such as cemetery units. In this case, several problems have affected the damage detection process. First of all, the operators chose the most suitable sheet to use. The answer to this question in 2012 was ambiguous and followed three different approaches. In some cases, the choice fell on the use of only "FORM A-DC church". This preference, which has the certain advantage of embracing all the aspects borrowed from ecclesiastical buildings (chapels with apses, domes, pediments, etc.), probably arises from the willingness to identify the element of greatest vulnerability in the portico. When filling in the sheet of the cemetery of Sant'Agostino, both mechanism 5 and 7 are identified as a vulnerability, i.e. 'transversal response of the hall' and 'longitudinal response of the colonnade', so as to be able to insert collapse mechanisms for both actions of the forces acting on the porch. In contrast, the "FORM A-DC church" does not face a problem such as the large spatial articulation of cemeteries, the wings of which can be damaged in different ways. This is the probable motivation that led most compilers to use "FORM B –DP palaces". It is a model that, since it is studied for buildings, by means of dividing it into areas, allows greater articulation in damage description, considering the responses of the structure and different collapse mechanisms for the different parts. Although from a first analysis, the sheet seems to allow greater descriptive freedom, it however lacks the description of the typical mechanisms of large halls of an ecclesiastical nature. The impossibility of indicating the mechanism in the section dedicated to the calculation of the damage index (although it is often correctly reported in the note) prevents the correct calculation of the index itself. Furthermore, it is the same freedom and at the same time the descriptive rigidity of the sheet that causes excessive simplifications in relation to the extension of the cemetery unit. In the monumental cemetery of Mirandola, with reference to the precise cataloguing of the walls, we finally come to describe the state of collapse of a portion of them but not the initial collapse of the surrounding areas, therefore indicating only one part of the damage.

The inadequacy is even more evident if it is reflected in the damage indices. Referring the two cemeteries mentioned above, as example, the index extimated are 0.17 for the Sant'Agostino cemetery and 0.12 for the Mirandola cemetery on a scale from 0 to 1, where 0 means lack of damage and 1 the almost totally building collapse. The first is severely damaged due to the relative movement between the parts generated by the liquefaction of the soil. In addition to collapsed areas, the second cemetery has large portions that are close to collapse. In both cases, the damage index should have been greater than was actually calculated. Another point to consider is the difference in index calculation between "FORM A-DC church" and "FORM B –DP palaces". With the same formula, $Id= d/5n$, the parameters "d" and "n" are counted differently in the two sheets. In particular, the "FORM B –DP palaces" requires greater attention, which, in general, is not well suited to a survey in an emergency phase. The result is an improper identification of the two parameters leading to damage indices which are in some cases only slightly different from the correct ones, as in the case of the cemetery of Cortile in Carpi (MO). In other cases, such as the cemetery of San Giovanni in Concordia Sulla Secchia (MO), the index is even greater than one.

Probably, the need to combine some elements of the two sheets pushed a certain numbers of compilers to break down the cemetery into two models, using “FORM A-DC church” for the mortuary chapel and “FORM B –DP palaces” for the remaining areas. Although the choice seems to be the natural solution to the problem of the inadequacy of a single instrument, in actual fact it does not provide a uniform indication of the damage to the building. Furthermore, the breakdown of the cemetery into multiple micro-units is an additional problem. The use of multiple sheets is in fact allowed in relation to the identification of a structurally separate unit.

However, for the specific nature of the cemetery, this simplification is not easy to apply and to consider the organism sometimes as unitary may lead to a rough description of the damage. On the other hand, a detailed description of each unit does not necessarily consider the interaction between the different parts. At least, the uncertainty on how to evaluate particular features of cemeteries - such as chapel (annexed bodies -same sheet- or structurally separated parts -new sheet), wall tombstones, sculptures or enclosure walls - has affected all the abovementioned approaches, making clear the needs of a new sheet, closer to cemetery *type*.

3 TOWARDS A CEMETERY SHEET

3.1 *From the typological analysis to the macro-elements definition*

The design of a new diagnostic tool, as a damage survey tool, require first the awareness of the investigated type and its development in order to define and structurally re-classify its features so as to allow the surveyors on-site to interpret each building belonging to the type.

About this, it must first be specified that modern cemeteries were born in 1804 with the Saint-Cloud edict through which Napoleon Bonaparte regulated the cemeteries construction and definitely demanded to build them far from urban areas.

Considered the founding event of the “culte des morts” (veneration of the dead) in the modern western culture (Aries, 1977), it is the act through which in France and then in Italy the criteria for planning new cemeteries were definitively established. The edict represents both the hygienic principles of the Enlightenment, which had already analyzed the problem of burials in the eighteenth century, and the new nineteenth-century feelings related to the singularity of each person and to mourning. The modern cemetery, also called by some scholar “cimitero borghese” (bourgeois cemetery) (AA.VV.,2000), was then defined and seen as a mirror of the society and of the new hierarchical organization. Nevertheless, this new attitude toward death did not lead to a new dedicated space but, according to the Saverio Muratori School’s interpretation, it changed the features of the pre-existing cemeteries, emphasizing some peculiarities and determining the definition of two typological series connected to different matrices of specialization (Maffei, Maffei, 2011). Through the ban of the stacked burial in the mass graves and the establishment of the practice of the singular burial as mandatory, sometimes combined with the incineration as well (Ragon, 1986), still the new rules of the edict demanded a rethinking of the model for burials.

On one hand we see the definition of the garden-cemetery, whose Père Lachaise -France, 1803- is one of the most famous examples. In this case, the matrix of specialization is a naturalistic one and it comes from the medieval cemetery built outside the city and settled in the twelfth century. Characterized by a wide but enclosed perimeter, the abundance of space makes family chapels and great singular tombs the primary and preferred method of burial here. The strong connection between death and nature will lead to the definition of several variants, from the American lawn- cemetery to the German forest-cemetery, up to the first current reflections on the cemetery-landscape.

On the other hand, especially in the south Europe, the Saint Cloud edict collided with a still strong medieval tradition, the “camposanto” (literally “holy field”), a cemetery with large porticoed wings where bones of exhumed bodies were drained before placing them in the ossuaries above. The new cemetery codes were incorporated into this pre-existing cemetery model defining a second typological series called by Donghi (Donghi, 1935) “a pianta architettonica”

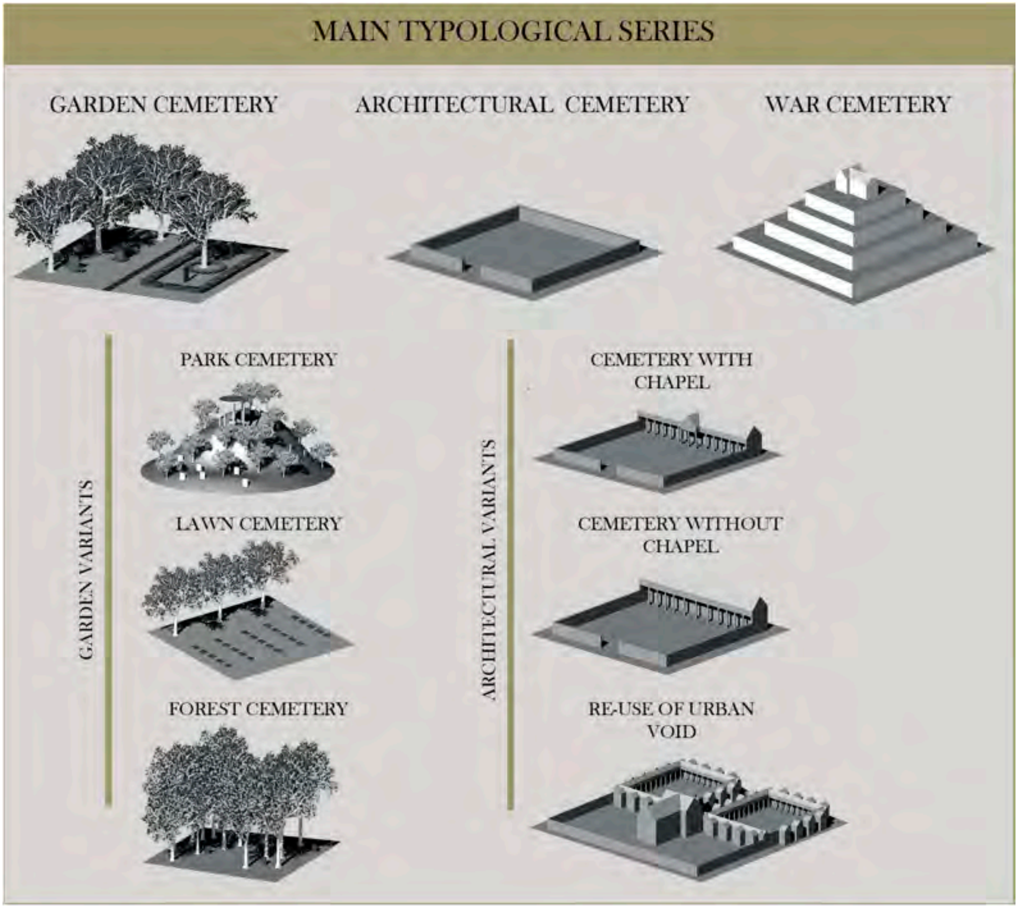

Figure 2. Scheme of the main typological series for cemetery type and its variants. Three different matrices (the nature, the enclosure and the monument matrices) can be considered the main matrices of the cemetery type during the ages.

(architectural drawing series). It adapts its pre-existing architectural features to the new regulatory requirements by reintroducing an archaic burial model that allowed responding to the new needs of singularity and recognisability, while also maximizing the use of space: the columbarium. This is a high architectural value solution, characterized by quadrangular areas fenced by walls, with porticoes of different sizes, in which are placed the new burials.

This is the most used solution in all small-and-medium-size cemeteries in Italy, especially in the area that we are examining: the Emilia-Romagna Region. Based on this model we identify three different variants: a cemetery delimited by porticoes with a central chapel (i.e. the cemetery of Concordia sulla Secchia (MO)), a cemetery delimited by porticoes without a central chapel (i.e. the cemetery of Finale Emilia (MO)) and the reuse and of huge buildings outside the city (the chartreuses of Bologna and Ferrara). Finally, it is worth noting that, especially since the beginning of the twentieth century, we are witnessing a so-called process of standardization, a tendency of the typological series belonging to the same specialization - here the cemeterial one - to equal out characteristics of the different series (Maffei, Maffei, 2011).

While the funeral chapel/family tomb initially represented one of the constitutive components of the garden cemetery with the columbarium playing the same role in the architectural one, today both elements are used within the cemetery perimeter to infill the space . In Italy it is not surprising to find cemeteries that are initially built with a chapel from which two arms of columbarium branched out and that develop afterwards through the use of family tombs, as in the case of the cemetery of Santa Caterina at Concordia sulla Secchia (MO). A final consideration here on the existence of a third typological series: the war cemetery. In this case the underlying matrix of the cemetery is the monument. These cemeteries do not develop like the others, but are a permanent monument to dead victims of a specific war (Figure 2). From the typological analysis it is possible to define the typical features of each type to which correspond homogeneous structural behaviours, the so called macro- elements, according to the definition of Doglioni (Doglioni et al, 1994). In particular, in this case it is possible identify five macro-elements that define the cemetery.

The first is the columbarium that describes most of the Italian cemeteries since they are belonging to the architectural-cemetery series where the columbarium is the main element. In addition, we can define as a further macro-element the family tombs. It is worth reminding, however, that such a model spreads in Italy due to a homologation of typological series process, thus in a second moment. Even though it is present in the crater area, the major use of this element occurs where the orographic characteristics make the use of the columbarium complicated or where the social concept of family is still strong, (i.e. in southern Italy).

From the beginning, then, common features to both typological series, and which have an autonomous structural behavior, are the presence of a surrounding wall and of a funerary chapel (required for the cemeteries distancing from cities and churches). A further one must be added to these four macro-elements. The religious function of the type inevitably leads to an ennobling, variously emphasized, of some elements of the enclosure: the entrances, or more in general, the crossing points. These, dividing themselves from the surrounding walls, or from the columbaria in which they can be included, define independent architectural elements, which allude to the concept of the passage, of moving from a live space to a contemplative one. The type subdivision in elements that are easily recognizable and intelligible by the surveyors is the first and indispensable phase to be able to design a new damage tools for the cemetery.

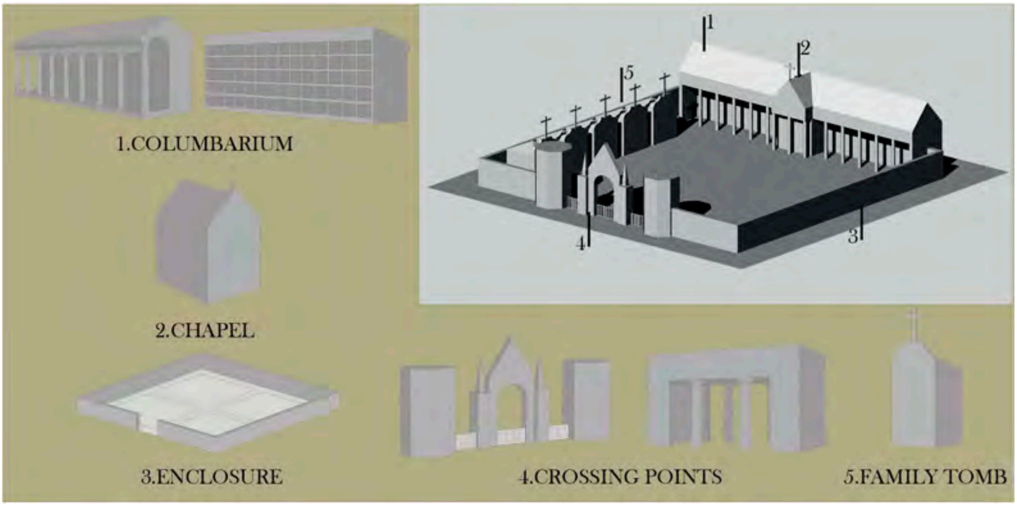

Figure 3. Scheme of the Macro-elements of the architectural cemetery type.

3.2 *Mechanisms of collapse occurred by Emilia-Romagna's cemeteries – a first recurrent mechanisms definition for the cemeteries sheet*

If on one hand the analysis of the damage sheets used for cemeteries in 2012 highlights the difficulty to apply it to the type, on the other hand the great photographic data that supports them leads to a first observation on recurrent collapse mechanisms in cemeteries that can be included in a new tool. The same observation can easily be considered on a national scale and subsequently adjusted. The impelling hygienic-sanitary requirements and the impossibility of function relocating in a provisional and alternative place, as it is possible for churches, have caused that securing and/or restoration of the cemeteries took place earlier than in other buildings, thus making it impossible to observe the damage directly. In this sense, the photographs collected during the surveys allow us to see today what the surveyors between 2012 and 2013 observed and identify the collapse mechanisms related to the type. However, their determination must be interpreted, as a typological analysis, also in relation to the macro-elements defined above: mortuary chapel, family tombs, surrounding wall, crossing points and columbaria.

With reference to the first mentioned two macro-elements it is undeniable that these mechanisms may derived from those already identified by the "FORM A-DC church" even though not all 28 mechanisms are statistically relevant to the cemetery type. Mortuary chapels, for instance, are usually single-nave, without transept or bell tower, where finding an apse is extremely rare. This makes it hardly possible to identify some mechanisms, such as those linked to the bell tower or to the side-chapels, without invalidating the studies previously carried out. A similar consideration can be applied to family tombs, generally simple recent elements, not exceeding two floors in height, with few openings, therefore with a good structural behavior to earthquake, but with pediments that are a great vulnerability. In these cases, the cemetery survey sheet will report only the recurring mechanisms for the cemetery, leaving out those statistically unrelevant, enabling further mechanisms and vulnerabilities to be filled in if necessary when we find particular elements, such as transepts.

The macro-element surrounding wall is one of the most common element in the cemetery building. Its presence and extension is closely related to the infill process of the cemetery enclosure. Where the infill process of the area has not been completed through columbaria or has been achieved by successive doubling of the built volumes (i.e. cemetery of Finale Emilia) or, again, where the saturation of the cemetery occurs through ground burial (i.e. in the Israelite cemeteries), the surrounding walls represent one of the first vulnerability. It generates, during an earthquake, out-of-plane overturning or foundation subsidence mechanisms. More challenging is the situation for the macro-elements of crossing points and columbaria. It should be specified that both macro-elements have two distinct configurations. In the case of crossing points, it is necessary to distinguish between entrances that are structurally corbel, with or without secondary construction, and elements with covered crossing points. The first case is typical when the macro-element is combined with the surrounding wall macro- elements. In this case, the element is also configured as a corbel variously monumental in relation to the cemetery relevance.

Its recurrent mechanisms are:

- Tipping over of the walls. An out-of-plane collapse mechanism that has the horizontal hinge not necessarily on the ground but often also at the end elevation of the adjacent surrounding wall.
- Tipping over of the projecting elements. These elements are particularly present in monumental entrances where pinnacles and other elements are used to highlight the entrance.
- Hinge formation in arches. In this case the presence of entrances with arches and an earthquake direction acting in-plane of the entrance can generate a behaviour just well defined by "FORM A-DC church" sheet for the triumphal arch.
- Damage to accessory spaces. The entrances can be combined with simple polygonal buildings in which the guardhouse or material collection functions are gathered. These are simple elements, with few openings and generally good earthquake behaviour. In this case, although rare, out-of-plane as in-plane mechanisms in the facades may occur.

When you are in the presence of elements with a covered through compartment, the most common damage is the overturning of the facades, damage to the vaults and suspended ceilings, hinge formation in arches and, where present, domes damage.

Finally, the last macro-element is the columbarium. These structures may or may not have a portico. In the particular case of Emilia-Romagna, however, it must be pointed out that in the crater area only 2% of the cemeteries show the non-porticoed variant.

In the presence of columbarium with portico among the recurrent damages, we can easily identify:

– Tipping over away from the colonnade floor. It represents the main collapse mechanism of the porticoed wings of the cemeteries, activated for most of the damaged units. This is a result of the combination of the seismic action of the roof on the portico.
– Collapse and/or damage to the vaults and suspended ceilings. Secondary mechanism with respect to that of the portico generally activated for the rotation of the plinths due to the tipping over of the colonnade.
– Tipping over of the projecting elements away from the floors. Although it does not trigger a structural collapse mechanism, the presence of attic solutions, point and/or linear architectural elements aimed at hiding the pitches of the roof constitutes a serious vulnerability in

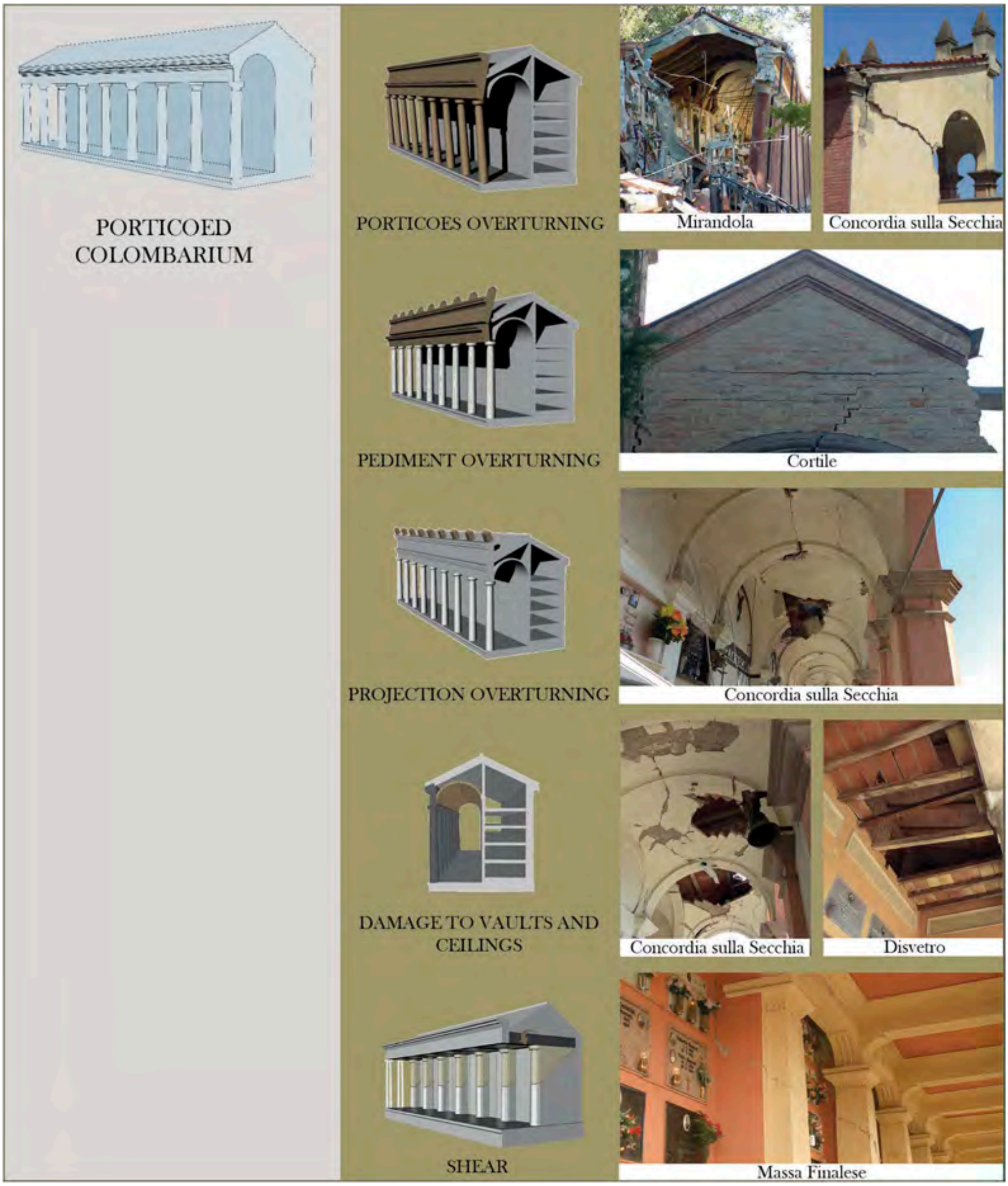

Figure 4. Recurrent collapse mechanisms for the columbarium macro-element identified by the analysis of photographical data realized during the 2012/2013.

the structure. The tipping over of these elements can take place externally or inwards as the case of the Concordia sulla Secchia Cemetery
– Shear damage. The cemeteries structure promotes out-of-plan actions as main action. However, the presence of mixed structures with columns and brick walls on which insist concrete-masonry floor with high beams, which architecturally configure ceiling coffered solutions, promotes the development of very dangerous shear effects as in the case of the cemetery of Massa Finalese in Concordia sulla Secchia.
– Damage by interaction of the structures. The heterogeneous set of buildings that develop by successive additions is conducive to triggering interaction mechanisms among the structure.

From the observation of photographs of the Emilia-Romagna cemeteries it is also possible to identify other damages whose presence, however, seems to derive from constructive lacks, usually not recurring in the cemetery type but belonging to a particular cemetery, instead. In this case, we are not dealing with recurrent mechanisms but with particular damages of specific cemeteries.

Finally, the lack of columbarium structures without porticoes in the area under investigation does not allow identifying collapse mechanisms in this architectural configuration. However, its recurrent mechanisms may be eventually analyzed by evaluating damage to cemeteries outside the crater area of "2012 Emilia" earthquake.

4 CONCLUSION

The "2012 Emilia" earthquake has enabled us to identify both the strengths and the weaknesses in the procedures of emergency management, which was very useful for the reconstruction.

The damage survey aims at giving a first description in order to understand the damage level of the Architectural Heritage and to improve safety measures. It also aims at making a first economic assessment of the reconstruction costs, that is why if the evaluation is as close as possible to the real needs, we will becoming more aware of the resource management and be able to easily identify priority actions.

For this reason the analysis of the cemeteries damaged by "2012 Emilia" earthquake, whose restoration has financially accounted for 20% of the resources provided in the Plan for the Reconstruction, represents a great opportunity to implement the existent instruments. Such as for previous earthquakes, elements like the typological analysis, the vulnerability evaluation and the observation deriving from the same sheets compiled after the "2012 Emilia" earthquake could give us new tools to combine with the existent ones.

This is a requirement that cannot be postponed considering the significant increase in terms of intensity and frequency of natural disasters - globally and locally - and it has all the potential to be soon integrated and improved following the results of examples other than those of the Emilia-Romagna crater.

ACKNOWLEDGMENTS

The author would like to acknowledge the Emila-Romagna Region for funding the research. Funding provided by European Social Fundings of the Operational Programme 2014/2020 Regione Emilia-Romagna: High Competences for Research, for Technology Transfer and Business.

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Built Heritage in post-Disaster Scenarios – Balzani et al. (Eds)

Analysis of damage mechanisms of fortified heritage and proactive information tools to prevent seismic risk

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ABSTRACT: The recent Italian seismic events have highlighted the high seismic vulnerability of a very common and distinctive architectural type: fortified architectures. This research project, in partnership with Regional Agency for the Reconstruction –2012 Earthquake, focuses on the analysis of 21 castles damaged by 2012 Emilia earthquake.This article shows a first analysis of the large amount of data, produced after the seismic events of May 20th and 29th 2012, about the fortified architectures. The data are reorganized according to two levels: building level and territorial level. The first part of the article is focused on the analysis of typical damage mechanisms of fortresses, including the critical aspects of the application of the inventory sheet (form B-Palace) to the castle typology. The second part illustrates a GIS database, designed with a predictive approach. Indeed, this geodatabase is not only a passive storage system, but, uploading the shakemaps, it can become a tool for seismic risk prediction and damage prevention.

Keywords: Damage mechanisms, Emilia earthquake, fortified architecture, GI, proactive geodatabase

1 INTRODUCTION

In Italy, the experience of past earthquakes has highlighted not only the vulnerability of architectural heritage, but also the critical aspects of tools for the prediction of their seismic behavior. Indeed, the standard modeling procedures for ordinary buildings cannot be used for complex masonry structures, which characterized the majority of Italian historical heritage, such as churches, palaces and last but not least fortified architectures. This article focuses on the analysis of 21 Emilian castles damaged by the seismic events of May 20th and 29th, 2012 (Figure 1). In order to forecast the real vulnerabilities of this typology, it is necessary to take a step back and adopt an empirical approach, linked to the observation of damage. Indeed, it has been widely recognized that each masonry building typology is associated with specific recurrent damages (Blasi, 2013). However, there are typologies that are more studied than others.

The 1976 Friuli earthquake, for example, provided the occasion for the first systematic study of the effects of a seismic event on specific masonry structures, such as churches (Doglioni et al., 1994). Then these studies were implemented by the *Linee Guida* (Guidelines, 2008), which include specific inventory sheets for churches (form A) and palaces (form B), with the abacuses of damage mechanisms. The inventory sheets divide churches and palaces into specific macro- elements and associate each of these to one or more damage mechanisms.

Therefore, the 2012 Emilia earthquake can become an opportunity to study the mechanism of other historical masonry structures, which are vulnerable to the earthquakes. In this regard, in 2018, a program of Emilia Romagna Region has funded three PhD researches, in collaboration with the *Agenzia Regionale per la Ricostruzione – Sisma 2012* (Regional Agency for the Reconstruction – 2012 Earthquake), for the analysis of three architectural types, until today

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DOI: 10.1201/9781003253730-17

great absents in the Italian technical laws, although they are widely spread: theaters, cemeteries and fortified architectures. These typologies get damaged by typical and recurring mechanisms. It would be necessary to define a specific tool for the damage survey of these typologies.

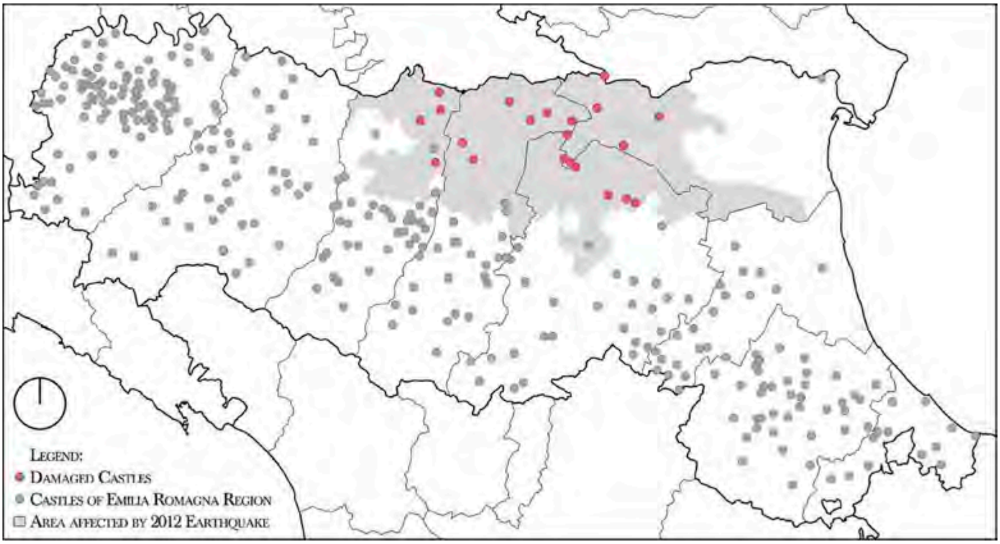

Figure 1. Localization of Emilia Romagna fortresses (in gray) and of the 21 damaged case studies (in red).

The fortresses, widely spread in Emilia Romagna Region, were affected, and extensively damaged, by the earthquake of 2012 and by the more modest of 2008. These events, especially the most recent, have prompted analysis of the effects of the earthquake on such historical structures, for example Cattari et al. (2014) and Coïsson et al. (2016), where it is pointed out that today, unfortunately, there is not an Italian national list of these assets and their state of conservation. Furthermore, in this regard it would be very useful to design proactive software to identify the vulnerability of architectural heritage on a territorial scale (Lenticchia et al., 2017). In compliance with the tools currently used by the government of Emilia Romagna Region, this research project takes advantages of the use of GIS (Geographic Information System), in order to highlight the main vulnerabilities and weaknesses of each building analyzed and to prevent the seismic risk.

2 THE HISTORICAL EVOLUTION OF THE FORTIFIED ARCHITECTURES IN EMILIA: CONSTRUCTIVE FEATURES AND VULNERABILITIES

The Emilia Romagna Region is characterized by the presence of more than 300 fortified architectures on its territory (Web-1). Indeed, the division and the political instability of the Emilia Romagna Region, which lasted until the end of the 15th century, had contributed to the wide spread of fortresses (Perogalli, 1972). The term fortified architecture actually includes a very wide variety of buildings, such as castles, fortresses, citadels, fortified villages and other constructions (Perogalli et al., 1979; Cassi Ramelli, 1964; Caciagli, 1979). This research project focuses on the analysis of 21 fortified architectures damaged by the 2012 earthquake (Figure 1). The case studies were selected thanks to the results of the queries of the WebGis of the Emilia Romagna Region (Web-1) and in order to identify a homogeneous set of case studies, with common and comparable characteristics:

2.1 *The materials*

The above fortified architectures, built or renovated under the impulse of an imminent danger, are characterized by the use of local materials, cheap and easy to find (Aceto, 1995; Tosco, 2003). Therefore, in Po valley the masonries are mostly made of bricks and lime mortar (Balestracci, 1989; Mantovani, 2003). After the analysis of the documentation deposited in the archives of the *Soprintendenza Archeologia, Belle Arti e Paesaggio per la città metropolitana di Bologna e le province di Modena, Ferrara e Reggio Emilia* (Cultural Heritage Department for the metropolitan city of Bologna and the provinces of Modena, Ferrara and Reggio Emilia), it emerges that these structures have usually a core walls made of reused bricks and poor lime mortar. For this reason, the leaves are not well connected and often they are completely independent. This circumstance represents a first condition of seismic vulnerability of the fortresses and it is the main cause of the delamination of the cladding.

2.2 *The historical period*

These case studies are included in a temporal range from the 11th century to the 15th century, in this historical period it is possible to include the historical parabola of Emilian fortified architecture (Perogalli, 1972), except in cases of massive restorations between the 19th and 20th centuries, due to gothic revival.

2.3 *The plan*

During the 14th century the plans of the castles in Emilia, especially those located in the Po valley, take a more defined and regular geometric shapes, usually square or rectangular, with square towers at corners and an inner courtyard, accessible through an entrance tower. However, the regular plan will only become the rule in the second half of the 15th century (Perogalli, 1972).

2.4 *Typical elements*

In a fortified complex, it is possible to easily distinguish primary characterizing elements (tower, curtain wall, *palatium*) and secondary ones (merlons, corbels, and other protruding elements). Each element corresponds to one or more damage mechanisms. However, these elements are the result of subsequent changes and improvements, due to a close dialogue between defense and offense, where the first follows and has to constantly adapt to the technological evolution of the second, in order to avoid the inadequacy of the fortress and its subsequent neglect (Cassi Ramelli, 1964). This stratification of different non-coeval structures, within the fortified complex, has certainly represented a second condition of seismic vulnerability. In detail, the two essential elements of the fortifications, until the 10th century, are: the curtain walls, the first ancestral defense, which consists essentially of a continuous fence, and the tower, with the function of sighting. Later the towers began to be built adherent to the walls and the space inside the walls was populated, in a spontaneous and unorganized way, by permanent buildings. The fortified architectures, characterized by a single compact building, are generally of 13th century and especially of 14th century. The Emilian castles of the late Middle Ages (in the late 13th and in the late 14th century) are of three main types: the castle in height (not common), the castle with a central tower, like the fortress of Reggiolo, and the one with angular towers, for example the Castle of Ferrara (Perogalli, 1972). In the provinces of Parma and Modena, in the first half of the 15th century, these buildings began to be equipped with protruding elements, such as corbels, for the pouncing defense. In the second half of the 15th century, the invention of artillery led to a thickening of the walls, in order to absorb the shots. However, at the end of 15th century, the development of warfare techniques will make the Emilian fortifications obsolete. Therefore, the castles take on a residential function, and, in several cases, are transformed into villas (Perogalli, 1972).

This diachronic evolution is one of the causes of poorly connection of the structures, and this condition has generated disastrous phenomena of hammering (tower-curtain wall), or of the presence of buildings adherent to pre-existing structures, for example this condition has caused widespread phenomena of slipping of the beams of the floors of the palatium adherent to curtain walls. Moreover,the considerable differences in height, between the towers and the other buildings, and the position of the towers (at corner, incorporated, protruding or isolated) are certainly elements of further vulnerability.

3 LEARN FROM THE 2012 EMILIA EARTHQUAKE

3.1 *Damage inventory sheets*

In the post-earthquake emergency, the surveys of listed properties, in the areas affected by the earthquake, were immediately started. In Italy, the census of the damages on the listed assets currently uses only two inventory sheets for two specific architectural types: form A, for the churches, and form B, for the Palaces (Papa et al., 2011). These damage inventory sheets are the result of a continuous evolution and integration, after every earthquake. In particular, the form A comes from the studies of Doglioni (1994), carried out through direct observation of the damages of the 1976 Friuli earthquake on churches. In 2001, the form A included only 18 damage mechanisms, increased to 28 in 2006. After theon-the-ground implementation of the inventory sheets form A, it appeared that it was necessary to integrate the damage survey tools with another specific form for palaces. Thus, the inventory sheet form B was born. Then it was applied, for example, in the 2002 Molise earthquake.

3.2 *Damage inventory sheets: Weaknesses*

However for the prompt survey of damages to listed assets, which do not belong to the two aforementioned architectural typologies, the forms A or B are still applied. After the 2012 seismic events, the form B – Palaces were used for the census of damages of fortified architectures. Therefore, the first critical aspects arise. Indeed, if some damage mechanisms of fortified buildings are similar to the mechanisms of the abacus of the inventory sheet B - Palaces, it is also true that fortified architectures are characterized by further typical elements (massive towers, curtain walls, battlements, corbels, walls…), whose seismic behaviors are not in the existing inventory sheets. In this regard, the analysis of the inventory sheets, drawn up in 2012, shows that, on several occasions, the surveyor has used the voice "other" to describe the mechanisms absent in the inventory sheet, but typical and recurrent in the castles: overturning of the battlements and torsion of the towers (Figure 2). Moreover, in several cases, in the same inventory sheet, the damage to the merlons has been recorded simultaneously in two different sections: B19 (damage to structural elements) and B20 (damage to non-structural elements). In some cases there are also transcription errors and forgetfulness. For this reason it is hoped that, in the future, these tools will be digitized, in order to guide the surveyor in the compilation and to speed up the procedure.

	CASE STUDIES	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16	M17	M18	M19	M20	M21	M22	M23
Bologna	Fortress of Pieve di Cento						3																	
	Galeazza Pepoli Castle	5		4			5	5			5	5	2	4	5		5	4	5	4	4			5
	Manzoli Castle	3						2	1		2		2		4				3		2			
	Bentivoglio Castle	2					1	2			2	1							2					
	Fortress of Minerbio			3			2	2			2		2	1	1					2				
	La Giovannina Castle				4	4	3	3		2			3		3					2	2			4
Ferrara	Castle of Ferrara	3			5	3	2	2	4		2		2	1	3	5	2		4					
	Lambertini Castle			3		3	3	4		2		3			3	2			5				1	
	Fortress in Stellata of Bondeno	3										4	4	4	3		3	3	3					
	Fortress of Cento	2				4											2							
	Castle in Santa Bianca of Bondeno					4		4			2					1	1				2			
Modena	Fortress of S. Felice sul Panaro	4			5	3	2	3	4		3	5	4			5	5	5	1		3	2		
	Campori Castle in Soliera					4		2		1					3		2		4		2	2		4
	Pico Castle in Mirandola	4	4		4	4	3	3		4	4	5	3		3		4	4		5	4			
	Pio Castle in Carpi	2				3	3	4		2	2	2		3	3	3	3		2	3	2	4		
	Fortress of Finale Emilia		1		3	2	2	1		4				3			4				1			5
	Carrobbio Castle in Massa Finalese			2			2	2		3		4			4	3	3				4		3	4
Reggio Emilia	Fortress of Reggiolo	3				4	4			5	5				4	5	5							5
	Castle of S. Martino					1	1	1			1		2	2	2		2		1	2	2	2	1	
	Guidotti Castle in Fabbrico						1	1		2	3			2	2									
	Gonzaga Fortress in Novellara					1		1						1	1									1

Legend of damage mechanisms:
M1 overturnig of the walls
M2 vertical flexural mechanisms,
M3 horizontal flexural mechanisms,
M4 overturning of the corner,
M5 shear cracks of façade (bearing wall),
M6 shear cracks of façade (lintel),
M7 shear cracks of internal walls,
M8 sliding of floor,
M9 damage to loggias and porches,
M10 slippage of the beam from the supports,
M11 local collapse of the floors,
M12 damage to the vault due to movements of the supporting elements,
M13 damage to the vault due to strain strength,
M14 damage to stairs,
M15 damage to roof frame,
M16 damage to roofing shingles,
M17 overturning of wall in the garret area and of gable wall,
M18 damage of protruding elements,
M19 local collapse due to construction irregularities,
M20 damage due to irregural shape,
M21 added buildings,
M22 foundation settlement, M23 other.

Figure 2. Damage levels from the inventory sheets form B draw up in 2012.

3.3 *Typical damage mechanisms of fortified architectures*

Therefore, starting from the analysis of the literature (Cattari et al., 2014; Coïsson et al., 2016, 2017; Ferretti et al., 2018) and from the observation of real damages of Emilian castles, through reports and photographic documentation, found at the above mentioned Soprintendenza, it was possible to census, in an organized way, the recurrent damage mechanisms for the typical elements of the Emilian fortified architecture, defining for each mechanism a damage level scale from 0, no damage, to 5, collapse. An overview of some of the most significant mechanisms is shown in Figure 3.

In view of these considerations, it seems therefore useful to implement the tools available today. In particular, one of the aims of this research project is to define a possible proposal for a specific damage inventory sheet for fortified architecture.

4 A PROACTIVE GEODATABASE FOR EMILIAN FORTRESSES

Essential key to the elaboration of this study is the use of GIS (Geographic Information System), which is not only a passive storage system of large amounts of data, but also a proactive tool to define the vulnerabilities on a territorial scale and to forecast and prevent seismic risk. In particular, ArcGIS Pro, a ESRI software, is the software in use. The geographic reference system used fot the geodatabase designed is WGS84 UTM32. In order to transform the experience of the 2012 earthquake on cultural heritage into an opportunity for prevention, it is necessary to start from the analysis of the large amount of documents produced after the 2012 seismic events. Indeed, the study started analyzing the digital data, provided by the Segretariato Regionale (Regional Secretariat), in shapefile format. The attribute tables of these shapefiles and the related physical models were implemented with further information obtained from the inventory sheets, but mainly from the documentation deposited in the archives of the aforementioned Soprintendenza. Indeed, as it is easy to imagine, the stored documentation is more detailed and it should not incur in errors and forgetfulness, typical of

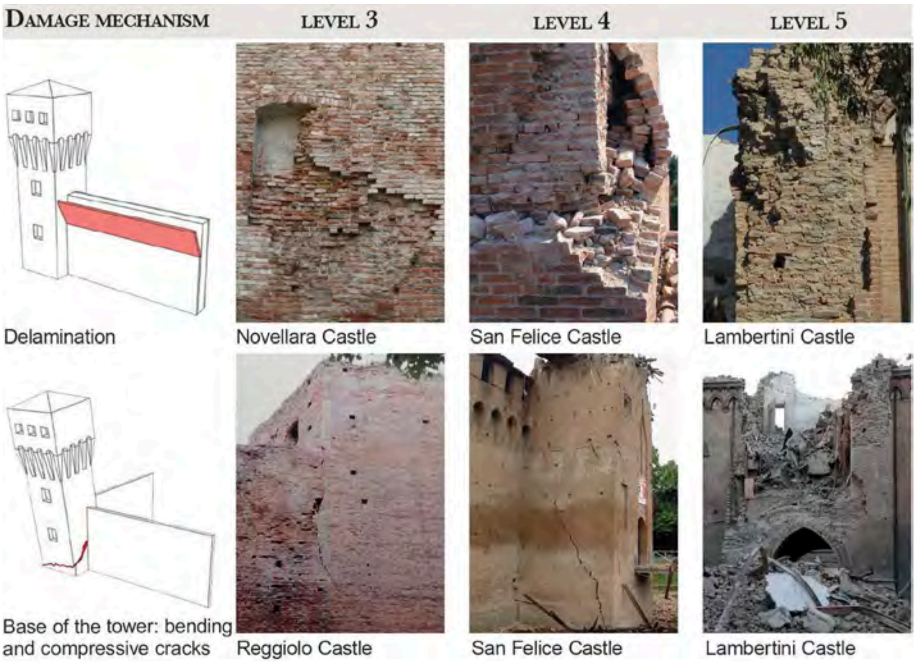

Figure 3a. Some of most significant damage mechanisms (Lenticchia et al., 2017) and the photos of the three most severe damage levels.

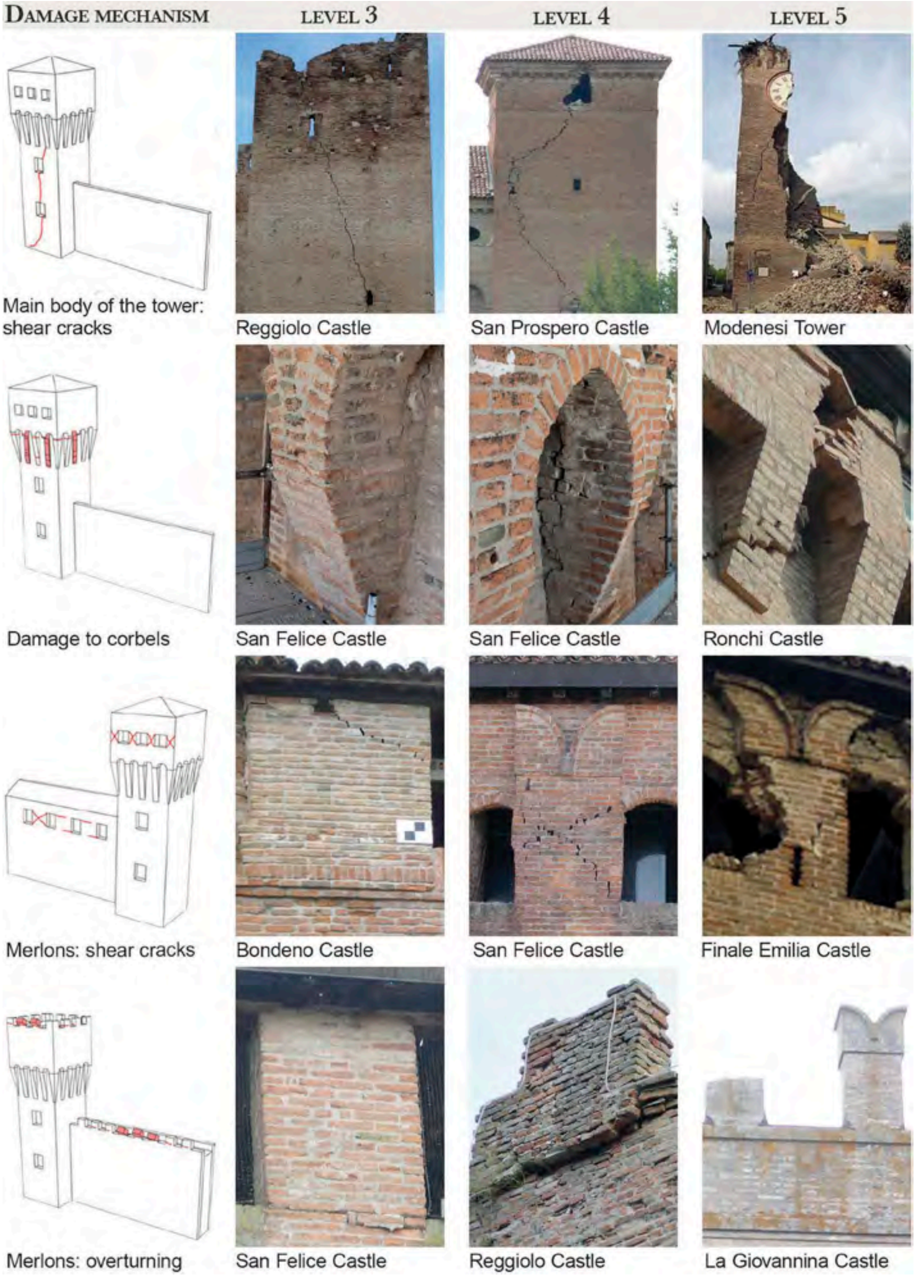

Figure 3b. Continued.

the prompt survey. However, as mentioned above, the project of this database is not only aimed at the systematic and organized storage of the data found. Indeed, a GIS database, being a query software, gives also the possibility to easily compare data of any kind (numerical or textual), even from a predictive point of view. For example, from the preliminary analysis of the data it emerges that free-standing merlons tend to overturning out of plane more frequently than merlons supporting a roof, while the latter tend to be damaged by shear cracks. This example shows that it is possible to identify in advance the main vulnerabilities of the listed assets and potentially prevent and avoid the damages. Moreover, in a second phase, shakemaps have been uploaded in the geodatabase. Shakemaps are a graphic representation of the soil motion (in terms of acceleration, velocity, or displacement). Shakemaps are created in real time by INGV, downloadable as shapefile from INGV web site (Web-3), and finally easily uploaded in the GIS. Thus, for each damaged castle, it has been possible to associate the damage levels to each mechanisms described above and to compare them with the maximum values of PGA, PGV, PSA, suffered during the 2012 seismic swarm (Figure 4), in order to understand which of the three values has a better correlation with each damage mechanism. In particular, 9 shakemaps of the events, with magnitude IM ≥ 5, have been overlapped thanks to the GIS software, in order to find the maximum values. Finally, this phase of analysis and data collection will be fundamental for the elaboration of vulnerability curves for each mechanism, useful to prevent the seismic damages.

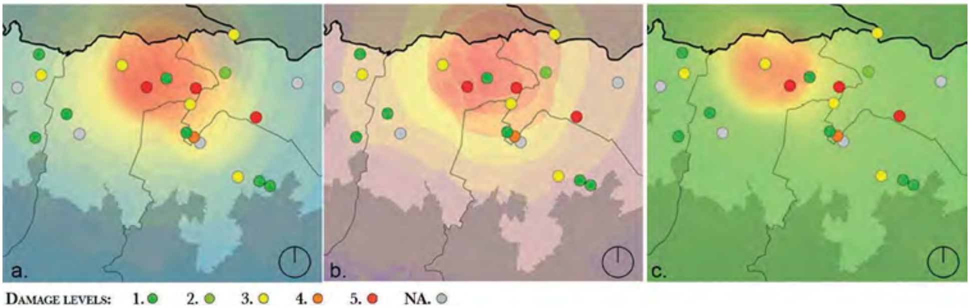

Figure 4. By way of illustration, the figure shows the damage levels for the mechanism of "shear craks" of merlons, with the shakemaps in terms of a. PSA, b. PGA, c. PGV.

5 CONCLUSIONS

Fortified architectures are a very widespread architectural typology in Emilia Romagna and in the whole national territory. This article has focused on the analysis on seismic damages of fortified architectures in Emilia Romagna, which have proved to be highly vulnerable to earthquakes, due to some of their typical characteristics: diachronic evolution of the buildings, not well-connected structures, constructive and geometric features. Thus, because of their recurrent vulnerabilities and, at the same time, because they are so widespread, it is necessary to define an ad hoc damage inventory sheet for fortified architectures. In this way, it will be possible to facilitate the prompt survey, without losing precious information in this first emergency phase.

However, at the same time, it is necessary today, in peacetime, to work to define tools that forecast the vulnerabilities of protected assets on a territorial scale. This type of analysis at a territorial scale takes large advantage of the use of GIS and could be replicated also for other seismic events; in order to act before the expected damage happens. In this regard, the designed geodatabase can be considered a predictive tool for the analysis and forecast of the seismic risk of the architectural heritage. Indeed, thanks to seismic hazard maps, uploaded in GIS software, it is possible to identify the structural elements which are mostly in danger, known their expected seismic action. In addition, it would be possible to do a list of the most urgent interventions and to plan a preventive maintenance program, avoiding operating always in an emergency phase.

ACKNOWLEDGEMENTS

I would like to thank the Agenzia Regionale per la Ricostruzione – Sisma 2012 (Regional Agency for the Reconstruction – 2012 Earthquake), in particular Architect Antonino Libro and Engineer Davide Parisi, for the numerous and valuable suggestions; Dr. Silvana Parisi for the help provided during the consultation of the material stored at the Archives of the Superintendence and finally Professor Eva Coïsson and Professor Daniele Ferretti for the supervision of my ongoing thesis project.

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Built Heritage in post-Disaster Scenarios – Balzani et al. (Eds)

Fostering economic and financial resilience through an ecosystem approach: Opportunities and peculiarities of cultural heritage

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ABSTRACT: The aim of this paper is to investigate economic and financial resilience of cultural heritage with reference to a cultural ecosystem approach. By means of a theoretical investigation and a case study analysis the author addresses the need to increase the financing diversification of cultural heritage organizations not only to ensure financial sustainability but also cultural heritage's ability to deal with calamitous events and damages. The empirical investigation analyses two French case studies of cultural heritage damaged by fire those funding campaign could be interpreted according to an ecosystem approach to financing: the case of the fundraising campaign for the reconstruction of Notre Dame Cathedral in Paris after the 2019 fire and the 2017 equity crowdfunding campaign for the purchase and restoration of the Castle of La Mothe Chandeniers in Le Trois Moutiers. The research results indicate that ecosystem financing for cultural heritage should be based on strong emotional components and the leading role of recognized associations or authorities that legitimate and ensure the accountability of the initiatives.

Keywords: Economic and financial resilience, ecosystem financing, cultural heritage financing

1 INTRODUCTION

In recent years, resilience has become an increasingly debated topic under different perspectives. In terms of management approaches to this theme, resilience is primarily interpreted as a reflection on the functioning of a system, its risk and its common determinants of vulnerability to shocks, stress and hazards. More specifically, the managerial perspective considers economic and financial resilience as an important component of the overall capacity of responding to sudden changes and catastrophes (Bahadur et al., 2010; Davies, 1993; Manyena, 2006). Economic and financial resilience is particularly important for those sectors and organizations that present an inner traditional fragility in their financing structure, such as the cultural heritage sector (Borin, Donato and Sinapi, 2018; Trillo and Petti, 2016). Among the strategies for increasing the financial resilience of the cultural heritage organizations, the cultural ecosystem approach to cultural heritage financing has been indicated as a potentially relevant path (Borin and Rossato, 2020). In this approach, financing should be differentiated and provided by the various components of the cultural ecosystem (public, private and civic) of the cultural heritage organizations. Recently, it means also thinking of both online and offline ecosystems, using also innovative ways of financing such as crowdfunding. This ecosystem interpretation of the financial differentiation strategy needs further investigation with reference to cultural heritage, in order to understand the peculiarities and the best practices that are key to this field. This research intends to address this topic, aiming at answering the following research questions:

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DOI: 10.1201/9781003253730-18

– Is it possible to foster economic and financial resilience of cultural heritage in case of catastrophic events through an ecosystem approach to financing?
– What are the characteristics of successful initiatives for financing cultural heritage interventions in case of disasters according to an ecosystem approach?

The paper is divided into six sections. After this short introduction, section two provides an in-depth literature review on managerial and economic resilience for cultural heritage, with a specific focus on ecosystem approaches to the topic and innovative ways to interpret the financial ecosystem as based on both online and offline communities. In section three, the research design and methodology are described. In section four, the case study analysis of two relevant cases in France is presented. In section five, the author discusses the research results, critically comparing them with the main points emerging in the literature review. In section six, some concluding reflections and remarks are drawn.

2 THE THEORETICAL PERSPECTIVES ON CULTURAL HERITAGE'S RESILIENCE OF CULTURAL HERITAGE: THE MANAGERIAL AND ECONOMIC PERSPECTIVE

Under a managerial and economic perspective, resilience is defined as the ability of a socio-economic system and its components to anticipate, absorb, accommodate, or recover from the effects of a shock or stress in a timely and efficient manner. It is a concept that is strictly related to the functioning of a system and starts from the analysis of risk and its common determinants of exposure, vulnerability and shock, stress and hazards. The managerial approach to resilience considers it to be about managing change and eventually thriving (Davies, 1993; Manyena, 2006) in the context of dynamic systems, which has been termed by some as 'bounce forward ability' (Manyena et al., 2011). Bahadur et al. (2010), identify six key characteristics of a resilient system: 1) a high level of diversity, in terms of access to assets and voices included in decision-making and the availability of economic opportunities; 2) a high level of connectivity between institutions and organisations at different scales and the extent to which information, knowledge, evaluation and learning propagates up and down across these scales; 3) a high level of blending of different forms of knowledge, that allow to anticipate and manage processes of change; 4) an acceptable level of redundancy within a system, that means that some of its components can fail without leading to the collapse of the whole system; 5) the extent to which the system is equal and inclusive of its component parts, not distributing risks in an imbalanced way; 6) the degree of social cohesion and capital, that allows single individuals to be supported within embedded social structures.

These principles also apply in the context of management of cultural heritage organizations. Moreover, resilience for cultural heritage means implementing a process rather than an outcome (Norris et al., 2008), that involves learning, adaptation, anticipation and improvement in basic structures, actors and functions related to the cultural heritage environment. Therefore, applying a managerial perspective on cultural heritage resilience implies setting the basis for a continuous process that includes supporting interventions to increase diversity, connectivity, learning, reflexivity, redundancy, equity, inclusion and cohesion, while brokering the blending of knowledge (Folke, 2006). In this framework, managing cultural heritage for resilience can be interpreted as the need to develop flexible and integrated systems that manage for change, to see change as a part of any system, (social or otherwise) and to expect the unexpected (Folke, 2006). The focus is therefore not only on exploring managerial options for dealing with uncertainty, surprises and changes but also on being proactive (Berkes, 2007; Holtorf, 2018; Obrist et al., 2010; Ravankhah et al., 2017). In sum, resilience means more specifically being able to properly manage resources (e.g. financial, human resources, etc.) and relations in order to increase the ability to manage shock, disasters and unexpected events. Bearing this in mind, a consistent stream of research has addressed the sub-domain of economic/ financial resilience (Allam and Jones, 2019; Burnham, 2018; Goryainova et al., 2018; Jaradat, M., and Mazilescu, 2017; Trupiano, 2005). These researches focused on economic and financial management of cultural heritage organizations as a key point in the managerial approach to resilience, considering that it is necessary to ensure enough streams of funding and financial resources to properly react to shocks and disasters. Financial resilience is still considered an Achille's heel for several cultural heritage organizations (Borin, Donato and Sinapi, 2017). For instance, in Europe a high percentage of cultural heritage relies primarily on funds by a main subject (often public authorities but in some cases also private owners) (Klamer, Mignosa and Petrova, 2010; Manda, Nicolescu and Mortelmans, 2017; Romolini et al., 2020), thus showing a higher degree of fragility in case this main actor will direct its funds elsewhere (Trillo and Petti, 2016). This is particularly risky since the investments in preservation and enhancement of cultural heritage are often consistent. This fragility becomes even more evident in case of disasters, when these costs will increase and the financing institution might not be able to provide the financial resources needed for the emergency interventions (Barakat, 2007). The need to overcome the reliance on limited sources of funding and differentiate funding streams could be met through different strategies including matching various funding sources and involving different stakeholders of the cultural heritage sector: in practice, this will mean applying a cultural ecosystem approach to financing (Borin, 2018; Goryainova et al., 2018).

Cultural ecosystems (Borin and Donato, 2015; see Figure 1) are based on the idea of overcoming «silo » cultural heritage management and rethinking governance systems and management models based on connections and interactions among a variety of actors that are related to a cultural topic or operating in the same field, often within a territorial perspective. With reference to cultural heritage, cultural ecosystems work in the framework of the broader ecosystem to enable the enhancement of cultural heritage potential (Borin and Donato, 2015; Borin, 2018). The cultural values (Klamer and Mignosa, 2019) and the cultural identity of the territory are the starting point for the dialogue among the various actors operating in the cultural ecosystem: cultural heritage and heritage authorities play a central role in shaping this ecosystem, and facilitate the interaction among the other actors and the development of the potential of the ecosystem itself (Borin and Donato, 2015). As a consequence, rethinking cultural heritage organizations with reference to the concept of cultural ecosystems implies changes in terms of governance, management and, more specifically to this paper, financing. In terms of governance, it means designing governance structures in which public, private and civic stakeholders (communities, citizens, etc.) can interact, generating good practices of collective decision-making process and co-governance, thus enabling co-creation. In terms of management, it means exploring the potential of co-management and outsourcing specific functions to the various components of the ecosystem. In terms of financing, it implies reflecting on the possibilities of financial contribution by each subject and increasing the possibility of balancing different funding streams coming from public, private and civic stakeholders (see Figure 2). The reflection on financing through ecosystem approaches has been recently enriched also by the reflection on the potential contribution of online stakeholders, for example through initiatives related to crowdfunding (Cosentino and Pasquale, 2016; Jelincic and Šveb, 2021; Steinbach, 2014). Crowdfunding has emerged in recent years as a buzzword and has been indicated as an alternative to traditional sources of funding for the cultural and creative sector. In short, crowdfunding is based on the collection of many donations of small amounts through specialized platforms (i.e. crowdfunding platforms), relying on the capacity of internet to reach broad online communities (Calveri and Esposito, 2013). Among

Figure 1. The components of cultural ecosystems (Source: author's elaboration based on Borin and Donato, 2015).

Figure 2. Financing in an ecosystem perspective (Source: author's elaboration).

the many categorizations of crowdfunding initiatives, the most common identifies four main crowdfunding models (Battisti et al., 2020; Giudici et al., 2012; Harrison, 2013): donation-based crowdfunding, in which small donations are asked from a large number of people without anything in return; rewards-based crowdfunding, in which donors earn rewards on the basis of the amount they donate; lending-based crowdfunding, in which money are collected from lenders with promise to pay them back at a later date; equity-based crowdfunding, in which donors-investors receive a percentage of ownership in the company.

Among these models, cultural heritage crowdfunding campaigns are for the majority based on the reward and donation model (respectively 83% and 15% of crowdfunding campaigns in 2015 were using these models – Massolution, 2015) while the lending and equity crowdfunding campaigns are the minority (1%). The amounts collected in case of not-so-famous institutions are usually rather small, questioning the relevance of this form of funding for cultural heritage. However, there are few interesting campaigns using equity crowdfunding to raise significant amounts of money. This is for example the case of the crowdfunding initiatives carried out in France by the association *Adopte un Château* with the crowdfunding platform Dartagnans, among which the equity crowdfunding campaign for *Château de la Mothe Chandeniers* in Nouvelle Acquitaine in the famous Loire Valley (France) that will be described in the next sections.

3 RESEARCH DESIGN AND METHODOLOGY

This paper aims at understanding the characteristics of financial and economic resilience of cultural heritage in cases of damages and catastrophes, investigating the topic of cultural ecosystem approaches to financing. Furthermore, the analysis aims at identifying best practices that innovative financing for cultural heritage interventions can trigger when an ecosystem approach is applied. For this purpose, after the initial theoretical review, this paper focuses on the analysis of two case studies of financing of cultural heritage interventions after disasters and damages in which a cultural ecosystem approach was applied. In order to meet the criterium of representativeness (Patton, 2003) the selection included two cases of built cultural heritage that were destroyed after a calamitous event (a fire). The selection focused on finding a case in which the cultural heritage asset that was particularly well-known and recognized and a less well-known case.

The case studies were selected in the same country in order to have the same socio-economic and legislative framework. As a result, two cases located in France were chosen: the financing of the *Notre Dame* Cathedral after the fire of 2019 and the financing campaign (2017) for the purchase and consolidation of the Castle of *La Mothe Chandeniers*, destroyed by a fire in 1932.

4 FINANCING INTERVENTIONS IN AN ECOSYSTEM PERSPECTIVE: SOME INSIGHTS FROM FRANCE

As specified in the previous paragraph, the analysis will focus on two case studies: the financing of the restoration of the *Notre Dame de Paris* Cathedral after the 2019 fire and the financing of the purchase and restoration works of the Castle of *La Mothe Chandeniers* in Les Trois Moutiers, that was previously destroyed by a fire and then left to ruins.

After an introduction of each case study, the analysis focuses on the financing initiatives of the restoration/preservation/purchase initiatives, highlighting the characteristics that are related to the diverse points of the financing campaigns.

4.1 Notre Dame de Paris: *A collective international campaign for financing reconstruction after the fire of 2019*

The Cathedral of Notre-Dame de Paris was partially destroyed by a fire that broke out on 15 April 2019 beneath its roof. More than 400 firefighters were engaged in the attempt to extinguish the fire, alongside another hundred government workers, including police and municipal workers, who helped removing objects from the cathedral. The interior was partially preserved and there was enough time to move artworks and religious relics to safe places. However, by the time the fire was extinguished, upper walls were harshly damaged, the cathedral's spire had collapsed, and most part of the roof had been destroyed.

The event had an enormous impact on Paris and the world, with Emmanuel Macron, the French president, immediately acting to solicitate support and funding. The impact of the president's gesture as well as the emotional resonance of the fire was paramount: French citizens as well as several public and private actors gathered around the cathedral and supported the collection of funds. Moreover, the French government announced a legal framework for donations for the interventions on the cathedral, accompanied by tax incentives, launching a fundraising campaign the same night of the fire. This initiative was based on the help from numerous players, either public, private and civic, that could be interpreted as a best practice in the framework of financing through an ecosystem approach. The fundraising involved first of all, four governmental bodies (the *Centre des Monuments Nationales, Fondation de France, Fondation Notre-Dame* and the *Fondation du Patrimoine*) that were in charge of collecting donations from private parties, that included both big private donors and companies (among others: Arnault family and LVMH group, Bettancourt family and company L'Oréal, BNP Paribas, AXA and Sanofi). Four platforms specialized in crowdfunding Leetchi, Dartagnans, lepotcommun and GoFundMe run one or more collection campaigns for raising money from citizens and individuals. Moreover, there were several contributions by public local authorities both French (e.g. among other Paris municipality and Toulouse metropole, the regions Île-de-France, Occitainie, Auvergne-Rhône-Alpes) and international from Serbia and Hungary.

In short, the funds collected had a significant representation of public, private and civic parties representing the stakeholders of the cultural ecosystem built around the famous monument. The resonance and success of the event was impressive: over €1 billion funds were already pledged as of 22 April 2019, and so far, already 833 M€ have been collected from the different parties.

4.2 *The Castle of* La Mothe Chandeniers*: An online community to purchase and enhance a historical ruin*

The *Mothe Chandeniers* is a castle located near the town of Les Trois-Moutiers, built in the 13th century and experiencing a period of splendor around 1650. Major renovation works were undertaken in 1809 and included the setting up of a vineyard in the castle gardens. Baron Edgard Lejeune bequeathed the castle and had it renovated in the romantic style that was very fashionable at the time. In 1932 a violent fire broke out from the central heating system and devastated the castle, only the chapel and the annexes were saved. The losses were such that the owners were unable to rebuild the destroyed parts. The property first passed to the industrialist Jules Cavroy (1963) and then to Crédit Lyonnais in the 1980s. The last owner was Claude-Alain Demeyer.

Recently, the ruins were threatened to pass to other private investors with the risk of speculation and distortion of the characteristics of this important but rather unknown cultural heritage piece. The risk of opportunistic behaviors that could potentially damage the values of the heritage and its link with the communities, led local inhabitants and cultural heritage associations to seek innovative solutions to purchase the castle and manage its consolidation, restoration and enhancement. In 2016, Julien Marquis, founder of *Adopte un château* (non-profit organization that has the statutory aim to protect and enhance French castles) met the founders of *Dartagnans* (a crowdfunding platform specialized in cultural heritage projects) and discussed the emergency of the *Mothe Chandeniers.* They realized that it was very unlikely to reach the necessary funding by means of traditional crowdfunding models. In 2017, *Dartagnans* and the association launched the idea of collectively buying the *Château de la Mothe Chandeniers* in order to save it and propose a new economic model to preserve the heritage. During the interviews, Marquis defined the initiative as an equity crowdfunding experiment.

With the vision "to raise people awareness about the promotion and preservation of our heritage, too often abandoned", they proposed a collective purchase of the Castle. As declared by the promoters of the initiative, "saving a monument in danger, develops an economically viable activity in its territory and creates a strong community around it. Our objectives are simple: build, be involved, think and innovate together". The campaign proposed to simply make a donation or opt to purchase a share of the castle for 50 € (under the slogan: *Devenez châtelain pour 50 €! (become a castle owner for 50€*). The scheme was innovative: each donor will have the opportunity to donate to the project during the crowdfunding campaign. After the crowdfunding campaign a company would be created (SAS - Société par Actions Simplifié) to purchase the castle with the funds raised through the crowdfunding initiative. Each donor would have the opportunity to become a shareholder and therefore a co-owner of the castle. Becoming a shareholder will require a symbolic payment of 1€ per share, which will be asked at the end of the campaign.

The attempt to involve the online community as co-owners of the castle bear however several risks, such as the threat of having too many shareholders, slowing down the decision-making process. Therefore, the proposers carefully designed a governance system and a management model that included not only the investors but the several stakeholders of the castle. In the newly created company, the association *Adopte un château* and Dartagnans kept the management of the project and they involved in an executive committee the representatives of the shareholders and another relevant association (the *Friends of La Mothe Chandeniers*).

A platform for discussion among the shareholders was created, with the possibility for anyone to propose initiatives and interventions. This system, together with a communication strategy based on emotional components stressing the possibility of participation in designing the future of the castle, was extremely successful: 1,615,244 € where collected against 500,000 € pledged, coming from 18543 donors from 88 countries all over the world.

The initiative served as a catalyst not only for the purchase of the castle but also for a series of initiatives that involved both the online and local community. Indeed, the project for the consolidation and enhancement of the ruins was elaborated through an international competition and awarded to a team of Japanese architects. In the meantime, the local communities (who were also involved in the financing) were involved in initiatives of valorization of the ruins through guided tours, thematic dinners, and other events for preservation and community building. The project, initially based just on an online ecosystem of stakeholders, later expanded and involved new partners and sponsors coming from the digital technology and construction sectors (among them: *Art graphique et patrimoine, Europizzaras and Lariviere, Bodet*). The project also benefited from the support of local authorities and associations.

5 DISCUSSION: FINANCING THROUGH AN ECOSYSTEM APPROACH

Both case studies show that their strategy to diversify funding sources through an appeal to the contribution of different components of their cultural ecosystem, could be a successful strategy in achieving financial resilience for cultural heritage in case of emergency. However, the two cases show a different approach to financial ecosystem building that is also due to the diverse framework of the two cultural heritage assets.

In the case of famous monuments such as *Notre Dame*, the process of financial differentiation is usually easier: indeed, financial ecosystem building is boosted from a strong support from big public authorities and VIPs to which the support of smaller donations through crowdfunding added up but was not determining in terms of total amount of needed funding. The emotional resonance of the campaign is often very strong and easier to achieve. The case of *Notre Dame* confirms that it is easier to collect a variety of funds for such a famous cathedral and in presence of a calamitous event that had a great media resonance. Indeed, the majority of funding were collected from traditional sources (public authorities and big sponsors and donors) whereas just smaller amounts were coming from communities (associations and crowdfunding platforms). In the framework of an ecosystem analysis, the ecosystem was clearly composed by a majority of big donors and well-known governmental organizations.

In the case of less famous cultural heritage, gathering the attention (and the funding) from big donors and sponsors could be more challenging. In that case it could be interesting to explore the capacity of other components of the ecosystems, such as citizens and online/offline communities, to provide funding for example through crowdfunding initiatives, such as in the case of *La Mothe Chandeniers*. Indeed, the castle of the *Mothe Chandeniers* was not so famous and did not receive at the beginning, the support of VIPs or such media resonance as in the previous case study. The campaign was therefore based on innovation in the ecosystem construction, proposing an equity crowdfunding campaign to encourage small investments to purchase the castle, and fostering the appeal to be later not just owner but also part of the decision-making process for designing the future of the castle.

Notwithstanding the differences, both cases present a clear appeal to the emotional component related to supporting the campaign. Even in the equity crowdfunding initiative, that normally are mainly related to the appeal of potential return on investments, the emotional side played a significant role in the choice of financially supporting the initiative. Another common feature is that in both cases the initiatives were led by a strong and recognized main authority that was also active in the field of cultural heritage (the government in the form of its president for Notre Dame, the association *Adopte un chateau* and *Dartagnans for La Mothe Chandeniers*), thus not only legitimizing the request, but also providing accountability and transparency to the whole campaign.

6 CONCLUDING REMARKS

This research aimed at exploring the possibility to interpret financial resilience of cultural heritage through an ecosystem approach. In the literature review, it was highlighted that the traditional financial fragility of cultural heritage constitutes an even greater threat during calamitous events. Therefore, increasing resilience of cultural heritage should also take into consideration a change in its funding schemes, that could assure a higher level of flexibility in addressing catastrophic events.

The empirical research aimed at investigating two fundraising campaigns in the aftermath of big fires that destroyed (partially) important cultural heritage monuments, (*Notre Dame Cathedral* and the *Castle of La Mothe Chandeniers*), through a cultural ecosystem interpretation. The case study analysis highlighted that differentiating sources of financing according to an ecosystem interpretation of the cultural heritage environment could be a winning strategy for increasing financial resilience, appealing to both public, private and civic stakeholders as well as offline and online communities. It moreover proves that successful ecosystem appeals to different members of online and offline communities is based mainly on emotional and cultural factors related to the specific cultural heritage, rather than financial benefits or fiscal incentives. Moreover, the case studies indicated that the presence of a recognized leading institution could work as catalyst to attract financing by various stakeholders in cultural heritage interventions, also providing legitimization and accountability for the whole fundraising initiatives. These results enrich the research on financial resilience for cultural heritage by contributing to the investigations that identify potential success factors for financial differentiation of this field. Furthermore, the research provides some interesting insights for policy makers and managers of cultural heritage who are looking to increase resilience of their institutions and developing strategies of financial diversification.

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Built Heritage in post-Disaster Scenarios – Balzani et al. (Eds)

Documentation and damage prevention in conflict areas: The acheiropoietos monastery, cyprus

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ABSTRACT: The analysis of the Αχειροποίητος monastery shows the superimposition of different buildings: a domed church with a central plan, built in late Byzantine times over the ruins of an early Christian basilica, enlarged by the addition of three successive narthexes, and therefore transformed into a longitudinal basilica. The name Αχειροποίητος, literally "made without hands", referred to a sacred icon hosted therein. A walled enclosure surrounds the church and contains the monastery, which developed in subsequent phases, with different additions, demolitions and restorations. We outlined the formation process of the complex, from the VI cent. Basilica, to the transformation of the monastery into military barracks in the 1970, as a premise for the restoration project. Recently the Department of Antiquities assigned the monastery to the Girne American University for its restoration and it is urgent to accomplish some restorations. The management of this site, hence the political situation of northern Cyprus, represents an interesting case study on the contested heritage issue. Nevertheless, the heritage management in Cyprus, for the complex political situation of the island, bears more difficulties than in other UE countries, but we should consider that every heritage site has someway a contested character. An architectural project was experimented, according to the typo-morphological approach of the Muratorian Italian School, based on the principle that new buildings should be the continuation of the old ones, without imitating them, but following their formation process, as the last step of an ongoing process. We did not conceive the new architecture as an object contrasting with the context, but following the full understanding of the processual transformations of the site, it was possible to design the new addition to the monastic building as a living organism, in conformity with the sacred context.

Keywords: Urban morphology, Architectural design, Architectural Heritage

1 FORMATION PROCESS

The complex is located in the outskirts of *Lapithos*, an urban settlement on the north coast of Cyprus, documented until the seventh century when, following the Syrian raids in Cyprus, the inhabitants abandoned it settling in other sites uphill. In 653 Abu 'L-Awar, leading a Syrian army, sacked Cyprus. *Lapithos* was the last stronghold of the invasion and after the destruction of its walls; it capitulated following an agreement to trade gold and silver in change of the life for the inhabitants (Hill 1940, p. 285). It was probably at this time that someone buried the *Lambousa* treasure to save it from the invaders. In 655 AD, a bishop of *Lapithos* named Eusebius is documented, in the same time also Eulalius is quoted as bishop of *Lapithos*, with an uncertain date. The urban area of Lapithos has undergone some archaeological searching in the past, John Myres excavated the acropolis in 1913, and some of the fragments that are now in the monastery derive from these findings, like the several mosaics now inside the southern building. Here is today still visible the base of a statue of the emperor Tiberius, with a Greek inscription, dated 29 AD, that was originally placed in the gymnasium of Lapithos

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DOI: 10.1201/9781003253730-19

(Dittenberger 1903, n. 583, pp. 274275). The name Αχειροποίητος, literally made without hands, in the first phase of the church, was connected to an icon "made without hands", so probably one of the numerous images of Christ or of the Virgin that are referred in history. There are other churches sharing this same name, including one in Thessalonica (built in 470 AD), and another one in Constantinople (built in 463 AD), both belonging to the Abramites. The name survives to this day through several misspellings, and we should consider it as an example of intangible heritage, testifying the history of a building conceived, and therefore named, to host this particular sacred image. The International Centre for Heritage Studies was established at Girne American University in August 2012 to bring together scholars and practitioners, and support a comprehensive approach to the study of heritage. The affiliates are academics in the fields related to heritage studies (such as architecture, restoration, history, and archaeology) working at local, national, and international levels. The research centre's mission is to host researches and studies on heritage, in Cyprus and abroad, with particular focus on Architectural Heritage, including history, survey, documentation, restoration and design. During the international workshop "Reading and designing the area of Lambousa, Karavas", held in Girne in 2014, we started different researches on the monastery. Specifically the activities accomplished include the laser scanner survey of the whole complex, the documentation of mosaics, *spolia* and wooden artefacts, the study of the different historical phases of the monastery, the design of a museum to host the *Lambousa* treasure, the design of a garden, and the design of an addition to the building. The international workshop was essential for the wider international cooperation framework and an essential prerequisite for the preservation and continuation into the future of the monument together with the UNDP and the Technical Committee for Cultural Heritage in Cyprus.

2 DESIGN METHODOLOGY

The reconstruction of the formation process of routes and settlements in the area of the monastery is one of the premises, following the Italian school of urban morphology, for the design of an addition to the monastery. On the northern coast of Cyprus, a main mountain ridge goes all the way from the East to the West; from this main ridge, secondary ridges descend towards the sea organizing the slope in a readable territorial organism. Only with the full multi-scalar understanding of the urban, territorial and built organism, it is possible to design an architecture conceived as the continuation of the ongoing process. We conceived the contemporary design not as opposed to history, but rather as a continuation of the past into the future. Teaching architectural design focused on archaeology is essential in Cyprus where ruins bear a relevant symbolic value: for the students the ruins become the living testimonies of a forgotten past. Several educational experiences have shown that architecture students, in front of a ruin, assume a reflective attitude that forces them to consider the *context*, in this case the *archaeological context*, as an integral part of the architectural design process. Often architecture students cannot understand ancient architectures, and therefore they are pushed to question their real subject expertise. They are indeed concerned about the ruins, since they belong to architecture, although old and abandoned, but cannot really deal with them. In other words, the relationship with the archaeological context triggers students' particular attention and leads them to consider the place and the artefacts that were there in the past as a single organism. The mental process of understanding the relationships between different parts of an ancient building facilitates the transposition of these relationships to the contemporary design of a *living organism*. Most difficult for an educational project within an archaeological area, is to transmit the choice of a quiet poetic: a compositional process based on the dialectics between foreground and background. If the main subject of the composition are the ruins, the proposed new architecture should assume a background role, cautiously avoiding any desire to emerge as an independent form. This composition exercise becomes crucial in contemporary architecture, where the research seems dominated by *striking figures* rather than by the silent construction of architectures in continuity with a still *ongoing process* (Strappa 2014). Designing within an archaeological area, we should also consider the absence of a given frame or limit. In the ordinary design process, the frame is determined by the property limits, and inside this frame, the architect usually displays his compositional figures. An archaeological project instead overlaps different frames, one given by the excavation perimeter, the other by the limits of existing public and private properties, another one comes from the limit of urban areas, the perimeter of archaeological restraints is very important, and finally the perimeter of the ancient architecture and its pertinence. In these cases, architects should design their composition within a complex framework, and not as a single meaningful subject. If the project normally consists in the elaboration of an architectural figure within a given frame, in this case the design exercise consists rather in the development of a complex system of frames inside an existing figure, the archaeological site. Usually ruins look like an incomplete figure, a partially obliterated picture, and herein the project should develop an *independent relationship* with the past avoiding any historicist mimicry.

Figure 1. Front view of the church (photo: A. Camiz, 2014).

The correct way for an architect to walk on a *classical soil* is to design the limit of the ancient site as a contemporary place. In addition, the design of an architecture within the ruins highlights the sustainability of pre-capitalist architecture, which can be opposed to most contemporary architecture. From Vitruvius to Alberti, from Michelangelo to Bernini, the *envois* of the *Prix de Rome*, Schinkel, Louis Kahn, Le Corbusier, Libera and Quaroni, most important architects have dealt with archaeology within their work: archaeology offers a *catharsis* for contemporary architecture; it is not a place where to bury *ancient* or *modern* repeatable styles. Designing the space between the city and an archaeological site therefore provides some educational tools to guide future designers even in small historical centres (Strappa, Carlotti, and Camiz 2016). Herein the same *silent poetic* and balanced relationship between foreground (historical context) and background (contemporary project), can reasonably be replicated and experienced with the specific purpose of reconstituting a formal relationship between the context and the contemporary design process. Different design groups, coordinated by the writer, have adopted a general strategy specification to design some small projects; all the proposed interventions follow the sustainability, and the design principles defined by Cesare Brandi, i.e. *reversibility*, *recognisability*, *compatibility*, *minimal intervention*

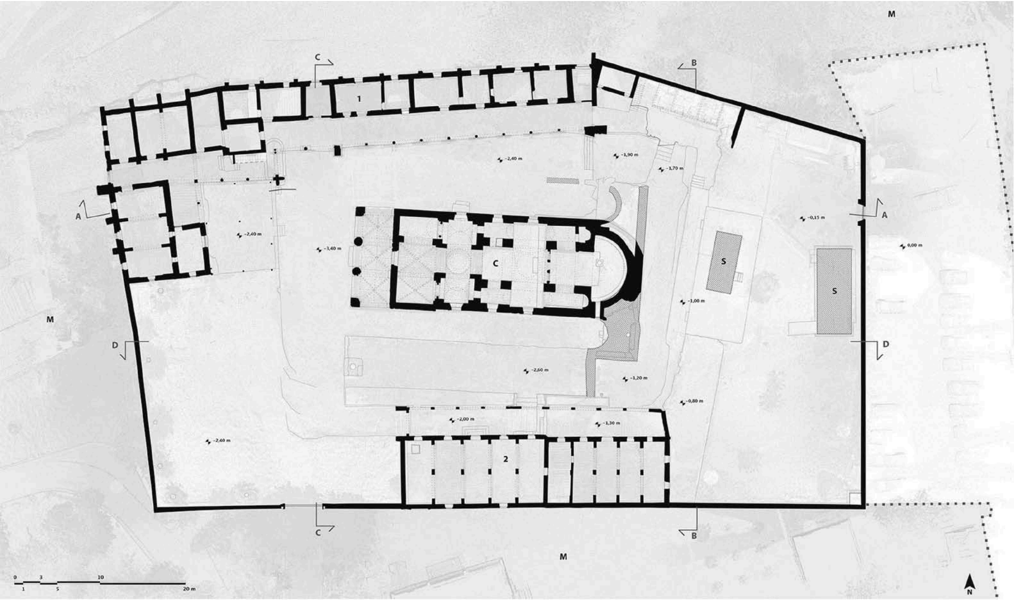

Figure 2. Carmine Canaletti (2015), Laser survey, plan of the Monastery, Lettura e progetto dell'area di Lambousa-Karavas, Cipro, rapp. G. Verdiani, co-rapp. A. Camiz, Università degli Studi di Firenze, Scuola di Architettura, Laurea Magistrale in Architettura 4/s.

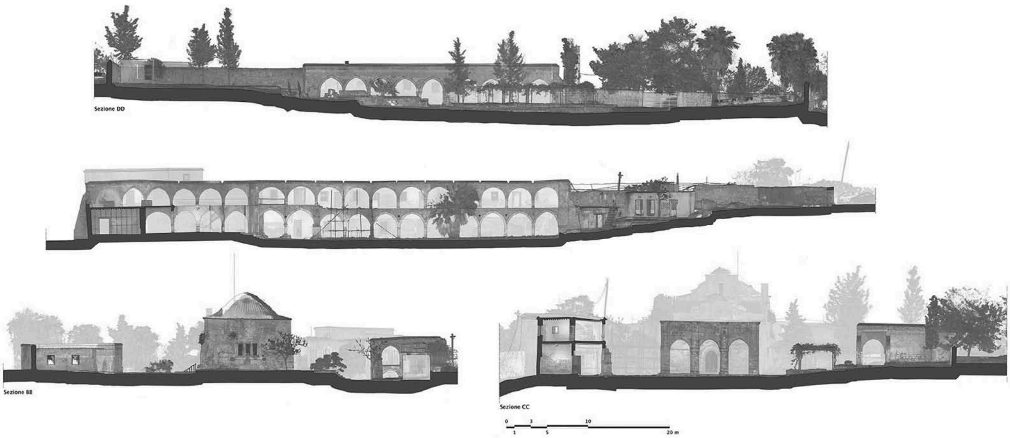

Figure 3. Internal elevations and sections of the Monastery, Lettura e progetto dell'area di Lambousa-Karavas, Cipro, rapp. G. Verdiani, co-rapp. A. Camiz, Università degli Studi di Firenze, Scuola di Architettura, Laurea Magistrale in Architettura 4/s.

and the partial image reintegration. (Brandi 1963). The project completes the formation process of the anti-polar Eastern special building. We considered the ancient monastery as a living organism to be continued by a new addition, the project therefore, using contemporary materials such as steel, stone and wood, replicates the same measure of the bays of the monastery so to develop the addition. We designed the elevation of the new composition to extend the fundamental lines of the ancient monastery: ground line, base, elevation, connection and conclusion lines were continued in the new composition, strictly avoiding any *mimesis* of the ancient buildings, and continuing the same organism started with the construction of the ancient church. The nodes where the new architecture encounters the old buildings are the crucial part of the design operation. The addition completes the living organism of the monastery, avoiding strictly any kind of aesthetical contraposition. Neither touching the old building, or bearing loads on the old walls. The new building is thus recognizable as another part and a different piece of a composition that shows even today and unique character. The distributive system of the complex, expresses the continuity with the past by granting full accessibility to all the parts, even for people with disabilities.

3 CONCLUSIONS

Within the workshop, we compared different definitions of landscape: the one given by the European Convention of Landscape, "an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors»" (EU, 2000), and that provided by Emilio Sereni, "the form that man, in the course and for the purpose of its agricultural production, consciously and systematically gives to the natural landscape" (Sereni, 1961). The discussion questioned if the landscape design should be a conscious material transformation of a living organism, or an aesthetically oriented manipulation of an in-animated object, and then proposed strategies for the education of conscious communities that can guide the transformations so not to follow only speculative interests. Following these premises, we conceived a garden within the monastery of *Acheiropoietos*, inspired to Walafrid Strabo's poem. The *Hortulus* was composed in Latin in the IX century using hexameters to describe the monastic garden of Reichenau. In the poem, 23 different plants are described. These same plants were chosen as a living model for the project. The project uses wooden floor and flowers beds with a self-sufficient irrigation system and green hedges, demonstrating how it is possible to design a contemporary garden, following a medieval model, in an

Figure 4. The scaffolding is holding in place the leaning column, urgent intervention is required (photo: A. Camiz, 2014).

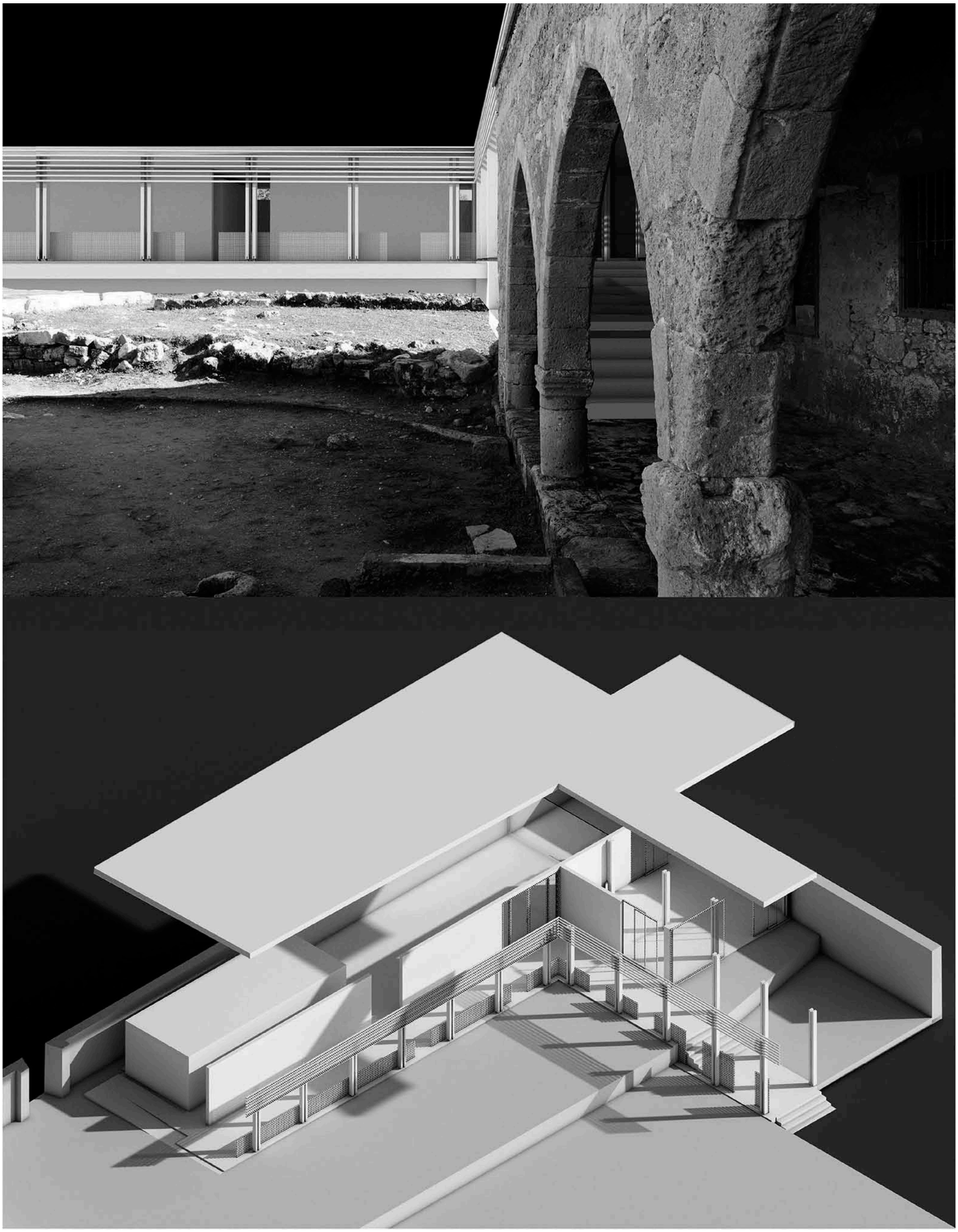

Figure 5. The formation process of the project, C. Camerota, A. Venneri, E. Vizioli, Architectural reading and design of the continuation of the Acheiropoietos Monastery, tutors: A. Camiz, L. Ferroglio, International design workshop/Graduation laboratory (Architecture and Restoration) Reading and designing the area of Lambousa-Karavas, Cyprus, 2014, Girne American University, "Sapienza" University of Rome, 2014.

archaeological site, according to the analysis of Urban Morphology, and the principles of restoration described by Cesare Brandi: i.e. recognisability, compatibility, reversibility, minimum intervention. (Brandi 1963). This enclosed medieval garden was designed to host, in one part the twenty-three plants described in Walafrid Strabo's *Hortulus*, and in the other part,

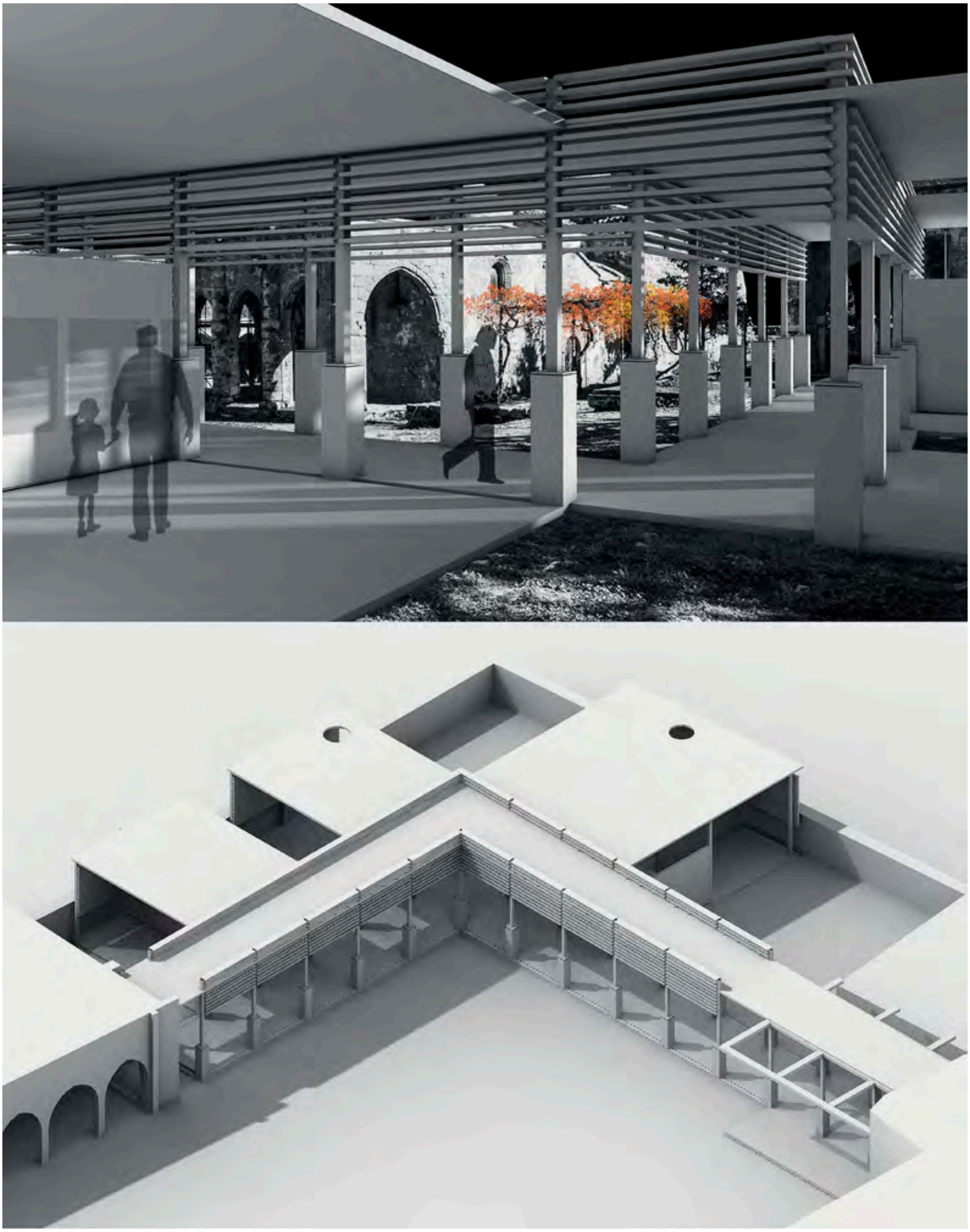

Figure 6. The formation process of the project, D. Michele Daniele, F. Lofiego, V.D. Matteis, Architectural reading and design of the continuation of the Acheiropoietos Monastery, tutors: A. Camiz, L. Ferroglio, International design workshop/Graduation laboratory (Architecture and Restoration) Reading and designing the area of Lambousa-Karavas, Cyprus, 2014, Girne American University, "Sapienza" University of Rome, 2014.

a garden dedicated to mint plants. Both of the two parts of the garden were designed, using sustainable materials and very simple technologies, so to propose a possible solution for a compatible, reversible and recognizable design within the site of the ancient Monastery. The continuation of the existing path of the portico was outlined as a system of matrix, planned construction and connection routes, so to dispose the flowerbeds containing the plants in a way that simulates the formation process of an urban tissue within the monastery. The result is a continuation of the formation process of the monastery that enhances the site and its history, without imitating the past.

None of the proposed projects will be built in reality, but they were conceived as the experimental application of a theoretical method. The proposed method, based on the careful examination of each context and its history, recovers the rules of the transformation from the analytical reading of the formation process of the artefact. Through a project, not intended as an *impromptu* academic exercise, but rather as a design experiment, we intend to suggest to the local authorities some possible interventions in the area of the Monastery. The projects represent diverse topics, such as the reintegration of the image, or that of the construction of the margin, but they are all, in different ways, set on the transposition of the Brandi's principles of restoration to the architectural composition. All proposed projects are reversible, recognizable, consistent, and based on the minimum intervention, but finally the resulting picture certainly does not belong to the domain of the restoration itself, but rather to that of architectural composition in an archaeological area. In the analysis of the formation process of the monastery, the contribution of urban morphology and architectural typology was essential, so to develop analytically the proposal of an addition to the monastery as the continuation of an ongoing process.

In the faculties of Architecture offer undergraduate curricula in architecture which usually include only two exams in history of architecture, one theoretical exam in restoration and no elective courses in history, archaeology, restoration and survey. In addition, the different curricula available in the bachelor, master and PhD, do not include any specific option regarding heritage, so no curriculum is available for the future architects, in restoration, history or heritage management.

By comparison in Italy most of the faculties of architecture include three exams in history, two studio exams in restoration, one exam in survey and one in heritage in their curriculum, in addition to this there are specific master curricula dedicated to heritage (such as the master in Architecture (restoration) at "Sapienza" University of Rome). Also in Italy there are a specialization course (post master courses) in restoration, and several PhD programs in restoration, history and survey within the faculties of architecture. Many Faculties of architecture do have a Department of History and Restoration: and before the last university reform, which forced all Universities to aggregate their departments (so to have over 50 members) every faculty had one Department dedicated to history and restoration. In addition to this, following the compulsory professional continuing education that every practicing architect have to follow, 20 credits per year, some Chapters of Architects (such as the Rome Chapter of Architects) developed specific professional training programs dedicated to heritage. There is a Department of Heritage in the Roman Chapter of Architects, founded in 2008 and directed by Virginia Rossini. In these last seven years the policy that the largest chapter of architects in Europe has adopted (Rome has 18224 registered members. Source: Chapter of Architects President, September 2015) for professional training includes heritage as an important topic.

In the last years seminars, conferences, and workshops contributed in increasing the level of understanding of heritage within registered professionals. In countries with a history of several millenniums of civilization such as Italy and Cyprus, adopting a specific teaching policy dedicated to heritage can increase the jobs available for the new generations, and help the registered professionals to catch up with the many activities the often are offered through tender calls by UNPD and EU.

Today with this situation in education there is no option for architects trained in this country to work in the Heritage sector. The professional activities that architects can follow in Heritage, include the survey of monuments, archaeological sites and urban tissues, the documentation of heritage, the restoration, the management of Museums, archaeological sites and archaeological parks, the design of all the above, and also the design of new architectures in historical and archaeological contexts and finally, of course, the historical research. We are proposing here a new direction in architectural education in Cyprus which would affect seriously the job offer in the future, but also help Cypriot architects to participate to heritage

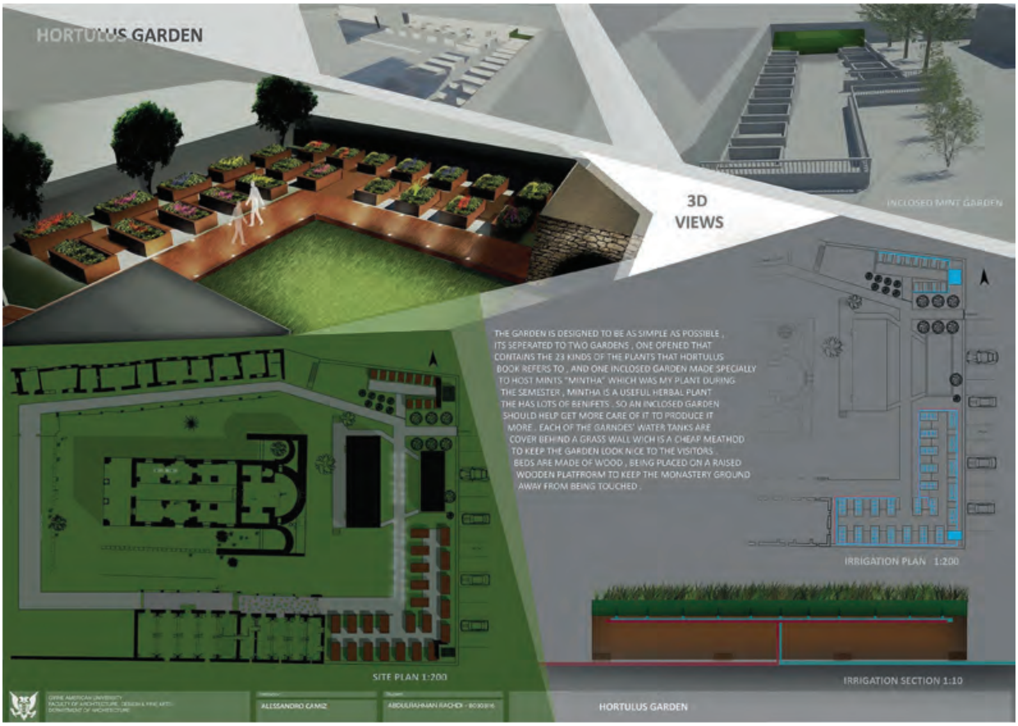

Figure 7. Abdul Rahman Rachdi, Walafrid Strabo's Hortulus in the Acheiropoietos Monastery, Cyprus, (ARCH371- Landscape Design, Asst. Prof. Dr. Arch. Alessandro Camiz, Girne American University Faculty of Architecture, Design and Fine Arts, Fall 2014). Designing the area of Lambousa-Karavas, Cyprus, 2014, Girne American University, "Sapienza" University of Rome, 2014.

design and management outside the island, and with a serious outcome in the perception of heritage in the people, and therefore in the inherited collective memory of the Country.

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Built Heritage in post-Disaster Scenarios – Balzani et al. (Eds)

Integrated systems for deformation monitoring

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ABSTRACT: To monitor a phenomenon means to perform repeated surveys using tools and methods appropriate to its extension and expected effects together with the processing strategies and expected results. However, each technique, in some applications, may have limitations that affect the result. To overcome this drawback, an integrated methodologies can allow to achieve high-precision and high-accuracy results for multiple monitoring projects. To work with integrated techniques means that the instrumentations work independently from one another, making their result completely independent and allowing their comparison and validation. If different methods provide the same result, the solution is robust. The other important aspect is that the use of various devices with different characteristics can substantially reduce avoid systematic errors. This paper gives an overview on some integrated monitoring applications at different scales demonstrating integration of techniques properly selected can be adopted for various problems related to specific phenomenon. Moreover, this paper explains how the advancement of technology is affecting the geomatics methods, moving from the traditional "manual" methodologies to modern solutions capable of returning similar or, in some cases, better results with fewer human inputs.

Keywords: geomatics, monitoring, integrated systems, surveying

1 INTRODUCTION

The effectiveness and robustness of geomatics techniques available to date, generate multiple monitoring possibilities for a wide variety of applications (different areas, scales, entities of displacement/deformation, etc.). When considering an object and the points that constitute it, the presence of a deformation is evident because some points change their position in time, with a certain module, direction, and magnitude.

Surveying is the detection of points position at a predefined epoch; monitoring means repeating the surveying at different epochs, analysing the results, and verifying, if the investigated phenomenon has produced deformation/movements. Monitoring with geomatics methodologies can be applied onto several fields of interest, such as engineering (e.g., structures, infrastructures, etc.), geophysics (e.g., plate movement), geology (e.g., landslides, coastal change, etc.) and architecture (e.g., cultural heritage). They allow to identify, for each specific case, the effects in terms of movements or deformations generated by the observed phenomena, and even define their relationship with external conditions, both natural and anthropogenic (Ogundare, 2015).

To monitor a phenomenon means to perform repeated surveys (discreetly or continuously) using tools and methods appropriate to its extension and expected effects. When planning a monitoring activity, it is mandatory to choose the frequency of the survey and its duration, relying on the risk associated to the investigated phenomenon and costs (Ogaja, 2016).

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DOI: 10.1201/9781003253730-20

The acquired data is than handled with proper processing techniques, as discussed below in the following section. When the results of the various epochs are available, the estimation of motion/deformation with relative uncertainties is performed comparing the coordinates of the points through time. While designing monitoring activities, the main aspects to consider are the tools/techniques that better fit the investigated phenomenon, the expected results, and the processing strategies.

The monitoring of geometric deformations trough a geomatic approach consists in the comparison through time of performed measurements and calculated points coordinates. The setup of a common and stable reference system for acquired measurements allows the integration of different methodologies and a direct comparison between subsequent epochs. The uncertainty of the comparison, and the accuracy of each measurement, must be considered to determine the significance of detected changes.

Otherwise, the operator can change the method adopted for the monitoring (with a more accurate one) or lower the surveying frequency. When the purpose is to conduct a high-precision monitoring, the integration of different monitoring methodologies must be considered. By combining traditional topographic survey with the newest technologies, a reliable restitution of architectures, shapes and 3D geometries can be provided. Such combination can be used for different applications and to describe the phenomenon in a refined and detailed way (Croce et al., 2019).

Other advantages of an integrated approaches are the possibility to exploit potentiality of different instruments for field activities and to have redundant observations from independent instruments, avoiding systematic errors and reducing factor scale due to adopting only one system. Even if cost and time consumption of integrated systems is relevant, when considering data processing, their integration allows multiple analysis, comparison, and more robust data validation.

In this paper a synthetic review of geomatics techniques used for integrated monitoring approaches and some relevant applications are reported.

2 INTEGRATED MONITORING APPLICATIONS

The techniques constituting geomatics are photogrammetry, remote sensing, laser scanning system, Global Navigation Satellite Systems (GNSS), SAR (Synthetic Aperture Radar) interferometry and Geographical Information System (GIS). More details about each technique can be found in the work of Gomarasca (2010). The use of the more appropriate technologies depends on scope, entity, and scale of the phenomenon that has to be investigated.

To intervene on a different scale means intervening at varying detail levels. If the scale decreases, the level of detail of the survey becomes higher. For example, working on a regional/ local scale, means to study the risks and effects due to localized events, such as landslides, subsidence, volcanism, and seismic cases. Nowadays, the most accurate available techniques are GNSS, aerial photogrammetry, laser scanners, traditional surveys, SAR interferometry and all the integrations among these.

Another fundamental aspect is the data processing strategies since each application requires a specific strategy. Other applications and the most suitable methodologies integration are explained in the next section.

A survey can be performed with terrestrial topography techniques or by satellite techniques; both technologies can be used directly or remotely and are characterized by the necessity to act in direct contact with the portion of the territory affected by the survey operation. For several years there has been an increasingly rapid development of geometric survey techniques at a distance which, although less precise in absolute terms, offer the indisputable advantage to describe large areas of territory (Biason et al., 2006).

2.1 *Regional and Large-scale monitoring*

For phenomena occurring at a regional scale (e.g., the subsidence), levelling was the first method with high accuracy to be adopted for the computation of specific heights differences in time. Despite a relatively simple measurement procedure and its sub-millimeter accuracy, this method is time consuming and provides sparse data. More recently, GNSS were used for their ability to provide the displacements of specific points with a sub-millimeter accuracy in an absolute reference frame. To solve the problem of the sparse data, interferometric techniques can be applied for the computation of the time series displacement of a high number (e.g., millions) of targets over very wide areas with millimetric accuracy. The main features to consider for a first insight of radar interferometry products are (1) the differential nature of the InSAR techniques and (2) the Line of Sight (LOS) acquisition geometry. Regarding the first feature, the displacement values are referred to a reference position and to a reference epoch. For this reason, to provide results in an absolute frame, the calibration of the SAR products with GNSS data is mandatory. Moreover, InSAR techniques can detect only the projection of the actual displacement along the LOS direction. Therefore, to compute the vertical and horizontal component of the displacement, dual orbit acquisition geometry (i.e., ascending, and descending orbits), need to be processed and combined through a decomposition analysis. Furthermore, interferometric techniques require a time-consuming processing of the raw data. An application of integrated regional scale phenomenon monitoring is shown in Figure 1.

For wide areas phenomena (e.g., plate tectonics) monitoring, GNSS is the most suitable technique thanks to its ability to detect 3D slow movements with the highest accuracy; this accuracy can be achieved with a network of integrated GNSS stations working in continuous mode. Interferometric techniques can be considered also, but, due to the lower accuracy and the LOS acquisition geometry, GNSS is still the most used technique for the discussed applications.

2.2 *Land scale monitoring*

The main result provided by an integrated monitoring approach in land applications is the accurate quantification of temporal changes. Changes are due to natural events or human interventions. Generally, the focus is the monitoring over time of specific points, main geometric features, and volumetric changes. Multidisciplinary and complementarity methods, combining and integrating different remote-sensing systems are required to investigate land phenomena and perform measurements and analyses that cannot be performed with only one monitoring tool (Pellicani et al., 2019). Remote and proximal sensing (e.g., radar satellite

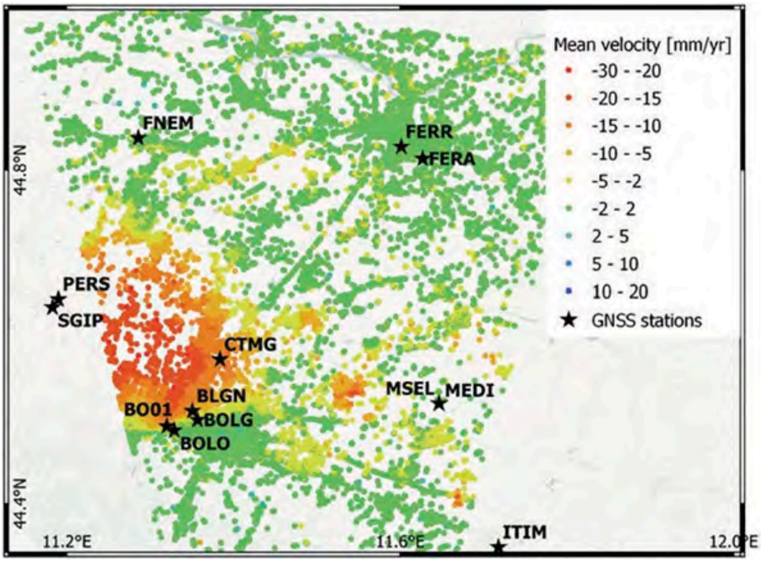

Figure 1. Subsidence monitoring using SAR interferometry integrated with GNSS as calibration over the Emilia Romagna region (Italy) (Mancini et al., 2021 with changes).

interferometry, GNSS, uncrewed aerial vehicles (UAV) photogrammetry, and topographic investigations) are increasingly used for studying and monitoring natural hazardous scenarios and events and are usually integrated with geotechnical in-situ surveys (e.g., inclinometers, piezometers, extensometers, etc.) (Figure 2). Analysis of two subsequent post-event measurements also proved to be very useful in the risk assessment, monitoring, early warning systems, and post- event phase of natural hazards (Turner et al., 2015).

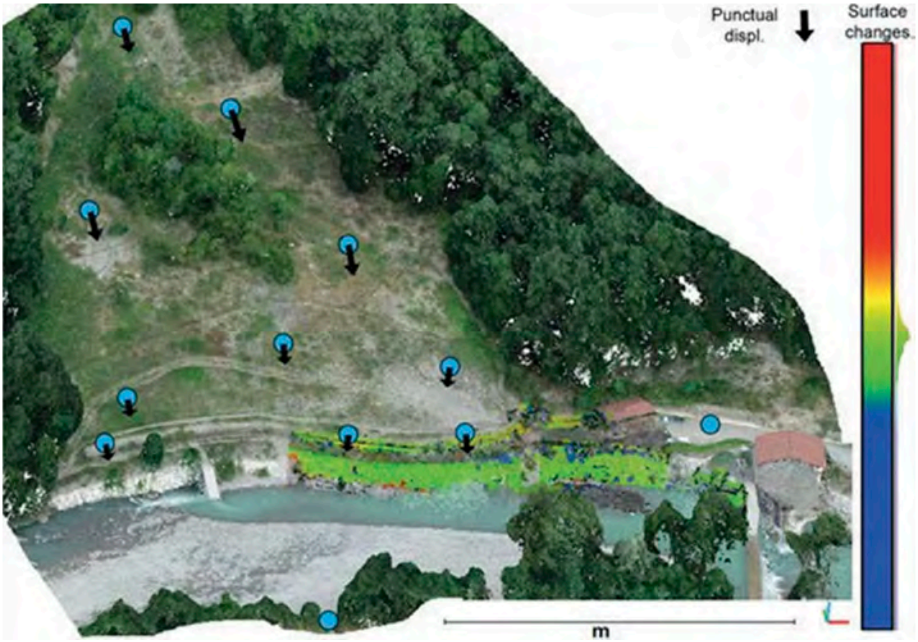

Figure 2. Integration of punctual and continuous techniques for landslide monitoring.

Permanent Scatter Interferometry based on radar satellite imagery led to the generation of ground surface deformations maps, measured in specific natural points with millimetric precision. GNSS methodology provides 3D coordinates of points by a receiver (placed over a specific point) that communicates with several satellites and other permanent GNSS receivers allowing for the calculation of its position in a global reference system (Carlà et al., 2019; Kyriou et al., 2021). Also, traditional topographic survey (TS), especially Total Station measurements, can be effectively used in land monitoring. TS instrumentation allows the calculation of coordinates of both natural and artificial points, through the remote measurements of distances and angles. When coordinates in a global reference system are required, integration with GNSS is mandatory. Both GNSS and TS provide punctual monitoring, requiring the materialization on site of specific points that need to be monitored. The two techniques are often coupled to have global measurements, repeatable surveys, avoid occlusions and reduce costs of intervention (Castagnetti et al., 2013; 2014). PS Interferometry provides punctual information on specific points (highly reflective for radar signals) and is often used as a screening technique for preliminary analyses of the phenomenon and the investigation. Techniques that provide spatially continuous measurements can be effectively used in these applications (Bertacchini et al., 2014). For example, UAV-based methods can be highly effective because of their technological developments (autopilot systems, lightweight cameras, miniature GNSS, miniature LIDAR) and the development of new processing methodologies, both for LIDAR data and photogrammetric datasets (Nikolakopoulos et al., 2017). Monitoring unstable slopes with a fixed array of cameras using time-lapse acquisition approaches and SfM techniques can be a suitable alternative to other methods to raise monitoring frequency (Eltner et al., 2017; Santise et al., 2017). These techniques allow for fast intervention, reduced field operations, and data management-processing can be highly automated. Also, the high resolution of generated products allows precise monitoring of volume changes and the extraction of various geometric parameters; unfortunately, the same point cannot be detected through time.

2.3 *District scale monitoring*

When considering a phenomenon acting on a restricted anthropized area, techniques able to collect data at different scales (both to the structures/infrastructures located in the area and at the ground) are needed. For this purpose, the most suitable techniques could be traditional topography, GNSS and radar interferometry. Interferometric SAR (InSAR) techniques are effective in Earth surface deformation phenomena applications due to their ability to provide high-resolution, daylight and weather-independent images of wide areas.

An InSAR-based approach allows computing time series of targets displacement at the ground with a millimeter accuracy (Moreira et al., 2013). Instead, level, total station, GNSS give information on specific points and require expert operators to conduct time-consuming survey for each measurement epoch. Nowadays, the most suitable solutions could be the integration of multiple punctual techniques (for a more detailed investigation of the phenomenon), and interferometric products properly calibrated with GNSS observations (for a broader understanding of the site of interest).

2.4 *Buildings monitoring*

Studying the critical aspects of a structure in terms of stability is fundamental for its protection and preservation. The structural analysis is accomplished through the application of numerical simulation models (finite elements algorithm) that evaluate the response of the structure in relation to distinct types of stresses. To obtain reliable results, it is useful to have both point- wise measurements and three-dimensional and geo-referenced models of structures that need to be of considerable detail and with a high degree of metric accuracy.

An example of traditional building monitoring is leveling that can be effectively applied for subsidence effect monitoring on the basement of a structure; a control deformation network can be made with a total station for points at height (Figure 3, a). The comparison of results of different techniques (Figure 3, c), which should be considered independent, allowed to verify a significant differential movement of the structure basement in a specific direction. In addition, a detailed and reliable description of the building is essential, especially in the case of ancient structures, to determine the vulnerability in static terms, see Gordon et al. (2004). For this purpose, UAV methods (both photogrammetry and Lidar) and terrestrial laser scanning can be used. Instrumentations mounted on an aerial platform, offer a favored point of view on the object of interest by solving problems of occlusion and reducing the efforts for data acquisition. Geometric irregularities can be easily identified on high-resolution 3D models, and changes occurred over time can be detected. Point clouds informative content can be exploited by focusing, for instance, on the verticality or horizontality of structural elements; thus, a documentation of the current geometric state of the structure and the analysis of interesting geometric anomalies can be performed (Abate, 2019; Guarnieri et al., 2004) (Figure 3, b). The measurement of structural dynamic responses to ambient and induced strains contributes to the identification of damages due to natural or anthropogenic events or material degradation (Atzeni et al., 2010). Structural health monitoring is traditionally performed with accelerometers, strain gauges, and other instrumentations installed on the structures to detect local or global structural parameters. Depending on the structural characteristics, the extensive surveying based on traditional sensors can be expensive and time-consuming and should face limitations related to the preservation of construction integrity or accessibility (Vincenzi et al., 2017). The High-frequency GNSS technique (> 20 Hz) has proved to be effective in monitoring structural health status (Moschas et al., 2014).

The GNSS receiver must be installed on the structure and provides punctual measurements. In the field of structural health monitoring also terrestrial radar with real aperture antenna can be effectively used. The technique is contactless, non-destructive, non-sensitive to dust,

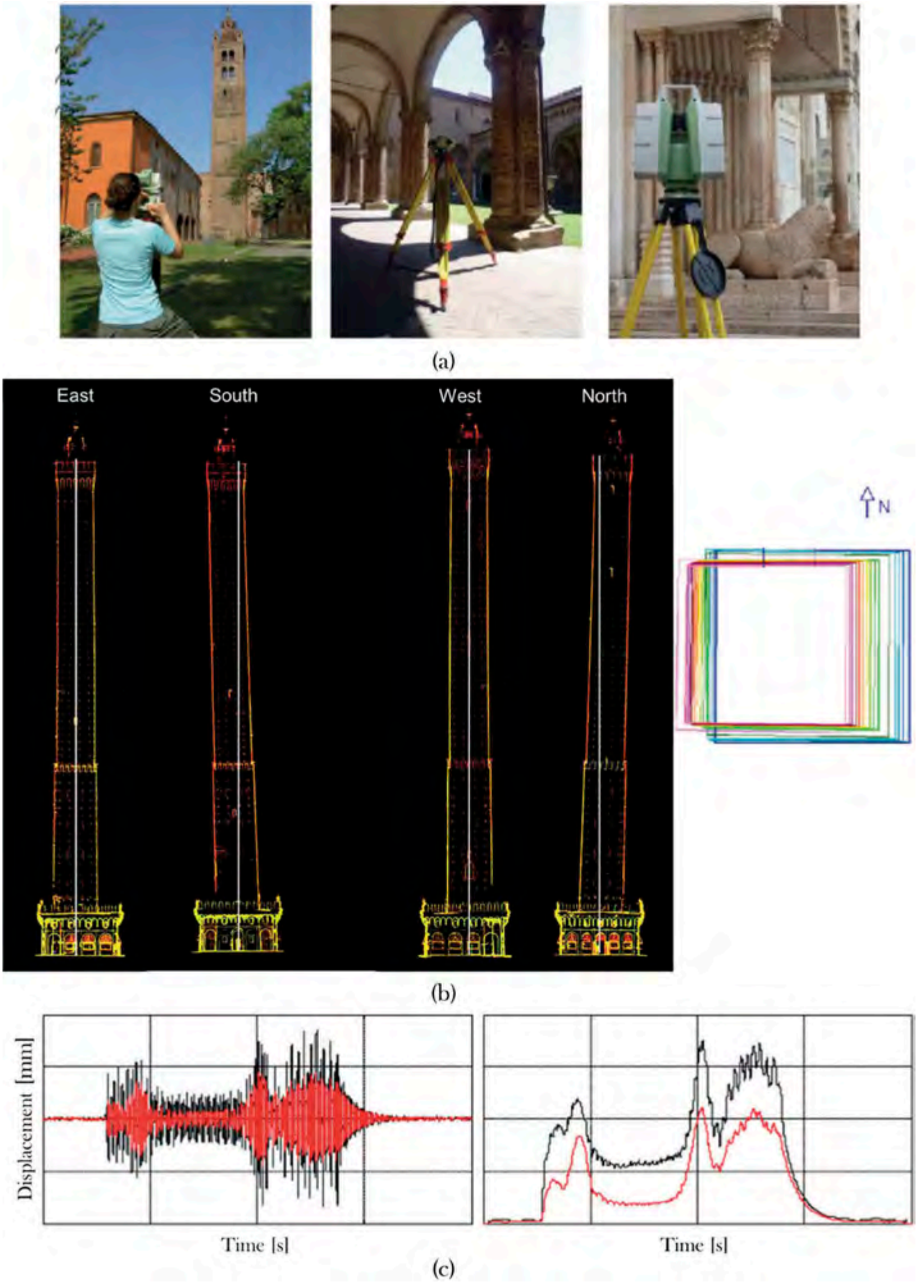

Figure 3. Buildings monitoring: (a) Use of different techniques, (b) 3D models and obtained measurements (Capra et al., 2015 with changes) (c) Results obtained in an integrated approach (Castagnetti et al., 2019 with changes).

and able to detect displacements with an accuracy of tenths of millimeters and a sampling rate up to 200Hz (Di Pasquale et al., 2018; Sofi et al., 2017).

2.5 *Structural damages monitoring*

In reinforced concrete structures, materials are subject to a progressive degradation due to chemical and physical effects related to the mixture of water, inert and binders, production, and installation. An accurate evaluation of long-term material degradation is fundamental for inspection, diagnosis, and service life prediction of structures (Shan et al., 2016). Also, fractures can be described and categorized depending on their widths, length, and orientation and, to simplify, can be divided as superficial and structural. Monitoring structural crack behavior over time is a critical step to interpret the health state of the construction and for the efficient and timely restoration interventions to heal or rebuild the damaged parts. Visual examination of degraded surfaces is carried by experienced operators who adopt contact surveying tools (e.g., measuring magnifiers, strain gauges, crack rulers, etc.) to measure specific characteristics such as width and length. The recorded characteristics suffer from subjectivity that can critically affect the measurement, particularly when multiple operators conduct the measurements over time. Since for monitoring purposes, it is critical that multi-temporal measurements are repeated on the same spot to correctly evaluate eventual change, these manual monitoring procedures can produce a loss of reliability. Recently, innovative, and less subjective structural degradation measuring systems based on contact (Barrias et al., 2018) and no-contact (McCarthy et al., 2014; Abate, 2019) sensors have been proposed. The adoption of a laser scanner system allows for generating a high-density and accurate 3D point cloud and for achieving satisfactory performance in detecting structural degradation (Feng et al., 2021, Castagnetti et al., 2016). Also, the integration of laser scanning and photogrammetric techniques can be an advantageous solution for an accurate and detailed documentation of the built environment (Alshawabkeh et al., 2020). Thus, compared to traditional measurements, such systems can achieve higher accuracy and can overcome the issue of subjective measurements (Bellagamba et al., 2009). Furthermore, recent advances in hardware and software technology led to a wide growth of image processing-based degradation inspection research works over the past few decades. Depending on the applications and the degree of accuracy desired, a wide range of image- based processing techniques and classification approaches can be adopted (Mohan and Poobal, 2018; Sizyakin et al., 2018; Shifani et al., 2020; Parente et al., 2022).

3 DISCUSSION AND CONCLUSIONS

This overview underlines the importance of adopting integrated monitoring systems, highlighting that the use of different techniques it is critical to get more detailed information on the investigated phenomenon, and also for the validation of the result ensuring that the data obtained is robust.

Furthermore, the advancement of technology supports the operator when planning specific monitoring projects because offers valid and inexpensive solutions amongst other traditional techniques. Current scientific and technical literature mainly demonstrates that integration of image-based approaches (at vary scales) and punctual techniques can provide efficient results in terms of detection and quantification, drastically improving results obtained with single and more traditional survey and monitoring techniques. These alternatives can provide comparable 3D reconstructions in terms of accuracy and resolution with a low-cost equipment and high portability. Moreover, the capability for network expansion allows to compute high frequency capture rate for dynamic change. All these advantages can make these new technologies the most versatile for a range of scale and applications even allowing unskilled operators to perform basic tasks and to implement ad hoc solutions when facing a situation that requires a higher degree of automation, thus reducing operator-related error.

AUTHORS CONTRIBUTION

Conceptualization, F.E., G.F., P.L. and R.P.; methodology, F.E., G.F., P.L. and R.P.; writing—original draft preparation, F.E., G.F. and R.P.; writing-review and editing, F.E., G.F., P.L., R.P. and C.A; supervision, C.A. All authors have read and agreed to the published version of the manuscript.

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Built Heritage in post-Disaster Scenarios – Balzani et al. (Eds)

Risk management for historic houses museums: Casa de Rui Barbosa, Rio de Janeiro, Brazil

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ABSTRACT: Founded in 1930, the Casa de Rui Barbosa Museum is considered to be the first historic house museum in Brazil established and managed by the public sector. The joint preservation of the historic structure and its collections has been guided by a preventive conservation plan for more than a decade. This process includes inspection, diagnosis, monitoring and reviewing of preservation actions, in which the building, collection, gardens and systems are integrally linked. In this sense, formulating preservation policies must consider prioritize the mitigation of deterioration and damages to the building and the collection, at the same time ensure the enjoyment of the visiting public. A risk management process has been launched in order to improve the identification of risks that threaten the joint preservation of buildings and artifacts and in developing strategies for mitigating those risks. The methodology adopted was the ABC Method, this article presents the processo, results and discuss the limits of such a methodology to foster preventive conservation in historic house museums.

Keywords: Casa de Rui Barbosa Museum, joint preservation, risk management

1 INTRODUCTION

Historic-House Museums have their own particular tools and strategies to narrate their stories to the public, and is considered one of the most precious means of preserving our cultural identity, as it is able to bring together tangible and intangible values, being a witness of a society, of an artistic taste, of an historical period, of a whole life. Historic houses constitute a special conservation system that imposes specific risks to the collections, mainly due to the risks that arise from nature and the use of buildings. In 1998, DEMHIST - The International Committee of Historic House Museums - was created by ICOM - International Council of Museums - in order to promote, at different levels, this typology of museum, has defined that a historic house museum can be royal palaces, houses of artists, writers, public figures. In general, the significance of the historic house museums is not placed on the value of individual objects but on the whole set of objects and its interaction with the spirit of the people who lived and the building. (Web -1)

In Carvalho´s publication Historic Houses in Brazil, from the DEMHIST Brazil (Carvalho, 2013), it was mapped out the existence of more than 300 museums - as in Brazil, including houses, palaces, common houses, farms and also palaces. More than 150 museums are in southeastern region, and the most of then are in the coastal cities from north to south. Considering the continental dimension of the country and also considering that most part of the country is in the tropical climate zone, the environment is a very huge risk to be considered. In this area, the air generally remains humid and the temperature over a year typically ranges from degree Celsius values in the high teens to the mid thirties, and the diurnal temperature fluctuation is also small, typically less then 10 °C. In 1994, the Canadian Conservation Institute (CCI) introduced the ten agents of deterioration that pose risks of damage to cultural heritage. Half of

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DOI: 10.1201/9781003253730-21

these ten agents from pest to incorrect humidity are particular to collections and buildings in hot and humid climate. The abundance of water and the elevated temperatures for substantial periods of the year make biological risk dominant to collections also for the buildings. High levels of temperature and relative humidity can cause also chemical reactions, as much as light and UV radiation. The major risks concerning tropical climate for historic house museums are fungal and insect attacks due to high and fluctuating humidity, high temperature, high intensity of natural light, and particulates and urban pollution. Due to the scenarios of climate change there is an increasing number of floods. This article presents the results we get so far of the research developed for foster a preservation policy for historic museums-houses in Brazil, based on the identification of risks that threaten the joint preservation of buildings and collections and the definition of strategies to mitigate these risks effectively, according to the available resources, holistic approach, conceived as a continuous process. This research is based on accumulated experience by managing the Preventive Conservation Plan of Casa de Rui Barbosa Museum, for more than two decades, which has been developing strategies for mitigating risks that threaten the joint preservation of buildings and artifacts.

2 CASA DE RUI BARBOSA MUSEUM – A HISTORIC HOUSE MUSEUM IN THE TROPICS

With almost 2.000 square meters, the interiors present a traditional layout of the period, in which the social area is located at the front of the house, and the private spaces are located at the back. The decoration presents stucco linings, wallpapers, hydraulic tiles and cast iron elements. The house's noblest chambers are in the upper levels. It is worth mentioning the service wing - with kitchen, restrooms and the servants' rooms. The highlight of the museum is the Library, which remains in their original location. The garden, with 6.000m² is currently one of the few green areas in Botafogo. Inspired by the French landscape designer Auguste Glaziou's romantic gardens, it is historically and artistically relevant as a domestic garden with such a treatment. The front garden is more elaborate, providing nobility and honour to the house. The backyard, which provides a domestic atmosphere, presents a metal and wood structure that supports grapevines, and has many fruit trees and several species of flowers.

The building vulnerability is related with the fact that the Museum's surroundings were heavily altered, accelerating deterioration processes caused mainly by air pollution, vibration, thermal radiation, and poor soil surface drainage, besides the climatic condition of the city, which is very hot and very humid. The annual mean temperature is 24°C, and monthly mean temperature ranges from 22 °C in July to 27 °C in February. The annual mean Relative Humidity is over 70%.

"The overall climate of Rio de Janeiro is classified as Tropical Savanna (Aw) by the Köppen-Geiger climate classification system [...]. Seasonal climate is distinguished by temperature and rainfall: the period from November through April constitutes the very hot-humid season, while May through October is the hot-humid season". [Maekawa et. al., 2015, 314]

The collection that belonged to Rui Barbosa includes the library, document archive, furniture, decorative and personal objects, and vehicles. The Rui Barbosa archive consists of approximately 60,000 documents that Rui Barbosa produced and received between 1849 and 1923, translates his public life as a minister, journalist, lawyer and diplomat. As well as his personal and family life, it is considered Memory of the World. The library that Rui Barbosa organized throughout his life, and which was acquired by the Brazilian government in 1924, brings together 23 thousand titles, in 37 thousand volumes. They are books on the most varied branches of knowledge, highlighting legal works - it can be said that he had the laws of all countries, their constitutions, codes and civil, commercial, criminal and procedural laws.

2.1 *From preventive conservation to risk management approach*

The experience at the Casa de Rui Barbosa Museum has already demonstrated the ineffectiveness of restoration cycles, realizing that specific restoration interventions, without a systemic view of the causes of deterioration, do not have lasting effects over time, functioning only on

Figure 1. Casa de Rui Barbosa Museum – Main Façade. (photo: C. Carvalho, 2016).

an emergency basis. To combat this trend, a new preservation strategy was initiated, seeking an integrated and preventive approach. The Preventive Conservation Plan launched in the late 1990's has consolidated an integrated approach for preservation actions, looking for causes of deterioration through monitoring, inspection and survey, as well as to establishing mitigation strategies, thus avoiding emergency actions. (Web – 2)

In order to broaden the perspectives of preventive actions, especially concerning the most difficult decisions; to identify the risks to the preservation of cultural heritage in order to reduce them effectively, according to available resources; and to establish resources for an institutional policy of long-term preservation, consolidating the efforts already made, a risk management approach was adopted in 2012. The risk management methodology used was the ABC Method, developed by The Canadian Institute of Conservation (CCI), the International Centre for the Study of the Preservation and Conservation of Cultural Heritage (ICCROM) and the Dutch Cultural Heritage Institute (ICN), which is based on the technical standard Australian and New Zealand risk management - Risk Management, Australia/New Zealand Standard - AS/NZS 4360: 2004. The overall structure suggests five sequential steps: establish context, identify risks, analyze risks, evaluate risks, and treat risks. There are two ongoing processes: communicate and consult, monitor and review. (Web - 3)

2.2 *The risk management ABC method*

This initial phase, which is the establishment of the context, was conducted through the compilation and organization of data and information on the objectives, mission, institutional organization and its impact on the management of the institutional cultural heritage of, including the Institution's budgetary perspectives for this field. The laws, policies and procedures that impact on the preservation and use of the collection were also identified, as well as the main actors that influence this process. The main work carried out at this stage was the quantification of the relative value of the different components of the collection.

Three value categories were established by the work team, in order to guide the comparison and classification of the relative importance of the different items of the collection, as well as the quantification of their respective contributions to their total value. The defined value categories were: ARB - own items or directly related to Rui Barbosa; A - items of high importance not belonging to the ARB category; and B - other items in the collection.

The subsequent stage, which is the identification of risks, has been developed using the tools that were developed to help us identify risks in a systematic and complete way. They are the ten agents of deterioration; the six layers of enclosure; and the different types of risk occurrence – rare events, common events and cumulative process.

The ten agents of deteriorations has been developed by Canadian Conservation Institute (Web - 4), and its effects are very well known. Water, Fire, Pollutants, Incorrect Temperature, Incorrect Relative Humidity, Criminals, Dissociation, Pests, Light, Physical Forces. The six layers of enclosures of the collection refer to the different scales of observation that are the geographic region, the site, the building, the warehouse or exhibition room or guard, the storage and exhibition unit, the support and packaging of the object. For each of the envelope layers, the main sources, propagation trajectories of deterioration agents, barriers, type of interaction and what are the resulting effects are identified. Among the three types of occurrence, only rare events that occur less often about once every 100 years, are not part of professional experience of organization staff. More frequent are cumulative process that can occur continuously or intermittently.

For analyse the risks, there is a ABC scale developed for this methodology, and it is relative with how soon, how often the risk occurs (A), how bad per object (B), how much of collection (C). The combination of A, B, and C define the magnitude of risk. Risks of extreme priority for treatment were identified. These risks tend to have a high probability of occurrence, involve a great loss of value of the affected items and/or involve, if not all, a large part of the collection and the building. As in many museums and other institutions that house cultural collections in Brazil and abroad, the greatest risk of extreme priority is that of a major fire in the Casa Museum, which affects a significant fraction of the collection value and may cause loss of total value or almost total in the affected items. After dimensioning the risk to cultural heritage, comes the risk assessment stage, which consists of comparing the magnitudes and associated uncertainties, identifying which aspects may be common to various risks, such as causes, sources and barriers, for example. At this stage, the values attributed to equity must be reviewed, as well as an assessment of the risk perception and the legal and financial context of the institution. In this way, priorities can be defined, as well as resources allocated more consistently.

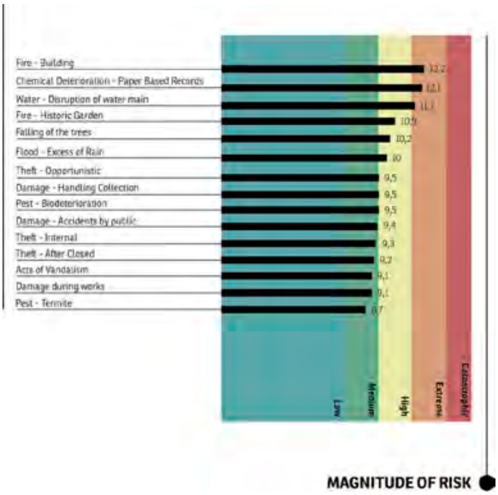
Following the assessment, the project entered a risk management phase with the generation of strategies to reduce each risk. Many options were proposed and evaluated. Each option was analysed to predict to what degree it would reduce the magnitude of the risk. The cost of implementing the option was also estimated. The cost-effectiveness of each strategy—the reduction in risk magnitude divided by cost—was determined. Options that best addressed the priority risks (extreme and high risks) were recommended. The communication and consultation stage is continuous throughout the risk management process, and involves an interactive dialogue with stakeholders, in a clear and unambiguous way, recognizing and overcoming differences and knowledge gaps. The monitoring and review activity is also ongoing, in order to avoid as much as possible the occurrence of failures, as internal and external factors that affect the occurrence, magnitude, or perception of risks may change during the process, as well as factors that are related to the feasibility or cost of implementing the risk treatment measures. Systematic documentation and monitoring of overall risk reduction from the treatments implemented will serve to guide subsequent cycles, accumulating experience and knowledge.

This first cycle of risk assessment for the cultural heritage of Fundação Casa de Rui Barbosa identified three risks as an extreme priority for treatment. These risks tend to have a high probability of occurrence, involve a large loss of value of the affected items and/or involve, if not all, a large part of the collection and building. In the case of the FCRB, similarly to many museums and other institutions holding cultural collections in Brazil and abroad, the greatest risk of extreme priority is that of a major fire in the Casa Museum, which affects a significant fraction of the collection value and typically causes total or near total loss of value on the affected items. The ten high priority risks identified for the FCRB collection involve different agents of deterioration such as water, fire, physical forces, criminals, etc. These risks can generate significant losses for a small portion of the equity in shorter periods or significant losses for a large part of the equity, in the long term. An example of this type of risk, which is directly related to historic buildings is the relatively rapid accumulation of changes in biodeterioration in their building elements, exposed to the hot and humid climate of the city of Rio de Janeiro, which is conducive to the growth of microorganisms. Although it typically entails very small value losses for buildings as a whole, it affects a significant fraction of the FCRB's collection.

The other risks, medium and low priority, are characterized by the slow or irregular nature of occurrence, the low loss of value for each affected item and/or limited number of affected items. In general, the treatment of these risks can wait until the extreme and high priority ones are resolved. However, it is important to identify which of these risks can be addressed immediately, simply and at low cost. As a case of medium priority, the risk of vandalism in the MCRB can be mentioned, and the risk of collapse of neighboring buildings as a low priority.

The risk assessment was carried out by a working group on risk management composed by architectural preservation specialist, collections curator and conservator/ restaurator and related research assistant. This working group has been trained in the use of ABC Method, by José Luiz Pedersoli Jr (conservation scientist and consultant in risk management for cultural heritage) who coordinated the process. Conducted during eight months in 2012, the group, with about 13 people, identified and prioritized key risks facing the historic house museum, its garden and its collection. (Table 1)

Table 1. Risk to Casa de Rui Barbosa Museum in order of decreasing magnitude of Risks



(source: Pedersoli, Jr. Jose Luis).

3 FINAL CONSIDERATIONS

Unlike other museum typologies, in historic houses the presentation of collections results from spaces and collections history, which provides a particular atmosphere. The conservation conditions of the exhibited collections are intrinsically linked to the conservation conditions of the building, and this privileged relationship between collections and buildings teaches us that there is an acute interdependence between changes in the materiality of the building and the materiality of the collections. The alterations, notably, the deterioration processes of the building's constituent systems alter their performance and interfere with the environmental conditions of exhibition of the collections, and consequently may compromise their preservation.

Thus, the challenge of incorporating preventive conservation strategies into the preservation of built heritage lies in the need to develop appropriate tools and technological support.

Risk assessment quantifies expected loss in value to a cultural property, although this process can be full of uncertainties in the beginning, the experience showed that to be useful for a historic house museum, the method must be as comprehensive and as informative to all people dealing with preservation. Almost a decade since the end of the first cycle of risk management at Casa de Rui Barbosa Museum, preventive conservation strategies for historic houses has been studied a great deal and the need for an assessment method dedicated to provide a global picture, considering clearly the damage factors and its impact in this particular context has been the major activity of many professionals around the world.

In Casa de Rui Barbosa Museum Risk Assessment process, one of the most important achievements was the information gathered and the increasing of fundamental understanding about preservation and prevention, and all the existent complexity in our organization. This also has been very challenging the communication between different Departments and Specialists about how their work influence the risk management of the Museum. The process guides the decision but does not automate it. By offering more robust efficiency criteria for analyzing treatment options, as well as alternatives for planning and implementing the selected options, it integrates the risk management approach to the knowledge established in the field of preservation.

Certainly, as the process itself predicts, some items already seen will undergo revisions in the future, which will lead to changes in results already achieved and decisions taken, but this fact does not diminish the credibility of the method and the importance of all the work already carried out for the preservation of the Institution's assets.

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Built Heritage in post-Disaster Scenarios – Balzani et al. (Eds)

Environmental disasters in Brazil: Case studies - cities of São Luiz do Paraitinga and Goyaz Velho

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ABSTRACT: The text presents a discussion about environmental disasters caused by river floods in two Brazilian cities of relevant heritage and historical value: Goyaz Velho (Goiás) and São Luiz do Paraitinga. In both situations there are two great vulnerability factors: the city's geographical location (at the bottom of a valley, along a watercourse), and the building material – mud (cob). There is great similarity regarding the factors that caused these two tragedies, which are associated to inadequate land management and disorderly urban sprawl. Finally, a series of preventive measures (before the damages) are proposed aiming at minimizing and mitigating the impacts of these accidents.

Keywords: environmental disasters, heritage risks, preventive measures

1 INTRODUCTION

This present work is part of studies developed by the author within the Post-Graduate Program in Architecture and Urbanism of Mackenzie Presbyterian University, in Brazil. The study of heritage urban areas and their preservation is the theme of a comprehensive research that addresses the threats inherent to this preservation, resulting not only from urban development and the pressure for changes arising from the real estate market, but also from threats from environmental factors such as floods, fires, and other impacts resulting of economic activity.

In the scope of this "After the Damages" seminar, it becomes relevant to broaden the discussion on preventive and mitigating actions involving risks to property. Many of the recently recorded catastrophes are also associated to civil wars, earthquakes and tsunamis, volcanic eruptions, slope slides, etc. Some of them occurred intentionally as a result of wars and uprisings, such as the tragic case of the destruction by Islamic State terrorists of the ruins of the Temple of Baal – a monument erected in the 1st century BC by the Romans in the city of Palmyra, Syria – listed as a UNESCO World Heritage Site.

In Brazil, cultural heritage is also not free from the risk of destruction. Recent cases show that there can be risks both from natural accidents, and from neglect in the maintenance of these constructions. We can name recent cases such as the fires in National Museum, in Rio de Janeiro, or Estação da Luz, in São Paulo. At environmental level, the biggest catastrophes happened in the last 20 years, when two severe river floods inundated the historic cities of Goiás (Goyaz Velho) and São Luiz do Paraitinga – the first a UNESCO World Heritage Site, and the second an IPHAN National Heritage Site.

2 HERITAGE IN BRAZIL AND ITS VULNERABILITY

São Luiz do Paraitinga and Goiás were created between the 18th and 19th centuries, using as building material a technique that was dominant in Brazil throughout the colonial period, until around 1850 - *taipa* (i.e., mud), a material that has earth as its main component.

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DOI: 10.1201/9781003253730-22

This was the basic building material used for construction during the first three centuries of colonization in Brazil. The technique, which exists since time immemorial, comes from the East and was brought to Brazil by the Portuguese colonizers, under Arab influence. It can be of two types: *taipa de pilão* (rammed earth) and *taipa de mão* (wattle and daub). According to Corona & Lemos (1972), “this consists of any system where the continuous panels are made directly on site, where the soil has not undergone any processing.”

Taipa de pilão or rammed earth is made by compressing the earth between two wooden molds that give shape to the walls. These walls are quite thick (minimum of 60 cm, or 23.6 inches), as they have a structural function. Therefore, constructions built with this technique present few openings (doors and windows), and very prominent eaves keep rainwater away from the base of the walls, thus preventing erosion. This technique was mostly used in the southeast region of Brazil, in São Paulo, from where it spread out to the states of Minas Gerais, Goiás, and Mato Grosso. The other modality of this technique - *taipa de mão*, *pau-a-pique* or wattle and daub - is a system in which moistened earth is applied as sealing to build walls in a pre-existing structural system made with wood.

These two systems where predominant in rural and urban buildings throughout Brazil almost until the 1900s, which lead some foreign travellers (scientific explorers and artists) who visited the country in the beginning of the 19th century to comment that in Brazil all cities looked alike, since they were all “*mud cities*” where earth dominated everything: the pavement on the streets, the construction system of the houses, their roofs (clay tiles), and the inner floor of the humblest houses were all made of earth. This was similar in all urban centers, where the uniformity of street patterns, the morphology of the blocks, the positioning of the constructions on the lots, their volumetry, and their exterior finishing also stand out.

Some of the representative cities of the most important economic cycles Brazil went through since before the 1900s - the sugarcane, mining, coffee, and rubber cycles - remained quite intact until the 20th century, and for this reason were the object of cultural preservation policies for their urban structure, architecture, and landscape. In the scope of global preservation (UNESCO World Heritage), we can mention the historical centers of cities such as Ouro Preto, Diamantina, Olinda, Salvador, São Luis do Maranhão, Goiás, among others. And in the scope of national heritage (IPHAN), we highlight the historical centers of the cities of Belém, Lençóis, Iguape, Vassouras, and São Luiz do Paraitinga.

Almost all the constructions found in these heritage cities have taipa (cob or mud) as their building material. Therefore, they are all extremely vulnerable to water damage, not being able to withstand floods. In the case of the two cities object of this study, Goiás and São Luiz do Paraitinga, both have in common a basic location criteria – the proximity to water supply sources, which led to their founding nuclei being located in valley bottoms, along waterways. Therefore, they are located in risk areas, vulnerable to situations of flooding and river flooding in the periods of higher rainfall, between the months of November and April. That is what happened two turn-of-the-year moments: 2001/02 in Goiás, and 2009/10 in São Luiz.

3 STUDY CASES: GOYAS VELHO AND SÃO LUIZ DO PARAITINGA

3.1 *Goyaz Velho*

In Goyaz Velho, currently known as Goiás, the overflowing of the Vermelho River has been a recurring fact throughout the almost 300 years of the city’s existence. But it had never happened with the destructive force of that 2002 flood, which occurred a few days after the city had been declared a World Heritage Site by UNESCO. The worsening of the phenomenon on that year was the result of an accumulation of environmental degradation actions that had been registered in the previous decades, with the growing deforestation of the gallery forests along the course of the river upstream from the city, the destruction of the vegetation cover on the slopes of the hydrographic basin, and the silting resulting from mining activities in the region. The flood affected 19 bridges and 170 properties, totally or partially destroying them, and leaving hundreds of residents homeless. Some of the most important historical constructions of the city, such as the home of poetess Cora Coralina, were partially destroyed. Since this event, many proposals were made aiming at the monitoring and prevention of new climate-related accidents. The main proposal was the creation of a managing committee for the hydrographic basin of the Vermelho River, with the elaboration of a management plan and execution of works to contain the floods and slow down the runoff flow in times of heavy rainfall. Among these works and actions, we highlight: the elaboration of a master plan for the occupation of the drainage basin, the replanting of gallery forests, the desilting of the riverbed, environmental education and technical assistance actions with rural landowners in the basin area and, above all, a coordinated action of the various municipal and state public authority agencies operating in the region (Cavalcanti, 2008). But despite the national exposure the tragedy received and the political mobilization at the time, few actions have been effectively implemented. New, less severe floods hit the city again in 2011 and 2019 caused by the same and previously identified problems: deforestation and environmental degradation caused by mining activities, both systematically worsening soil permeability and river silting, effectively contributing to the reduction of its flow capacity, the main cause of the floods.

3.2 *São Luiz do Paraitinga*

This city had its origin in 1768, from a foundational nucleus in one of the important roads in the Vale do Paraíba region, in São Paulo. But its importance lies in the 19th century, when it became relevant as a coffee producing region, as coffee was one of the greatest Brazilian riches of that time. The city, with its orthogonal urban layout, has a rich residential architecture typical of the 19th century, with manors and houses, squares, and churches, all built in rammed earth. Like Goiás, it is located in the basin of the Paraitinga River, in a section of the river where it forms meanders, which greatly increased the probability of flooding in summer periods. The heavy rains that occurred on the night of December 31, 2009, especially in the headwaters of the Paraitinga River, were the main factor responsible for this disaster that destroyed a large part of this heritage city. The average rainfall during that month was heavy, 50% above the historical monthly average. The factors that contributed to the environmental disaster that was similar to the one recorded in Goiás were: deforestation of the upstream slopes to form pastures, and disorderly expansion of the urban area, with sections and embankments for new settlements, contributing to the silting of the river and the reduction of its water flow capacity. The flood left more than 4,000 people homeless. The destruction reached almost all houses located near the banks of the Paraitinga River (houses from the 19th century, built with taipa de mão or wattle and daub), reaching even the Oswaldo Cruz Square, an important structural element of the city, where the *Igreja Matriz* (i.e., Mother Church), built in *taipa de pilão* (i.e., rammed earth), was located and became collapsed.

3.3 *Post-disaster actions*

In both cases, the participation of the community was essential for overcoming the crisis, especially considering the fragility and social deprivation of the residents. Specially in the case of São Luiz, this participation was intense, with great synergy in the actions of the residents, public authorities, NGOs, and universities. Thus, most of the adversities were overcome and, slowly, the economy and the cultural and touristic daily life were able to recover, thus guaranteeing a reasonable resilience process. Among these actions, it is important to highlight the emergency work done immediately after the disaster, under the coordination of a municipal agency, the CERESTA, with actions such as: interruption of power and water supply to the affected areas to prevent accidents; organization of rescue teams to rescue the population isolated in the rubble, in the middle of the flooded area; removal of the debris resulting from landslides from the streets; public cleaning actions in streets and squares to avoid the risk of sanitary collapse, with the spreading of diseases; inspection of all remaining constructions, relocating families and closing off properties at risk of crumbling; definition of technical, urban, social and heritage criteria for the process of rebuilding the constructions.

The rebuilding process was long, but participative, and received technical support from universities, and resources from the state and federal governments. The axis that guided the works was that of taking into account and considering relevant the collective memory of the city residents regarding the cultural and architectural landmarks of the city destroyed by the waters. In this way, a complex process of reconstruction of the city's Mother Church, a cultural reference for all, was undertaken, opting for a "*com'era, dov'era*" reconstruction, considered quite controversial by the theories of restoration and heritage intervention, but meeting the wishes of the population and their desire to reconnect with the city's historical landmarks (Mioto et al., 2016). Currently, in São Luiz, both the government and the community are better prepared to face emergency situations using monitoring and prevention processes that meet international recommendations such as: leveraging collaborative and information networks; monitoring environmental data related to the river water regime and rainfall in the region; defining, in the city's Master Plan, land use and occupation parameters that favor the increase of permeable urban areas, preventing the occupation of steep slopes, and favoring the sustainable use of land in rural areas; increasing the empowerment capacity of local government and organized civil society entities; in emergency situations, conducting the resident's relocation and urban reconstruction processes in an agile and quick manner, considering the respect to the restoration of the city's cultural heritage. (Mioto; Simões, 2016).

4 DISCUSSION

As a conclusion, we can summarize some of the recommendations for events of natural accidents involving heritage areas, especially in the case of flooding. The main recommendation regards the planning of preventive actions (Before the Damage) to minimize the impact of accidents, and eventually facing them (After the Damages) in an agile and efficient manner, integrating actions performed by the public authorities and participation of the community.

- Actions at regional level – create a basin management committee, integrating the municipalities located in the area to implement a Regional Master Plan for the hydrographic basin, which defines parameters for environmentally sustainable land use and occupation. This study should consider the characteristics of the basin (climate, geomorphological aspects, pluviometry), and the existing land uses that are relevant for the local economy.
- Actions at municipal level – definition of a land occupation Master Plan for urban and rural areas (integrating the Regional Master Plan) to promote sustainable agricultural uses, prevent deforestation, prohibit the construction of landfills and sections that might cause silting, increase soil permeability in urban areas, expand the drainage capacity of the basin through the restoration of gallery forests along the watercourse, promote the permanent collection of solid waste to prevent it from being thrown into the river, in addition to environmental education processes with the urban and rural population, and the creation of an Emergency Actions Committee, involving the population, along the lines of CERESTA from São Luiz do Paraitinga. In addition to these measures, it is also worth recommending a sustainable cultural and touristic agenda for these areas, as, being heritage sites, these cities become tourist attraction centers, bringing intense seasonality to the floating population of the city, with negative impacts on infrastructure, land use and occupation, and heritage conservation.

ACKNOWLEDGEMENTS

I would like to thank Pq/CNPq for funding and also for Tania Mioto contribution with relevant information for this research.

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Built Heritage in post-Disaster Scenarios – Balzani et al. (Eds)
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Reclamation plants between history and conservation: The effects of the 2012 earthquake

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ABSTRACT: Since the late 19th century, a complex system of draining systems, culverts, and barrels allowed to subtract the land to floodwaters and dedicate it to agricultural production. The hydraulic lifting implants can be distinguished based on their function as irrigation and/or drainage systems. The former has an important economic function for agriculture, while the latter is essential for preserving the territory. The most important plants were built between 1920 and 1930. The majority were damaged during the World War II and were later rebuilt in the years1950/60 in the absence of anti-seismic regulations.. Many of the buildings that contain these systems are subjected to protection restrictions by MiBACT (Italian Ministry for Cultural Heritage and Activities and Tourism).

These architectural constraints only allow interventions that are not excessively invasive. The buildings, therefore, whether consolidated and strengthened or not, can withstand earthquakes with return periods of about 100/150 years. Nevertheless, it is possible that while they are damaged and out of service, extreme meteorological events – such as extraordinary rainfalls - occur with such magnitude as to cause the flooding of thousands of hectares of land and numerous towns.

However, the use of modern high-speed pumps, which have much smaller dimensions compared with those in service with the same flow rate and hydraulic prevalence, can allow the use of light and modest-sized anti-seismic buildings for new lifting systems. This, together with new technologies that allow the remote control of the various equipment used to manage reclamation of the soil, can allow to reduce the hydraulic risk and make the combined hydrogeological and seismic risk unlikely.

Keywords: environmental disasters, heritage risks, preventive measures

1 INTRODUCTION

The seismic sequence that struck Emilia in 2012 highlighted how the seismic risk present in the area could increase the hydro-geological risk. In this paper, we will discuss the effects of the 2012 earthquake on the reclamation works of the lower Emilian plain. A number of buildings containing the water lifting facilities, subject to restriction by the MiBACT (Italian Ministry for Cultural Heritage and Activities and Tourism), suffered severe damages. For a complete report on the damage reported by the reclamation plants see (Tralli and Bucchi 2016). These buildings represent, indeed, some of the most valuable examples in Italy of industrial architecture of the beginning of the last century and are an example of the use of the then-innovative technology of reinforced concrete; therefore, certain restrictions appear justified.

Furthermore, the drainage works represent today a characteristic element of the landscape of the Emilian plains. Figure 1 and Figure 2 show two of the buildings damaged by the earthquake that highlight these artefacts' architectural and landscape quality. The most

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DOI: 10.1201/9781003253730-23

important plants were built between 1920 and 1930 and, mostly damaged during World War II, have been rebuilt around 1950 and reached their current functionality about a decade later. The buildings are seismically vulnerable; however, their function is strategic as they guarantee the usability and resilience of the territory. We are, therefore, in the presence of both a seismic and a hydro-geological risk. The 2012 seismic sequence highlighted that the two risks, obviously well known, are both present at the same time and, as such, must be considered and addressed simultaneously. The history of the Emilian plain, briefly discussed in the second Section, is essentially the history of its reclamation. This story is also the story of the floods that occurred over the centuries and changed the course of the Po and its tributaries. All this demonstrates the hydro-geological fragility of the plain, not always perceived by the population, but highlighted by the recent ANCE/CRESME report 2012 (Web-1), which shows how the urbanization and the risk exposure have risen in the last 50 years with the increase of the population in the lowlands. The ongoing climate changes that show a decrease in rainfall but an intensification of extreme events or of the amount of rain in short periods potentially further increase the risk. In the third Section, we will recall the historical seismicity of the territory. Then, we will briefly discuss the typological and constructive reasons why the buildings of reclamation plants are seismically vulnerable.. A study of the correlation between hydro-geological and seismic risks is presented for the lifting plant of Mondine situated east of the town of Moglia (Mantua). The building in question was the one most damaged by the earthquake and has been now replaced with a new drainage plant. We will end the paper with some brief considerations on how these multiple risks can be reduced with an improvement in the reclamation systems and the use of more modern technologies.

Figure 1. Lifting plant of Bondeno Palata built in 1925 (Burana Reclamation Consortium).

Figure 2. "Botti of San Prospero" near Moglia (Central Emilia Reclamation Consortium).

2 THE RECLAMATION OF THE EMILIAN PLAIN AND THE HYDROGEOLOGICAL RISK

The basin of the Po River, characterized by the presence of the Alps to the north and west and of the Apennines to the south, has significant slopes in the orthogonal direction to the great river. However, from Turin to the sea, the river has an average slope of only 0.34%, which comes down to about a tenth from Piacenza; the city is only 65 m above sea level and about 300km from the river's mouth. From west to east are also present significant depressions in the ground.

The first is near the town of Moglia in the province of Mantua, and it is noteworthy that, in the local dialect, this toponym means "wet."

The second one is near the town of Bondeno in the province of Ferrara; and let us remark that for Celtics the old name of the Po was Bodinkòs or Bodenkùs, from an Indo- European root (bhedh -/* bhodh-) which indicates "to dig," or "make deep" (Web-2).

The last depression, which has a depth greater than 5 m below sea level, is near the delta of the Po River in the municipality of Jolanda di Savoia. The men-made canals, built over the centuries for the reclamation of the plain by gravity, concentrate the waters in these depressions; the lifting facilities are necessarily located in these areas as well. Since the soils near the banks of the Po are mainly clayey, the territory - if not drained -becomes unavoidably marshy.

The history of the civilization and reclamation of the Po Valley is not within the scope of this paper. It is sufficient to remember that at the beginning of the Italic Bronze Age (1700-1100 BC), peoples who lived on pile-dwellings inhabited the plain, and this civilization is known as the "Terramare" civilization (Strobel and Pigorini 1864). The Po River had no embankments, and the plain hit by the 2012 earthquake showed itself at the time covered with marshes and dense forests where villages rose in clearings. Later, the Etruscans, Celtics, and Venetians settled in the great plain throughout the centuries.

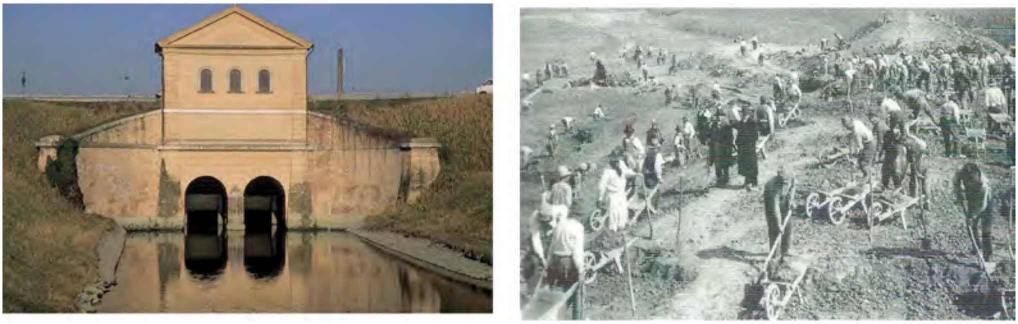

Figure 3. "Botte Napoleonica" Burana Reclamation Consortium on the left and "Scariolanti" during the construction of a plant of the Central Emilia Reclamation Consortium 19th century.

The first phase of authentic reclamation of the territory dates back to the Roman era. It took the Romans almost a century to conquer the region they called Gallia Cispadana. The first Roman colonization route was the foothills area on the slopes of the Apennines, where the Via Emilia is located, built by the consul Marco Emilio Lepido and finished in 187 BC (Quilici and Quilici Gigli 1995). The Romans began a monumental work of canalization, reclamation, and construction of roads and cities, in order to control this region.

They organized the region according to the rational method of centuriation, traced and oriented following the natural slope of the land and forming an orthogonal network over the whole territory, traces of which remain in the current arrangement of the farms. A large swamp remained, Padusa Palus, towards the mouth of the Po, where the tributaries Secchia, Panaro and Reno dispersed their waters (Web-3). In the late imperial age, the climate changed significantly, with an intensification of rainfall and consequent floods. In addition, the economic-institutional crisis of the Empire and the Barbarian invasions had considerable repercussions in the territories of the Po Valley. As a result, the organization of the territory was abandoned, and the forest and swamps gradually regained their former place on the plain.

The second major reclamation work occurred, around the year 1000 AC, in conjunction with an improvement in the climate, technical advances in agriculture, and an increase in population that had raised the demand for arable land. Fundamental in this regard was the work of the Benedictine monks, in particular of the Abbey of Nonantola. The Benedictine presence meant above all the cultivation of vast wooded and marshy areas thanks to deforestation and reclamation works, the construction of embankments, and finally, the restoration and maintenance of the drainage ditches.

Of particular importance was the excavation of new canals, which were essential pillars of the local economy and still constitute an integral part of the irrigation works (Web-4). Later starting from the 17th century, public intervention was lacking, in conjunction with a period characterized by wars and political changes. Moreover, in the meantime, the Po changed its course several times following disastrous floods: 138 events are known (an average of about one extraordinary flood every sixteen years) (Web-2).

The changes in the course of the river lead in the modern era to two important interventions. The first major hydraulic work, the Benedectine Canal, began in 1740 thanks to Pope Benedict XIV Lambertini. It was intended to create a stable riverbed to the Reno River and introduce it into the now dry riverbed of what had been the Po di Primaro. Then, Napoleon, in 1807, intervened to complete the hydraulic arrangement of the lower course of the Po, starting the construction of the so-called Napoleonic Canal, connecting the Reno and the Po, shortly after the mouth of the Panaro, to pour the floods of the Po into Reno and vice versa, see (Cazzola 1987, Web-3).

The completion of the reclamation of the lower Po valley began in the mid-nineteenth century with the use of steam pumps for lifting large quantities of water, introduced for the first time by Camillo Benso, Count of Cavour in his estates near Vercelli. Farmers' associations gathered in ever-larger consortia to buy, with the help of the State, and manage the new machines and new plants. As in the Middle Ages, these activities required massive use of seasonal labor consisting of the so-called "scariolanti," which have left a large trace in the Emilian folklore, Figure 3.

Therefore, since the late 19th century, a complex system of draining systems, culverts, and barrels allowed to subtract the land to floodwaters and dedicate it to agricultural production. The hydraulic lifting implants can be distinguished based on their function as irrigation and/or drainage systems. The former has an important economic function for agriculture, while the latter is essential for preserving the territory. The areas interested by the drainage were organized in Consortia. The Consortia structure is still in place, and nowadays, the Emilia-Romagna region counts eight Consortia. Figure 4 shows on the left the area hit by the earthquake, and on the right the subdivision into Consortia of the region; the most damaged buildings belong to the Consortia of Central Emilia and Burana. It is noteworthy that in Italy, the facilities are owned by the State, and Consortia use them in concession.

Figure 4. The area hit by seismic sequence in 2012 with localization of the epicenters of the two main events and of the accelerometric stations of the RAN network, on the left. MOG0 and BON0 denote the position of the towns of Moglia and Bondeno (Cattari et. al. 2012). The Consortia of reclamation in Emilia-Romagna on the right.

3 THE SEISMIC RISK OF LIFTING AND DRAINAGE PLANTS

Based on historical data and geological knowledge, INGV (Italian Institute of Geophysics and Volcanology) classified the Emilian plain as a low seismic area (zone 3) only after October 2003 (OPCM3274), although numerous earthquakes had hit this area in the past. The seismic hazard map (Interactive Seismic Hazard Maps) produced by INGV classifies this zone in the medium- low range risk and provides an acceleration peak approximately equal to 0.15g on hard soil and of 0.22g on C Category (180 m/s < VS; 30<360 m/s) soil which is most commonly found in the area. Historically, this same area had never been involved with a seismicity reaching magnitude MW = 6.0 over the past 1000 years. The maximum historical earthquake struck the area of Ferrara in 1570, with reportedly an intensity of VIII MCS (MW = 5.5). Indeed, it is to be reported that other more recent estimates would lead to by far higher hazard levels (Zuccolo et al. 2013).

The current drainage systems, in most cases, date back to the early decades of the 1900s; therefore, the buildings were built without any anti-seismic criteria. The flow rates to be drained and the necessary hydraulic prevalence were the criteria for choosing the pumps' type, size and power. These, built by the best electromechanical industries of those years, (Tosi, Magneti-Marelli, Riva-Calzoni, etc.), have considerable dimensions, approximately 3x5x5 m, and very high weight. These characteristics influenced the architectural distribution of the buildings containing them. Figure 5 shows the suggestive pump room of the Pilastresi plant on the left, while on the right is depicted the model of the building. The Pilastresi plant, built between the years 1928-37, and activated in 1949 due to the war, was defined as the most important plant in Europe due to its dual functions of drainage and derivation. The plant - damaged in May 2012, and out of service for a few months - was subjected to seismic improvement interventions that ended in 2014. According to the designer, it is currently capable of withstanding a horizontal seismic action equal to 40% of design acceleration provided by the NTC 2018 for a new building.

According to MiBACT (Guidelines 2011), these buildings belong to the group defined as "Churches, places of worship and other facilities with large spaces without intermediate horizontal elements" that for simplicity, in the following, we refer as basilica-like constructions. One or two main single-storey naves housing the body pumps indeed form these industrial plants. Typically, they have a slender rectangular shape, with one or two lateral towers or turrets, for the shelter of the control room and the electrical systems. From a technological point of view, these systems present an unreinforced masonry vertical load-bearing or mixed masonry/concrete structure. Long walls along with large openings and, sometimes, stiffening pilasters usually delimit the pumps room.

Large metal reticular frameworks that, in many cases, exceed 15 m in length often support the roof, usually at the height of more than 10 m. (Artioli et al. 1917, Tralli and Bucchi 2016). This type of structure typically presents extreme seismic vulnerability linked above all to the walls' high slenderness and the lack or insufficiency of bracing. Different local collapse mechanisms dominate the structural behaviour, and therefore it is reasonable to treat this type of building with an approach similar to that adopted for the churches. With this in mind, the Italian legislation provides for the use of the so-called "card with 28 mechanisms" designed for churches and introduced among the tools available to technicians, see (D.P.C.M. 23/02/2006) but applicable, at least in general principles, also for all buildings of the basilica type (MiBACT 2010).

Namely, a critical aspect to be considered is that the buildings under consideration are listed as cultural heritage patrimony. By virtue of the MiBACT provisions, in order of safeguarding the artistic and cultural value of the building, it is allowed to downgrade the structural interventions on these buildings to simple seismic improvement, this in compliance with point §8.4.2 of the NTC 2018 norms, or simply to a local intervention, according to §8.4.3.

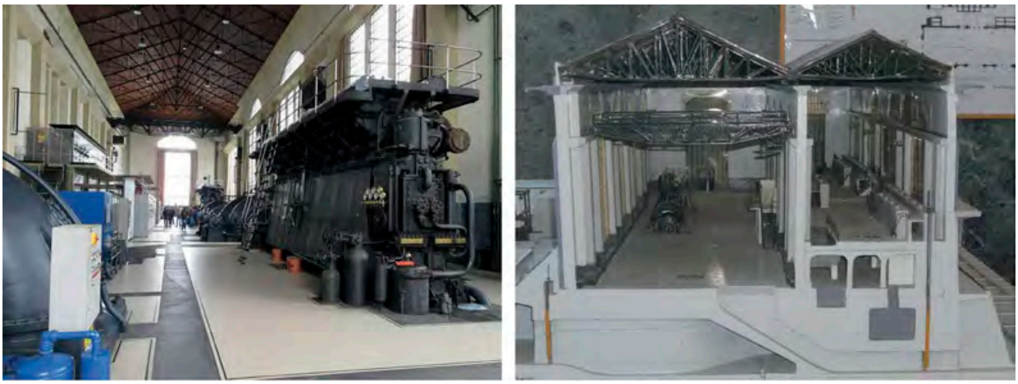

Figure 5. Pump room of the lifting plants of Mondine Pilastresi (Burana Reclamation Consortium) on the left and its scale model.

For these buildings considered part of cultural heritage patrimony, there is no possibility of operating deep interventions. This fact, as in the case of the Pilastresi plant, can at most allow a seismic improvement able to guarantee safety for seismic events with a return period of approximately 100-150 years.

4 A CASE STUDY FROM EMILIA EATHQUAKE 2012

The study of the correlation between hydro-geological and seismic risks is presented considering the lifting plant of Mondine situated east of the town of Moglia (Mantua). Although located in Lombardy, the structure, completed as of 1922, is part of the Central Emilia Reclamation Consortium. It serves the basin of the river Secchia ensuring the safety of the territories in the areas north of Reggio Emilia and Modena. Figure 6 portrays the relative flooding maps for the service basin. In the absence of drainage activity, the critical area can flood because of a meteorological event that involves a rainfall of 60/80 mm of water in 24/48 hours. Within the same amount of time, the entire basin could be flooded in consequence of a rainfall of greater than 80 mm.

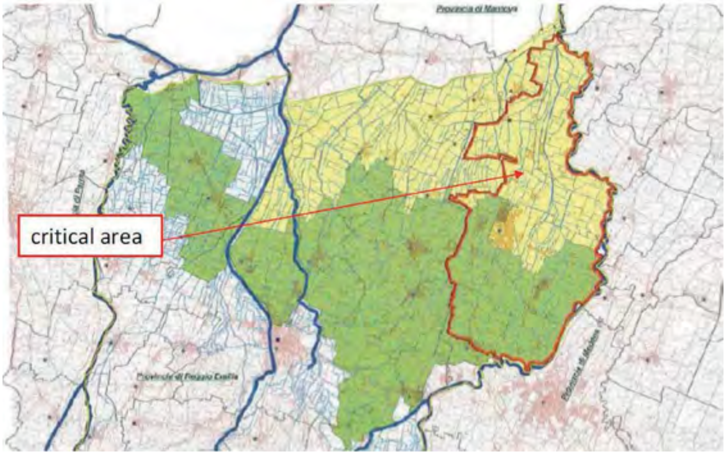

Figure 6. Flooding map of the Mondine Lifting Plant (Web-5).

The structure in elevation is made of unreinforced masonry, consisting of a main building where the pumps are located and a side turret containing hydraulic and electrical controls. The masonry elevations have a texture with multiple heads in bricks and mortar of lime while covering floors, firstly flat, were replaced in 1970 with pitched ceilings and masonry for a total 300% increase of weight. The dimensions of the structure are 60.10 m long and 14.50 m wide, while the eaves heights are 12.10 m for the pump room and 20 m for the tower. It has exhibited significant structural damage after the earthquake, probably amplified by the strong asymmetry of the building and by the new heavy roof.

In particular, a deviation at the level of the link between the tower and the main body and the expulsion of the outer angles of the tower have occurred (see Figure 7). The level of damage has made the site completely unusable. Within four months, the structure was made safe, and a new drainage system was activated for a cost of about 20 million euros.

The structural analyses and the numerical models for this building and the Bondeno-Palata buildings are reported in (Artioli et al. 2017). For masonry basilica-like structures such as these, the return period of the earthquake to which they can withstand results of the order of 50-70 years, mainly due to the onset of local collapse mechanisms. This result indicates that a modest earthquake (which has a high probability of occurring in the area) can lead to exceeding the limit state of operation and the consequent loss of functionality of the hydraulic lifting system. An event of this type, associated with violent weather-related events, could generate the flooding of the drainage basins with serious damage to the territory.

Figure 7. Mondine dewatering station, collapse of an angle of the turret and, at right, damages of the Vierendel beams supporting the floor of pumps room.

The available rainfall data of the reclamation areas here considered show that, on average, an important meteorological event requiring the timely use of the pumping systems occurred 20 times during the time period indicated above, Figure 8 on the right. The probability exceedance of this event, therefore, seems to be about 3%. By comparing these data with the probability of seismic events that can cause a loss of service of the lifting system (and the flooding of tens of thousands of hectares), a probability can be obtained over a period of one hundred years of about 2.5%. The probability becomes about 1.5% if Consortia intervene with an adequate seismic improvement as allowed for the buildings in the presence of MiBACT restrictions. Figure 8 on the left represents the combined seismic hydrogeological risk curve, i.e. it provides the annual probability of flooding, for the not rare scenario of 40-80 mm of rain in 24-48 hours, depending on the return period of the earthquake that jeopardizes the functionality of the system.

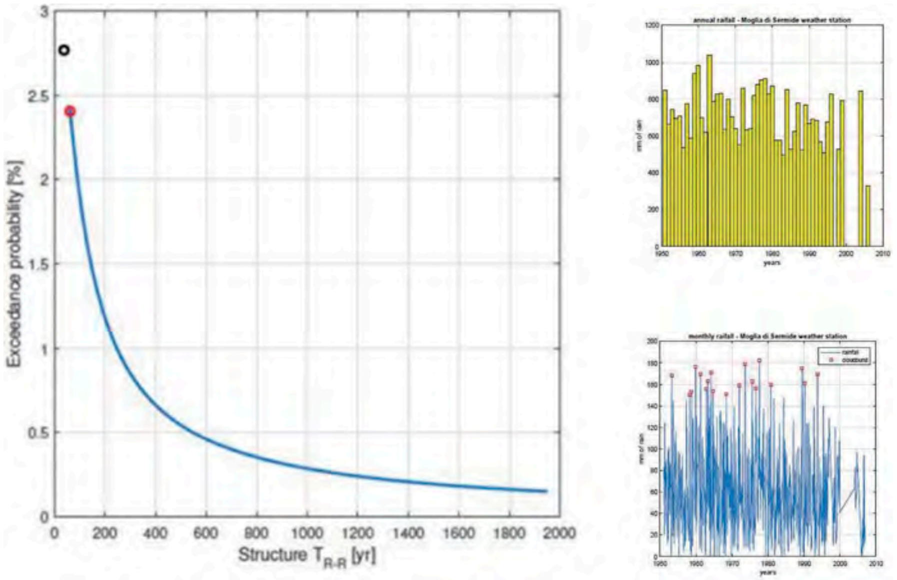

Figure 8. On the left the combined risk curve, represents the combined seismic hydrogeological risk, i.e. it provides the annual probability of flooding, for the not rare scenario of 40-80 mm of rain in 24-48 hours, depending on the return period of the earthquake that affects the functionality of the system. The red dot relates to the Bondeno-Palata plant. The black one in Mondine (Artioli et al. 2017). Rainfalls data at Moglia on the right.

5 DISCUSSION

The overall reconnaissance of the damage connected to the earthquake was carried out immediately after the seismic events by me, together with technicians of the Seismic Geological Service and other interested bodies. It concerned the hydraulic works managed by the Reclamation Consortia, AIPO (Interregional Agency for the Po), and the STB (Technical Services of the Basin). Due to the risk of flooding potentially connected to the autumn rains, the need to promptly intervene and secure the damaged building was immediately evident, especially to allow safe access to the electromechanical systems that govern the drainage mechanisms. The first interventions were indeed started as early as August 2012.

However, it is worth noting that the case examined shows the possible disastrous consequences of combined seismic and hydro-geological events in the lower Emilian plain. The plain is apparently safe; in reality, it is if the drainage plants work. However, the use of modern high-speed pumps, which have very small dimensions with the same flow rate and hydraulic prevalence, can allow the use of light and modest-sized anti-seismic buildings for new lifting systems. Moreover, new technologies that allow the remote control, and automatic computerized use of the various equipment necessary to manage the reclamation of the soil, can allow both to reduce the hydraulic risk and to make the combined hydro-geological and seismic risks unlikely. This involves in the next 30-50 years investments of hundreds of millions of Euros.

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Built Heritage in post-Disaster Scenarios – Balzani et al. (Eds)

Preliminary knowledge in post-earthquake interventions. The case studies of Navelli-Civitaretenga (AQ) and Codiponte (MS)

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ABSTRACT: A preliminary survey campaign is essential in projects of restoration, urban renewal, rebuilding or promotion of architectural and urban heritage. Today several survey techniques allow full 3D object restitution and modelling that provides a richer description than 2D representations. However, the amount of data to collect dramatically increases and a trade-off must be found between efficiency/productivity and accuracy /completeness of the results. Depending on the extent and the complexity of the task, a single technique or a combination of several ones might be employed. Especially when documentation at different scales and with different levels of detail are foreseen, the latter will likely be necessary. The paper describes two architectural surveys in Italy preliminary to a project of restoration and conservation: the old village of Navelli (AQ), affected by the earthquake in 2009, and the two most relevant remains in Codiponte (MS), damaged by the earthquake in 2013. In both sites, a 3D survey was necessary to effectively represent the objects. An integrated survey campaign was performed, which consisted of a GPS network as support for georeferencing, an aerial survey and a field survey made by laser scanner and close-range photogrammetry. Thanks to their peculiarities, the two case studies are exemplar to wonder if the integration of different surveying techniques is today still mandatory or, considering the technical advances of each technology, it is in fact just optional. The approach assigns to survey activities a central role, as a tool of critical knowledge through which the built heritage reveals the wealth of information of which it is the bearer. In particular, through a highly integrated approach applying both traditional tools and techniques and innovative methods, the archives permit the representation of the characteristics of the entire urban context in descriptive and interpretative graphic documents.

Keywords: Architectural and urban heritage, Earthquake, Integrated survey, Knowledge, Restitution

1 INTRODUCTION

The survey of the architectural and urban heritage is a highly interdisciplinary activity that involves surveyors, historians, architects, planners, structural engineers. Their goal can be the documentation, but also preservation, restoration, enhancement, rebuilding, maintaining or monitoring the heritage. In the operating environment of the survey for restoration or reconstruction, the three-dimensional acquisition and graphic restitution of data are particularly important as they allow to transmit a number of significant information higher than two-dimensional representations, granting a global view of the object studied, by simultaneously managing all components and aspects. The 3D survey techniques permit to acquire, quickly and with a high level of automation, a large number of real-time and high-resolution data. The 3D models obtained are highly corresponding to reality, letting the user to manage and integrate in every moment the complexity of the restituted information, depending on the chosen scale of representation or the finality of the survey.

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DOI: 10.1201/9781003253730-24

Referring to the urban studies conducted on contexts of similar dimensions, such as *Castella della Valleriana*, Berat and Gjirokastra in Albania by Alessandro Merlo, and through the description of two case studies referring to contexts affected by seismic events, the paper illustrates the procedures and operational methodologies for acquiring the quantitative and qualitative data necessary to deeply understand the specific peculiarities of the contexts investigated, in order to define the most appropriate way to intervene, according to planning purposes aimed at reconstruction and restoration of architectural and infrastructural heritage.

2 NAVELLI CASE STUDY

The town of Navelli (AQ) rises on the south-west side of Mount San Nicola about 700 meters above sea level. On 6th April 2009 a strong earthquake measuring 5.9 on Richter scale shook L'Aquila and most of his province, causing severe damage. As a result of this tragic event, the Italian central government implemented some policies for reconstruction, transferring to the municipalities of L'Aquila the tasks of arranging planning instruments and of defining strategic guidelines to ensure socio-economic recovery, settlements retraining and harmonious reconstruction of the urban centres. In 2011, the Municipality of Navelli charged the Department of Civil and Environmental Engineering and Architecture of Parma University to provide an urban planning project for the reconstruction and valorisation of the old town centres of Navelli and of its fraction Civitaretenga. Navelli's old town centre, founded during the Middle Ages, still clearly shows the different eras of the urban settlement. The area of the original settlements, characterized by narrow building blocks bordered by roads that run parallel to the contour lines, shows many buildings now reduced to ruins or in very bad preservation status. The urban structure is typically medieval, characterized by narrow streets and buildings following the typical shape of "lotto gotico", adapted at the slope of the terrain. Instead, the part located outside the medieval walls is less steep and the narrow buildings are replaced by more regular plans, with some true renaissance palaces. Here the blocks are more compact, though morphologically very articulate and quite varied in size. The need to adapt blocks and buildings to the land resulted in clear differences: urban planners faced a very the complex historical context and built environment.

Figure 1. Aerial view of Navelli town centre and classic 2D representation of footprints at 1:500 scale.

The main survey operations have been restricted to the old historical centre built on the hill, since the modern town expansion took place at the hill foot and, not having been damaged, is not part of the restoration plan. Considering its unique features (small streets, staircases, arches etc.), even if the overall area to survey was quite limited, from the very early stages of the survey design the need of adapting several techniques to the specific requirements was already evident. The survey activities were, first, devoted to the digital mapping of the historical settlement, to provide the urban planners with a topographic DataBase to support the design of reconstruction intervention in a GIS environment. Besides the building footprint, the identification of all the technological network elements (sewer and power grid) and the street network (in many cases made by staircases) were considered essential. In old historical city centres, conservation constraints prevent new constructions and only allow maintenance or reconstruction of buildings: however, to increase the appeal of living in the old city centre, renovation and improvements of standards of houses has been foreseen in the plan.

To promote joint effort from owners of adjacent buildings, the blocks were divided in smaller sections. Carrying heavy goods can be a problem due to fact that most uphill street are realized by stairs or contain at least same section with steps. For the above reasons and to facilitate the process of communication and discussion of the plan with the population, the possibility to display the proposed changes in an easy-to-understand 3D visualization was considered worth the effort of producing a 3D city model.

Therefore, a dedicated aerial photogrammetric survey has been foreseen. Moreover, given the historical and artistic relevance of some buildings and of some architectural elements, a detailed documentation of this selected heritage was foreseen as the basis for future promotion of the ancient village which, in the last decades, suffered a progressive depopulation. Particular attention has been devoted to building entrance doors and to some squares and corners with peculiar juxtaposition of architectural elements.

Figure 2. Sketch drawing for collecting measures on site and restitution of data sheet containing photos and all the qualitative characteristics of each building, identified in the map on the left. Features: address, cadastre, floors, pedestrians and car entrances, building type, position in the block, functions, building materials and details/technical elements of the façade.

2.1 *Survey campaigns*

Overall, the area of interest is roughly enclosed in a rectangle of 400x200 m, with a height difference of 80 m from the upper Castle to the church square below. Two scales of intervention were considered: the city scale for the entire village and the architectural scale for some prominent buildings. The necessary connection between the two surveys, carried out by different people, has been ensured by providing common reference points. The survey has been carried out with a straightforward hierarchical scheme: a GPS network providing the Ground Control Points (GCP) for the photogrammetric aerial survey and the reference coordinates to adjust the network of traverses along the streets.

2.2 *Old city centre survey*

A reference GPS station has been set up and determined with three separate sessions with respect to 3 permanent stations of the regional network. From this master station, 25 points have been surveyed. In most cases, the points lie at the border of the surveyed area and at the southern side, because inside the village the streets are too thin and the few squares are too small to ensure an acceptable PDOP. The aerial photogrammetric survey was performed mainly to provide the information of the rooftops and to complete the mapping of the village areas (especially near the north-eastern border, but also in some block) that were inaccessible from the ground for safety reasons. The images were taken from a Robinson helicopter by an operator with a Nikon D3x high resolution camera with a calibrated 35 mm lens, flying around midday to minimize the shadows. The parallel strips were flown correctly, ensuring high longitudinal and side overlap. Since the images were taken by the operator leaning out of the cabin window, they are inclined with respect to the nadir by about 30-40°. This prevents in many images the stereo coverage of the streets at ground level, but allows studying the area morphology as well as the building facades, that are usually occluded by the roofs in nadir images. Overall, 14 strips were performed to cover the built-up area and the neighbouring

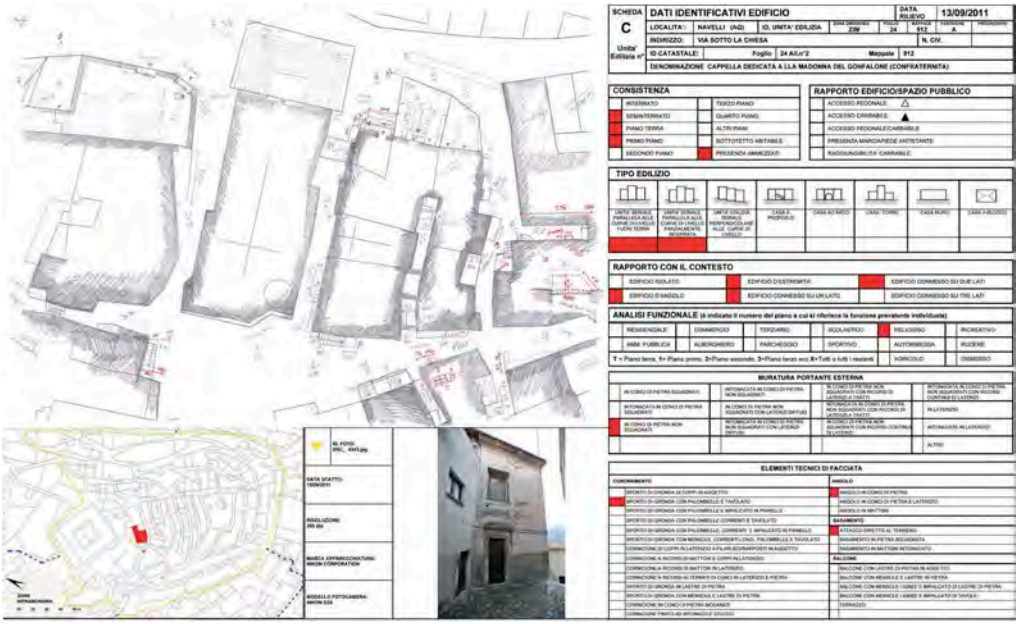

Figure 3. Sketch drawing for collecting measures on site and restitution of data sheet containing photos and all the qualitative characteristics of each building, identified in the map on the left. Features: address, cadastre, floors, pedestrians and car entrances, building type, position in the block, functions, building materials and.

lands, but only four were used to perform the block orientation and the photogrammetric restitution. The first three strips have N-E to S-W direction and a distance between flight lines of about 100 m, the fourth has been taken in the opposite direction at a larger distance (160 m). For the restitution of some details, additional pictures were taken by other strips with perpendicular flight direction and added to the block.

The flight line elevations ranged from 850 to 915 m, while the complementary images were taken at higher altitudes up to 1050 m. Because of high depth changes on the ground and the use of non-nadir images, the image scale varies from about 1:5.000 to about 1:10.000. The average image scale is 1:6.400; the Ground Sampling Density (GSD) is 3/6 cm. About 1500 tie points were automatically extracted for the bundle adjustment with the in-house *software EyeDEA* that implements Structure-From-Motion algorithms, while 14 signalized ground control points were manually measured. The estimated average accuracy of the tie points coordinates is 4 cm on X, 7 cm on Y and 7 cm on Z.

The photogrammetric restitution was carried out again using *Photomodeler*, exporting points, lines, polylines and surfaces in .dxf format. The following objects classes were considered: road edges, main walls, roofs slopes, abandoned buildings and ruins and unsafe areas. The building footprints were obtained with a field survey by measuring a network of 3D closed traverses, executed with the classical scheme of the three tripods with forced centering. In a few cases, open traverses have been used bound to the extremes by GPS points; mostly the traverses enclose a block or move along the main streets, linking the stations of the traverse outgoing from the side street. Whenever possible, the traverses include and are oriented on GPS points. All the metric and dimensional data necessary for the construction of the three-dimensional model of the town and for the realization of the two-dimensional plans have been collected. The average accuracy of the stations is about 3 cm in (E,N) coordinates and 1 cm in elevation. From each station, the essential points were measured to define the outlines of the masonry walls of the buildings. To document the off-plumb walls and the scarp walls, for each building metric information were collected at two different levels: at the junction between the perimeter walls and the ground, and at the intersection of the same perimeter walls with the roof. In addition, data on technological networks were collected, through the survey and classification of manholes covers, light points and storm drains.

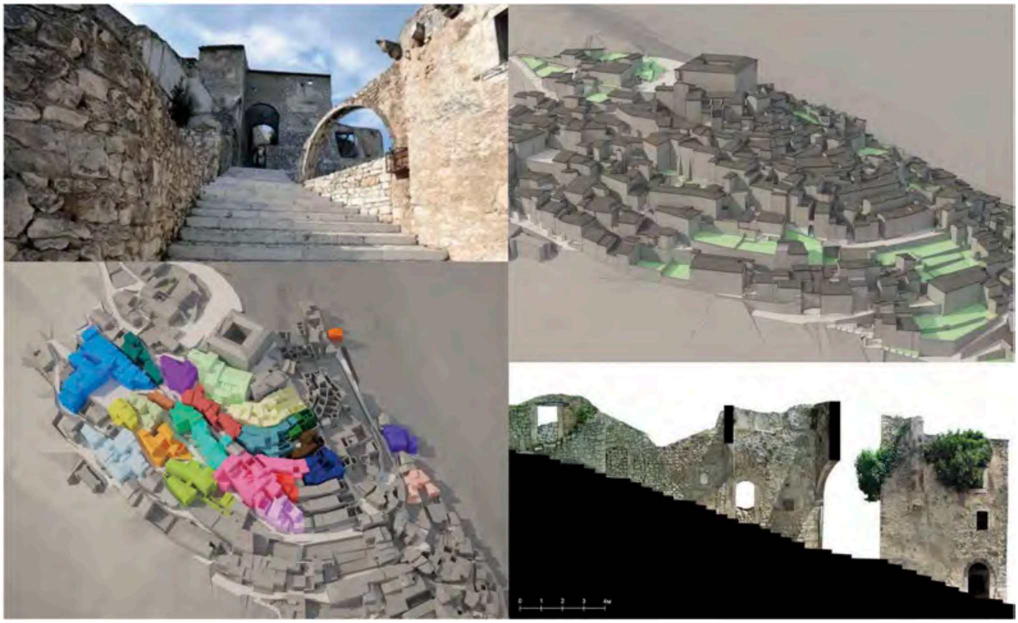

Figure 4. View of Via dei Macelli staircase, render of the 3D model of rooftops and the same with GIS query that highlight functional blocks, a vertical section from terrestrial photogrammetric survey.

Finally, the anchor points were determined, to connect the measurements of all the directly surveyed architectural elements. A total of 150 stations were used for the survey, with more than 4000 points measured overall. By joining the photogrammetric restitution to the topographic restitution from the fieldwork with Total Station, the base map skeleton has been obtained in vector format (.dwg). By extrusion and 3D modelling, the three-dimensional model of the entire town has been produced. Besides 3D visualization, two-dimensional plans and cross sections along were drawn. The cadastral map has also been added as layer to the map, to show property ownership in the urban planning and to highlight possible discrepancies with respect to the new map.

2.3 *Architectural and detail survey*

The elements that characterize the urban centre at the architectural scale (such as stairs, walls, curbs, ramps and stairs to access to the buildings) were accurately measured by direct survey, performed with the typical instruments such as laser distance meters, measuring tapes, etc., since a survey with Total Station would have been time consuming. Later, these elements have been added to the general urban drawing to complete the map. So, all the connecting elements between public and private space were documented. Concurrently with the field measurements, for each housing unit a report has been compiled containing all the information needed to characterize the building (localization, consistency, building type, functions, construction type, decorative apparatus, etc.).

All geometric and thematic data acquired during the survey campaigns were inserted in a GIS environment to assist the urban planners in the elaboration of project and in the production of thematic maps of the actual and planned status. In addition, to reconstruct at high resolution the most interesting part of the village, a Terrestrial Laser Scanner (TLS) and a close-range photogrammetric survey were performed on the staircase of Via dei Macelli. Though its current state is not original, this stairway has great relevance for its size and architectural quality. It runs uphill for over 100 m, climbing about 30 m of height. It is an element with high urban relevance, since it passes through a sequence of places belonging to the various phases of construction of the village and creates a beautiful perspective view.

The TLS survey was performed with a Leica C10 time-of-flight Scan-station. The staircase is made of sections of different slope and width, while at both sides the narrow passages, buildings reduced to ruins, articulated facades, arcs and other stairs make it difficult to avoid occlusions in data acquisition. Overall, 40 scan stations were necessary to avoid gaps in the point cloud. The scans were registered through common targets surveyed by Total Station and linked to the general reference system. A close-range photogrammetric survey of the staircase provided high resolution/high quality images to texturize the point cloud acquired by the C10 scanner, whose integrated camera did not give satisfactory results. At the same time, the photogrammetric survey allowed to evaluate the effective drawbacks and strengths of this approach compared to TLS survey. Over 300 images were taken on both sides of the staircase and oriented in the general reference system, thanks to natural and artificial targets surveyed by Total Station. The photogrammetric DSM was generated with *Agisoft PhotoScan*. Then, the mesh models were completed with the TLS data and used for the export of orthophotos.

Many portals are architectural elements of true artistic relevance and were therefore to be considered in case the building would be included in the restoration plan. A detailed survey of them was performed using both TLS and photogrammetry. The color-coded discrepancies of the two models after ICP registration shows that the different techniques agree within ±2 mm for most of the surfaces. The lighting condition and shadows might be the cause of other discrepancies (e.g. below the arch key). Overall, in this case data acquisition by photogrammetry is much faster and easier to execute compared to TLS, while data processing time and the quality of results are really similar.

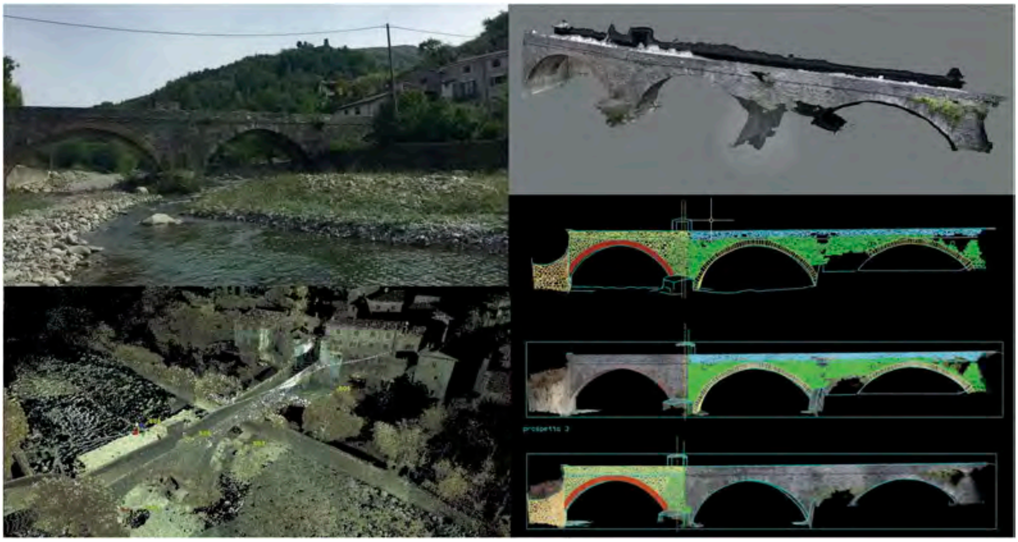

Figure 5. Codiponte: view of the bridge, rough point cloud with RGB data, 3D photogrammetric model and texturized orthophotos from which the 2D drawing of geometries and masonry blocks has been extracted.

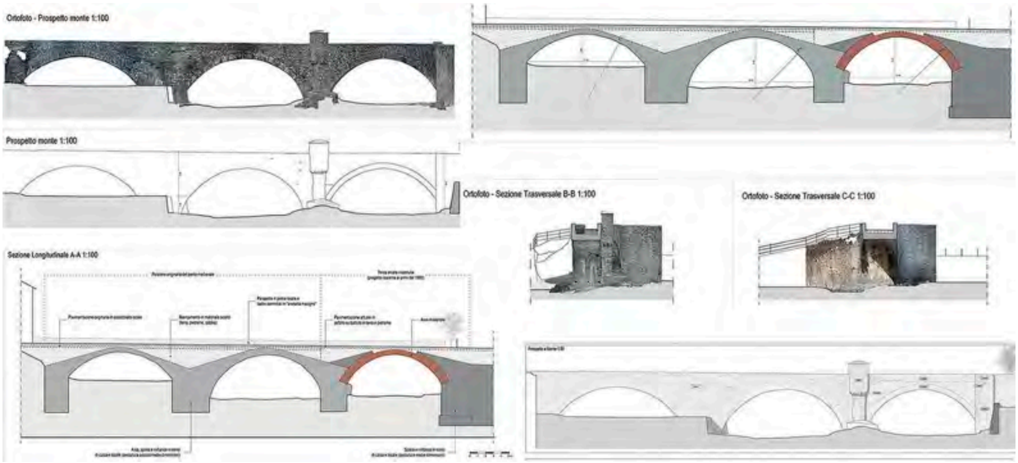

Figure 6. Excerpts of the drawings of graphic restitution of the geometric and thematic survey of the medieval bridge in Codiponte.

3 CODIPONTE CASE STUDY

Codiponte is a village in the municipality of Casola in Lunigiana (Tuscany, Italy), in the Province of Massa-Carrara at about 250 metres above sea level. It takes its name from the ancient bridge ("Ponte" in Italian), set over the River Aulella, still open to traffic and important and distinctive feature of the village. The village rises on the Via Francigena and has been an important settlement since the 7th century BC. The present settlement dates to Middle Ages and it is placed on the slope of the hill.

The bridge and the castle represent the most significant elements of the village, both for their history and for their architectural and artistic features. The bridge dates to

11th-12th Centuries, it is a three-span bridge, the masonry is of bricks and stones depending on the time of construction. In fact, the bridge underwent numerous reconstructions and reinforcement because of collapses and damages due to flooding of the river. The castle overlooks the entire village. It would represent the focus point of Codiponte, but it is now in ruins and largely damaged by weed and collapsed. Due to its advanced state of decay, its original structure is anymore not well recognizable. Originally, it had a square perimeter with many internal elements, with stairs and vaults, and it was subdivided in two levels.

On 21st June 2013, a big earthquake hit the village and the castle was further damaged. Due to its current state, the complete recovery for its reuse is unrealistic. However, the local administration required a project of promotion of the entire village, with emphasis on the conservation of the ancient castle to preserve at least its state of ruin and to avoid additional collapses that could endanger the houses below, and a project of reinforcement of the bridge, which was damaged in particular in correspondence of the arch and the abutment near the road. The project has been awarded to DICATeA and an accurate preliminary survey campaign was performed of the village and specifically of the castle and of the bridge.

3.1 *Survey campaigns*

The aims of the survey campaign were essentially two: collecting all the information on the artefacts (such as geometry, structure, materials, state of damage, crack system etc.), to address the restoration project, and, at the same time, providing a 3D model of the castle as useful instrument to evaluate the restoration choices and planning the maintenance actions. For these reasons, a 3D survey was performed, and the models obtained were used both to extract the standard two-dimensional documents required (orthophotos, plans and cross-sections) and to implement the 3D model. Differently from Navelli, the object of the survey was more circumscribed, and the range of survey scales was more limited, corresponding to architectural and detail scale.

3.2 *Bridge survey*

The survey of the bridge was rather simple, because it has a linear structure that allows measuring all parts without occlusions and it is easily accessible, especially in summer and first months of autumn, when the riverbed is almost empty and the flow rate negligible. In this case, the advantages and disadvantages in the use of TLS or photogrammetric survey are comparable, because the bridge is accessible both to position the terrestrial scanning stations and to take the images even under the arches, while the texture, the light conditions and the object dimensions did not favour a technique. Nevertheless, having the possibility of using both techniques and considering the benefits that an integrated survey generally produces, both surveys were caried on. The survey was supposed to bring a complete knowledge of the object status, in order to assist the restoration project. Photogrammetry was particularly efficient in producing orthophotos as base for surface deterioration analysis.

At the time of the survey campaign, the bridge was affected by weed, above all bushes in correspondence of the abutment near the road, so it was necessary to update the 3D model after weed removal to observe cracks in the masonry. Additional surveys were required to update the model during the restoration works. Again, photogrammetry was more suitable than TLS, thanks to its flexibility and possibility to add new images to the original block. However, terrestrial photogrammetry was not sufficient for the complete acquisition of the bridge, being impractical for the survey of the extrados: laser scanner has been used to this aim. Seven scans were performed with a Leica C10 scanner over and all around the bridge to have points in common with the photogrammetric model and co-register them. The photogrammetric survey was performed with a Nikon D3x camera with calibrated 35 mm optics. Overall, 131 images were taken and processed with *Agisoft PhotoScan*. A bundle block adjustment was performed using some points gathered from the laser point cloud as GCP, so that the two models were generated in the same reference system. The comparison of the two DSM (photogrammetry-based and TLS-based) showed minimal differences, in the range of TLS expected accuracies (ca. 5 mm). The upper part of the bridge, acquired by the TLS, was used to integrate the missing parts in the photogrammetric DSM. From the assembled model, all the traditional products, such as orthophotos and cross-sections, were obtained.

3.3 *Castle survey*

The castle stands on steep, very rugged terrain covered with vegetation that infests the ruins. It was in fact necessary to remove a large part of vegetation to carry out the survey. As already mentioned, the castle is in a very precarious state of conservation, with many collapsed parts reduced to heaps of stones. Performing a complete and time-consuming direct survey with tapes and range finders, also in the less damaged parts, would have been dangerous for the safety of the surveyors, due to the precariousness of the structure.

So, the direct architectural survey of the accessible and less unstable areas has been integrated with a TLS and terrestrial photogrammetry survey, the latter much faster (and consequently safer) in data acquisition. Also in this case, an integration of the two techniques was not strictly required: both approaches provided satisfactory results with comparable overall workload. The photogrammetric acquisition is faster, but it requires a careful planning of the block geometry to provide a complete reconstruction. Its integration with UAV acquisition of the top parts of the castle (such as the top of the walls or the extrados of the vault, not visible from the ground) is straightforward, and DSM and orthophoto generation can be successfully operated with automatic Structure from Motion and Dense Matching algorithm implemented in commercial software. The survey of GCP is mandatory and requires additional field operations. On the other hand, TLS survey requires longer measurement sessions on site, but provides immediate reconstruction with lower chance of incompleteness. If georeferencing is not required, TLS does not need the survey of GCP if a strong network of scan stations can be set.

Figure 7. Aerial and close photo view of the ruined ancient castle in Codiponte.

Figure 8. Photogrammetric block of the Castle, views of the dense point cloud and texturized 3D model.

4 DISCUSSION

Codiponte is a village in the municipality of Casola in Lunigiana (Tuscany, Italy), in the Province of Massa-Carrara at about 250 metres above sea level. It takes its name from the ancient bridge ("Ponte" in Italian), set over the River Aulella, still open to traffic and important and distinctive feature of the village. The village rises on the Via Francigena and has been an

Figure 9. Excerpts of the drawings of graphic restitution of the geometric and thematic survey of the ancient castle in Codiponte.

important settlement since the 7th century BC. The present settlement dates to Middle Ages and it is placed on the slope of the hill.

In the first half of 2000, with TLS spreading fast, photogrammetry seemed to lose ground and surveyors split between the opposing factions. After some time, in most paper a settlement for "integration is better" seemed to prevail. Then, "the comeback of photogrammetry" (Haala, 2009) opened again the discussion on which technique would have been the best. There is a little chance that the debate will see the end and certainly this is not the goal of this paper. However, there is no doubt that the progress in DSM generation from images has greatly improved in recent years, both in completeness and accuracy of the survey.

Once the characteristics of the field of study and the purposes of the survey activities are known, strictly connected to the type and contents of the cognitive framework being defined, the choice of the operating methods with which to proceed is simple, especially considering the always more widespread conviction of the need to proceed by integrating increasingly performing tools and techniques. An aspect on which it is increasingly necessary to focus is that of the methods of acquiring and documenting the qualitative aspects that must necessarily integrate the quantitative ones to define a complete and exhaustive cognitive framework as a necessary premise for any subsequent transformation intervention, at whatever scale it occurs.

ACKNOWLEDGMENTS

Agreement between the Department of Civil Engineering, Environment, Territory and Architecture of the University of Parma and the Municipality of Navelli (AQ) for the realization of activities related to the post-earthquake reconstruction of April 6, 2009. Scientific Responsible Prof. Paolo Ventura - July 2011/October 2012. Execution of preliminary operations aimed at defining an accurate cognitive picture of the state of the places after the earthquake of 6 April 2009 in view of the formation and approval of the Reconstruction Plan of the perimeter areas of the capital of the municipality of Navelli and of the fraction of Civitaretenga (AQ). Working group for the execution of the architectural and urban survey: prof. Arch. Paolo Giandebiaggi; prof. Arch. Chiara Vernizzi; prof. Arch. Andrea Zerbi; PhD. Arch. Maria Melley; PhD. Arch. Andrea Ghiretti; PhD. Arch. Daniela Paltrinieri; PhD. Arch. Ilaria Fioretti, PhD. Arch. Giorgia Bianchi. Working group for the execution of the topographic and photogrammetric survey and restitution: prof. Eng. Riccardo Roncella; prof. Eng. Gianfranco Forlani; PhD. Eng. Cristina Re, PhD. Eng. Letizia Bagnaresi; PhD. Eng. Matteo Fornari; PhD. Eng. Roberta Lanubile; PhD. Eng. Marina Santise; PhD. Eng. Benedetta Pastarini; PhD. Eng. Davide Ettore Guccione.

Agreement between the Department of Civil Engineering, Environment, Territory and Architecture of the University of Parma and the Municipal Administration of Casola in Lunigiana (MS) for survey, analysis, evaluation of seismic vulnerability and technical-scientific support in the identification of technical solutions for the restoration and consolidation of the fortress and the medieval bridge of Codiponte (MS). Scientific Responsible Prof. Chiara Vernizzi - October 2015-June 2016. Execution of preliminary operations aimed at defining an accurate cognitive picture of the state of the architectural and infrastructural elements after the earthquake of 21 June 2013, in view of the restoration and consolidation of the Rocca and the medieval bridge. Working group for the execution of the architectural survey: prof. Arch. Chiara Vernizzi; prof. Arch. Andrea Zerbi; Eng. Andrea Lusignani. Working group for the execution of topographic and photogrammetric survey and restitution: prof. Eng. Riccardo Roncella; PdD. Arch. Nazarena Bruno; PhD. Eng. Marina Santise.

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Built Heritage in post-Disaster Scenarios – Balzani et al. (Eds)

Emergency management: Awareness, knowledge and communication after the Emilia earthquake in 2012

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ABSTRACT: This contribution wants to focus on the different ways of managing the emergency following an earthquake. The experience developed in Emilia, after the seism of May 2012, gives useful suggestions on specific measures to be set for informing local communities, for improving the knowledge of the damage in the area affected by destructions, and for managing the removal of debris from the fields.

Keywords: Architectural and urban heritage, earthquake, integrated survey, knowledge, restitution

1 INTRODUCTION

Managing an emergency is no easy task. Dealing with a totally unexpected and devastating earthquake can be a great physical and mental strain. Working within a structure that must manage the aftermath of an earthquake means appealing to all available resources, never being certain of how and when all activity resulting from the disaster will be brought to a close.

The vast area affected by the earthquake of May 2012 is located between the towns of Ferrara, Modena, Mantova and Bologna. The two extremely strong mainshocks of May 20 and 29, with magnitude of 5.9 and 5.8, caused deaths and severe damage to the surrounding territory as well, in near regions of Lombardy and Veneto.

The effects have been severe on monumental buildings because of their history and their materials. Traditional construction materials and methods, often with lack of chains, produced structures that were incapable of withstanding the horizontal forces of the earthquakes. Moreover bricks were made with local fired clay and mortar was often a mixture of earthy sand poor in lime. Cities, towns and villages – like Finale Emilia, Concordia sulla Secchia, San Possidonio, Cavezzo, Mirandola and many others- are suddenly pushed to the fare, while general public lacked exact knowledge of their characteristic and location.

While it is true that the toponyms of these Emilian towns may have previously sounded unfamiliar to the people from distant places, the seism has been perceived by the people living in the area as an unexpected and devastating event also because they were not prepared to such a disaster and its consequences -as it may be in other Italian regions- and is has particularly generated a huge psychological trauma amplified by the lack of familiarity with earthquakes.

The first thought of the authorities involved in the conservation of cultural heritage, in the aftermath of the earthquake of May 20, 2012, was to establish a database that could help provide an overview of the situation. Dozen of officials, sometimes with the help of professionals, academics and volunteers from across the Emilia-Romagna region and other

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DOI: 10.1201/9781003253730-25

Italian regions as well, immediately begun to gather to perform a survey of the damage to the cultural heritage scattered throughout a territory that is as vast as it is unknown to most Italians. Many teams needed to be organized and their activities coordinated. Any and every kind of information from every corner of the vast area affected needed to be collected. Finally, it was necessary to extract fragments of the works of art from the collapsed or unsafe historical buildings, to note the state of conservation of walls, frescoes, structures, archives, and decorations, to collect data and often partial and incoherent information, to reorder the documentation, to have the complete and exhaustive picture of what had happened, as soon as possible. Each team meticulously catalogued the rubble, performed an inventory of movable assets, rescued historical archives and surveyed monuments, churches, villas, palaces and castles.

From the early stages dedicated to collecting, cataloguing, and surveying, within a few months they moved on to the task of evaluating safety and restoration projects.

Along with all purely technical procedures and activities for the restoration, conservation and the future reconstruction of the damaged or lost heritage, innovative initiatives, focused on the acquiring of data, the construction of an innovative database, the promotion of scientific studies, were setup to inform the public of the vast range of actions defined by the authorities for cultural heritage.

Figure 1. More than 2200 historical buildings suffered of damages or totally collapsed.

2 THE CREATION OF A NEW WEBGIS

The reports that flooded in from the devastated area spoke of damaged and unsafely built cultural heritage and of the need to save what had survived. The need of reliable maps and data grew up as did the complexity of the information that had to be elaborated: damage report, works to remove the rubble, projects to render safe and to restore damaged buildings, and so on. For this reason a first relational database and a Geographic Information System (GIS) became a full-blown geo-database of Emilia-Romagna's cultural heritage in 2013. The experience and skills acquired during the earthquake emergency went beyond the scope of the mere emergency to form the basis for a better knowledge and management of the whole protected heritage. Not only would it be possible to deal more effectively with future emergencies, but also a useful everyday tool could be made to the community . The system was developed entirely with open source technologies, and beside including the over 1400 historical buildings affected by the earthquake, the database includes now the mapping of the entire cultural, archaeological and landscape heritage of all the region. It is available to the public and government bodies through an online cartographic portal (www.patrimo nioculturale-er.it).

Figure 2. A new online tool, with a GIS base, for the knowledge of cultural heritage.

Figure 3. Artists and photographers developed the theme of the emergency state due to the 2012 earthquake. Top- left: Chiavica, Poggio Renatico, Ferrara (ph. Beatrice Lontani). Centre and top-right: Chiesa arcipretale, San Felice sul Panaro, Modena (ph. Chiara Baldini). Chiesa arcipretale, San Felice sul Panaro, Modena (Giuseppe Toscano). From the archives of the Unità di Crisi - Coordinamento Regionale (i.e., UCCR), Ministry of Culture, Bologna, and Fondazione Studio Marangoni - Florence.

3 RUBBLE MANAGEMENT

A quick and effective rubble management was needed for conservative reasons, for the safety of the areas to assure the traffic and for important psychological implications, to avoid the people to perceive any form of abandon and mismanagement . For the first time in similar scenarios, a team of experts (archaeologists, restorers, architects) has been created to assess the collapsed materials and to provide the much-needed indications to the owners of the building. The experts, starting from the information and localisations received in the central office installed in Bologna (UCCR, Unità di Crisi Regionale) thanks to the database defined, moved through the areas for specific surveys of collapsed buildings, to be done with each owner.

During the visits a report was signed by all people participating, to define specific operations and criteria of selection, study, disposal or storage of the debris along with their characteristics, cultural value and potential interest for a future reconstruction.

Figure 4. Immediate management of the rubble: debris have been selected and stocked according to their historical and artistic value. (From the archives of the UCCR, Ministry of Culture, Bologna).

4 COMMUNICATION ACTIONS

A group of officials from the Ministry of Cultural Heritage tenaciously and passionately developed a project that could bear lasting and effective witness to what had happened to the territory, landscape and especially to the cultural heritage. The ultimate goal of the project was to establish a documentation centre on the damage to cultural heritage caused by the earthquake in May 2012. The hope was that the wealth of data and the vast amount of work carried out could provide the basis for a rational, informed and careful reconstruction of fragments of memory, and a crucial point for meeting a studying what was irretrievably lost.

When a creative team suggested naming the project Terreferme, the team was fascinated by the idea that everything they had been working on might have a form of closure. They imagined a haven, a safe place after a long journey. They felt reassured by a noun that evoked the security of something stable, only letting go on the idea of the earthquake. They also thought of the contrast between land and water, which makes up the Emilia-Romagna area hit by the earthquake. The choice of lettering in sober solid colours a simple evocative word full of meaning seemed like the best way to begin a new adventure.

Communicating in silence, away from the press and as effectively as possible, all the work done, also involved the preparation of an exhibition that recounted the highlights of the emergency management carried out by the officials responsible for the protection of cultural property. Choosing a somewhat less scientific approach with the hope of conveying the essential care of the experience, we developed an engaging streamlined exhibit with the aim of giving the sense of unceasing impassioned activities, using tools provided by modern communication technologies.

More than 200 thousand photos have been catalogued, viewed and filed. These were not only an iconographic heritage for the historical memory but also represented the starting point for a major documentary journey. In addition to this wealth of images, with the first works to implement safety measures, a start has been made to regularly video-record the various phases of the work. The hours, days and months of work have been digitally recorded including the removal the debris, the installation of scaffoldings, the shoring work, to reveal the hard work by the teams of architects, engineers, firefighters and workers. In the exhibition, the nature and strength of the images inspired a narrative sequence full of colours, materials, nature, emotions and at times even poetry.

The exhibition, with its innovative and immersive setup, was held during the Triennale of Milan from the 29th May to the 20th July 2014, and afterwards took place in Bologna (2014-2015), Ferrara (2015) and Minsk (2015). Along with the exhibition, events and meetings have been organized to inform scientific and general public, and to up-to-date information thanks to publications, always under the naming of Terreferme. Part of these communication actions has been the organization of several guided visits to the working sites, hold by the representative of the Ministry involved in each project. This has made possible for the populations to enter again their churches and cultural buildings, to re-appropriate of their cultural and identity symbols, to check the state of the working sites and to understand the vast and hard work done and to be done.

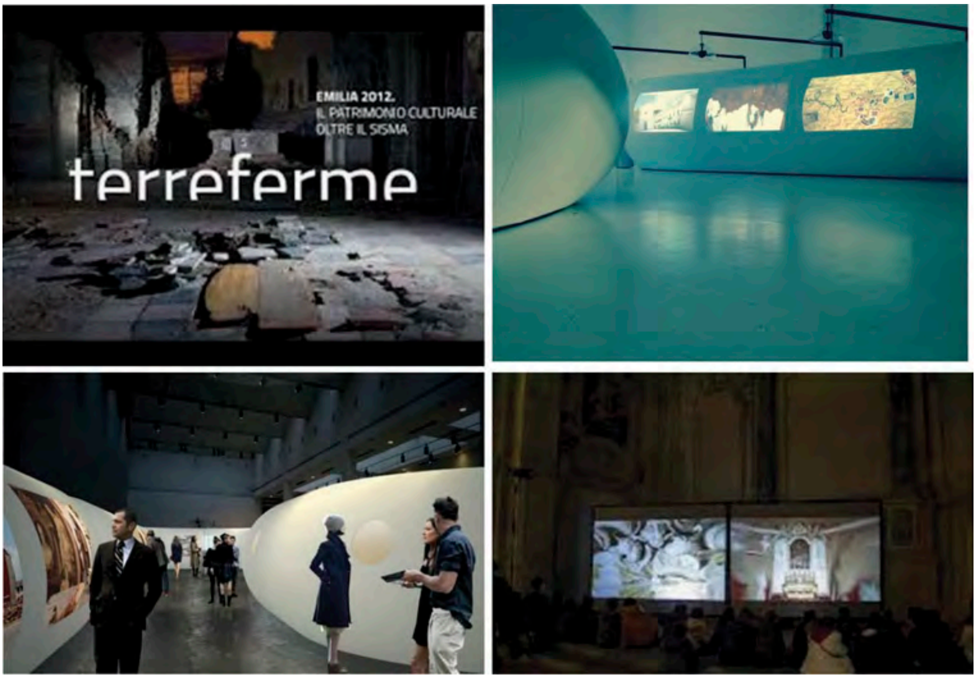

Figure 5. The communication actions included a specific and coordinated graphic image and 4 different location for the exhibition. (From the archives of the UCCR, Ministry of Culture, Bologna).

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WEB SITES

Web-1: http://www.terreferme.beniculturali.it
Web-2: http://www.patrimonioculturale-er.it

Part 2

Thematic lectures

Built Heritage in post-Disaster Scenarios – Balzani et al. (Eds)

From disaster to community restoration through interventions on the historical and artistic heritage

Antonino Libro*
Coordinator of interventions for the post-earthquake reconstruction of protected buildings Agenzia Regionale per la Riostruzione Sisma 2012 – Regione Emilia-Romagna

ABSTRACT: Introduction to the case studies presented by the Agenzia per la Ricostruzione Sisma 2012 della Regione Emilia-Romagna (Regional Agency for Reconstruction/2012 Earthquake).

As part of its training offer, the International Academy "After the Damages" has included in-depth studies on cases of post-earthquake reconstruction of historical and artistic heritage buildings as emblematic examples of the interplay of best practices and complex actions necessary following calamitous events, and specifically, after an earthquake.

This heritage was the most affected and the most fragile: about 80% of the buildings affected by the earthquake between 20 and 29 May 2012 were listed by decree or by force of law.

Therefore, for the first year of the school, the Emilia-Romagna Regional Agency for Post-Earthquake Reconstruction has identified some cases that have sought to demonstrate the governance experience gained in the post-disaster period. However, at the start of planning Covid 19 came along, with all its uncertainties, and this made it impossible to deliver on-site training, with visits to the sites where work is in progress, accompanied by an explanation of the project authorisation process.

After a long discussion within Technical Scientific Committee, of which we are a part, the conclusion was reached that the reconstruction experience should not be lost, and that a story could still be produced remotely. So, once the buildings had been identified, we set about building a kind of "screenplay" for the lessons, a story in images that made up for the lack of visits to the places and buildings that the lessons were about. We realised that, yes, the pandemic would leave us in lockdown at home, but it would allow us to reach as many people as possible who, although not present in the flesh, would be able to hear, through specially commissioned videos and specific lessons, what for us was important to communicate, without losing sight of the scientific aspect required by such a highly qualified school.

The key word was interdisciplinarity, a term that brought with it, in a domino effect, other concepts such as preliminary analysis and risk mitigation and management, as well as socio-economic issues of governance and increasing resilience, adding more specific aspects such as investigation, diagnostics, digitisation and finally arriving getting to the central topic, restoration.

The 2012 earthquake hit an area that is vast, not only in terms of population and industrial concerns with international profiles (in biomedicine, fashion, motor vehicles etc.), but also in terms of the number of municipalities - 59 to be exact - each with its own historic centre made up of churches, palazzi, theatres, castles and cemeteries.

We identified four examples to present within our training proposal, one for each affected province:

– The Schifanoia Palace in Ferrara
– The Collegiate Church of Santa Maria Maggiore in Pieve di Cento, Bologna

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DOI: 10.1201/9781003253730-26

– The Duomo of Mirandola, Modena
– Palazzo Sartoretti in Reggiolo, Reggio Emilia

Each represented specific aspects within the post-disaster activities. Four buildings whose restoration brought heterogeneous contents, all part of the wider complex of post-disaster management that has had successful and effective outcomes. The lessons were each described as a "virtual visit to the restoration site". Palazzo Schifanoia, one of the finest examples of the Italian Renaissance, has been returned to the community through the governance of its restoration as a synergistic work involving a range of skills from design to administration. Not only was the damage to the building repaired, but the intervention was an opportunity to launch a more complex project that led to a review of the museum's offer, rediscovering its original volumes and updating the lighting that enhanced the extraordinary decorative scheme, thus returning a building of greater value than before the earthquake.

In the case of the Collegiate Church in Pieve di Cento, the story of the reconstruction of the collapsed dome as an example of how different skills can be superimposed on one another, and this made it possible to depict what is intended to be a "knowledge work site". A set of studies, surveys, investigations and choices to recreate what is missing, the balancing of which returned the church to the community in a relatively short time and with it all the extraordinary works of art it contains.

The Duomo of Mirandola can be considered a paradigm of the of reconstruction in Emilia. Its significant collapse, affecting more than 50% of the building, was followed by design solutions in a contemporary language which at the same time respects the protection aspects while guaranteeing safety, and represents an example of restoration which carries with it a major debate on the reconstruction of large portions of buildings that had been lost forever with a catastrophic event.

Finally, the fourth event focused on Palazzo Sartoretti in Reggiolo, which was transformed from a noble residence to a strategic building that will house the municipal offices. The earthquake is therefore seen as an opportunity to not only repair the damage but to rethink heritage buildings through a wider and more effective participatory planning of a territory. The case study is therefore to be considered the final synthesis of an inclusive vision of the community on the part of the authorities, which in different contexts and emergency situations tend to act autocratically, for operational reasons and in order to shorten time frames, finally succeeding in delivering what the townspeople want, together with the courage to redesign the centres of gravity of the town.

We have tried to provide a broad range of contributions, an example of that balance between technical aspects and management skills, in order to present a pathway for risk management and the effects that can be generated by collecting some examples from our Cultural Heritage assets, already thinking about the next set to bring to the second cycle of lessons of the following year.

The path set out by the Regional Agency for Reconstruction/2012 Earthquake, although limited to specific cases of reconstruction of cultural heritage damaged by seismic events, purports to transfer those notions necessary to the recovery of heritage buildings as a way for the community to recover and to increase its cohesion and specific value. In fact, the review of the cases selected, through the narration of what was done "After the damages" has the final ambition to promote debate on what actions and decisions should be taken "Before the damages", processes that would certainly increase the resilience of the community, by increasing awareness of calamitous events.

Built Heritage in post-Disaster Scenarios – Balzani et al. (Eds)

Palazzo Schifanoia in Ferrara

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ABSTRACT: The paper aims to illustrate the restoration process that interested one of the most important 15th-century buildings in Italy to stand as a point of reference in the post-earthquake reconstruction governance, an almost mandatory stage in the management of all actions relating to its recovery in the aftermath of the May 2012 seismic event. The conservation track includes a multifaceted restoration project that comprises not only the restoration of the decorated surfaces but also the function renewal of its spaces and paths, resulting in an illumination plan intended to improve the wall- painted cycle. The assessment of the damage mechanism activated by the seismic actions and the analysis of the crack's framework addressed the structural interventions enhancement plan intended to repair the damage and improve the overall seismic response of the whole structural unit. In addition, it was the opportunity to rethink the museum's functionality by arranging a single broad itinerary covering the exhibition spaces, the astonishing rooms on the main floor, and new rooms on the ground floor, shaped by removing the mezzanine floor in order to recall the original spaces. The complexity and variety of spaces that characterize the building, the multiplicity of situations and testimonial traces of the Palazzo itself, and the great variety of works present in the exhibition itinerary required a sensitive approach to define a homogeneous and coherent museum path and, at the same time, to appraise the visiting experience with specific solutions. Thus, the earthquake created the opportunity to reconsider the museum framework of the entire palace and re-establish it in its earliest volumes, which had been lost or were arduous to be interpreted due to the building's several uses over the centuries.

Keywords: Salone dei Mesi, Sala delle Virtù, timber floor stiffening, composite timber beams

1 INTRODUCTION

The cycle of lectures by the Regional Agency for Reconstruction within the International Summer School "After the Damages", delivered as virtual visits following the Covid restrictions, opened with the story of Palazzo Schifanoia in Ferrara.

The palazzo, one of the most important 15th-century buildings in Ferrara, is a paradigmatic example in the governance of post-earthquake reconstruction, an almost obligatory stage in the

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DOI: 10.1201/9781003253730-27

management of all actions relating to its recovery and restoration in the aftermath of the traumatic event. Schifanoia is a treasure trove of architectural history that reached its artistic peak with the creation of the decorative schemes by Francesco Del Cossa and Ercole de Roberti, among the outstanding protagonists of the 15th-century Ferrarese school.

The lecture recounted the path that a building of such importance followed to be returned to the community after the damage caused by the earthquake. A path that involved a complex restoration project, which did not stop at the surfaces, but also included the restoration of function to its spaces and paths, that culminated in a lighting scheme aimed at enhancing the pictorial cycles and volumes.

Although catastrophic, the earthquake was an opportunity to rethink the entire museum system of the palazzo and restore it in its original volumes, which had been lost or were difficult to read due to the diverse uses made of the building over the centuries (from an Este delight to an abandoned building, then the site of the tobacco production offices and also classrooms for the Faculty of Chemistry). The operation was financed in part by the Commissioner for Reconstruction, who allocated €1,357,476.91, and in part by its owner, the Municipality of Ferrara, which allocated €1,550,000.00 from insurance funds and donations for the restoration of functionality and completion work. Following the damage survey, carried out by the Ministry of Culture (formerly the Ministry of Cultural Heritage and Activities) in July 2012, the damage mechanisms activated were identified and the building was included in the plans of the Ministries of Public Works and of Culture and the Commissioner.

The technical and economic feasibility project was formally approved with prescriptions by the Joint Commission for the examination of projects relating to buildings of cultural interest under the protection of the Regional Agency on 18 February 2015. It was this first approval that stated that some of the interventions, i.e. those strictly related to restoring functionality, such as the demolition of the intermediate wooden slabs of the mezzanine floor of the fifteenth-century wing, could not be covered by the reconstruction funds as their structural elements had not shown any damage attributable to the earthquake. As a result, the municipality planned to carry out these works with its own funds. In addition, prescriptions were imposed, such as limiting the use of reinforced drilling and preferring the use of alternative, less invasive design choices. It was also recommended that the behaviour of the Structural Units, both collectively and individually, be investigated in depth before proceeding to the detailed design.

The detailed design was then examined by the Joint Commission on 12 November 2015, and approved with a favourable opinion with a request for supplementations to obtain the authorisations issued by the competent offices:

- 11 February 2016 authorisation ex art. 21 legislative decree 42/2004 (issued by the competent Superintendence)
- on 19 February 2016, seismic authorisation (issued by the Regional Geological, Seismic and Soil Service)
- on 11 March 2016, certification of economic appropriateness (issued by the Regional Agency for Reconstruction/2012 Earthquake).

In the meantime, the building remained closed only for the time needed to carry out the works, which began on 16 April 2018, reopening to the public on 2 June 2020. In fact, work to make the building safe, funded by a donation, made it possible to keep at least the extraordinary Salone dei Mesi open during the states in which the overall works were planned.

This governance of the restoration of the building, the work of several offices, with different skills, expertise and responsiveness, allowed visitors to enjoy part of the building while being denied this only for the time necessary to carry out the work of a more complex restoration, which included both the seismic improvement of the building and the repair of the damage, and the restoration of function to and enhancement of the building, making it more efficient in terms of routes through it, and fulfilling its museum function, and obviously safer.

2 DESCRIPTION OF THE DAMAGE AND MECHANISMS ACTIVATED, THROUGH SURVEY PHOTOS

For the first virtual tour, we have chosen a building that is particularly emblematic, in terms of its monumental importance and the virtuous process of planning and reconstruction after the 2012 earthquake. Prior to the more in-depth analysis from the technicians that will follow, in this first talk we decided it was important to illustrate how the damage survey forms are completed, the skills involved, and the importance, when filling these in, of a good understanding of the asset and its historical transformations.

As one of the most outstanding examples of historical noble palace construction, Palazzo Schifanoia is one of the most important cultural sites making up Italy's artistic heritage. Its great historical and critical success as a delight for the ruling class - designed so that the court could find a way to dispel boredom ("schivar la noia") in its extensive halls and spacious garden - is primarily thanks to the monumental cycle of murals that runs around the Hall of the Months, the reception hall of the palace.

Below is an extract from the historical and artistic description attached to the Decree for its protection:

«[. . .] T*he palace, the seat of the Civic Museum, is made up of two buildings commonly categorised as the "14th century wing" and the "15th century wing". The 14th century wing has two floors above ground, while the 15th century wing has three floors above ground, and a basement. The facades are entirely built in brickwork, and the horizontal structures are almost entirely made from wood, as is the structure of the roofing, with a finishing surface of tiles. Starting from early 1960s, the entire complex underwent substantial restoration work, carried out both by the Superintendency and by the Municipality of Ferrara, which was primarily focused on the conservation of the important paintings and wooden ceilings that adorn the 15th century wing. Between 1998 and 2002, extensive reinforcement, upgrading and system standardisation works were carried out in order to turn the building into a museum. In 2008, the "ex- University building" was demolished, along with some of the facilities attached to the perimeter wall, in order to restore the original courtyard area that belonged to the palace.*

The Plan can also involve city-planning incentives and reward measures to encourage the quick completion of the interventions. With the aim of ensuring the feasibility of the relocation work, the Reconstruction Plan must be careful to fully engage all the private parties involved, through compensatory agreements in accordance with the regional legislation in force, or by demonstrating the availability of the financial resources necessary to carry out the work within the validity term of the expropriation agreement. In the same way, in the event of identifying and planning MIUs (city planning aspects to introduce into the plan), and also of making changes to the urban morphology, city planning frameworks, or identifying new, significant investment projects, the Reconstruction Plan has the task of establishing the project-based and regulatory aspects belonging to the Urban Implementation Plan (structural systems, overall plan dimensions, the most appropriate project characteristics, and every other detailed regulation) in order to ensure that it is possible to proceed immediately to the construction phase with direct interventions.

Palazzo Schifanoia, one of the ancient Este "delights" (places of leisure), is an architectural complex of great historical value. It was built in 1385 at the request of Alberto V d'Este, who extended it to the east in 1391. Between 1465 and 1469, Duke Borso commissioned the elevation of the building added in 1391; on completion of these 15th century works, designed by architect Pietro Benvenuti dagli Ordini, the palace was very close to its present-day volume.

The facade, today in exposed brick, was originally crowned with battlements and featured decoration made from false multicoloured marble; traces of this are preserved in the eastern wall that has today been absorbed into the palace. The marble gate built in around 1470, dominated by the Este coat of arms and a unicorn, is of particular interest.

The work carried out in 1493 by architect Biagio Rossetti is also of great importance: this is when the battlements were demolished and replaced with the beautiful cornice in terracotta decorated in relief, and at the same time, the building was extended to the east for a further 7 metres. The palace had various different uses over the centuries; in 1898, the Civic Museum was set up there. Bought in 1918 by the Municipality of Ferrara, between 1950 and 1984 the building *underwent significant renovation work: as well as the restoration of the architectural complex and the extension of the Civic Museum, the restoration of the frescoes in the Hall of the Months and the precise stratigraphic investigations carried out in certain areas are also worth mentioning, as they allowed more interesting murals to be identified. Finally, the work carried out between 1989 and 1991 by the Superintendency for Architectural Assets is also noteworthy; this restored the entrance atrium and the main staircase, and recovered the palace's 14th century wing, which was then reopened to the public.*

[...] Inside the palace, as well as the Hall of the Months, the Marble Hall and the Hall of Virtue, graced by a gold painted stucco ceiling from the 15th century (the work of Domenico di Paris), the Civic Museum preserves archeological finds, collections of art, coins, illuminated manuscripts, bronze statuettes, ivory objects, engraved ceramics, wood marquetry, medals and sculptures. It is an architectural complex that still today preserves the great historical and artistic value that makes it famous around the world» (Make reference to the report attached to protocol 5453 of 09/04/2008 from the Superintendency for Architectural and Landscape Assets for the provinces of Ravenna, Ferrara, Forlì-Cesena and Rimini, as fully reported in decree for protection no. 1575, issued by the Regional Direction for Emilia-Romagna of the Ministry for Cultural Assets and Activities on 17/06/2008).

In accordance with DPCM 23/2006, for all building types, it is the Ministry official who must complete the appropriate form, to be chosen, based on the type of building, from the options of "churches form" and "residential buildings form".

The survey teams are made up of an architect or art historian from the Ministry, possibly assisted by a structural engineer and the fire brigade.

The goal is to draw up an index for the calculation of the parameters that will make it possible to estimate the cost of the interventions to carry out. This is a precise, structural choice made by the law to ensure the immediate feasibility of the reconstruction, without needing further procedures, through planning that is directly operational.

The Region therefore entrusts important goals and tasks to the Reconstruction Plan; this plan is the city-planning tool needed to imagine and design the reconstruction in the long term, addressing the issue of regenerating consolidated urban areas, revitalising historical centres and their relationship with the new polarities that have come about in response to the earthquake, and the need to reallocate public functions and temporary housing. However, this structure and the system of objectives that the Region wanted to provide has a strong impact on the national legislation and financial contributions for the reconstruction, which is all focused on the principle of "as it was, where it was", and does not consider taking advantage of opportunities for regenerative processes, risking making the provisions of the regional laws weaker. In this sense, the set of Decrees adopted by the President of the Region, acting as

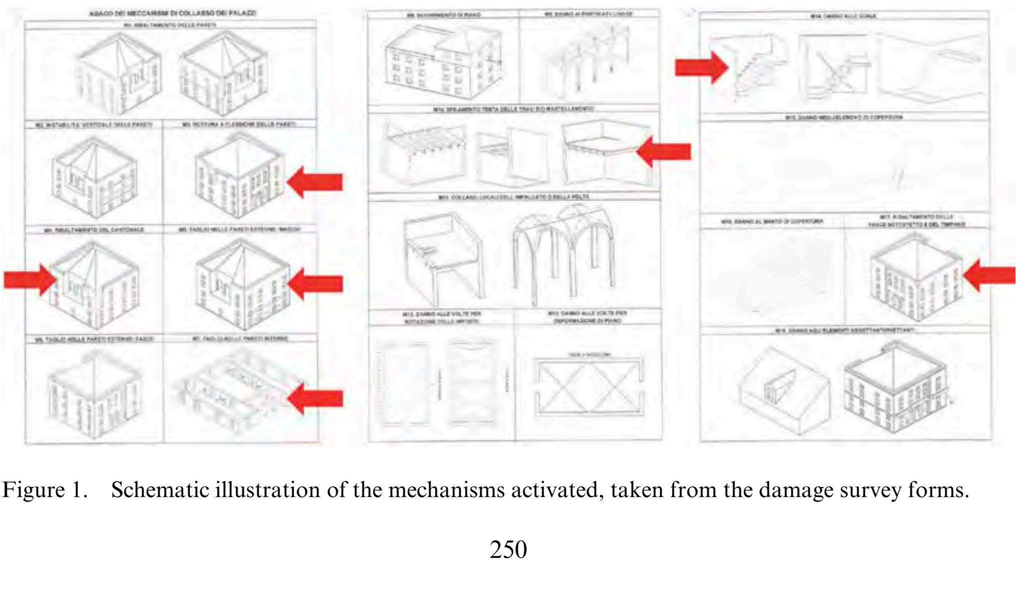

Figure 1. Schematic illustration of the mechanisms activated, taken from the damage survey forms.

Deputy Commissioner for the reconstruction, and the replaced guideline of the stability law L. 147/2013, open up a few possibilities in the direction of the regional law.

The damage survey form provides essential information, such as: intended use, location, infrastructure, the access that is required for securing the building, and is useful for verifying the asset's accessibility.

Knowledge of the building's historical transformations, as well as the more recent modifications listed above, is an important prerequisite for the effective identification of damage mechanisms that have been activated when completing the damage survey form, and, in particular, for breaking down the different areas, required when filling in the residential buildings form.

The residential buildings form is much more complex than the churches form, because for every structural element, the dimensions of that individual element and the specific level of damage must be defined (walls, both external and internal, roofing, floors, stairwells, etc.)

The different damage mechanisms that have affected the palace are: flexural rupture of the walls, breaks in the wall bays of the external walls, breaks in the internal walls, strain, damage to the stairs and toppling of the sides of the gable attic.

Figures 2-5. A few images of the damage, representative of the most prevalent damage found.

3 THE EARTHQUAKE DAMAGE

The 2012 earthquake damage the entire heritage of historic buildings of the city of Ferrara, although not as devastatingly as in the neighbouring municipalities where the epicentre occurred. Palazzo Schifanoia was declared temporarily unfit for use, but thanks to the generous and timely contribution of a private donor, it was possible to repair part of the damage in a few months and reopen the Salone dei Mesi and the Sala dei Vizi e delle Virtù to the public in March 2013.

In January 2013 the design phase for the seismic upgrading of the building started, financed by funds from the Emilia Romagna regional government, and at the same time the municipal government allocated part of the post-earthquake insurance funds received and funds of its own to undertake an operation for the overall enhancement of the museum complex, in terms of systems and lighting, but also renewing and expanding the exhibition system on the basis of a new and ambitious museographic design.

The synergy between a team of professional experts in restoration, consolidation, museum lighting, exhibition design and installations on the one hand, and enlightened government authorities on the other, made it possible to breathe new life into a building/museum that had been "asleep" since the 1980s and no longer up to contemporary exhibition standards.

The earthquake manifested its devastating and destructive force, but it also "shook" consciences, drawing attention to the protection of heritage buildings and the importance of appreciating them, thus activating a virtuous process that would not be a mere repair of the damage suffered, but also a "spark" of new life and the beginning of a new cultural "rebirth" for this important historical and testimonial complex.

Figure 6. On the left, damages to the hall of the months side and re-opening of the damage caused by the 1570 earthquake. On the right, detail of the damage to the Vice and Virtute side.

4 PALAZZO SCHIFANOIA: PLAN FOR RESTORATION, ENHANCEMENT AND RESTORATION OF FUNCTION FOLLOWING THE 2012 EARTHQUAKE

In approaching the Palazzo Schifanoia plan, the first and most important starting point was historical-critical analysis which, through historical research, in the archives and by retrieval of documents, allowed us to reconstruct the sequence of the phases of transformation of the construction and the modifications to it over time, an indispensable guide for the subsequent operations to study the existing building.

Palazzo Schifanoia in Ferrara is perhaps the building that best tells the story of the history and magnificence of the d'Este family in Ferrara. The building was developed in successive phases from the late 14th century with the succession of different marquis of Este and then used in various ways until the rediscovery of the frescoes in the Salone dei Mesi and its acquisition by the Municipality of Ferrara. All these phases have left traces in the building, many known and some rediscovered in this work. The next phase, necessary to understand its progressive development, was the investigation, which took the form of a geometric survey, a structural survey and a survey of the cracks and damage: its purpose was to identify the parts that needed to be repaired and it informed our understanding of the static problems and possible kinematic responses in the event of an earthquake, constituting a sort of "photograph" of the response of the building to the actions that had prompted it.

The building covers about 1400 square metres distributed lengthwise with an axis parallel to the road (Figure 8).

The western part of the building, with a surface area of approximately 400 square metres, constitutes the original 14th century core. At present, this core consists of a ground floor, a first floor located only in certain portions of the building and an attic. However, the eastern part of the building was started in the first half of the 15th century, undergoing modifications until the end of that century. It has a floor area of about 1000 square metres and, in its pre-intervention configuration, was divided into three floors: basement, mezzanine and main floor. There is also an attic, the floor space of which is supported by the chains of the roof trusses.

In terms of materials, the building has main walls in a regular pattern, in solid bricks and lime mortar of a quality compatible with the period in which they were built. The floor slabs are almost entirely in wood, with a main frame, secondary frame and single planking. The roof is three-pitch, with cantilevers, trusses, main beams in solid wood, secondary joists and planks.

The need to restore the building after the damage caused by the 2012 earthquake provided the management of the Schifanoia museum with an opportunity to rethink the museum's functionality, to create a single broad itinerary covering the exhibition spaces of the 14th-century building, the extraordinary rooms on the main floor in the 15th-century wing and new rooms on the ground floor, created by removing the mezzanine floor to recall the original spaces.

The intervention had a major impact on the structures and systems. In order to be able to carry out the post-earthquake work on the slabs of the main floor and on the roofing structures of the 15th-century wing, where there are rooms that preserve decorative schemes of extraordinary historical and artistic value, protective structures had to be created, designed to fully protect the wall paintings and the wooden and stucco ceilings from vibrations, shaking, dust and anything else that might risk causing damage. Following the earthquakes of May 2012, many existing cracks re-opened (Figures 2-6) including those caused by the 1570 earthquake; in the past, these cracks had not been undergone proper and thorough repair, but only non-structural restoration. There was also a series of recurring cracks such as extensive cracking in the brick flanges of the over-windows and doors, diagonal cracks through the top corners of the transversal walls caused by the thrust exerted by the struts of the roof (which did not have chains in correspondence with the load-bearing walls) and signs of the start of tilting of the walls of the façade, extensive diagonal cracking in the transverse walls of the mezzanine floor, vertical cracks caused by the detachment of poorly toothed orthogonal walls, detachment of the wooden beams and joists of the horizontals from the perimeter walls, while non-structural elements such as cornices, chimneys and roof tiles had fallen (Figure 12).

The analysis of the cracks that appeared as a result of the seismic events of May 2012 led to the planning of structural interventions to repair the damage and reinforcements aimed at improving the overall seismic response: repairing the cracks by injecting a binder mixture, deep reinforcement of the joints and like-for-like replacement (compatibly with the frescoes), supplementary masonry, stiffening of the attic slabs by inserting a new layer of planking fixed to the secondary frame and perimeter of the masonry with a dowelled metal profile (Figure 8), stiffening and simultaneous static consolidation of the slabs of the main floor by inserting two

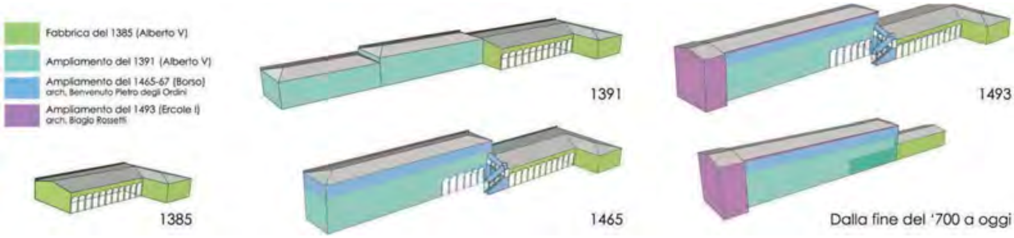

Figure 7. Volumetric evolution of Palazzo Schifanoia over time, taken from the Historical Research of the Seismic Improvement Works Project.

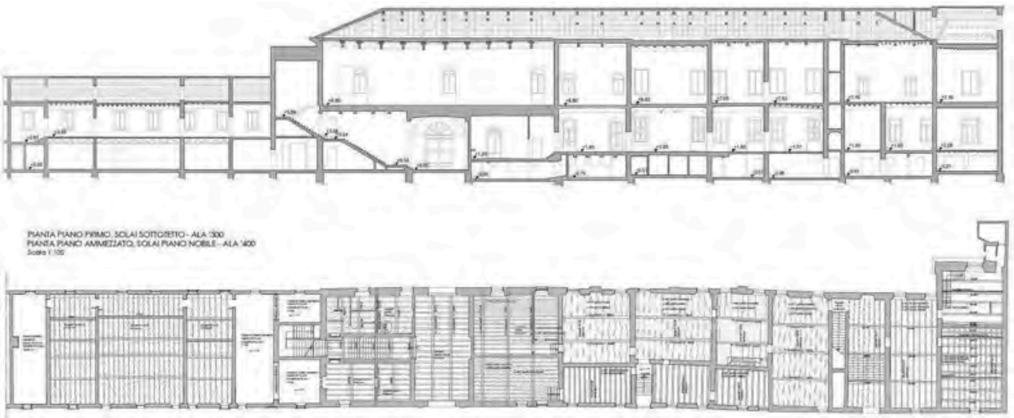

Figure 8. Survey: section and floor plan of the main floor structure of Palazzo Schifanoia before the restoration site works were carried out.

new layers of sloping boarding fixed extensively to both the primary and secondary frames and to the perimeter of the masonry using dowelled metal plates, reciprocal solidification of the main beams of the roof, insertion of metal chains, reconstruction of the chimneys or their reinforcement with specially designed anti-tilting systems.

The removal of a large part of the incongruous inter-floor slabs and the consequent elimination of the basement in the 15th-century wing in order to restore the original spatial characteristics of the Palazzo was the first intervention carried out on the 15th-century wing. During the work phases, it was possible to confirm the original volumes, by the traces of the ancient thresholds and floors found at the walls (Figures 13-14). The demolitions also revealed the recent date of the slabs removed, which had planks with machined joints (Figure 14). In addition, many cubic metres of material were removed from the floor slabs of the main floor (ineffective lightweight concrete), which had been laid during the previous restoration and which constituted a weight for the structure without performing a structural or stiffening function. The most important and demanding intervention concerned the stiffening and simultaneous static consolidation of the wooden slabs of the main floor: these are double-structure floors (beams and joists) with wooden planking, with the peculiarity that the main elements are composite beams (Figure18). The consolidation was carried out, as planned, by making double boards crossed over the existing boards, anchored with hardware to the perimeter walls of each room and made to cooperate with the secondary joists and composite beams by means of metal pins in holes with resin (Figures 15-19). First of all, wooden segments (Figure 16) were inserted between the secondary joists and above the composite beams, suitably shaped and joined, in order to prevent the problem of inflection of the connection dowels between the "wooden slab" and the composite beams themselves. In some cases, it was necessary to integrate the intervention with thick metal plates (Figure 17)

Figure 9. New project for the distribution of spaces in Palazzo Schifanoia with intended uses.

above the planking or, as in the case of the Salone dei Mesi, with an intradossal supplementation specifically designed to integrate with the restoration project and consisting of metal tie rods (Figure 19).

Figure 10. Salone dei Mesi with its structures in wood and panels in non-woven fabric and plastic material, created to protect the cycle of frescoes.

The work on the façade of the 15th-century portion of the building made it possible to remove the cement plasterwork and recover the earthenware moulding on the garden façade (Figures 20-21), to restore the entire 16th-century terracotta cornice by means of dowels, plasterwork and colour fixing (Figure 23), to restore the plaster fragments on the façade with injections of filling adhesives (Figure 21) and to consolidate the window surrounds (Figure 22). Interesting were the fortuitous fragments searched for and found throughout the work site. Removing the suspended ceilings on the ground floor revealed the Renaissance wooden slabs, which were then restored by cleaning, consolidating the paintings and toning the wooden parts (Figure 27). In the bookshop room, which occupies the former loggia, the fascia that also framed the large composite beams was recovered (Figure 28).

Emblematic of the important work carried out to bring the Palace back to life is the sequence of works involving the Salone dei Mesi.

Figure 11. Hall on the main floor with structures in wood and panels in non-woven fabric and plastic material, created to protect the decorated wooden slab.

Figure 12. The reopening of old cracks and the formation of new ones.

Figure 13-14. Removal of incongruous slabs.

Figure 15. Stiffening of attic slabs and metal curbs.

Figure 16. Insertion of wooden beam segments in the extrados between the rafters - Stiffening and consolidation of slabs by means of triple planking and connectors.

Figure 17. Stiffening and consolidation of slabs by means of triple planking, thick metal plate and connectors – Slab.

Figure 18. Composite beams of the Salone dei Mesi.

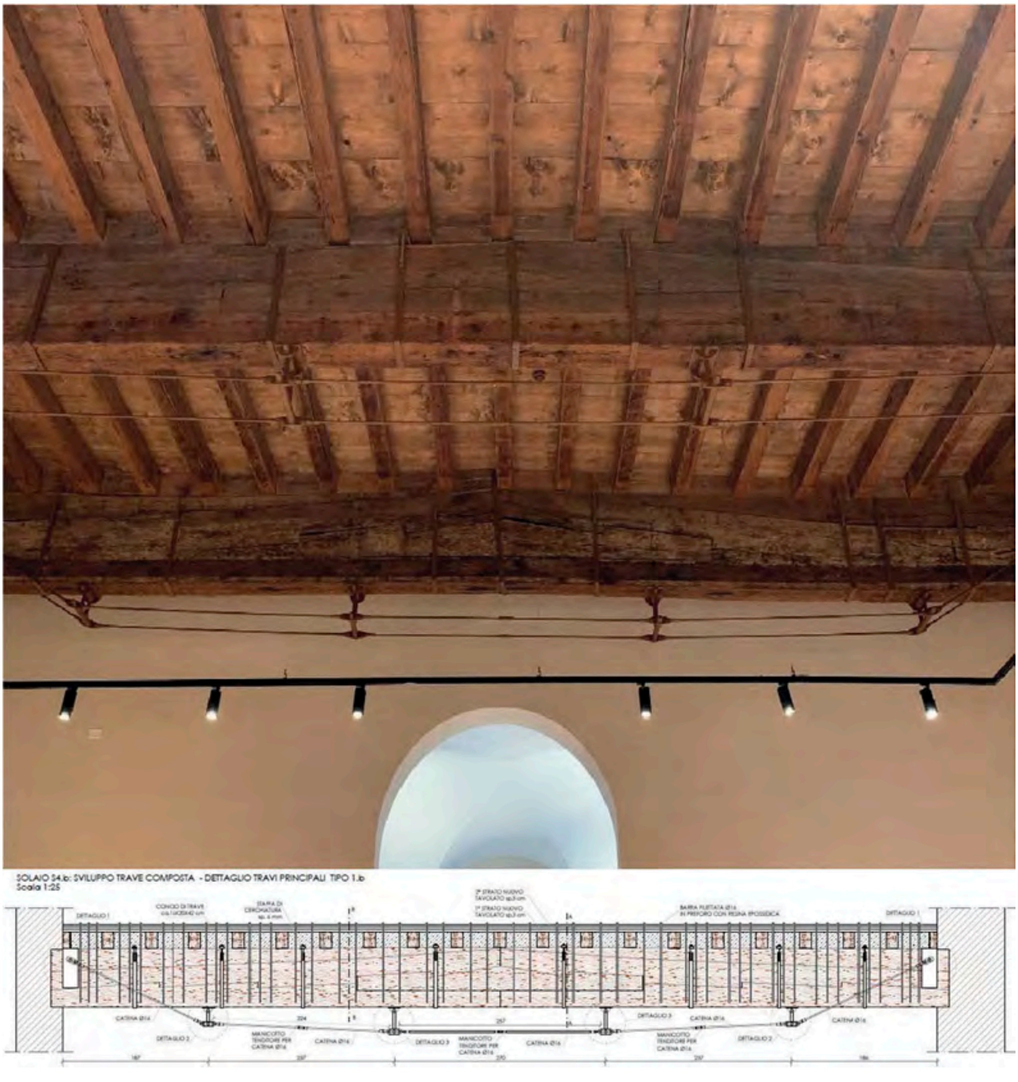

Figure 19. Use of intrados ties in the consolidation of the Salone dei Mesi.

Figure 20. On the right, new earthenware moulding. On the left, resembling that found in the 18th century closure of the garden loggia.

Figure 21. Restoration of plaster fragments.

Figure 22. Restoration of plaster fragments and window surrounds.

Figure 23. Restoration of the 16th-century terracotta cornice.

Figure 24. Half-column on the left of the ancient loggia facing the garden. (from S. Ghironi, F. Baroni, 1975, p.147).

Figure 25. a. Reconstructive axonometry of the Schifanoia complex, 1493 simulation. (from S. Ghironi, F. Baroni, 1975, p.147). b. The foundations of the original external staircase for access to the Salone dei Mesi found by excavation based on measurements taken from a historical report.

Figure 26. Detail of the foundations of the original external staircase for access to the Salone dei Mesi.

Figure 27. Restoration of the wooden slabs on the ground floor of the 15th-century part.

Figure 28a, b and c. Restoration of the painted fascia in the former loggia on the ground floor of the 15th-century part.

AUTHORS CONTRIBUTION

This paper is the result of a shared work between the authors. Introduction: Antonino Libro, Agenzia Regionale per la Ricostruzione/Sisma 2012 (Regional Agency for Reconstruction/ 2012 Earthquake). Description of the damage and mechanisms activated, through survey photos: Maria Luisa Laddago, Soprintendenza Archeologia, belle arti e paesaggio per la città metropolitana di Bologna e le province di Modena, Reggio Emilia e Ferrara. The Earthquake damage: Natascia Frasson, Municipality of Ferrara. Palazzo Schifanoia: plan for restoration, enhancement and restoration of function following the 2012 earthquake: Francesca Pozzi and Marco Roversi. All authors have read and agreed to the published version of the manuscript.

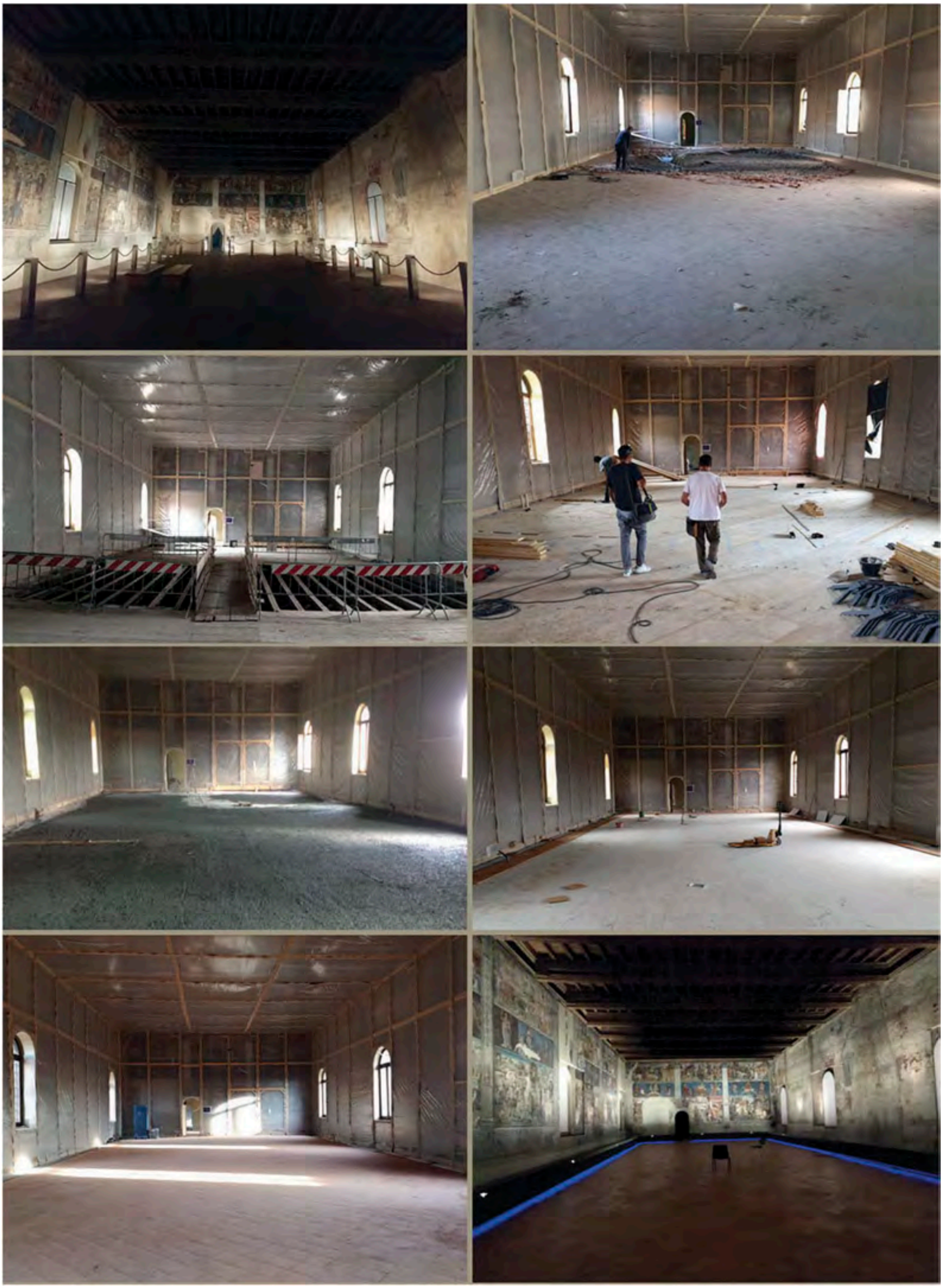

Figure 29a and b. Stages of the Salone dei Mesi work site: before, during and after the work.

Built Heritage in post-Disaster Scenarios – Balzani et al. (Eds)

Collegiate church of Santa Maria Maggiore in Pieve di Cento

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ABSTRACT: The paper aims to illustrate the complex process, either in terms of assessment and repair work, that the Collegiate church of Santa Maria Maggiore experienced in the years after the May 2012 earthquakes, bringing it back to its devoted people as the result of a series of efforts that began the very day after devastating event. The parish complex arrived at us as a building partially rebuilt at the end of the seventeenth century when the chapter decided to restructure the church due to previous interventions that weakened the load-bearing structures. Due to several construction activities that often added and removed parts without providing continuity between its main elements, the load-bearing structure became vulnerable in many parts. In the aftermath of the earthquake that caused the collapse of the dome, a temporary structure was built, not only to meet the basic safety principles of construction, but also to limit the progression of the damage and provide a useful residual utility that would be complementary to the subsequent design and execution phases. Thus, the restoration of the church, including the reconstruction of its dome, is one of the most interesting case studies in the post-earthquake site work in Emilia because it involved many interrelated interventions that guided the church restoration in a pretty short period, but also addressed the implementation of the worksite knowledge in which the ongoing site activities backed studies, investigations, and surveys.

Keywords: Collapse mechanisms, damage survey form, stratigraphic analysis

1 INTRODUCTION

The Collegiate Church of Santa Maria Maggiore in Pieve di Cento (BO) is recognised as a treasure trove of the great Felsine school of painting, with a succession of paintings of exceptional value in the history of world art. From Guido Reni to Guercino, Gennari, Passarotti, Scarsellino and Lavinia Fontana, this is the Holy of Holies of the art of Bologna and the surrounding area of Emilia. The building that has come down to us, whose foundation dates back to the 8th century, is the one that was partly rebuilt at the end of the 17th century, when the chapter chose to rebuild the church, since the restorations of previous centuries had only contributed to making the load- bearing structures weaker and weaker (documents attest to threats of collapse and even the collapse of the bell tower on the church in 1483). However, the project was not completed until 1710, when the church took on the appearance closest to what we see today.

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DOI: 10.1201/9781003253730-28

This succession of interventions has rendered the building weak in some of its parts, as the sequence of construction initiatives often added and removed without creating continuity between the main structures. Thus, the apparently majestic church, with its clear 18th-century imprint, the considerable size and grandeur of which is emphasised on the façade by pilasters, cornices, statues and volutes, showed all its vulnerabilities during the 2012 tremors, to the extent that a significant part of the building - its dome - imploded, collapsing inside the church and endangering many works of art. For this reason, we considered it of fundamental importance to be able to present at the Summer School the restoration that this building has undergone in the years since the catastrophic event. A journey that it would be simplistic to ascribe to only the final work undertaken, which returned the church at the end of 2018, since the process is the result of a number of actions, which began the day after the first seismic event.

Through careful management of the emergency, the first phase focused on the removal of the movable works of art, consisting of the large paintings and furnishings, which were transferred to a private museum to be stored for the duration of the church repair work. At the same time as removing the rubble, which is a complex phase that must ensure that the rubble is recovered through careful analysis, cleaning, inventorying and possible referencing for subsequent reuse. These steps were taken to protect all the removable parts of the building consisting of altars and decorations. After this came the phase of making safe, with provisional works that protected the building and prevented further collapses and deterioration: this work also proved to be a precursor of the subsequent design and repair phases. For example, the structure installed to protect the large gap created by the collapse of the dome was not dismantled to make way for the final work site but became an integral part of the scaffolding and a platform for the reconstruction of the same gap. So, thanks to a careful preliminary analysis, the provisional structure complied with the basic principles of making buildings safe, limiting the progression of the damage as much as possible, going beyond its primary objectives to offer valuable residual utility that sees it as complementary to the subsequent design and execution phases of the works, extending its use until the definitive works had been completed.

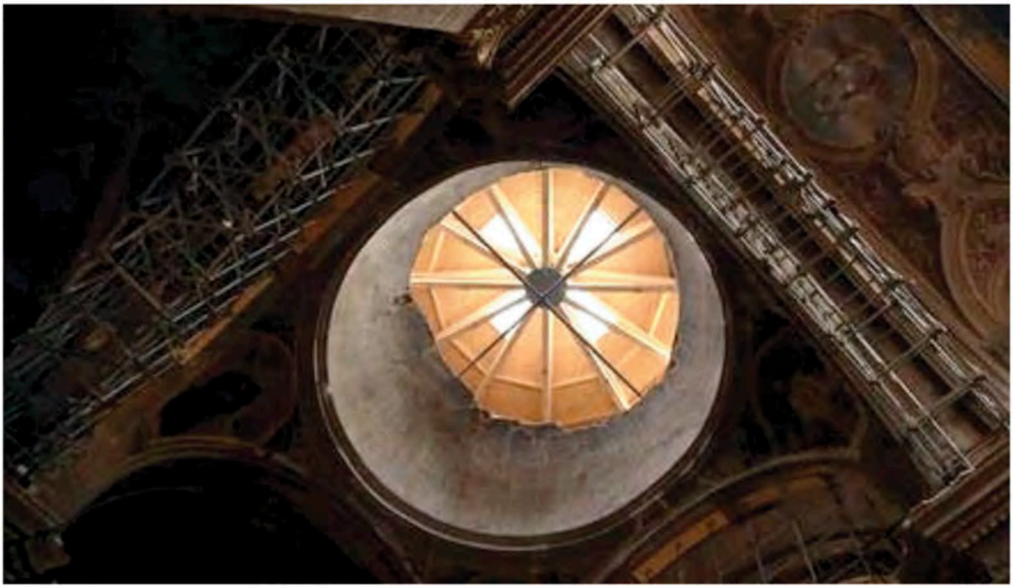
In other words, the concept of safeguarding with disposable elements was set aside, and the intervention thus became a fundamental part of the restoration. Following the inspection of the damage survey carried out by officials from the Ministry of Culture (former Ministry of Cultural Heritage and Activities) in September 2012, which certified the mechanisms activated and economically quantified the damage, the building was included in the plans of the Ministries of Public Works and of Culture with total funding of €2,628,857.62, financed by the Commissioner for Reconstruction. The technical and economic feasibility project was formally approved by the Joint Commission for the review of projects for buildings of cultural interest under the protection of the Regional Agency on 24 September 2014. At that meeting, the Commission decided to specify the methods for consolidating the top spire of the bell tower, and at the same time to add to some sections of the survey; focusing on the positioning of the plates on the façade, it invited (the planners) to consider in greater depth the work of hooping the apse and to review the works to consolidate the extrados of the dome to be rebuilt.The executive project was examined by the Joint Commission on 3 November 2015, and a favourable opinion with prescriptions was also issued at this stage. The Commission specifically recommended that the lantern be built using traditional construction methods (suitably improved), although in a context of seismic safety.

The competent offices finally issued their authorisations:

- on 16 December 2015, authorisation pursuant to article 21 of legislative decree. 42/2004 (issued by the competent Superintendence)
- on 15 January 2016, seismic authorisation (issued by the Regional Geological, Seismic and Soil Service)
- on 03 February 2016, certification of economic appropriateness (issued by the Regional Agency for Reconstruction/2012 Earthquake).

Work began on 13 July 2016 and the church was reopened for worship on 25 November 2018.

The restoration of the building, with the reconstruction of the dome, represents one of the most interesting cases of the post-earthquake work in Emilia precisely because it brings with



Figures 1-2. Picture of the dome seen from below before and after the temporary cover had been put in place.

it an overlapping of interventions that have made it possible not only to restore the church in a relatively short period of time but also to launch what we refer to as the “knowledge work site”, in which studies, investigations and surveys, undertaken while the works were underway, have clarified the best way forward, when faced with damage to buildings of such importance.

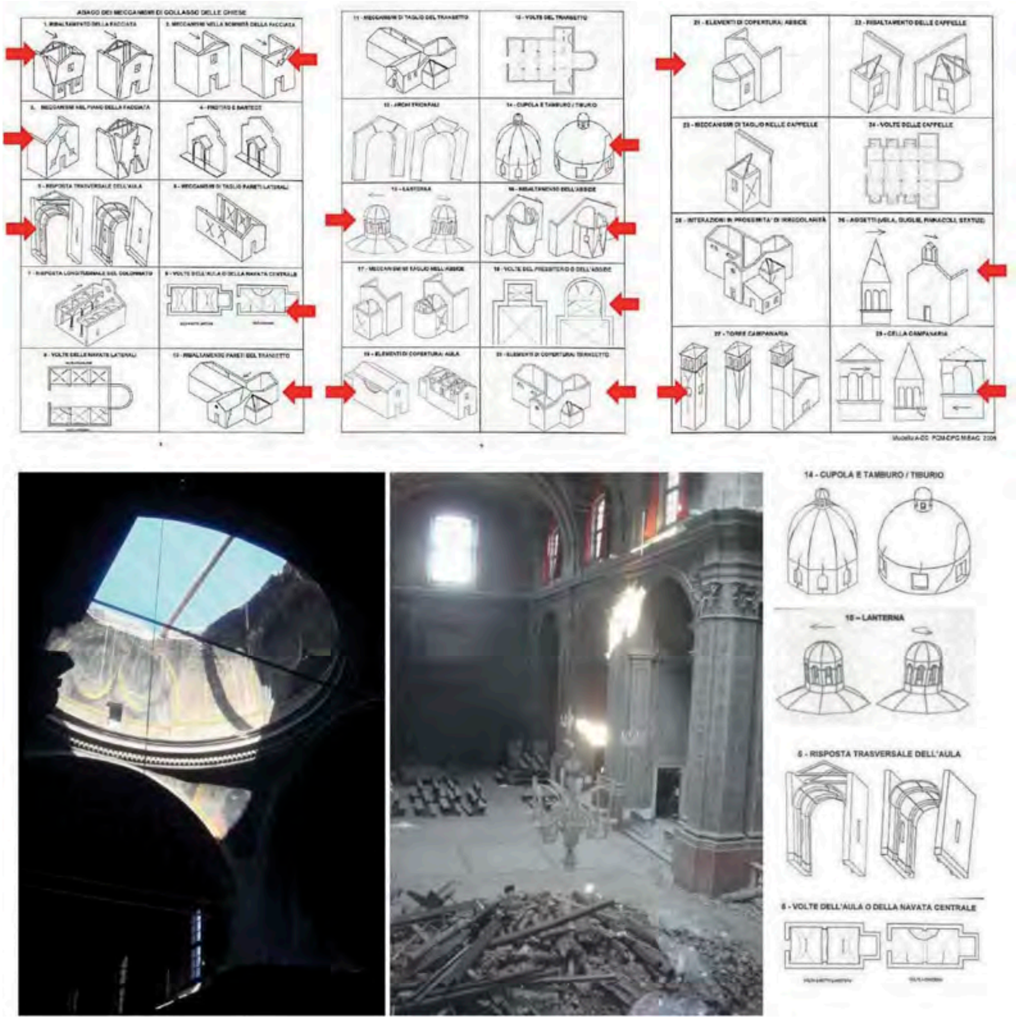
Figure 3. E. Corty, Parish Churches of the Diocese of Bologna illustrated and described, Vol. 1, Bologna 1844, p. 157.

2 DESCRIPTION OF THE DAMAGE AND MECHANISMS ACTIVATED, THROUGH SURVEY PHOTOS

The Collegiate Church of Santa Maria Maggiore is the oldest church in Pieve di Cento, built in the 8th century and appearing in a document for the first time in 1207. In the Late Middle Ages, it took on the name of "collegiate church", which it also retained afterwards.

In the 14th century, the apse was rebuilt in gothic style, while the following centuries saw a long series of restoration and reconstruction works, many of which were ineffective. However, after its demolition, it was rebuilt, which officially took place between 1702 and 1710. Only the apse remains from the original building, while the rest is the result of the 18th century reconstruction. The publication by E. Corty, *Chiese parrocchiali della Diocesi di Bologna ritratte e descritte* (Parish Churches of the Diocese of Bologna illustrated and described), from 1844, also confirms that the form taken by the Church of Santa Maria Maggiore in 1710 is the same one it shows today. In 1890, a succession of more recent interventions began, such as the renovation of the flooring, restorations to the roof in 1950, the bell tower in 1980, and finally the repainting of the facades in 1994.

The damage survey form, completed on 18/09/2012 by the competent official from the Ministry of Culture (i.e., MiC), reports a slight activation of all possible damage mechanisms on the facade, both at the top and the base. But the most obviously serious damage is the complete collapse of the lantern, and almost total collapse of the brick cupola.



Figures 4-5. A few images of the damage, representative of the most prevalent damage found, with indications of the respective mechanisms as filled in in the damage survey forms.

There are also a few mechanisms partially activated in the transept, the apse and the bell tower. Before the completion of the damage survey, the fire brigade had already acted to secure the seriously damaged structures. Some particularly important interventions were the operations to secure the mobile artworks kept in the Collegiate Church, which are of notable historical and artistic value. These operations were the result of a vital collaboration between the fire brigade and official art historians, architects and conservators from the MiC.

At the time of the earthquake, important works were housed inside the church, top-class examples of Bolognese painting: from the famous altarpiece of the Assumption by Guido Reni to an Annunciation by Guercino, as well as canvases from Scarsellino, Passerotti and Lavinia Fontana, and the remarkable wooden crucifix from the 14th century which is revered as a miracle. The works were promptly taken down, and, with appropriate protection, taken to the MAGI '900 Museum, where they were kept for the time needed to finish the work on the church Following the restoration, it was then possible to return the artworks to their home, making this place of worship even more precious.

Figure 6. A few images of the damage, representative of the most prevalent damage found, with indications of the respective mechanisms as filled in in the damage survey forms.

Figure 7. Images of the Collegiate before the 2012 earthquake (on the left) and an image of the collapse taken during the damage survey by the MiC official (on the right).

3 MAKING THE BUILDING SAFE AND THE RESTORATION WORK SITE

In 2016, work stated to make the building safe. The fundamental operation involved the construction of a temporary cover over the collapsed dome, carried out by creating a temporary structure designed to also be used during the restoration and reconstruction of the church that would take place in the following years.

The work to make the building safe continued on the façade, with the cradling of the openings and niches, making safe the statues installed inside the niches and covering them with protective fabric while awaiting the subsequent restoration work.

Figure 8. Lavinia Fontana, Assumption of the Madonna (3 x 1.9 m), securing operations by the fire brigade with the supervision of a MiC official personnel.

Figure 9. Guido Reni, Assumption of the Madonna (4 x 2.8 m), securing operations by the fire brigade.

Another fundamental operation was carried out on the painted and moulded decorations seriously damaged by the earthquake and the weather, which had begun to cause deterioration, creating cracks and phenomena that could lead to an irreversible process of loss of the decorated surfaces. In the first phase of the work, the adhesion between the collapsing and flaking layers of painted plaster and the underlying masonry support was strengthened by injections of light structural mortar, free of soluble salts and very fluid, based on natural hydraulic lime; after the injection and filling operations aimed at restoring the structural continuity of the masonry-plaster elements, support bandages were applied. Finally, the cohesion and adhesion of the paint film to the finishing layer of plaster was restored by applying a consolidating product and installing a shoring system for the portion of the cap still in place. An important part of the intervention in the initial stages correlated with the design activities were the analyses that continued throughout the period in which the work site was operational in order to better understand the structures and materials that were being worked on.

From the analysis of the surfaces carried out both inside and outside, we moved on to the testing of the wall structures using a diagnostic plan prepared by “SOING strutture e ambiente”, a company run by architect Annalisa Morelli which included georadar analysis, videoendoscopy and strength and load tests on the masonry. For the surfaces, we were able to reconstruct the colour sequence plan of the various stages of maintenance of the building, which has undergone different interventions over time. The building is in fact the synthesis of a series of buildings that were created and replaced over time, as shown by the correlation between the written sources and direct analysis of the masonry. Each part of the building had been painted in similar colours but without a unified vision, restored in the earthquake intervention thanks to the presence of scaffolding on all surfaces. In terms of the structures, the tests revealed the extensive vulnerability of the core walls, often composed of inconsistent filler, which therefore require extensive consolidation works. Being able to undertake testing, including while the work was in progress, was fundamental. It identified voids and discontinuities in apparently solid masonry portions such as the case of the façade, where additional structural consolidation works were carried out.

Stratigraphic analysis of the surfaces, on the left survey points, on the top right an example of a stratigraphic test, on the bottom right, a proposal for the restoration of the north elevation attributable to period 3 (first half of the 20^{th} century).

4 DETAILS OF THE RESTORATION

The structural aspects of the major restoration and reinforcement works carried out after the major collapse caused by the earthquake were particularly complex, regarding the entire body of the roof lantern, the entire roof of the dome containing the cupola and a large portion of the walls of the cupola itself. The centrepiece of the work was the reconstruction of the collapsed cupola and lantern, both technologically, regarding the wall structures and, more specifically, the restoration of the original fragments and the reproposal of the architectural and ornamental features on the large portions that had collapsed and been rebuilt.

Initially parts of the painted plaster where the masonry support was seriously damaged, compromised and affected by fractures passing through and strongly decomposed were detached using the “stacco a massello” technique, thus making it impossible to restore the geometric morphology of the slightly elliptical dome; then the same portions of masonry were taken apart by hand, as they were in such a compromised and precarious state as to be unable to guarantee suitable laying surfaces for the new brick elements of the part to be reconstructed. The wall structure of the collapsed dome was rebuilt ex novo in brick with the aid of a provisional rib designed and made for the purpose, made of metal rods, from which the bricks that formed the cap of the dome were subsequently “hung and sewn” concentrically, one after the other, bedded with structural mortar based on hydraulic lime with excellent mechanical properties.

The dome and lantern have thus been repaired and rebuilt in the same brick as previously, but they have been structurally improved thanks to both the construction technology used

Figure 10. Picture of the interior of the church after the removal of rubble and the construction of temporary structures to support the walls in the area around the central dome.

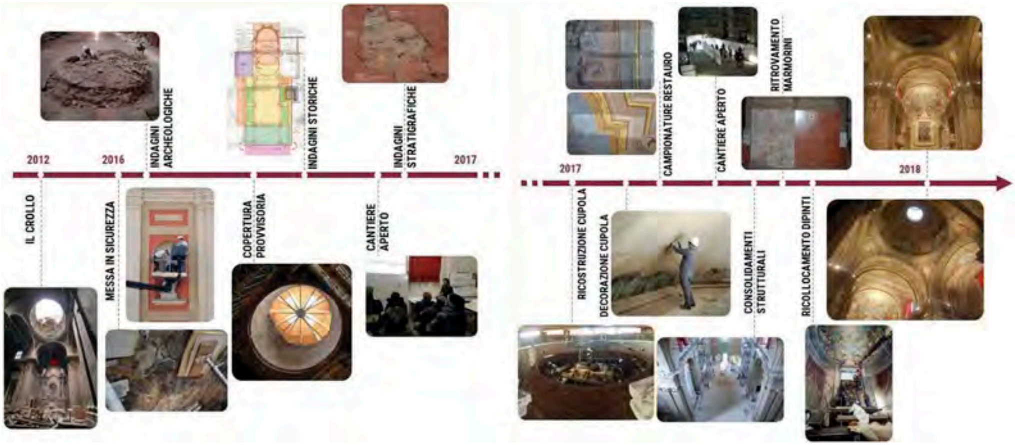


Figure 11. The work-site timeline.

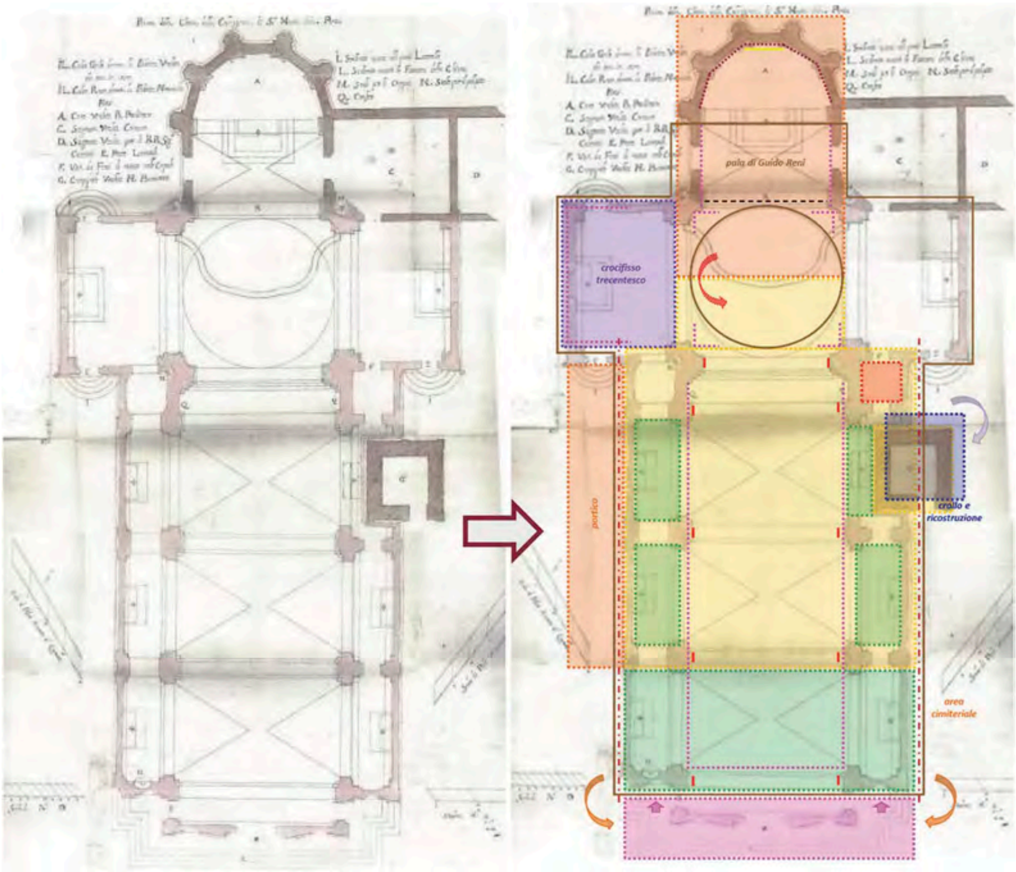


Figure 12. Collegiate Church of Santa Maria Maggiore in Pieve di Cento, analysis of the construction and transformative phases through the identification of the structural units.

Figure 13. The non-destructive diagnostic campaign and the sampling points identification to characteriza and increase knowledge levels and confidence factors of historic materials.

and to the subsequent installation of carbon fibre reinforcements as part of a meticulous and detailed plan.

The seismic improvement works carried out also include the insertion of new tie rods and metal plates, the hooping with metal plates and stainless steel stays both inside the church and in the roof space, where most of the reinforcing metalwork is concentrated, the consolidation of the spire of the bell tower using carbon fibre banding, the doubling of the wooden roofing planking, The structural aspects of the major restoration and reinforcement works carried out after the major collapse caused by the earthquake were particularly complex, regarding the entire body of the roof lantern, the entire roof of the dome containing the cupola and a large portion of the walls of the cupola itself. The centrepiece of the work was the reconstruction of the collapsed cupola and lantern, both technologically, regarding the wall structures and, more specifically, the restoration of the original fragments and the reproposal of the architectural and ornamental features on the large portions that had collapsed and been rebuilt.

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The seismic improvement works carried out also include the insertion of new tie rods and metal plates, the hooping with metal plates and stainless steel stays both inside the church and in the roof space, where most of the reinforcing metalwork is concentrated, the consolidation of the spire of the bell tower using carbon fibre banding, the doubling of the wooden roofing planking, as well as the more traditional operations of restoration and repair of cracks and fissures by means of structural injections and like-for-like replacement of masonry.

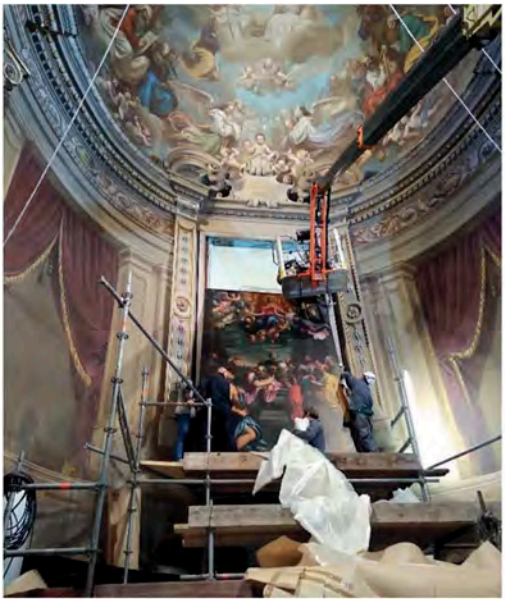
Based on the conservation problems observed both during the interventions to make the building safe and in the initial phase of the works, several areas of intervention were identified: the wall paintings of the vaults and walls, the wall paintings of the drum and the dome in the area of the collapse, the stucco and plastered walls, the altars and the stone elements. The reconstruction of the dome was certainly the most experimental phase, not only from a structural point of view but also because of the ethical problems involved, which raised various questions regarding the recognisability of the intervention while at the same time trying to satisfy the aesthetic integrity that is fundamental for devotional purposes. It was decided to opt for a subdued re-proposition of the pre-earthquake state in its essential architectural and perspective lines. For the reconstruction of the decoration of the dome in the area of the collapse, high-definition photography was used, from which 1:1 scale "cartoons" were obtained and then reproduced on site using the pouncing technique to reproduce the morphology and colour scheme of the pre-existing decoration, while maintaining the original parts and those attributable to post-earthquake interventions.

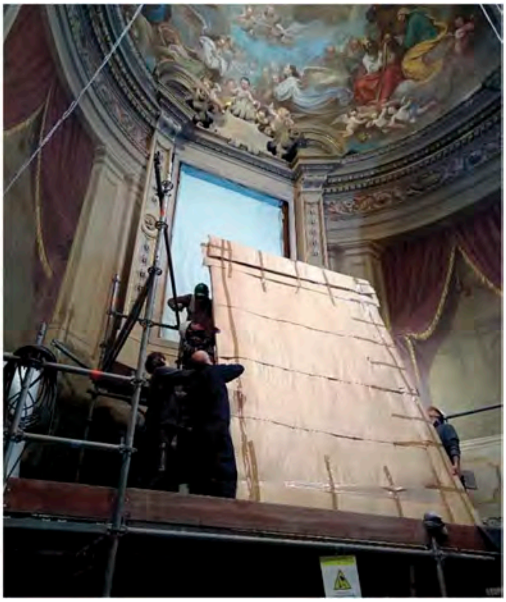
Once the restoration of all the interior and exterior decorations had been completed, another fundamental step in returning the Collegiate Church to the community was the relocation of the mobile works of art removed by the fire brigade immediately after the earthquake. The large altarpiece by Guido Reni and the other paintings on the altars in the side chapels were returned to their original location thanks to the coordinated work of restorers and specialised workers, with the aid of a lifting work platform.

Figures 14-15. The phases and methodology of the construction: extradossal rib made of metal rods and laying of the brick elements from inside the wall cap under construction.

Figure 16. The internal brick elements from inside the wall cap.

Figures 17-18. The dome during the painting supplementation phase.





Figures 19-20. Securing operations by the fire brigade with the supervision of a MiC official personnel.

Figures 21. The decoration of the dome maintained the principle of recognition of the new and the previously existing.

AUTHORS CONTRIBUTION

This paper is the result of a shared work between the authors. Introduction: Antonino Libro, Agenzia Regionale per la Ricostruzione/Sisma 2012 (Regional Agency for Reconstruction/ 2012 Earthquake). Description of the damage and mechanisms activated, through survey photos: Maria Luisa Laddago, Soprintendenza Archeologia, belle arti e paesaggio per la città metropolitana di Bologna e le province di Modena, Reggio Emilia e Ferrara. Making the building safe and the restoration work site: Rossana Gabrielli, technical director, tests of Leonardo srl, Bologna. Details of the restoration: Marika Oprandi, site operations manager for building works, Leonardo srl, Bologna; Michela Boni, site operations manager for restoration works, Leonardo srl, Bologna. All authors have read and agreed to the published version of the manuscript.

Built Heritage in post-Disaster Scenarios – Balzani et al. (Eds)

Duomo of Santa Maria Maggiore in Mirandola

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ABSTRACT: The paper illustrates the results of the reconstruction site of the Mirandola Cathedral, which, among the buildings hit by the May 2012 earthquake, is one that suffered the most damage, becoming a representative case study of the overwhelming effects caused by the seismic action which stressed its structures so that a large part of the church collapsed.

The Cathedral, built in a late Gothic architectural style with a three-nave basilica floor plan and a system of pointed vaults, showed structural stress from the very beginning, as the vaults' considerable weight strained the interior columns and exterior walls, which had to be reinforced with buttresses. The archival fonts document several crises to the bearing structures that led to major works being carried out by re-arrangement of its structural framework, already through the centuries, and when the 2012 seismic crisis hit the church, the lack of homogeneity triggered by all these interventions amplified the heterogeneity of the building's constituent parts, causing significant collapses. The cross vaults of the nave and a portion of the roof behind the main façade collapsed, then the sidewalls of the clerestory resulted in an extensive collapse of the nave roof with severe damage to the side walls.

The restoration of the Cathedral addressed by the reconstruction of the whole vaulting system with lightweight materials suspended from the new roof structure stands as one of the first cases of post-earthquake reconstruction in Emilia that takes into account a new language that re-proposes ancient forms while fulfilling the safety and protection issues that the church may not have had over the last six centuries. Thus, the worksite resembles a complex restoration project that dealt with issues related to the seismic improvement of the severely devastated building and the reconstruction of large portions of its formal and figurative structure by creating a language from scratch for a story worth to be told.

Keywords: Damage mechnaisms, lime paints, stone fragments assemblement, lacuna reintegration

1 INTRODUCTION

Among the buildings damaged by the 2012 earthquake, the Mirandola Duomo is one of those that suffered the most damage, becoming a true icon of the devastating effects of those calamitous events.mAnd yet, the majesty of these church buildings has always been accompanied in our imagination by an idea of robustness, of strength, which the seismic events inverted, displaying their weakness instead.

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DOI: 10.1201/9781003253730-29

We could not have imagined that the tremors would undermine the structures so deeply that a large part of the church would collapse.

For these reasons, the choice of dedicating one of the Summer School's virtual lessons to this example of reconstruction was almost obligatory. A complex restoration project that not only had to deal with issues related to the seismic improvement of the severely devastated building, but also with the reconstruction of large parts that were grafted onto the existing structures, creating a language from scratch for a story that is worth telling.

The cathedral was built in the first decades of the 15th century by Giovanni and Francesco Pico, governors of the city of Mirandola, who decided to promote the creation of a new Renaissance-style district with a new church at its centre. The building was erected in a late Gothic architectural style, with a three-nave basilica floor plan and a system of pointed vaults.

The bell tower, which was modified several times over the centuries and made higher and higher, dates from the same period as the foundation of the church. By the following century, however, the church had already shown displayed structural shortcomings, as the considerable weight of the vaults had stressed the interior columns and the exterior walls had started collapsing, to such an extent that they had to be reinforced with buttresses.

There were several crises for the fabric of the building over the following centuries - for example, there are reports that in 1700 the cathedral was threatened with sudden collapse. This led to the major works carried out in the 19th century dictated by the urgency to avoid abandoning the church, up to the late post-war period and the 1990s, when the building was heavily remodelled.

The 2012 seismic shocks only confirmed the lack of homogeneity caused by all these interventions on the church over its centuries-long history, amplifying the heterogeneity of the building's constituent parts and thus causing major collapses.

Specifically, with the first tremor on 20 May, the cross vaults of the nave and the portion of the roof behind the main façade collapsed. The second tremor caused the side walls of the clerestory in the nave to disconnect from the façade, causing extensive damage with the collapse of the roof of the nave, with the breakage of the transverse chains and severe damage to the side walls, which however behaved differently, as well as damage to the apse basin.

Following the inspection of the damage survey carried out by officials from the Ministry of Culture (former Ministry of Cultural Heritage and Activities) in September 2012, which certified the mechanisms activated and economically quantified the damage, the building was included in the plans of the Ministries of Public Works and of Culture with total funding of €5.829.024,65, financed by the Commissioner for Reconstruction.

Because of the difficulties involved in rebuilding some parts of considerable size, and with the proposal of new structural elements, the project went through the Joint Commission several times. The technical and economic feasibility project was approved with prescriptions on 24 September 2014, while the executive project received a first request for supplementation on 7 July 2015, and two further reviews in excerpts on 17 February 2016 and 21 September 2016.

The competent offices finally issued their authorisations:

- on 30 March 2017, authorisation pursuant to article 21 of legislative decree. 42/2004 (issued by the competent Superintendence)
- on 28 July 2017, seismic authorisation (issued by the Regional Geological, Seismic and Soil Service)
- on 21 July 2017, certification of economic appropriateness (issued by the Regional Agency for Reconstruction/2012 Earthquake).

Work began on 28 September 2017 and the church was reopened for worship on 21 September 2019.

The restoration of the Mirandola Duomo, with the reconstruction of the entire vaulting system using lightweight materials suspended from the new roof structure, is one of the first cases of post-earthquake reconstruction in Emilia that takes account of a new language that re-proposes ancient forms and fulfils the safety and protection aspects that the church had perhaps never possessed over the last six centuries.

Figures 1-2. Mirandola Cathedral in its final state after restoration. Above, general view of the Central Nave; below, detail of the Left Side Nave.

2 DESCRIPTION OF THE DAMAGE AND MECHANISMS ACTIVATED, THROUGH SURVEY PHOTOS

As a third subject, for the province of Modena, we have chosen a case involving significant reconstruction: the Mirandola Cathedral. This project, again starting from a careful examination of the historical and morphological characteristics, the construction phases and the very serious damage, involved all the possible problems relating to the reconstructive language of architecture in connection with seismic improvement.

Figures 3-4. Gaps caused by the earthquake were treated and analyzed from case to case. In the image above, we can see how the gap in the Christ figure was filled in under the level with a fine charcoal drawing. In this way, the work was recomposed to become more coherent. In the case of the high altar, the small plastic gaps have been treated on the same level by repositioning the damaged profiles.

Figures 5-6. Above, the large gap on the top part of the façade has been repaired in the same manner as it was before the earthquake. The use of terracotta bricks and tiles cast from the originals allowed for the reconfiguration of the façade, which now only has a few scars marking the most significant lesions. To make the new additions chromatically consistent with the old ones, all surfaces were tonally glazed with lime water and coloring earths. Below, the right aisle, the only one not affected by the collapse of the vaults, after restoration. On the right, the gilded wooden altarpiece known as the Borelli altar.

The church, which was originally built as a parish church, with its facade facing west and the apse to the east, was built starting in 1440 on the commission of Francesco III and Giovanni I Pico, lords of the Duchy of Mirandola, and completed in 1470 at the behest of Galeotto I and Antonio Maria Pico, the brothers of Giovanni Pico della Mirandola, based on a late-gothic design.

The creation of the Cathedral had strategic importance, as thanks to this, the Pico family was able to establish the Parish of Mirandola in the citadel, whereas before, the religious control of the area had depended on the Parish Church of Santa Maria della Neve in Quarantoli. Located in the new quarter, named Borgo Novo, the church was consecrated on 27th July 1491. It was decorated with valuable works of art, including frescoes, religious paintings and funerary mausoleums, as well as a few noteworthy paintings from the 17th century. The chapel of the Madonna of Pompei was decorated with an altar from the 17th century. Inside the sacristy there was a Madonna appearing to St. Felix of Cantalice, painted in 1612 by Alessandro Tiarini. The bell tower, in the part behind the southern side of the Chapel of Sant'Ubaldo, has a height of around 48 metres.

The building underwent significant structural restoration works as early as 1521, reinforcing the buttresses. It was closed in 1884 for the restoration of the facade, when the clock was inserted, while a few years later the bell tower was also completed, with the insertion of an octagonal dome in stone, topped with a domed cover. The damage survey form reports a damage index of 0.5, which is very serious when we consider that 1 corresponds to total loss of the asset.

Indeed, several mechanisms were activated with the maximum level of damage. The earthquake caused the gable on the facade to completely topple, which, in relation to the left side aisle, underwent not only a rotation, but also a hammering action, which caused a crack along the roof line and a misalignment in the left spire. At the time of the second earthquake, the lateral walls of the clerestory and the central nave were already detached from the facade, meaning that the large movements caused the cross chains to break and the roof to collapse. The bell tower suffered serious damage to the spire, the belfry, the walls and the stairwell.

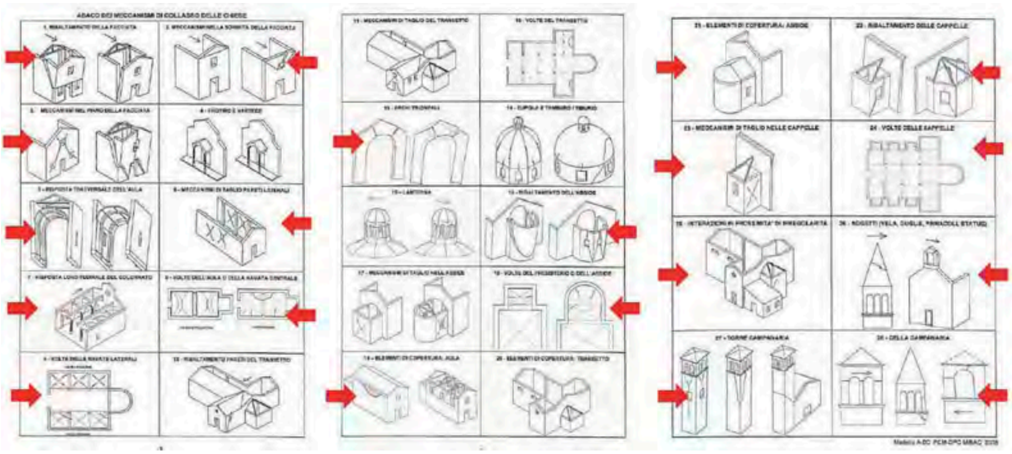
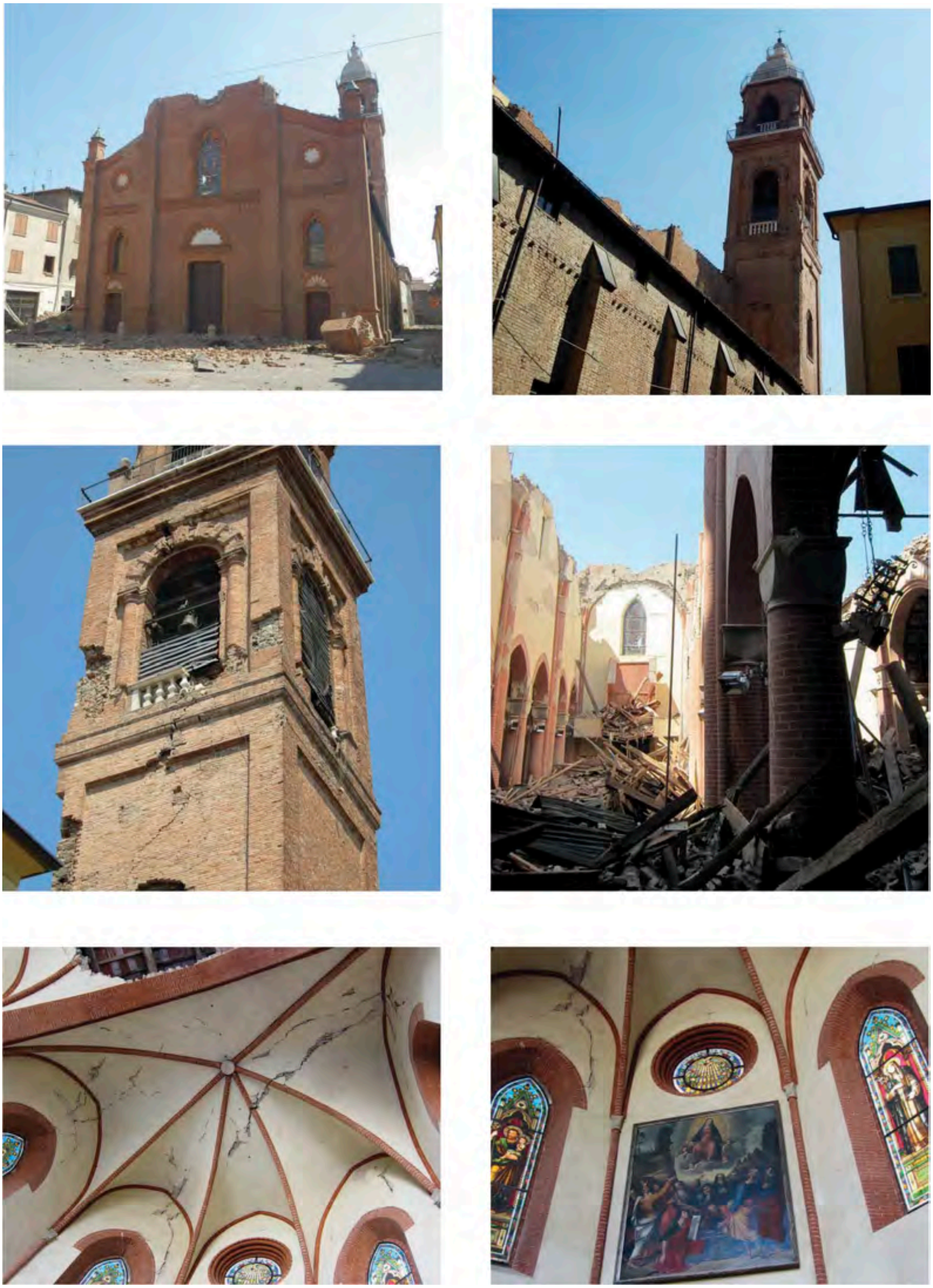


Figure 7. Schematic illustration of the mechanisms activated, taken from the damage survey forms.

3 THE RESTORATION WORK SITE

The restoration of the Parish Church of Santa Maria Maggiore, which began in 2017 and ended in 2019, involved work on all the interior and exterior surfaces: the work permitted not only restoration and consolidation following the seismic events, but also significantly enhanced the value of the building, particularly in terms of its interior fittings. The works



Figures 8-13. Images of the collapses and cracks on the outside and inside of the church and the bell tower, attached to the damage survey forms.

Figure 14. Historical research and a cognitive campaign using stratigraphic essays determined the metric and chromatic layout of the decorative system dating back to the early 20th century. As a result of an accurate study of the details and continuity solutions between the architectural parts, the threading system that traced the masonry apparatus was reproduced and applied to all the internal surfaces.

affected multiple supports characterised by different states of preservation and state of damage that involved both repair and restoration work and more complex interventions involving the recomposition, reconfiguration and supplementation of fractured and broken elements. The work involved an initial phase of making safe, pre-consolidation and protection of painted plasterwork and fixed furnishings, preparatory to all the subsequent structural work, at the end of which it was possible to start the restoration work proper.

The site was conducted with an average of three teams working in parallel on the walls, painted plaster, altars and altarpieces according to a work schedule updated weekly in order to coordinate with the architectural finishes and plant works.

3.1 *Columns, walls and vaults*

Over the centuries, the subsidence of the foundations of the bell tower had led to significant interventions, including the reinforcement of the colonnade, the construction of the external buttresses, the reconstruction of the foundations of the bell tower, the construction of a counter wall behind the counter façade and a wall adhering to the north side, as well as various reconstruction and restoration interventions following collapses, fires or wartime events. As a result of these events, no trace remains of the original 15th-century decorative scheme of frescoes on the perimeter walls and the counter-façade, which also showed signs of deterioration due to rising damp from the start. In the second half of the 19th century, the church was completely restored: the windows of the side aisles were changed and there was further massive and extensive restoration in 1937, during which the statues and Baroque altars were removed. Starting in 1990, there was extensive work on the church for a decade, involving the almost complete removal of all the interior plaster on the vaults and walls, and repainting, including the reproposal of a faux- brick plasterwork decoration that differed substantially from the photos taken in the 1930s which document the interior before the 1937 work. This explanation was necessary, and it justifies the new proposed decorative scheme, which differs substantially from the last work carried out in the 1990s, i.e. it corresponds to the faux-brick patterned decoration characterised and sized on the basis of photographs from the 1930s, partly found in the apse area through stratigraphic tests. This system is composed of horizontal fillets 8.5 centimetres apart, which is the pitch of the bricks of the colonnade exposed after the plaster had fallen off. The outlines of the fillets necessarily had to cope with dimensional anomalies and unevenness in both the vertical and horizontal planes of columns and arches due to all the events mentioned in the introduction. It is important to emphasise this aspect of the intervention, because the final regularity of the fillets is only apparent, since, particularly on arches and quadrilobed columns, the outlines follow a radial pattern that reflects the curvature of the architectural element and masks its distortion.

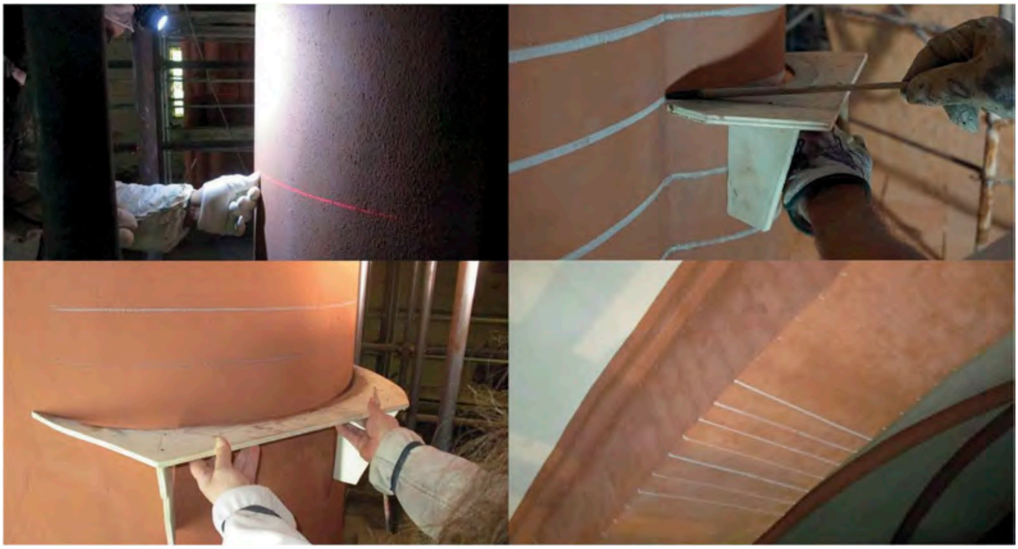
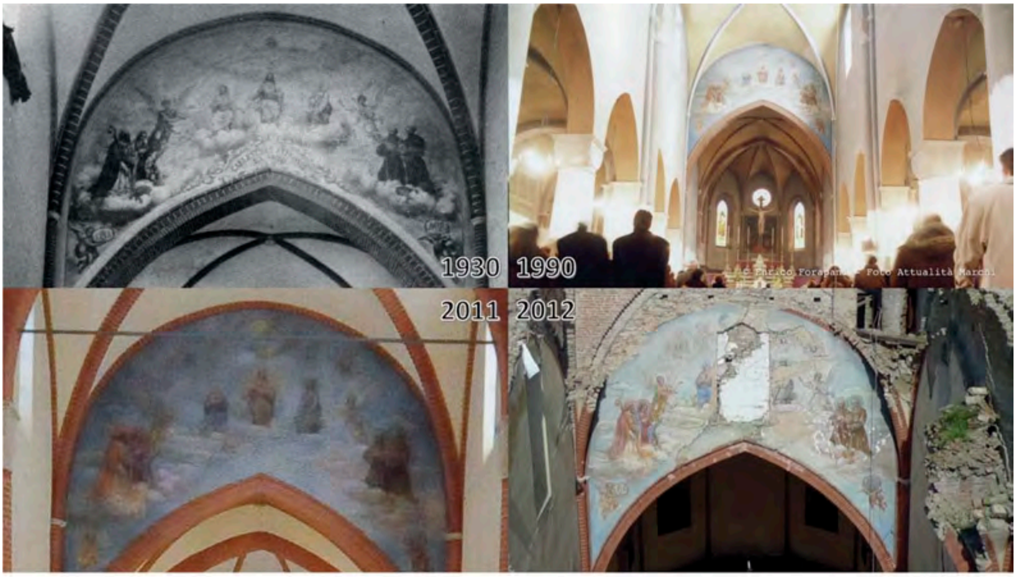


Figure 15. After tracing with a laser level and using shapes and templates with variable curvature to follow the splay of the columns, a pictorial reconstruction of the decorative draft on columns and arches was established using lime paints.



Figures 16-17. Above, picture inspection using archive images of the Triumphal Arch's wall painting and its state following the earthquake's collapse. Below, following that, injections of micronised fluid mortars and perimeter grouting were used to secure the portions of painted plaster that were detached from the wall surface.

3.2 *Triumphal arch*

The painting featuring Jesus Christ, Franciscan saints and angels occupies the entire surface of the triumphal arch and immediately catches the eye of the faithful as they enter the church. The work involved conservation of the painted plaster which had cracked and detached from the wall support and supplementation of the central part showing Christ, which was missing because it was located in correspondence with an old infill which had fallen during the earthquake. Prior to the repair and consolidation of the fabric of the wall, fragments in danger of falling off were removed and the paint layer, which was particularly weak and lifted, was prefixed.

During the restoration, the large gaps in the plasterwork were filled in below level and the cracks and abrasions were carefully filled. The depiction of Christ was recovered from period photographs and printed full size on tracing paper, transferred to the wall and its main features outlined in charcoal to reconstitute the unity of the work, making the intervention distinguishable and reversible.

3.3 *High altar*

The high altar was built between 1771 and 1776 to replace the previous one dated 1660, at the same time the 16th-century choir was replaced with the current one in walnut from the church of Santa Maria del Paradiso in Mantua. The collapse of the presbytery vault severely damaged the altar, in particular the tabernacle and the upper mouldings, with stone fragments to be found among the rubble. The patient work of the fire brigade, coordinated and supervised by the officials of the Superintendency, made it possible to recover almost all the fragments, and this is confirmed by the fact that very few parts were missing after the altar had been put back together.

It took about four months to relocate and dry-fit the recovered stone fragments, and about the same amount of time for gluing and the actual restoration. Casts had to be made in situ to reproduce the few lost parts that were structurally necessary for the recomposition of the work. Similar work was carried out on the balustrades of the altar of the Blessed Sacrament and the chapel of the Rosary, and the statues of Faith and Hope located there, which were damaged by the collapse of the vaults in the left aisle.

3.4 *External elevations*

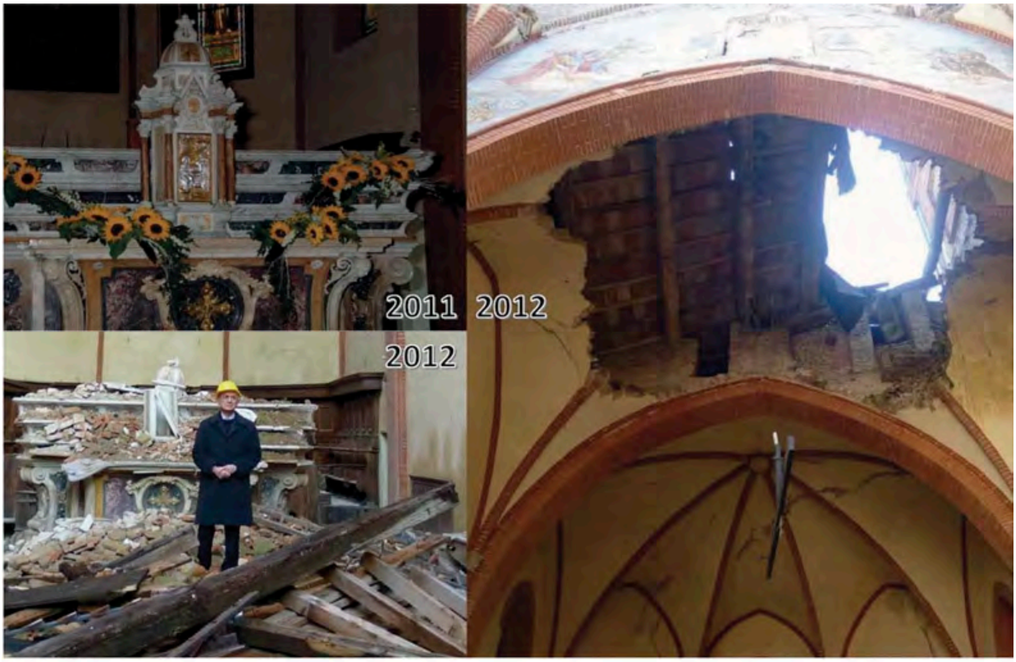
The external elevations have undergone significant consolidation, recovery and reconstruction works, also using materials other than brick. The façade, the upper part of which had collapsed, was faithfully reconstructed, using first all the bricks recovered from the rubble and then similar new elements. In order to mitigate the visual impact of the additions and ensure a homogeneous view of the whole, tonal glazes were carefully added in successive steps. On all the remaining masonry affected by the repair of the lesions and the restoration of the wall face by means of like- for-like replacement, calibrated glazes were used, as on the façade, based on lime water, slaked lime and natural earth pigments.

The glazes applied, as tested prior to their extensive application and shared with the Superintendency and the Officer of the Director of Works, allowed the tone of the elevations to be made uniform, while maintaining the chromatic characteristics of the individual bricks.

3.5 *Works of art*

The work regarded all the elements of the historic building: wooden furnishings, doors and gates, altars, altarpieces, statues and paintings. The majestic wooden choir was partially dismantled and its supporting structure was consolidated and strengthened. And it was treated against woodworm, reassembled and restored. The Borelli altar and the altarpiece in the Rosary Chapel, carved and gilded wooden artefacts, were restored and their paintings put back, as were all the rest of the pictures, which were removed from temporary storage and relocated to the site.

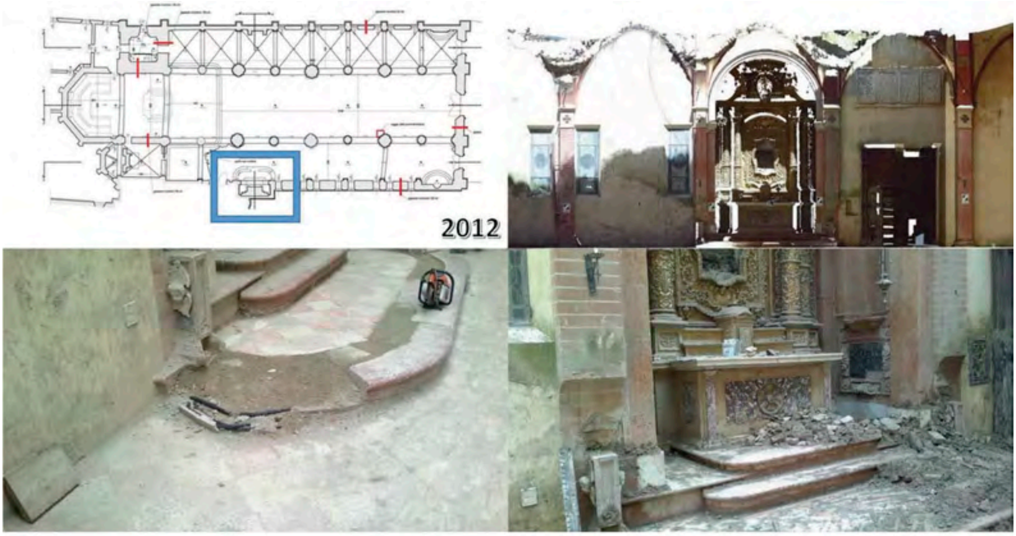
Figures 18-19. Above, underpainting of painted plaster gaps with lime mortar. Below, retouching and pictorial integration of the figures using tempera colours and watercolours, executed underpainting with mimeograph technique and pictorial integration of the neutrals by glazing with lime paints.



Figures 20-21. The high altar before and after the earthquake event is shown above. Documentation of the stone fragments recovered by the fire department is provided below. After several months of drywall reassembly tests, all of the fragmented artifacts were reassembled.

Figures 22-23. Above, the stone fragments of the Tabernacle columns are assembled with pins and epoxy resin. Bottom, a plaster casting in mouldable silicone rubber was used to recreate the missing Tabernacle capital from an intact original elements.

Figures 24-25. Top-left, the reconstruction of the Tabernacle of the High Altar: sorting and identifying the proper position of the fragments took a long and patient process. As stated in the introduction, the Fire Brigade's meticulous work in rescuing the rubble granted the recovery of nearly all of the fragments. Top-right, the high altar: dry composition tests of the tabernacle to identify the missing parts and establish the points of reference for the final assembly process. Below, the composition of the recovered stone elements for the upper part of the Tabernacle.



Figures 26-27. The altar of the Rosary, involved in the collapse of the vaults above, suffered extensive damage to the stone balustrade and the two statues located within the side niches. Above, the post-earthquake state of the altar. Below, the benches with all the recovered fragments including the winged putti and their fragmented parts.

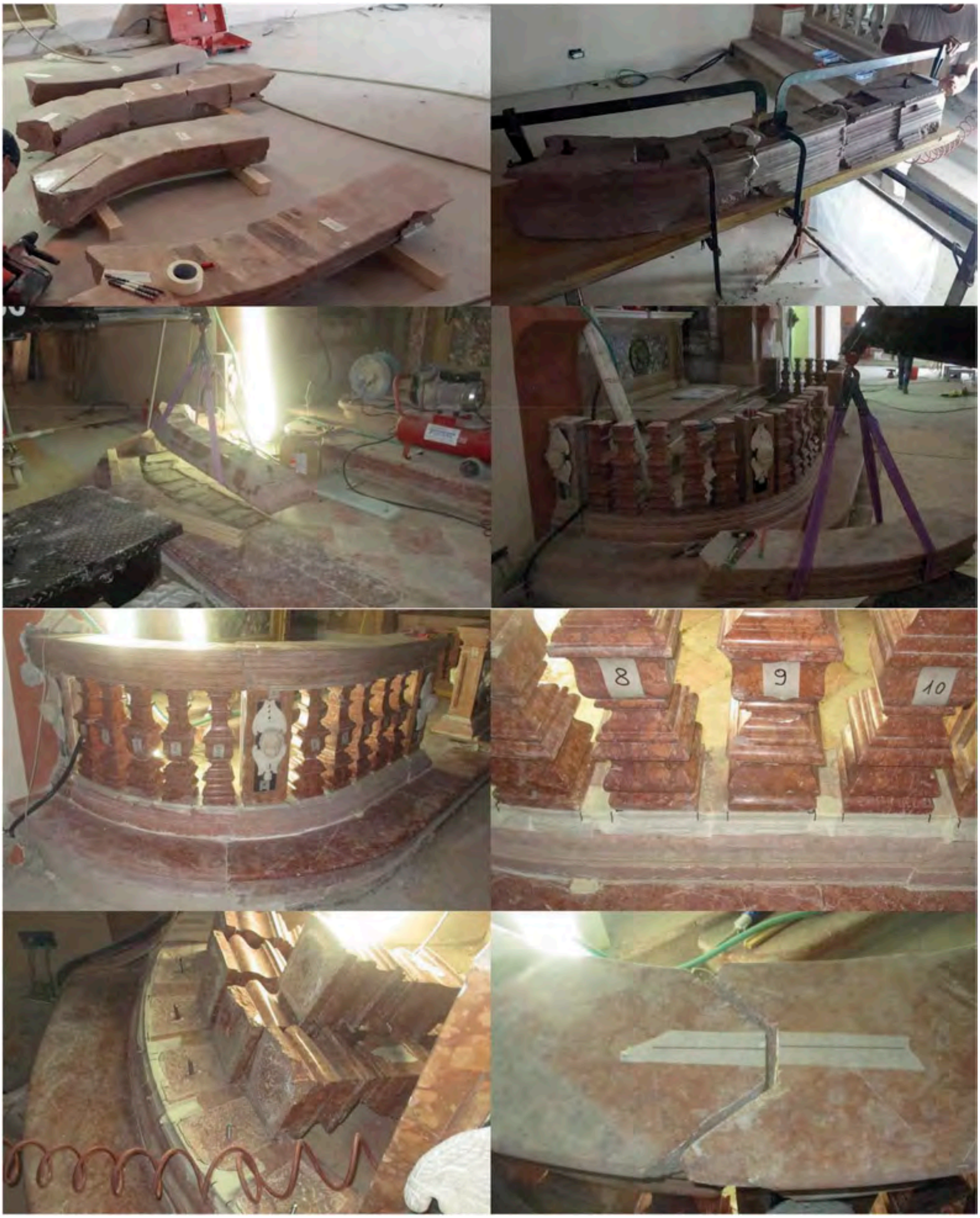


Figure 28. For the recomposition of the altar of the Rosary, each small column was carved at the imoscape and the sommoscape with a particular profile of variable curvature from the outside to the inside in order to place them in the recesses made in the base and handrail. The complexity of the recomposition of the balustrade consisted in finding the specific location of each column in its housing. For the handling of the larger ashlars, plinth and handrail, it was necessary to use a small indoor crawler crane. Also in this case, similarly to the high altar, a preliminary dry assembly was necessary to verify positioning, joints and alignments.

Figure 29. Above, the recomposition of the recovered stone winged putti with cast reconstruction of the missing portions. Below, the Statues of Faith and Hope with their fractured elements recovered from the rubble.

Figure 30. Above, the Altar of the Santissimo, details of the balustrade shattered and the destroyed Tabernacle spire by the collapse. Below, the identification and assembly of the recovered fragments of the balustrade columns.

Figure 31. The Altar of the Most Holy Sacrament, assembly process of the stone fragments of the balustrade by gluing, pivoting and cast reconstruction of the missing cusp to the right of the Tabernacle.

Figure 32. The Borelli Altar, a wooden protective structure of the gilded wooden altarpiece and images of the cleaning operations by swabbing, fixing by injection of the gilded film and grouting of small gaps and cracks.

Figure 33. The wooden Ancona of the Borelli altar, controlled dust extraction, buffer cleaning of surfaces and pictorial retouching of gilding.

Figure 34. Above, the Bernardi Monument: transfer of the stautaria and relocation. Below, recovery and transport of the works of the Via Crucis in the Cathedral, temporarily stored in the Sala della Comunità in Via Posta in Mirandola, and their subsequent relocation to their original locations in the aisles.

Figure 35. The wooden choir: disinfection, cleaning, repair and shellac treatment.

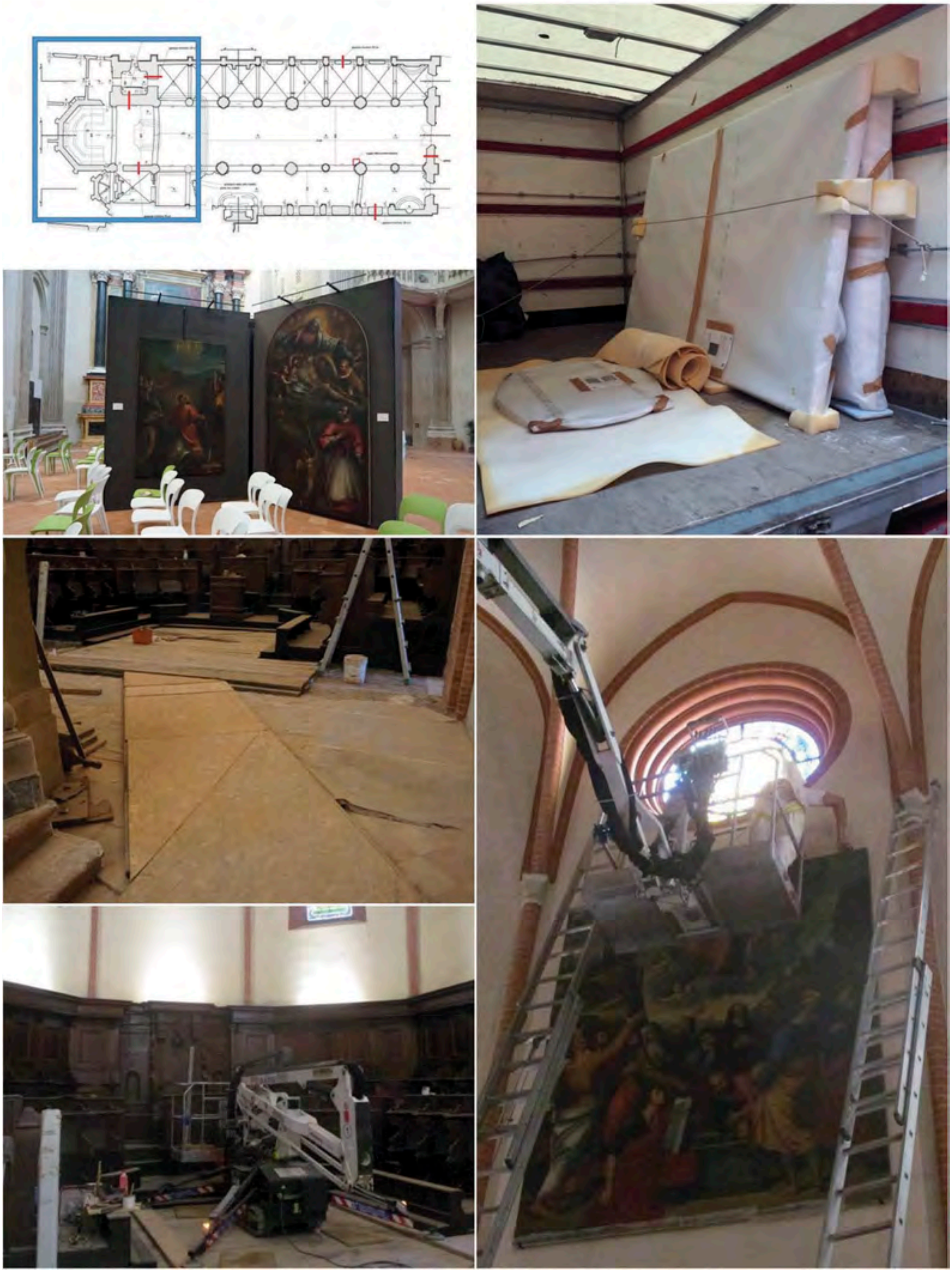


Figure 36. The recovery and transport of the painted altarpieces from Mirandola Cathedral, temporarily housed in the Diocesan Museum in Carpi, and their subsequent relocation.

Figure 37. The large lacuna in the top portion of the façade was restored in analogy to the pre-earthquake state. The use of terracotta bricks and tiles reproduced on the cast of the existing ones allowed for the reconfiguration of the façade on which only a few scars remain, marking the most significant lesions. To make the additions chromatically uniform with the pre-existing ones, all the surfaces were tonally glazed with lime water and colouring earths.

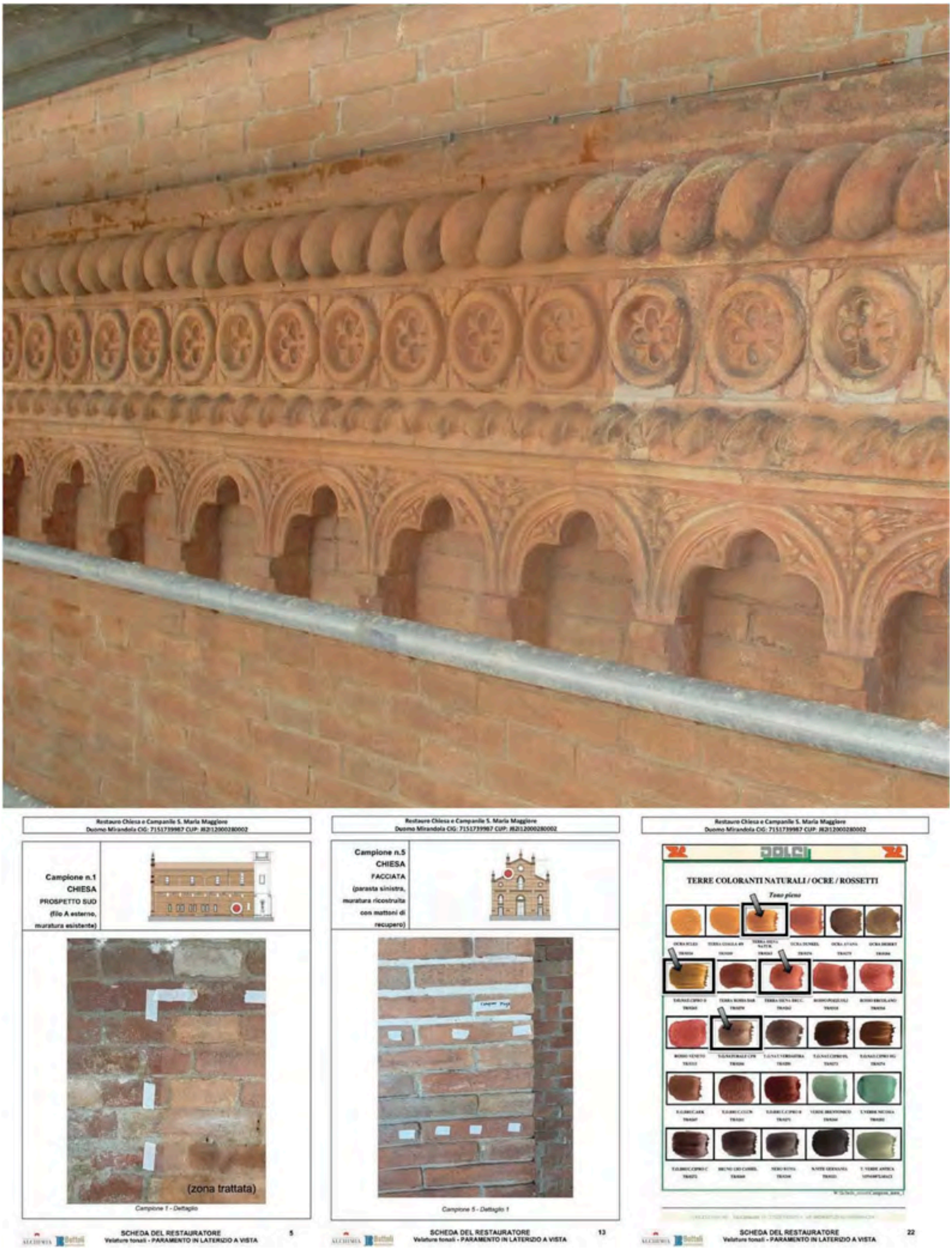


Figure 38. Tonal glazing of the decorative terracotta elements of the cornices: the glazing was formulated following calibrated on-site sampling aimed at unifying the face, which was noticeably heterogeneous as a result of the structural interventions and scuci e cuci.

Figure 39. The state of conservation of the main and side entrance doors with images of the stratigraphies conducted to identify the restoration colours and the final state of the doors at the end of the restoration.

AUTHORS CONTRIBUTION

This paper is the result of a shared work between the authors. Introduction: Antonino Libro, Agenzia Regionale per la Ricostruzione/Sisma 2012 (Regional Agency for Reconstruction/2012 Earthquake). Description of the damage and mechanisms activated, through survey photos: Maria Luisa Laddago, Soprintendenza Archeologia, belle arti e paesaggio per la città metropolitana di Bologna e le province di Modena, Reggio Emilia e Ferrara. Giulio Azzolini, captions of the intervention records. All authors have read and agreed to the published version of the manuscript.

Built Heritage in post-Disaster Scenarios – Balzani et al. (Eds)

Palazzo Sartoretti in Reggiolo

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ABSTRACT: The paper aims to illustrate the project outcomes that, as part of a broader participatory process, the Municipality of Reggiolo devised and shared a strategic plan to revitalise the historic centre with the townspeople.

Palazzo Sartoretti came to us after several interventions and renovations that severely altered its original 16th-century structure. The archival fonts document the most significant transformations, which occurred in the 18th century when the eastern wing of the first floor and the imposing three-flight staircase were added, and many of the rooms were decorated. Furthermore, once it became public property, a significant alteration of the historic framework involved Palazzo Sartoretti with many adaptations that amplified its seismic vulnerability and structural fragility resulting in severe damage after the May 2012 earthquake.

As the result of the Municipality of Reggiolo's decision to house strategic functions in the building while reserving other spaces for a public library and a civic art gallery, the project is intended not only to repair the damage through seismic strengthening but also to upgrade those parts designed to house municipal offices and the town council.

Then, due to the remarkable actions taken by the Municipality and designers in accordance with safety and protection regulations, the restoration project and its ongoing site activities represent a paradigmatic case study showing how the palace's reconstruction is an uncommon process that will allow a historic building and its strategic use to be restored.

Keywords: Sala dello Zodiaco, reversibility, timber floor, box-like behaviour

1 INTRODUCTION

The cycle of virtual site visits concluded in Reggiolo with Palazzo Sartoretti, a symbol of the post- earthquake reconstruction and rebirth not only of the individual building but of the entire community.

The project is part of a broader comprehensive plan in which the municipality, as the owner of the building, has devised and shared with the townspeople a strategic plan to revitalise the historic centre. In this wide-ranging project, Palazzo Sartoretti is located in a very important

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DOI: 10.1201/9781003253730-30

urban area, namely Piazza dei Martiri, where not only the Palazzo but also the ancient Rocca Gonzaghesca and the Rinaldi municipal theatre are located. Buildings and urban fabric that are connected to the dynamics of community "life" in order to give back a revitalised historic centre with a strengthened identity, including redevelopment of the cultural heritage and spaces, after the seismic events, with the completion of the subsequent phase of reconstruction.

Thus, with its imposing architecture, Palazzo Sartoretti, located directly opposite the Rocca, has come down to us after a series of interventions and renovations that have greatly altered its original structure, which dates back to the 16th century. Among the most significant transformations documented are those that oc-curred in the 18th century, when the eastern wing of the first floor and the majestic three-flight staircase were added, and many of the rooms were decorated.

The building only became public property in 1979, when the last descendant of the Sartoretti family be-queathed it to the municipality. Its use as a residential building has thus preserved the Palazzo from the typical adaptations that many heritage buildings, palaces of the nobility, underwent in their transformation from private to public functions between the end of the 19th century and the late post-war period. Adaptations that in many cases, after the 2012 earthquake, amplified seismic vulnerability and structural fragility, caus-ing very significant damage.

For this building, the implementing entity chose to house strategic functions, that is to transform the build-ing into the seat of the Municipality, and to reserve other spaces inside it to house a Municipal Library and a Civic Art Gallery. The major project therefore did not stop at repairing the damage through seismic upgrading, but went even further, upgrading those parts in which the municipal offices would be housed, including the rooms used by the mayor, his cabinet and the town council, which by law must meet specific Class 4 seismic safety crite-ria (§2.4.2. NTC 2018 and D.G.R. 1661/2009), the highest possible. Furthermore, for the rest of the build-ing the design choice to heavily emphasise restoring its function meant that its owner could contribute sig-nificant funding to the completion of the works.Following the damage survey, carried out by the Ministry of Culture (formerly the Ministry of Cultural Her-itage and Activities) in July 2012, the mechanisms activated were attested and the damage was quantified in economic terms. The building was then included in the plans of the Ministries of Public Works and of Cul-ture with total funding of € 8,094,763.09, of which € 5,792,202.73 financed by the Commissioner for Re-construction and € 2,302,560.36 co-financed by the Municipality of Reggiolo.

The technical and economic feasibility project was formally approved by the Joint Commission for the re-view of projects for buildings of cultural interest under the protection of the Regional Agency on 26 No-vember 2014.

The executive project was examined by the Joint Committee for the first time on 30 November 2016, when further information was requested, and subsequently approved on 23 June 2017 once the requested infor-mation had been received.

The competent offices finally issued their authorisations:

- on 27th October 2017, authorisation pursuant to article 21 of legislative decree. 42/2004 (issued by the competent Superintendence)
- on 2nd November 2017, seismic authorisation (issued by the Regional Geological, Seismic and Soil Service)
- on 14th November 2017, certification of economic appropriateness (issued by the Regional Agency for Reconstruction/2012 Earthquake).

The restoration of Palazzo Sartoretti in Reggiolo, recounted during the lesson at the Summer School, was a paradigm, given the extraordinary actions taken by administrators and planners, in agreement with the com-petent authorisation offices and in compliance with the safety and protection regulations. The itinerary embarked on for the palace is a very heterogeneous one, but it will allow a building of historical importance with uses of great relevance to be restored. The lecture also allowed us to witness work on site in full swing during July 2020. The works will return the completed building on 7th July 2021.

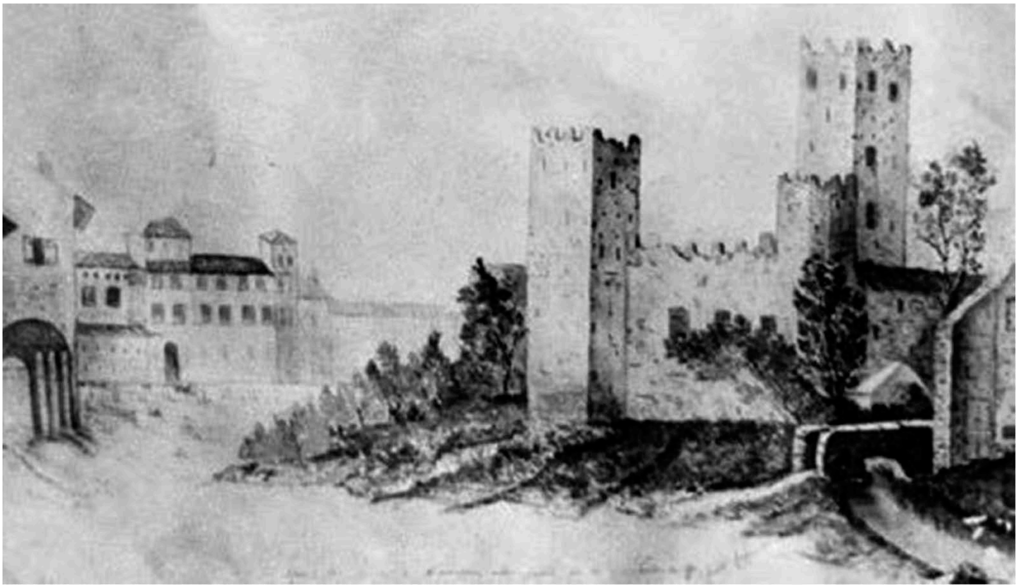

Figure 1. Photograph of the 1613 painting by Ambrogio Viarana depicting the Rocca and Palazzo Sartoretti (Archive of the Bologna Superintendency).

2 DESCRIPTION OF THE DAMAGE AND MECHANISMS ACTIVATED, THROUGH SURVEY PHOTOS

Palazzo Sartoretti, in the province of Reggio Emilia, has been chosen for the last virtual tour. It takes its name from the Sartoretti family, who donated the important Monumental Palace to the Reggiolo community in the 1980s. «[. . .] *It is a distinguished monumental complex with 16th century origins, modified and extended during the 18th century, incorporating the previous building. At that time, the monumental main staircase was built, and the palace was given its present-day appearance - elegant and majestic at the same time, both on the outside and the inside. The impressive building preserves its original C-shaped floor plan with two lateral wings, one of which was never finished, at a right angle to the main building. It has 3 floors above ground, topped in the centre with a small, single-level attic - an architectural element of Mantuan origin, visible in other notable buildings in the Po Valley from the late 16th century, such as the ducal palace in Guastalla and Palazzo Bentivoglio in Gualtieri. The main view from the north is characterised by 3 rows of rectangular windows with mixtilinear brickwork frames, and a large, arched front door that leads into the entranceway, characterised by two series of columns that support elegant vaults. The first floor, which is accessed via a monumental three-flight staircase, is made up of a series of rooms and a great hall, most of which are decorated with fine monumental paintings and lively decorations in neo-classical and late-baroque style. Various service buildings are part of the monumental complex*». (Make reference to the declaratory judgement of 10/07/1986 from the former Superintendency for Architectural and Environmental Assets of Bologna).

The building was affected by two seismic events: the earthquake of the 15th October 1996 at 11.56am, with its epicentre in the area between Bagnolo, Correggio and Novellara, and the earthquakes of the 20th and 29th May 2012. The succession of interventions between 2002 and 2008 primarily involved functional and technical aspects connected with the activities carried out in various spaces, without adding any significant seismic improvements.

After the 2012 earthquake, the building was declared unfit for use, and therefore promptly underwent interventions to secure it, carried out by the fire brigade. These were necessary

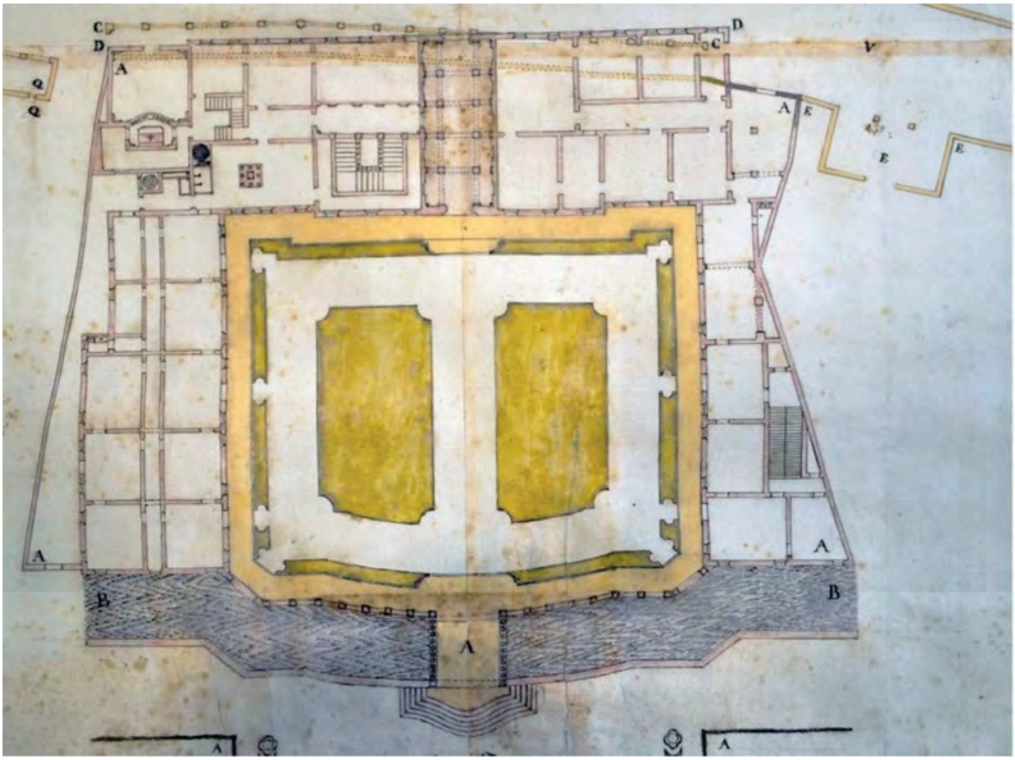

Figure 2. Historical Plan evidence of the Piazza di Reggiolo and its surroundings (Parma Historical Archives)

both to strengthen and brace the openings, and to counteract the first and second level mechanisms activated by the earthquake.

The banquet hall contains decorations on lime plaster with “a secco” finishes, in late 18th century neoclassical style. The main hall is covered by an elliptical vault made from plaster and joists, which has an inherent lightness that allows the horizontal supports to be kept to a minimum, plastered like the walls. Complex decorations cover the entire surface of the space. The vault, with a central rosette and fake coffered ceiling, with alternating mythological scenes and decorative rosettes, has a protruding false balcony as a cornice, with corbels (built from wood and painted like the walls). The walls are punctuated with false architecture: columns with capitals, sculptures in recesses, busts over doors, and linear cornices in perfect chiaroscuro. Close to the main hall is the monumental staircase, which also has three levels starting from the ground floor.

These large areas, misaligned and uncoordinated, constitute the most vulnerable elements of the building, both in terms of the lack of bracing for the excessively thin walls of the space, and in terms of the “false” placement of part of the supporting walls in relation to the walls below. The survey for the residential buildings form was carried out on 11th July 2012. The residential buildings form is more complex and substantial than the churches form, and all the damage regarding structural elements was identified. The main mechanisms were: toppling of the external walls, flexural rupture, breaks in both the wall bays and panels, both external and internal, detachment of the beams, damage to the stairs, including the monumental staircase, and collapses. As we can see from the photographic documentation attached to the damage survey forms, the banquet hall suffered serious damage to the walls.

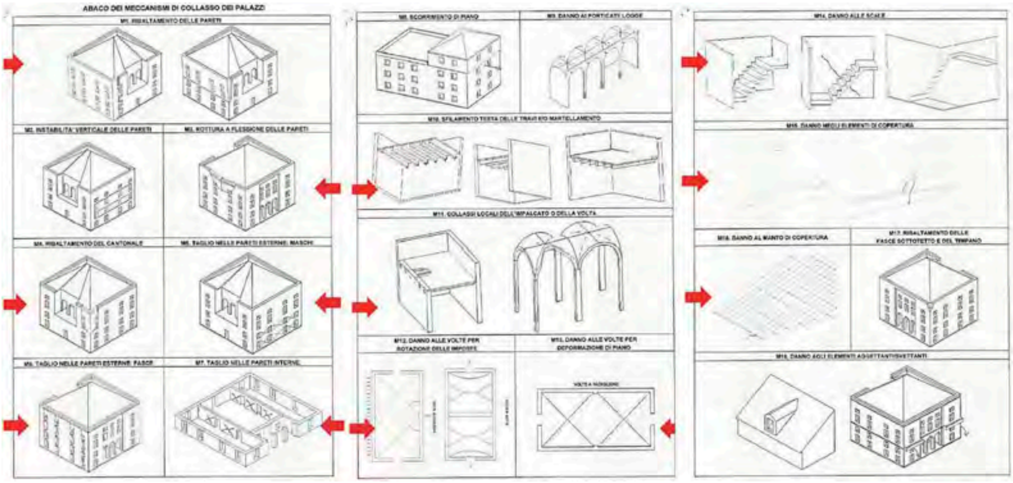

Figure 3. Schematic illustration of the mechanisms activated, taken from the damage survey forms.

3 THE PARTICIPATORY PROCESS FOR PALAZZO SARTORETTI IN REGGIOLO

Nine years after the terrible earthquake that struck Emilia, reconstruction has been completed in most of the municipalities affected. The crater has thus shrunk to contain just 15 municipalities of the initial 60. So much has been done.

Today our towns and villages are different, safer, more beautiful and also more welcoming, thanks to the in-itiatives that the Emilia-Romagna Region has introduced with the commissioner structure. A structure that in recent years has never abandoned the mayors, who have always been in the front line in the tough strug-gle of reconstruction.

Now, however, we must think about the post-reconstruction period, making the most of the experiences and ideas put forward by the communities to cope with the emergency and revive the areas affected by the earthquake. This capacity to react, to create networks, activating skills and expertise, can now become a real model.

This was also the case for the Palazzo Sartoretti work site. This was the symbol of reconstruction in Reg-giolo, not only because of the amount of work, but also because of the functions that will be housed in this building. It will be the future seat of the municipal authority, as well as a place of culture, since it will house the municipal library, an art gallery with various works of art donated by many local artists over the years, and a space dedicated to children, with a series of rooms intended as studios which, in synergy with the library, will provide a unique and innovative service for families.

This is an exemplary work site, created by many people, with a close partnership of enterprises, technical people, the local municipality and the heritage superintendency, who worked together to revive a building that had been severely damaged by the earthquake.

This intervention is part of the draft comprehensive plan that the municipality approved, thus equipping it-self with a strategic plan that could enhance the thinking, based mainly on the revitalisation of the historic centre and the outlying areas.

Every intervention that has been implemented has had this planning as a guideline and has made it possible to understand over time every transformation that the municipality was undergoing during these years of construction.

In fact, the strategic vision that we have tried to pursue was to study the territory together with the towns-people, thus making them an active part of the reconstruction process; with a series of participatory pathways, financed by the Region, we have pursued the idea of trying to imagine the post-reconstruction Reg-giolo. It was a very ambitious participation which, with the help of mediators, gave us the opportunity to turn peoples' ideas into real projects, which we then prioritised in order to seek the appropriate funding lines.

Today the construction work is coming to an end and the building is returning to its splendour. Soon all the townspeople will be able to experience its grandeur and elegance, which will enhance the urban landscape context of the other public and private buildings overlooking the beautiful, revitalised Piazza Martiri.

4 PALAZZO SARTORETTI IN REGGIOLO: THE MAIN CONSTRUCTION PHASES

The genesis and evolution of the Palazzo are closely linked to the history and transformations of the urban centre in which it is located, which developed on the eastern side of the Rocca dei Gonzaga along the two axes formed by Via Giacomo Matteotti and Via Cantone, where the oldest residential buildings are concentrated. A few centuries later, two villas and the theatre were built near the Rocca, but outside the pre-existing urban core. Palazzo Sartoretti overlooks the main piazza to the south-east of the Rocca.

The historical evolution of the Palazzo is documented by a very limited number of archival and iconographic sources and therefore hypotheses of its historical and architectural evolution have been formulated based initially on direct observation, primarily. During the course of the work, it was possible to substantially confirm the initial hypotheses that identified a transformation pathway through successive amalgamations and extensions determined by changes of ownership and of use of the different parts of the complex.

In fact, the building seems to have developed from an original modestly sized nucleus from the early 1500s which was located near the fortified perimeter of the Rocca. The only architectural element attributable to this historic nucleus is the still existing staircase on the west side of the main body, consisting of ramped vaults with a masonry parapet completed at the top by a shaped handrail also made of brick. To the south of this nucleus, there must have been an adjoining secondary building, probably not intended for residential use.

From the only iconographic source available, a photographic record of a painting from 1613, it can be deduced that the main body overlooking the square was substantially completed at that time, although with very different architectural elements. Indeed, a tower can be seen on the western edge and a portico on the eastern side. Of both these elements, no evident traces emerged, including during the work, because they were probably lost in the various transformation processes that the building underwent. However, the presence of a few small underground rooms and some tunnels on the eastern side suggests the existence of activities linked to the use of water on that side.

The only historical plan available, which could date back to between the end of the 18th and the beginning of the 19th century, shows a layout that is essentially the same as the present one. The presence of the monu-mental staircase can be observed, and it is presumable that the central roof-terrace and the ballroom, as well as the decorations of the ballroom itself and the adjacent rooms and the configuration of the current elevations date from the same phase of intervention. In this period the building took on its palatial configuration, which recalls in some of its elements the typical features of the "Gentilizia" residencies of the nobility of the period, widespread in the surrounding area. Towards the end of the 19th century and in the early 20th century, the building underwent a number of evolu-tions in both functional and aesthetic terms. This phase includes the new service staircase in the east wing of the main building, the secondary buildings to the south-east, the late Rococo decorations in some rooms on the first floor of the west building, which, due to their location, became an extension of the main floor and were used for more private functions, and the late 19th century decorations in the small hall behind the ballroom. These elements testify to continuous transformations probably linked to new needs for use as perma-nent dwellings and not only for representative functions.

A further transformation that significantly affects the morphology of the architectural complex took place in the 1920s-30s. This involved the insertion of the new volume on the side of the main façade on the right. The decoration with geometric modules and stylised floral motifs, a hybrid of neo-mediaeval and Art Nouveau decorative stylistic elements, in the room next to the ballroom overlooking the main staircase, dates from this same period. Another element to highlight is that

Figure 4. Top-left: Stage 1 (green), the building originated from a modestly sized building dating back to the early 1500s. Evidence of this is the staircase with rampant arches and a masonry parapet culminating in a finely crafted handrail. Top-centre: Stage 2 (magenta), at the end of the 18^{th} century the building was enlarged and embellished with the addition of the west wing, which had been left unfinished after the earlier work. Top-right: Stage 3 (light brown), it was at the turn of the 18^{th} and 19^{th} centuries that the building took on its present palatial configuration. The fine lime decorations in the Salone delle Feste and the adjoining parlours date from this period. The creation of the Inner Park with access from the atrium used as a carriage way also dates back to this phase. Down-left: (red) in the early 1900s, probably with an increase in permanent residential activity, some of the rooms on the first floor of the west wing were refurbished, becoming an extension of the main floor, and the tempera decoration of the Sala dello Zodiaco was added. Down-right: (purple) the last phase of the process ended in the 1920s-30s with the insertion of the new volume on the side of the façade. The lime decoration of the Sala Neo-Medievale e Liberty with a false projecting balcony with a shelf and painted festoons of flowers and fruit also dates from this period.

the different levels of the west body were never directly connected to each other, but always through the main body, given the absence of traces of vertical connections within the secondary body.

After it was gifted to the Municipality of Reggiolo, the Palazzo became the home of public services such as the Library and the Municipal Offices located in the main building while only the ground floor of the body to the west was used. Following the 1996 earthquakes, consolidation and restoration works were carried out on the entire complex except for the upper floors of the secondary building.

5 THE LOCATIONS AFTER THE SEISMIC EVENTS OF MAY 2012

Palazzo Sartoretti had already been damaged by the 1996 earthquake, following which both structural consoli-dation and surface restoration works were carried out. In spite of this, given the extent and type of seismic events that occurred in 2012, the Palazzo suffered extensive damage and was declared unfit for use and the subject of a series of Fire Department initiatives to make it safe, which, specifically, included the installation of boarding to support the windows, external and internal ties and shoring up of the most compromised and valuable areas, to ensure safe access and inspection, a fundamental aspect during the design phase. As has been made clear in the previous paragraphs, the Palazzo is the result of successive additions, modifications and changes of use over time.

Figure 5. The main front of Palazzo Sartoretti, the backdrop of Piazza Martiri, as it looked after the 2012 earthquake.

Figure 6. Safety operations by the Fire Department to preserve the central tower and the building from possible structural collapse.

At the time of the earthquake, the main body overlooking the Piazza, structurally named US1, housed the Municipal Library while only the ground floor of the westernmost body perpendicular to it, structurally named US2, was in use, while the first and second floors were unused and had not been accessible for some time.

In the main body, extensive cracking was found, with wide and deep cracks at all levels, probably due both to the presence of large openings in the load-bearing walls and to the poor quality of the masonry itself and an insufficient connection with the floor elements. In addition, the large double volume of the central tower proved to be an extremely vulnerable element due to both the accentuation of the accelerations due to the change in stiffness and the absence of effective connections and bracing elements between the masonry walls. In spite of the extensive damage, the tower did not collapse, perhaps because of the presence of a light vault in canniccio cladding and wooden panels and also thanks to the roof, which functioned, albeit to a limited extent, as a connecting element to the field walls. In addition, most of the masonry platbands of both doors and windows were damaged, most of the wooden structures were dislodged, both hollow-core and brick vaults were damaged, and the attic and roof walls were disjointed and disconnected.

In the west wing, named US2, the crack pattern was very different at each level due to the work carried out on the ground floor in the early 2000s and the non-renovation of the upper floors. In fact, there was little signifi-cant cracking on the ground floor, and it was concentrated at the large openings because the inter-floor slabs contributed to the box-like behaviour of the lower level. On the other hand, on the upper floors the presence of concentrated and widespread cracks of considerable size could be observed, caused by the defects in the wall section and above all by the absence of effective connections at deck and roof level. At the southern end of the building, there was also the start of partial overturning, and in some rooms on the first floor the decorated plaster and arelle ceilings collapsed, revealing wooden decks and decorated tiles.

6 THE ARCHITECTURAL PROJECT

The evolution of a building or a complex of buildings is characterised by several phases. Each phase leaves traces and clues on the building, which can give precise information on the material life of the architectural artefact and constitute an indispensable tool for defining a correct design approach. The last stage of this process is the beginning of a new story that the work will tell its own story, and for this to happen, it must come to fruition to allow the building to continue its journey over time.

This approach was used to plan the restoration works on the Palazzo and, as it is a cultural asset, criteria of compatibility, reversibility and non-invasiveness were adopted for the elements of historical and architectural value of the building. Both the interior and exterior surfaces were investigated to assess their state of preservation resulting not only from the seismic events and the consequent state of abandonment of the building, but also from other possible causes of degradation in order to eliminate or significantly reduce them. Only after this activity of analysis and synthesis of the data collected through graphic mapping was it possible to proceed with the definition of the consolidation, integration and protection of the plaster, stone and wooden elements, which privileged the choice of materials generally based on characteristics such as compatibility, durability, maintainability and reversibility, preferring where possible natural materials belonging to the local tradition. From a distribution and functional point of view, the local government decided with great foresight and determination to use the entire building for functions open to the public, allowing the townspeo-ple to reappropriate all the spaces of Palazzo Sartoretti. From a distribution and functional point of view, the fundamental principles that have guided the architectural choices have been, above all, the need to enhance the characteristics and historical-architectural quality of the spaces, the decision to house uses with a strong impact on static loads, such as the archives, on the ground floor, and the identification of a clear system of accesses and connections, paying particular attention to disabled access. In particular, the main body will house the Municipal Library and some exhibition spaces for both permanent and temporary exhibitions. The main entrance of these spaces from Piazza dei Martiri will be from the hallway that connects the square to the park behind, and it will be possible to access the main floor through the majestic staircase. The other two staircases, secondary but just as historic, will be mainly for service use and the one to the east will also serve the second floor where there will be spaces for young children. Within the Library, the main hall can also host events not related to the main activity because it is directly accessible from the majestic staircase. The ground floor will mainly house exhibition spaces and related services as well as a room for the municipal archives. The west wing of the building will be used entirely for municipal offices, and for this reason it has undergone structural work to ensure its seismic upgrading. These spaces will be accessed through the entrance hall connecting Piazza dei Martiri and the Park. The ground and second floors will house the services with the largest number of visitors, while the main floor will host function rooms and other offices. In order to ensure independent access from the main body to the upper floors, a new staircase was built in the only room on the main floor that did not have

Figure 7. The back of Palazzo Sartoretti opening onto the large park. The works to make it safe included large steel pillars and chains to prevent the brick walls from collapsing out of level.

Figure 8. The first floor of the west wing was in a very critical condition, with deep cracks in the masonry, partial collapses of the suspended ceilings and widespread rotting of the wooden beams.

Figure 9. The critical condition in west wing's first floor with deep masonry cracks, partial collapses of suspended ceilings. In the foreground are the chainrings for safety measures.

Figure 10. Some pictures of the rooms on the first floor of the west wing. The earthquake damage also caused large infiltrations of rainwater.

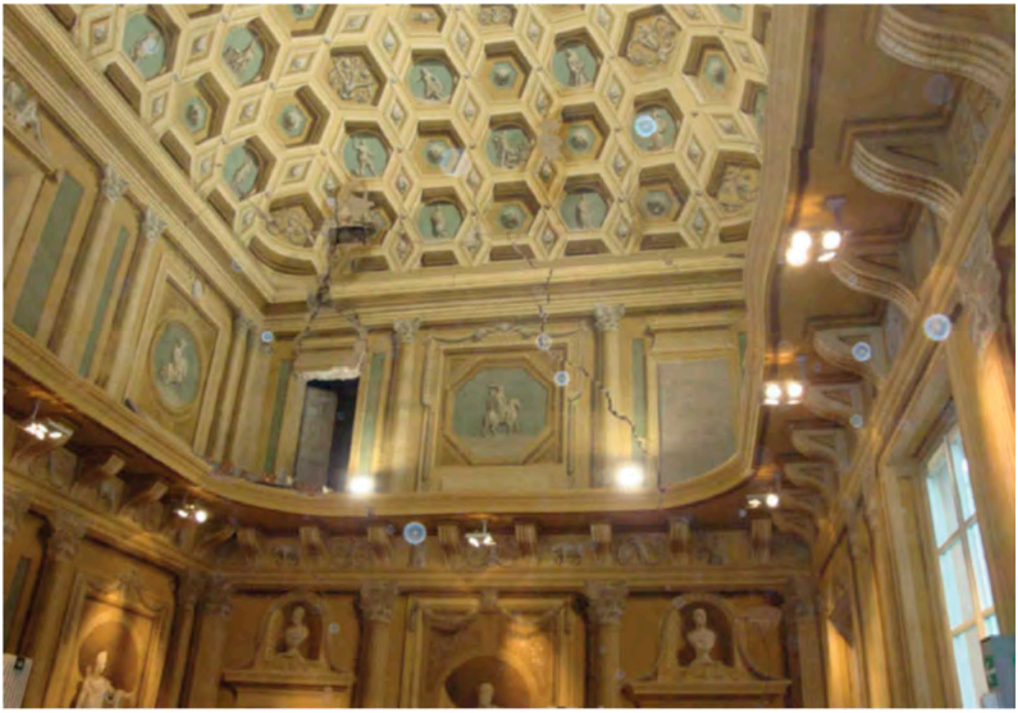

Figure 11. The hall immediately after the earthquake and before the safety devices was installed. Deep cracks in the ceiling and walls.

Figure 12. The decorations in the rooms on the main floor of the main body of the building were seriously damaged.

Figure 13. In one of the cornices of the Sala Centrale, the earthquake damage caused the decoration to shift by almost 10 cm.

Figure 14. The decorations in the rooms on the main floor of the main body of the building were seriously damaged.

Figure 15. The rooms on the first floor of the western enfilade have wooden ceilings with lime-washed brick tiles and fine decorations that echo the motifs on the walls. There is evidence of water leaking from the roof as a result of the earthquake.

decorative wall decorations. The project paid particular attention to the conservation and restoration of elements of historical and architectural value in the Palazzo, both internally and externally, such as the pictorial decorations on the main floor, the historic staircases and the external facades, which were upgraded by restoring and reinstating the plasterwork.

For the interior decorations, pre-structural consolidation works have been hypothesised and planned in detail in order to ensure they are conserved, interventions as pre-consolidation with protective coatings or injections to "fix" the plaster material and subsequent cleaning, both dry and wet, prior to consolidation and restoration of the paintings. The project also included an almost complete refur-bishment of the interior finishes as a consequence of both the damage caused by the earthquake and the extensive structural work required. Therefore, the flooring, which is not historic, and installed since the 1990s, was replaced with terracotta floors similar to the preceding floors, while the exterior window and door frames and some interior doors were restored and renovated, improving their energy performance in some cases. The stone and cobble paving of the main entrance hall was protect-ed during the construction period and restored later. For both the new interior and exterior plaster and the paintwork, the project opted for lime because it is more compatible with the historic masonry.

7 THE STRUCTURAL DESIGN

As illustrated in the previous paragraphs, the building complex was rendered unusable by the earthquakes of May 2012, which caused significant damage to the load-bearing structures and the decorative scheme. Analysis of the discussion of the damage inflicted, as a whole, and the structural characteristics of the building, identified the principal critical points and vulnerabilities of the building due to its geometric conformation, its histor-ical evolution over time, and the construction characteristics of the structural elements of which it is com-posed.

In many respects the building exhibited an earthquake behaviour typical of masonry buildings with wooden and sometimes masonry floors, in other respects there were peculiar and special circumstances. The external façades, particularly those of the main building, are characterised by a slight outward tilt, resulting in diagonal cracks up to 15-20 cm in width on the interior walls at right angles to them. These are first-mode failure mechanisms, which are typical of masonry buildings without rigid floors, and are particularly evident in this case, partly because there is little toothing between orthogonal walls. Small horizontal actions (3-5 % of the force of gravity) may cause portions of the façade to tilt out of plane, with possible progressive collapses of the whole building.

In the specific case of Palazzo Sartoretti, the extensive and remarkably wide cracks caused severe damage to the decorative scheme, the recovery of which was one of the main challenges of the project.

The main objective of the structural design was to respect the existing building not only in its "material" but also in its structural functioning, and therefore the design used systems (generally in steel) and structural mecha-nisms (generally of the reticular type), which therefore come into operation in the event of an earthquake or exceptional event, that are supplementary, not replacements.

As mentioned earlier, the accentuation of earthquake damage in some areas was also caused by the inability of the intermediate decks and the roof to act as floor diaphragms to redistribute the forces of inertia deriving from the masses of the masonry walls and the forces acting on the floors themselves, on the masonry walls parallel to the seismic action, due to the lack of rigidity in their own plane or of an effective and widespread system of connections between the floors and the masonry walls and between the various walls. The building therefore demonstrated a behaviour governed mostly by local crisis mechanisms and was not able to react to seismic actions by drawing on the totality of its structural resources for the premature occurrence of localised damage and crises.

The aim of the project is to improve the seismic behaviour of the building, with interventions that respect its original historical and construction characteristics as far as possible, without introducing incongruous construc-tion elements or technologies; first of all by repairing the

Figure 16. The condition of the rooms in the attic of the western body, which had been uninhabited for decades, was such that even accessing them during the survey was very difficult.

Figure 17. Partial collapses of floors and unsafe portions of the roof represented the main difficulty.

Figure 18. Project plans.The spaces in the west wing designated for municipal offices are highlighted in orange, the premises of the municipal library in light blue and the spaces for cultural events for public use in green.

damage to the masonry walls using mainly traditional techniques such as stitching with bricks and mortar similar to the existing ones and scarifying and pointing the joints, which restores the pre-earthquake resistant characteristics, and with an orderly and rational set of interventions aimed primarily at allowing the building to fully express its resistant capacities. In the absence of toothing of the joints between orthogonal walls, bands of fibreglass netting were applied with lime-based structural plaster. To earthquake-proof the west wing, given its strategic function and historical and morphological characteristics, new longitudinal load-bearing walls were planned on the ground floor to restore the continuity of the walls originally present in the building, but which had been removed at an unspecified time. A seismic joint was introduced between the two buildings that make up units US1 and US2 to separate them and obtain a compact and symmetrical geometric and structural conformation for each building, capable of ensuring that they would behave well in the event of an earthquake and in particular to avoid dangerous torsional effects, which are very difficult to predict and generally cause serious damage in the event of an earthquake. Systems to increase rigidity were also planned for the intermediate floors and the roof, consisting of metal trusses under the floor or tiles, or, in the case of the roof of the main building, double wooden boards capable of effectively tie all the walls of the space. In the presence of double or triple volumes, as in the case of the turret, it was necessary to specify the inser-tion of metal lattice structures, placed in a ring, integrated and masked in the architectural elements, to eliminate the risk of first mode mechanisms such as the overturning out of plane of the walls.In both buildings structural ventilated crawl spaces were introduced at foundation level, with the dual function of ventilation and insulation, and also to prevent differential settlement and distribute across the ground any concentrated forces of any kind. In brief, the structural interventions planned can be traced back to interventions directly aimed at repairing damage, interventions aimed at remedying structural shortcomings and vulnerabilities such as, for example, in-creasing the rigidity of the floors, interventions aimed at reducing the vulnerability of the building, improving its overall seismic behaviour, for example through the construction of additional load-bearing walls, the plugging of niches and flues, the creation of effective connections between decks and walls, and interventions aimed essentially at increasing the load-bearing capacity of certain parts of the building with respect to vertical loads, such as the construction of slabs that work with the wooden structures.

The implementation of this plan of action made it possible to achieve a safety level of over 60% for the main building (US1) and a seismic adjustment level of 100% for the secondary building (US2).

8 THE WORK SITE

Work at Palazzo Sartoretti began on 19 September 2018. The enterprises that won the contract were the CAMAR S.C. consortium based in Castelnovo né' Monti, which assigned general coordination and execution of the construction work to consortium member TAMAGNI COSTRUZIONI s.r.l. of Boretto, and R.W.S. s.r.l., in a temporary association of companies acting as principal, with headquarters in Vigonza, which undertook the surface restoration and wall consolidation work. The creation of the technical facilities and of some finishes was assigned to mainly local subcontractors.

The project management office involved several professionals with different roles from both Politecnica, an engineering and architecture cooperative company based in Modena, and Coprat, also an engineering and architecture cooperative company, based in Mantua. Specifically, the lead professionals from Politecnica who were involved were architectural engineer Micaela Goldoni as general works manager, engineer Fabio Camorani as director of operations for the structural works, architects Francesca Ferrari and Giovanni Daniele Malaguti as assistants in the architectural direction of the works, and engineer Fabrizio Rossi as assistant structural operations manager. Coprat's professionals were mainly responsible for the technical facilities and accounting, and in particular engineer Daniele Ferrarini (operational management of the mechanical installations) and engineer Gianni Andreani (operational management of electrical installations) and surveyor Sara Bernardelli (site accounting). The close cooperation of the same working group, first at the design stage and then at the construction supervision stage, achieved very satisfactory results and an excellent integration of the different specialist disciplines that are essential in cultural heritage restoration.

As mentioned above, the project included an initial phase of works aimed at securing the decorated surfaces in preparation for the consolidation of the walls. In particular, in addition to the more common interventions such as the application of facings and wraps, in some cases off- site repairs were done. Off-site repair was only undertaken for the portions of decorated plaster in correspondence with serious cracks and instabilities, where the project envisaged consolidation through like-for-like replacement. A support bandage was applied to the area to be detached by applying acrylic resin with a brush and using gauze or Japanese paper, depending on the size and thickness of the plaster. For each fragment, a panel the size of the portion

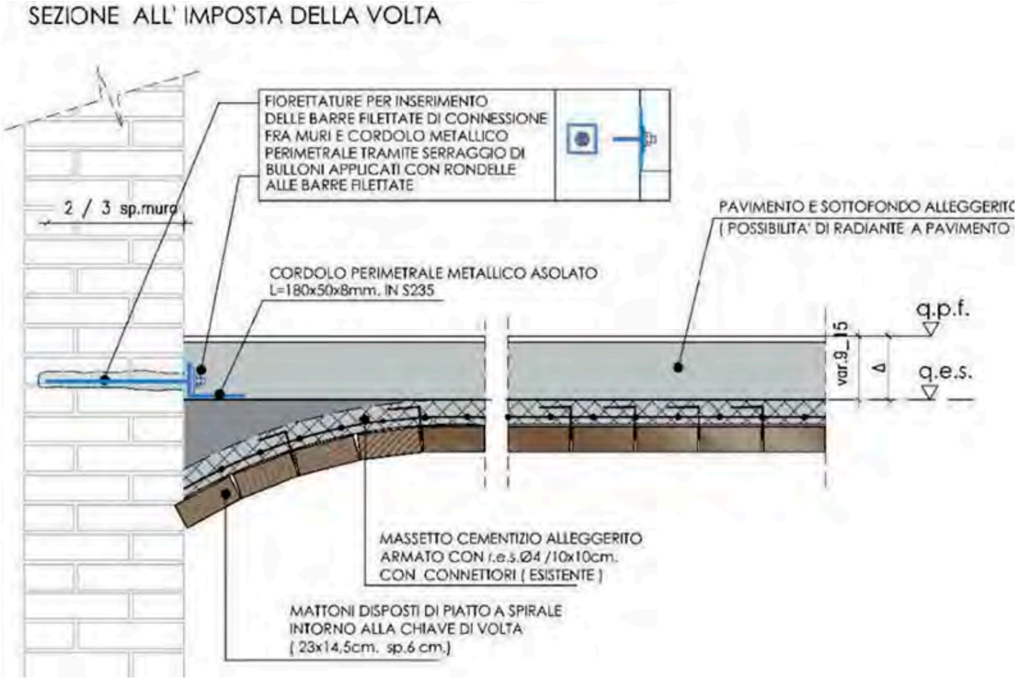

Figure 19. Increasing the rigidity of the floors was a key element of the project. One of the techniques used for the wooden decks, in the absence of criticality for vertical loads, was the construction of trusses with steel plates placed under the floor. In correspondence with the masonry vaults, on the other hand, it was noted that consolidating hoods had been created in a previous inter-vention, so the project merely provided under-floor curbs with metal angle pieces connected to the masonry.

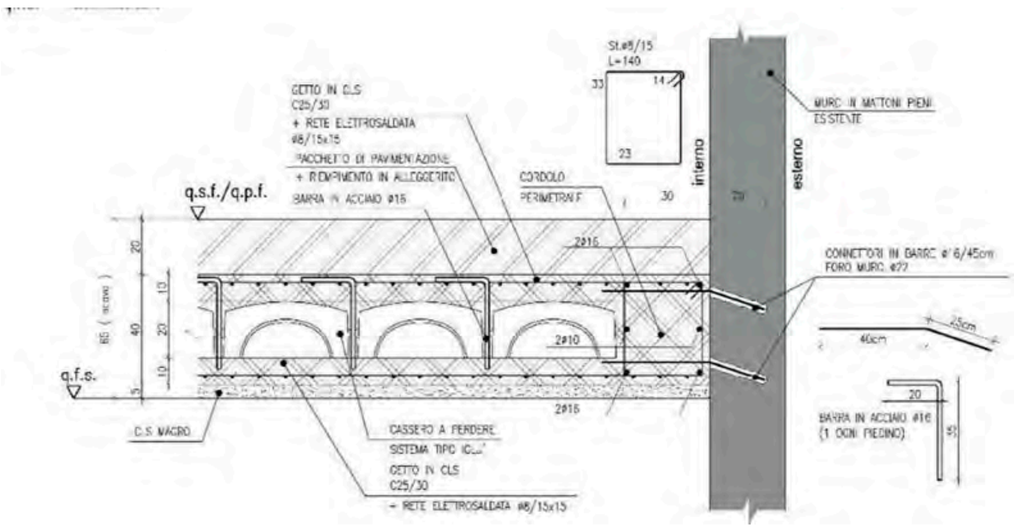

Figure 20. Structural crawl spaces with reinforced concrete slabs and disposable formwork in recycled polypropylene were used for the foundations. This solution constitutes a slab of great horizontal and vertical rigidity and limited weight and bulk, and also represents a layer of insulation and ventilation.

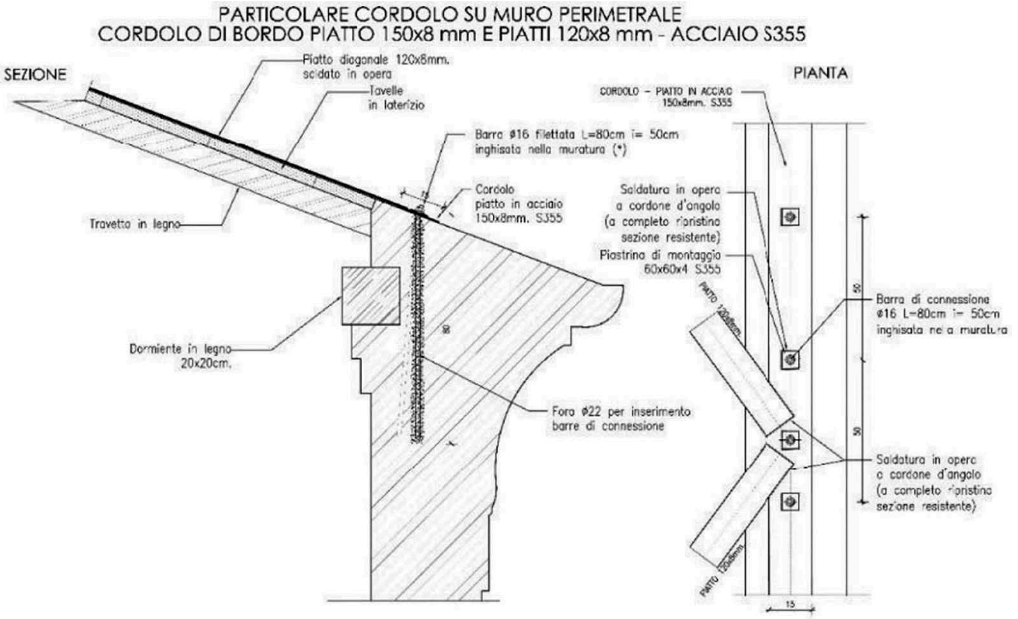

Figure 21. The roof reinforcements were created with metal trusses for the west body and with double wooden boards for the main body.

to be detached was then created off-site and glued onto facing to provide additional support for the detachment phases. Removal of these parts, which were cut with precision mechanical tools such as micro-cutters and sabre saws, traced the existing cracks and fissuring. Once the parts had been removed, they were catalogued by room and placed on special trays, and the first consolidation work was done on their backs.

Once the safety work on the decorated surfaces had been completed, it was possible to consolidate and reinforce the masonry, such as patching the main through cracks or masonry males that were not in contact with each other, using bricks and mortar with similar morphological and mechanical characteristics to the existing ones.

In some cases, intervention techniques that are innovative but just as compatible with the historical masonry were adopted, such as, for example, the laying of fibreglass fabrics connected with flakes, also made of composite materials, and lime mortar support, which also made it possible to remedy some significant anthropic discontinuities in the masonry, such as missing or reduced toothing in rubble core masonry walls during construction, or discontinuities created in recent times to solve problems such as rising damp. These are reversible interventions using materials compatible with the historic masonry such as glass fibres and lime mortar matrix.

After completing the wall consolidation, it was possible to work safely in the foundation.

The planned intervention made it possible to limit excavations to a depth that had already been reached in recent times, reducing both the impact on the structures and the risk of possible archaeological finds.

The construction of a "structural aerated crawl space", as better specified in the previous paragraphs, will make it possible to avoid differential settlements, given the different types of existing foundations, and to adequately connect the load-bearing masonry resting against the ground in an anti-seismic way, also improving underfloor ventilation and consequently mitigating the effects of rising damp.

Once the interventions on the foundations had been completed, the work focused on the decks of the first and second levels, both to statically reinforce the floors themselves with a reinforcement system with dry peg connectors and a reinforced concrete slab, and to connect the decks to the load-bearing perimeter walls with a steel curb. A vapour barrier was introduced between the deck and the slab to make the intervention potential-ly reversible and to protect the underlying deck, which is sometimes covered by decorated ceilings.

In the case of the vaults and some of the wooden floors where a reinforced slab had already been created dur-ing the preceding post-earthquake interventions, the work was confined to the creation of an anti-seismic rigid floor with a metal lattice underneath.

Fortunately, both the main and secondary wooden floor frames were generally in a fairly good state of preser-vation. Only in the case of one of the attics in the secondary building, which was originally intended to be finely decorated, was a beam found with a very damaged head, probably due to prolonged exposure to the weather and parasite attack, which had completely rotted the wood. In this case, the support of the head of the beam was first checked by making an opening in the wall, and once it had been ascertained that it had not decayed, the rotten area was removed, with carefully cutting until a healthy part was reached, while maintaining all of the external area with traces of decoration. A prosthesis of the same wood species was then prepared and secured with wood screws. Holes were drilled in the side for the insertion of threaded stainless steel bars. The joints were filled with Balsite, a two-component pigmented putty, and finished with white wood filler. The entire beam was then dusted using vacuum cleaners and brushes and subsequently treated with woodworm-proofing and fungicide. To further secure the beam, it was decided to anchor the entire beam to the beam of the floor above, using screws, and thus the beam is suspended.

Once the consolidation of the masonry and decks had been completed, it was possible to proceed with the restoration of the decorated surfaces on both the walls and vaults. In the case of 'light' vaults, i.e. those built us-ing the 'arellato' or 'canniccio' technique, careful consolidation of the extrados was carried out before tackling the consolidation of the intrados. First of all, all the rubble was removed using vacuum cleaners, and all the beams, rafters and planks were examined, identifying all the elements that needed to be consolidated. In some cases, wooden elements anchored with screws were placed side by side, and the system for hanging the ribs using stainless steel cables and clamps was integrated into the framework above. In some of the extrados, where the support was made up of wooden laths that were not continuous, it was decided to carry out further consolidation using bands of fibreglass laid fresh on fresh on fibre- reinforced mortar and anchored to the pe-rimeter walls using loose connectors that secured the individual wooden laths.

Once the consolidation work on the extrados was completed, it was possible to work on the intrados surfaces in the same way as for the walls. After an initial phase of cleaning using various dry and wet techniques, de-fined according to both the type of deposit and the type of support, consolidation work was carried out where necessary, particularly in the secondary section, using sprays to fix the paint film. Subsequently, the gaps were filled in, while the retouching of the paintings was only carried out once the work was almost complete, so as not to risk compromising the work of the restorers by creating dust. All the works were authorised in advance by the competent Superintendency at the project stage, but above all the interventions on the decorated sur-faces were sampled while work was in progress and agreed in detail.

In particular, the restoration operations were carried out as indicated in the restoration project in the items of the bill of quantities, using the materials indicated. In particular, the restorers carried out a surface cleaning by dusting with soft brushes followed by soft paste restoration rubbers (wishab). The paint film, which had de-fects of adhesion and cohesion, was then fixed, including small, speckled areas of faded colour due to the me-chanical action of the salts present in the plaster. The point fixings in the areas concerned were carried out with Primal B60 acrylic resin at 3% in demineralised water, after application of protective glazing, with Japa-nese paper, adhered with polyvinyl alcohol. Following this, the entire surface of all the vaults was thoroughly and completely tapped, to identify flaking plaster. The loose parts were filled and returned to their original position using syringes, introducing low spe-cific gravity consolidation mortar into the empty pockets.

The consolidations affected different portions of the plaster layer structure, since the flaking was sometimes located in the innermost part of the rendering, while at other times it only affected the most superficial layer between the plaster and the finish. The numerous cracks present were opened up, any old, cracked filler removed, if present, and they were then repaired with lime-based mortar, made with aggregates of medium grain size for the deep layers and fine grain size for the surface layers.

To complete the intervention, the plastering and gaps were toned with glazes, giving chromatic unity to the surface. The reconstruction of the geometries and the architectural decorative scheme was possible because, even in the presence of numerous flaking or demolished parts of the decorated plaster, the restorers in the preliminary phases always tried to preserve the cornices in the corner parts, so that it was easier to reconstruct the entire architectural scheme of false stucco and false cornices. In general, the decorated rooms of Palazzo Sartoretti had different pathologies depending on the area in which they were located. In addition to the large number of cracks, and in addition to the portions that had to be removed for repair, there were portions of plaster that were severely damaged due to rainwater infiltration from the roof, particularly in the west enfilade and the large vault of the Salone delle Feste. In fact, the force of the rainwater percolating from the roof reached the vault, penetrating the canopy, then the plaster and then the decorated plaster. In the following drying phase, the plaster, loaded with salts, tends to solidify and crystallise, causing tension, flaking and breakage of the plaster. The photos show the restoration sequence of the de-tached portions of plaster.

After completing the work on the floor slabs, we moved on to the roofs. The wooden frames of the roofs were the subject of a detailed investigation, both during the course of the design and during the works, by expert wood technologists. This made it possible to define exactly which elements could be kept in place and which had to be replaced either because of their state of preservation or because of insufficient structural dimensions or poor timber characteristics. After consolidating or replacing in some cases the main and second-ary frames, stiffening systems were inserted into the pitches, consisting of metal plates connected to the wooden structure by metal connectors, in the case of US2, where there were brick tiles that were recovered and relaid, while in the case of US1, where there were recently laid perforated hollow blocks, these were replaced by a double wooden board. At the same time as the work on the roof, work was carried out on the

Figure 22. The pictures show the sequence of securing the decorations by sticking gauze and tissue to prevent any detach-ment of the decorated plaster. Micro-cutters, whose low vibration and absence of rotating blades ensure maximum precision, were used to cut the plaster. Laying the panels and cataloguing. In the panels, the ‘back’ of the decorated detached piece can be seen.

Figure 23. Several masonry walls had little or no toothing between corner walls. Two types of intervention are envisaged, angular like-for-like replacement or the laying of fibreglass fabrics, also placed at an angle, on lime-based adhesion promoters.

Figure 24. The construction of ventilated structural crawl spaces at the foundations. In correspondence with the wall- cutting sheath present along the entire perimeter, wall continuity was restored with the application of bidirectional glass fibre mesh.

turret, the most vulnerable element and the one that suffered the most damage. In addition, the turret contains a majestic hall surrounded by dec-orated walls and surmounted by a plaster and plaster vault supported by wooden ribs anchored to the roof structures. For these reasons, metal stiffeners were provided at various levels, in some cases positioned in correspondence with projecting architectural elements capable of hiding their presence. Upon completion of the structural work, it was possible to remove the structures and provisional works installed by the Fire Department immediately after the earthquake, such as the structural scaffolding installed in the main hall, and to proceed with the completion of the finishes and technical facilities.

Figure 25. Prolonged exposure to the weather and parasite attack completely damaged a painted wooden beam head in one of the rooms on the main floor of the west wing, requiring the insertion of a wooden prosthesis. The rotting area was removed by carefully cutting down to the healthy part of the beam. The prosthesis of the same wood species was prepared and fixed with wood screws and threaded stainless steel bars.

Figure 26. Images of the restoration of the wooden structures of the decorated vaults. In addition to some meticulous replacements of completely rotten elements, some doubling of the structures was carried out with new anchors, safety restraints with steel hangers and fibre matting with lime-based adhesion promoters.

The installation of technical facilities in a historic building always presupposes perfect synergy between the various disciplines, both at the design stage and during the execution of the works. In the case of richly decorated listed buildings such as this one, additional measures and strategies must be adopted. In this specific case, for example, a series of elements called totems have been installed, which will contain inside them all the active equipment of the electrical and special systems such as ignition systems, emergency lighting, sound diffusers, lamps for basic lighting and will make it possible to reduce, if not completely eliminate, the need for masonry work. Particular attention will also be paid to the type of light fittings, which will be sampled on site to check all aspects of the mounting system. In addition, the distribution of the air-conditioning system has been rationalised by making use of connecting corridors where present.

Once the flooring, fixtures and fittings were completed, it was possible to proceed with the painting of the surfaces, allowing the main floors to regain their former splendour.

Figure 27. Images of structural reinforcements on the extrados of the vaults. A large two-dimensional steel girder lattice will make any movement of the central tower's masonry more difficult.

Figure 28. On the floor slabs, diagonal steel plates and lightweight concrete copings were used as rigid diaphragms in order to prevent their movement with respect to the vertical walls as much as possible.

Figure 29. The photo shows an in-teresting moment of the restoration where, after the recovery and sealing of the cracks, and hand-beating of the entire areas (with the knuckles), the detached portions of plaster are identified and out-lined with chalk. Then, using a hand drill to avoid any vibration, holes are drilled, into which lime mortar with a low specific gravity is inserted.

Figure 30. Picture of the Salone during the laying of the terracotta floor after the scaffolding had been removed.

AUTHORS CONTRIBUTION

This paper is the result of a shared work between the authors. Introduction: Antonino Libro, Agenzia Regionale per la Ricostruzione/Sisma 2012 (Regional Agency for Reconstruction/2012 Earthquake). Description of the damage and mechanisms activated, through survey photos: Maria Luisa Laddago, Soprintendenza Archeologia, belle arti e paesaggio per la città metropolitana di Bologna e le province di Modena, Reggio Emilia e Ferrara. The Participatory Process for Palazzo Sartoretti in Reggiolo: R. Angeli, Mayor of Reggiolo. Palazzo Sartoretti in Reggiolo: the main Construction phases, The Locations after the seismic events of May 2012, The architectural project, The structural design, The work site: M. Goldoni, F. Camorani, F. Ferrari and G. Malaguti, Politecnica Ingegneria e Architettura, Modena, Italy.

All authors have read and agreed to the published version of the manuscript.

Built Heritage in post-Disaster Scenarios – Balzani et al. (Eds)

Mapping the cultural regeneration. The pilot experience of the "Crateri" project

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ABSTRACT: "Crateri" is the winning project with which a team of associations and professionals, directed by Planimetrie Culturali, responds to the call launched by the IBC for the reactivation processes of the architectural heritage in nine municipalities of the province of Modena, hit by the earthquake of 2012. The project is divided into two phases: the first consists in the mapping and census of abandoned places aimed at creating a register of urban reuse; the second involves the planning of community actions on the urban and peri-urban landscape. In an open vision and transversal sharing of skills and tools, the project provides a methodological "toolbox" which, through a process of identifiability of the so-called "community potential", aims to undertake temporary reuse paths of disused spaces and guide the regenerative process. It is a multidisciplinary work in implementation of the two important articles of the regional law, n.24 of 2017 (articles 15 and 16) for the containment of land consumption to give life to a process of activation of resources, material and intangible, capable of triggering benefits for the landscape and for the community.

Keywords: urban regeneration, temporary uses, mapping, abandoned heritage

1 INTRODUCTION

The Covid-19 emergency has made everyone, institutions and individual citizens as well, understand the importance of rethinking the relationship between human beings, space and nature. When the IBC, the Cultural Heritage Institute of the Emilia-Romagna Region, conceived the tender on cultural regeneration - won by the Crateri Project[1]-, it was thought to intervene in a territory and a landscape damaged by the 2012 earthquake, where the communities still carried their wounds despite the prompt reconstruction. Today, after the lockdown phase, a consequence of the world pandemic, it is worth stopping to reflect once again and even more deeply on what are the values on which to base the relationship between man and nature, between quality of life and territory, and how a community can take care of a collective heritage of history and places, in conditions of limited social and community mobility. Developing the resilience of communities to natural and health events is necessary, but it is even more necessary to formulate a new thesaurus on the basis of relationships, which puts terms such *as sustainability, care, regeneration, taking in charge, knowledge and safeguard first*.

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DOI: 10.1201/9781003253730-31

2 SECTIONS

2.1 *For a new methodology of investigation of the contemporary territory and landscape*

Environmental sustainability is one of the most ambitious goals to pursue: it is a challenge, not towards the environment, but towards ourselves, our habits. Fortunately, at the institutional level, in the government of the regional territory, something is being done. The Emilia-Romagna Region, with the approval of the Law on the containment of land consumption (LR n.24 of 2017) and by adhering to the directives of the Agenda 2030 on Sustainable Development of the United Nations, intended to promote interventions aimed at urban regeneration and reuse of abandoned architectural heritage, in order to reactivate social, environmental and territorial processes that can be useful to local communities in improving the quality of life and the environment, recognizing a close link between human well-being and the health of environmental and natural systems.

The theme of urban and social regeneration is therefore part of this paradigm shift and can only be the result of a polyphonic project of activities that respond to needs and questions of well-being that can no longer be postponed: knowledge of the territory, communities, economy, culture and the environment.

In this historical phase, the culture, the territory and the landscape are inserted in the activity of the IBC with new objectives and purposes. The Institute took the opportunity provided by the Earthquake Documentation Center (established by the Region in 2017)[2] and developed a call for proposals aimed at defining tools and actions for the knowledge of the landscape, the urban territory and for social and cultural regeneration activities; in September 2019, at the end of the selection of the proposals, the most convincing answer was that of the Crateri project.

The goal was to enhance, through practices of resilience, cultural regeneration and community actions, the areas of the nine municipalities of the province of Modena included in the Earthquake Documentation Center. A new path of knowledge of the places was thus undertaken which, while taking into consideration methods of analysis and cataloguing of architectural and environmental assets (activities that have characterized the IBC in the past under the guidance of figures such as Lucio Gambi and Andrea Emiliani)[3] has made contemporary, turning attention to an extended concept of cultural heritage of identity and rooted in the interests of the communities that inhabit the landscapes of the region. In full compliance with the actions identified by the Faro Convention (2005) which, in fact, goes beyond the concept of "cultural asset" in favour of the more innovative principle of "cultural heritage", as a set of resources inherited from the past and as an expression of values in continuous evolution, the Crateri project well identifies this multidisciplinary path of knowledge of the territory; knowledge aimed at cultural reactivation projects of abandoned places (due to the seismic events of 2012).

Starting from participatory community actions and practices, we are thus able to define useful methodologies for the regeneration of spaces and places that belong to the memory or history of the communities, favouring the birth of new and different social and economic energies. The Planimetrie Culturali Association of Bologna, leader of the project, has been able to involve an associative ensemble of different realities, which, in some cases, have previously carried out research in areas affected by the earthquake in central Italy. Among the nine Municipalities of the Modenese crater to which the call was launched, the Municipalities of Concordia sulla Secchia and Medolla joined the project.

The strength of Crateri lies in having brought together different energies in the common goal of activating and reactivating the social and urban potential development interrupted by the earthquake, involving, at the same time, more municipalities of the same territory with similar but not equal histories. The survey methodology was developed in successive phases: in phase 1 we started from a mapping, through the iconic restitution of abandoned places (theatres, cinemas, schools…) and of the forgotten landscape. Images returned to the communities through the gaze of a collective of photographers (Forza Maggiore), and "talkings" through the narration of "emotional maps" (Spazi Indecisi and Amigdala). The story of the places and the perception of the contemporary territory is implemented through the voices of the little ones with the elementary school children of the third and fifth year, and with the stories of the adults who have remembered what those places and landscapes represented for them.

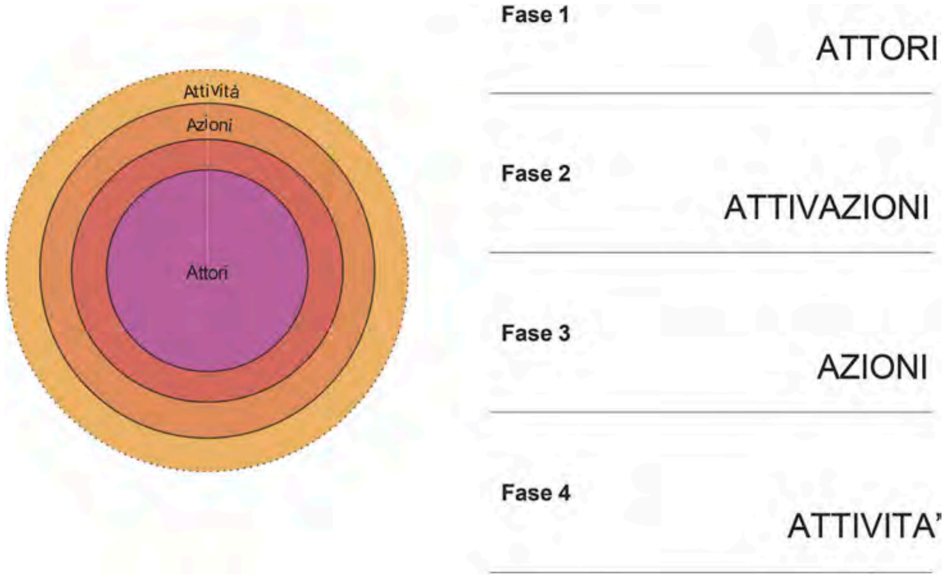

Figure 1. Urban regeneration is a process of redemption of abandoned properties, which have exhausted their life cycle, pursued through temporary use practices of an experimental nature, with implications on a social, economic, cultural and political level. It presupposes the preliminary deactivation of the "discipline of uses", through which urban planning exercises its deontic function of control and management of the territory in all its components and scales of complexity. In order to fully express the corresponding potential, and to translate it into action, the regenerative process is divided into four distinct mutually collaborating phases, taken from current practice, each of which contributes to the pursuit of a common goal: identification of the ACTORS; ACTIVATION of dialogue; development of project ACTIONS and promotion of ACTIVITIES, to be understood as virtuously reverberated outcomes on the areas invested.

Phase 2 of the project, on the other hand, was directed towards the administrative and legal processes available to administrations and citizens, useful for reactivating abandoned spaces and regenerating places dedicated to the social, cultural and economic life of local communities (from art. LR n.24 of 2017, to civic uses promoted by municipalities in southern and northern Italy for the management of common goods). For this reason, many meetings were aimed at studying possible solutions and involved local administrators, stakeholders and municipal technicians (Accademia di Belle Arti di Bologna, Studio Performa A+U, a team of lawyers) with the aim of creating a "toolbox" useful for administrators to undertake temporary reuse paths of disused spaces. Crateri taught us that the road to sustainable and shared development is possible, that the path undertaken by the associations of the project can constitute a method, not the only one, to make places and communities recover an identity relationship of reciprocal correspondence and that this can be done with sustainable costs. This opens up a new path, alongside local administrations, in the practices of participation, knowledge and enhancement of cultural places and regional landscapes.

2.2 *Mediate between communities and institutions. The territorial activator for urban regeneration*

The CRATERI project was born in response to the call conceived and promoted by IBC, with the aim of identifying innovative criteria, methods and tools for the enhancement and cataloging of cultural heritage, both tangible and intangible, in relation to the principles expressed by the new Emilia-Romagna Regional Law on land use, No. 24 of 2017.

In particular, the call made direct reference to arts. 15 and 16 of the text, respectively concerning the “Register of properties to be used for urban regeneration” and “Temporary use”.

Starting from these assumptions, the CRATERI project considered that the premises of the call should be framed within a more general critical reflection on the processes of urban and human regeneration, insofar as the latter assumes the mutual collaboration between a plurality of subjects, institutional and non-institutional, who claim a role in the management of the assets, in and with which they interact, and the distinctive characteristics of it.

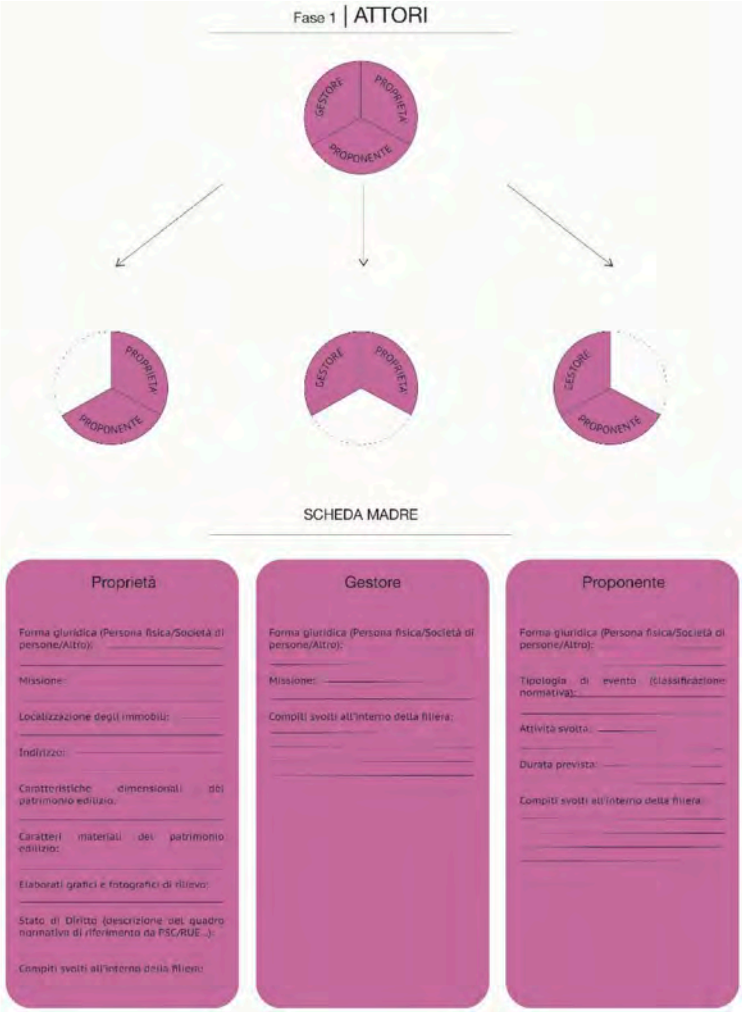

Figure 2. The protagonists of the process have been identified in three priority ACTORS, who are always present, even if, in some cases, the relative roles can also overlap, simplifying the process, listed below: the property, who makes the properties available; the manager, which guarantees its operation and programming; the proponents, which offer the contents of the regenerative process, implementing the related practices. The Administration, in this sense, can play a facilitating role.

In this sense, the fundamental criterion adopted, on which the entire work is based, presupposes the identifiability, through the development of the regenerative process, of the so- called “community potential”. The starting assumption is, in fact, that the structural fragility of the territorial area under investigation, the Modenese crater, following the traumas deriving from the 2012 earthquake, returns a widely representative image of a more general upheaval deriving from the combined effect of the financial crisis of 2007 and the health crisis of 2020, which

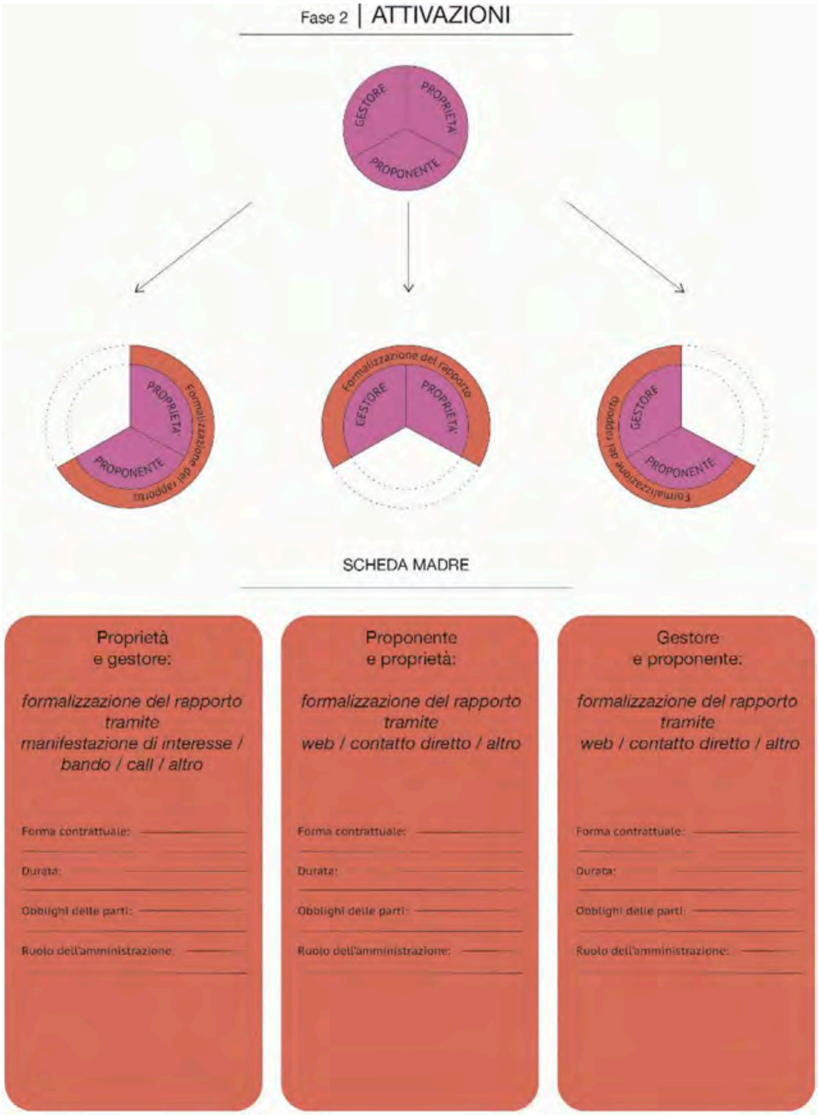

Figure 3. The ACTIVATIONS describe the ways in which the ACTORS enter in relation to each other, coached by the designers. Although, in many pioneering experiences, this phase has had an informal trigger, based on relationships of personal knowledge, the mapping highlights the emergence of recurrent and therefore classifiable methods, whose replicability contributes to promoting the diffusion of processes in territories. These methods substantially affect the ACTORS according to bilateral relations (Property/manager; manager/proposer; property/proposer) although, at times, these relations can be simplified, if not even superimposed, by involving some of the ACTORS.

destabilized the conventional ties on which social reality is built. In the light of the aforementioned issue, it seems legitimate to affirm that the recognition of the value of the real possibly compensated by the restoration discipline, acted by name on behalf of the Institutions, through its conventional instruments.

On the contrary, this recognition must presuppose a new evaluation parameter that takes into due consideration the ability of the same patrimony, object of shared transformation, to trigger virtuous processes, which pervasively involve large layers of civil society - on the process of rebuilding the community ties that the crisis has led to exhaustion, releasing the held creative energies. This innovative methodological and intervention approach is part of a more

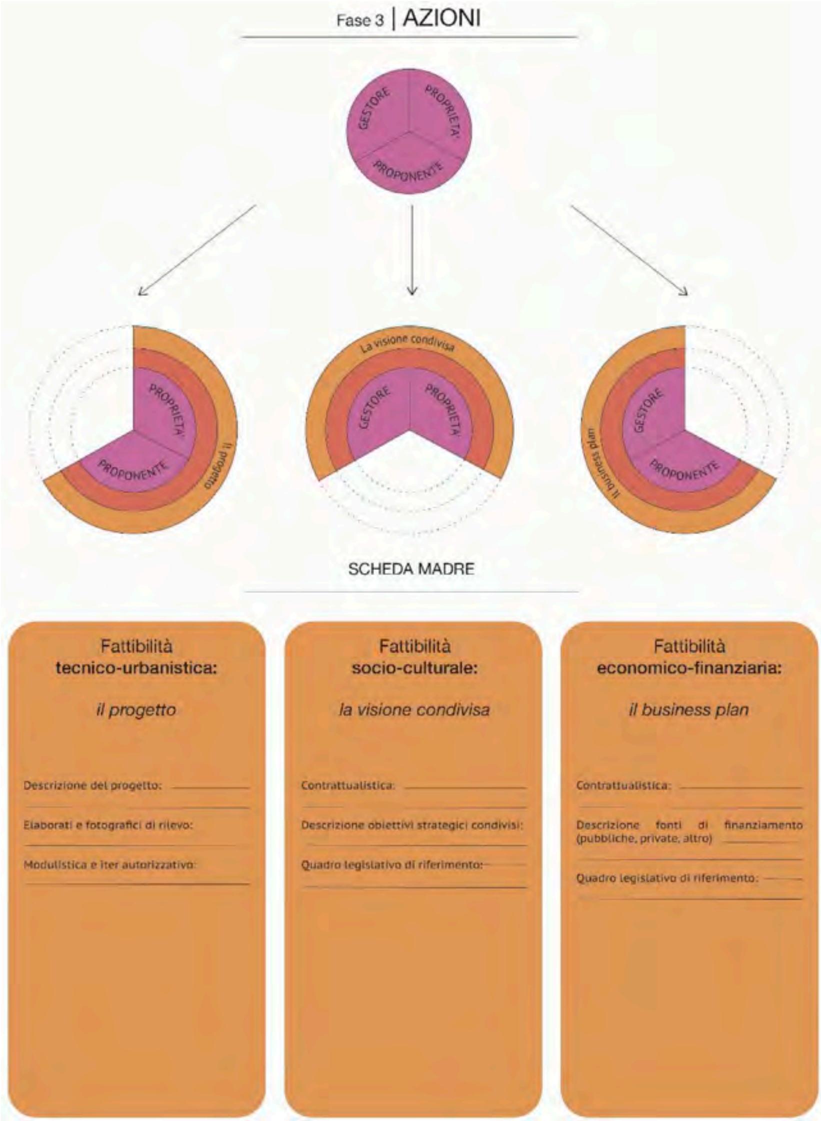

Figure 4. The ACTIONS describe the processes on the basis of which the ACTORS begin to work together, in order to guarantee the feasibility of the regenerative process. This feasibility, as it is clearly represented in the explanatory diagrams, is not only technical-urban (the project) and economic-financial (the business plan) but also socio-cultural, presupposing a communion of intentions (the vision). Each of the aspects mentioned, also in this case, involves the ACTORS in a differentiated manner, based on priority and specific skills, even if they collaborate in the pursuit of the regenerative result.

general rethinking of territorial infrastructures, where the "extended" networks, promoted by the processes of globalization, are confirmed to be increasingly fragile, as they are exceptionally onerous to finance, implement and manage, in favor of the so-called "short" ones, which require less investment and guarantee a prompt reaction in the face of programmatically unstable and constantly changing scenarios.

To this end, the CRATERI project favors that heritage, material and immaterial, which, although today excluded, in its original meanings, from the reference horizon of the collective consciousness, due to the profound upheaval generated by the earthquake, is still an object of alive requests for claims by majority expressions of civil society, confirming the possible attributions of new meaning. In this sense, it should be reminded that the post-earthquake reconstruction process does not seem to have taken into account the aforementioned mutual implication between spatial and socio-cultural aspects, having treated them separately, thus not allowing the pursuit of collective interests. The CRATERI project intended to compensate for this lacuna, of both method and merit, which is shared by citizens and local institutions, by experimenting in the field the necessary premises for the regeneration process. Through a preliminary phase of Mapping of objects and subjects, it has therefore identified the potential protagonists of the regenerative process, or rather the ACTORS, subsequently called - through targeted Community Actions, publication of calls, dissemination of social media, interviews and training activities - for starting the construction of a dialogue between the parties, using participatory workshops, capable of reverberating, in open and unconventional ways, the encounter and interaction between different interests.

These workshops have allowed a broad involvement of the citizens and, in particular, of local associations, guaranteeing, among other things, to promptly verify the need for coordination work between the parties who, in an attempt to give voice to the various instances expressed, with the aim of translating them into shared project ACTIONS, the group of researchers defined as TERRITORIAL ACTIVATION. The corresponding professional figure, already recognized by the Clust_ER BUILT of the Region as a strategic priority to be trained and promoted through appropriate initiatives, does not however exhaust the tasks of the regenerative process. The times required by the call, in fact, did not allow to complete the cycle, which provides for the need to develop specific ACTIONS to reactivate the abandoned properties, capable of producing concrete ACTIVITIES, in the form of temporary events and/ or more stable initiatives. Only in this way it will be possible to evaluate the effectiveness of the measures taken to enhance the material and intangible assets in a state of abandonment.

Therefore, the group responsible for the project, together with the creator and promoter of the call, hope that it will be possible, especially in relation to the delicate situation we are going through, and with the support of the institutions in charge, to complete the experimental path already started, finding, to this end, the appropriate resources. If in fact, as already mentioned, the priority purpose of the work was to allow the expression of a value judgment on the tangible and intangible heritage, based on the ability to involve, in and through its reactivation, a broad and articulated spectrum of interests, and the related stakeholders, the economic and employment emergency generated by the coronavirus will make this expectation increasingly urgent and non- deferrable.

AUTHORS CONTRIBUTION

This paper is the result of a shared work between the authors. Introduction: N. Marzot and L. Bolelli; Paragraph 2.1: L. Bolelli; Paragraph 2.2: N. Marzot; Figure captions: N. Marzot; Images: Courtesy studio PERFORMA A+U. All authors have read and agreed to the published version of the manuscript.

NOTES

[1] The project team was leaded by Planimetrie Culturali. Team member were: Accademia delle Belle Arti, Bologna; Amigdala Aps, Modena; Cittadinanzattiva E.R, Bologna; Collettivo Forza Maggiore, Roma; Iperpiano, Novara; Planimetrie Culturali, Bologna; Spazi Indecisi Aps, Forlì; Studio Performa A+U, Bologna; PhD Paola Capriotti; lawyer Elia De Caro, Bologna.

[2] The Earthquake Documentation Center was established by the Emilia-Romagna Region with D.G.R. 288/2017 and addressed to nine municipalities in the province of Modena (Cavezzo, Concordia sulla Secchia, Finale Emilia, Medolla, Mirandola, Novi di Modena, San Felice sul Panaro, San Possidonio, San Prospero,) included in the areas of the crater of the earthquake of 2012. The goal through the establishment of the Center is to collect and make available studies, materials, photographs and mappings that help to re-define the narrative of a destabilizing event for the affected communities, at the same time able to change the relationship with one's own landscape, with the historical, architectural, environmental cultural heritage, and the history of a community.

[3] Lucio Gambi and Andrea Emiliani were respectively President and Vice President of the Institute for Cultural and Natural Artistic Heritage of the Emilia-Romagna Region founded in 1974.

Built Heritage in post-Disaster Scenarios – Balzani et al. (Eds)

Public space and landscape: Recovery strategies and risk mitigation for the management of disaster events

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ABSTRACT: The contribution explores the importance of a territorial regeneration or reconstruction approach through the use of strategies based on the application of natural systems (Nature-Based Solutions) following a calamitous event. In Italy, as in many countries of the world, we continuously experience disastrous events that afflict cities, small villages and the territory in general, just think of the earthquake that hit central Italy in 2016, the Emilia-Romagna earthquake in 2012, or the repeated floods of cities or peri-urban areas due to climate change that cause torrential rains, rise in temperature, rise in the level of rivers and streams in such a way that water and mud escape from their banks and flood the built and non-built landscape. Events of this magnitude cause the loss of human life and environmental and social balance, as well as substantially modify the inhabited area and the landscape.

Keywords: environmental disasters, public spaces and urban void, urban regeneration, landscape, nature-based solutions

1 FOLLOW THE CHANGE

Adaptation to the effects of climate change implies a series of measures or actions that can be taken to reduce the vulnerability of society and improve resilience against predicted climate change. There are multiple adaptation measures to manage climate change, which can take many forms and be effective on a wide range of spatial and temporal scales, planned proactively or as a result of socio-political factors such as new planning regulations, demand for market or even social activity. (Kabisch, Korn, et al.,. 2017) According to UN data - i.e., Agenda 2030 (Web-3)-, climate change will transform our way of life and our planet; a large number of small towns will tend to become depopulated due to the objective difficulties of liveability of the same and the increasingly current strategies of technological increase and resolution of mobility - i.e., 15 minutes cities (Web-5) - of the big cities, where most of the activities and economic resources are also concentrated, will attract more and more people. This process of race towards change will have to take into account the existing built heritage and it will be necessary to activate governance strategies to ensure that the current state of the places can cope with the calamitous phenomena affecting the area. This process of race towards change will have to take into account the existing built heritage and it will be necessary to activate governance strategies to ensure that the current state of the places can cope with the calamitous phenomena affecting the area.

From the previous graphs, a strategic and governmental action that can provide joint and univocal solutions appears inevitable, with the aim of not impacting the environment, but creating solutions that can generate an infrastructural and eco-systemic system between anthropic action and environmental needs. For this reason, the use of Nature-Based Solutions (i.e., NBS) is expanding more and more (especially in developing countries) within the Disaster Risk Management for water security, urban sustainability, etc… The growing number of

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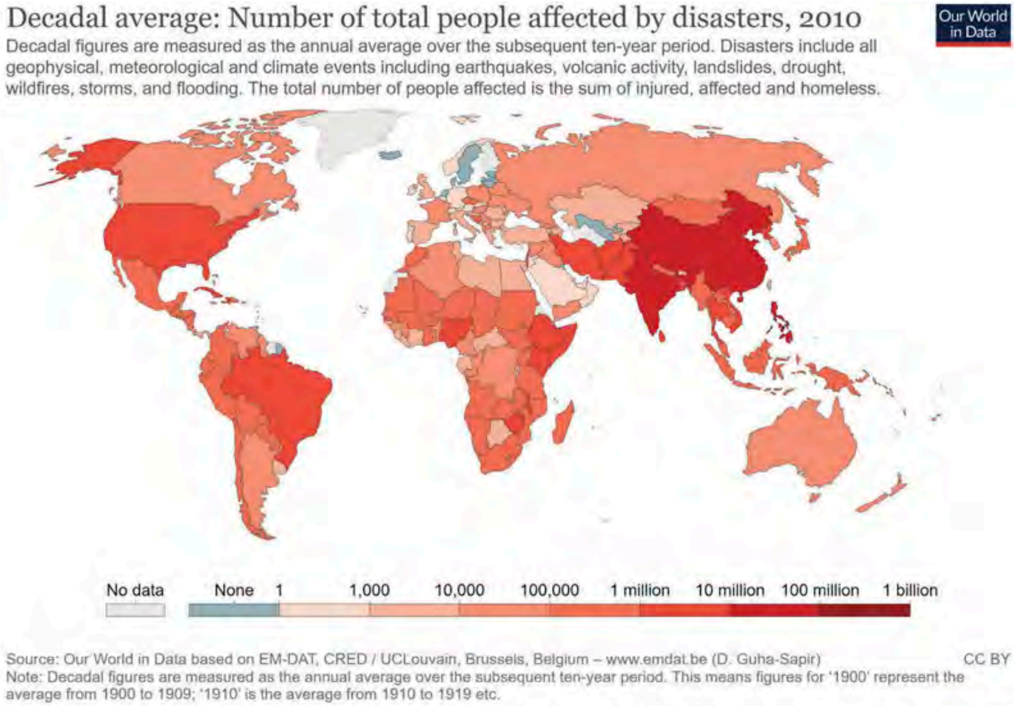
DOI: 10.1201/9781003253730-32

NBS[1] projects offer lessons and insights to help integrate NBS into development decision making. Nature-based solutions (NBS) that strategically preserve or restore natural elements to support conventionally built infrastructure systems (also referred to as gray infrastructure) can reduce the risk of disasters and produce more resilient and lower-cost services. In the areas of disaster risk management (i.e., DRM) and water security, NBS can be applied as green infrastructure strategies that work in harmony with gray infrastructure systems. NBS can also support community welfare, generate environmental benefits, and make progress on Sustainable Development Goals (SDGs), which gray infrastructure cannot do on its own. Several development programs are currently underway, including the World Bank's Nature-Based Solutions Program, which aims to facilitate the adoption of NBS in water management and DRM projects. (World Bank Group, 2018)

NBS are approaches that use nature and natural processes to provide infrastructures, services and integrative solutions to address the growing challenge of urban resilience. NBS can provide multiple benefits to cities and address various societal challenges, including reducing disaster risk and strengthening climate resilience, while also contributing to restoring biodiversity, creating leisure opportunities, improving human health, water and food security, and supporting community welfare and livelihoods. Nature-based solutions for urban resilience can be applied on spatial scales and contexts in and around cities. Examples include small-scale green spaces, on buildings, bioswales and green corridors along roads and water bodies, urban parks and forests within the city limits, and larger areas with wetlands and forests upstream or along the coast, in order to protect cities from flooding and improve water availability and quality. Figure 4 includes an overview of NBS. The process therefore resolves problems based on the type of environment: vast landscaped and coastal areas, basin areas, urban areas, individual buildings, aiming at protection, rehabilitation, recovery and development and new planning. For each of these areas there is a strategy that contains specific solutions. In recent years, momentum has been growing for NBSs as a vehicle to provide green resilient and inclusive development, particularly in the context of economic recovery from the COVID-19 pandemic. In this paper some examples of application solutions through Nature-Based Solutions will be shown; some examples and good practices will be analyzed starting from the past, observing various parts of the world, with respect to different types of disastrous events.

Figure 1. The City of Grado (Italy). The city of Grado represents an example of an urbanized site within a lagoon, which continually suffers the effects of the sea on its territory, and, as in many coastal areas, is suffering from the phenomenon of coastal erosion.



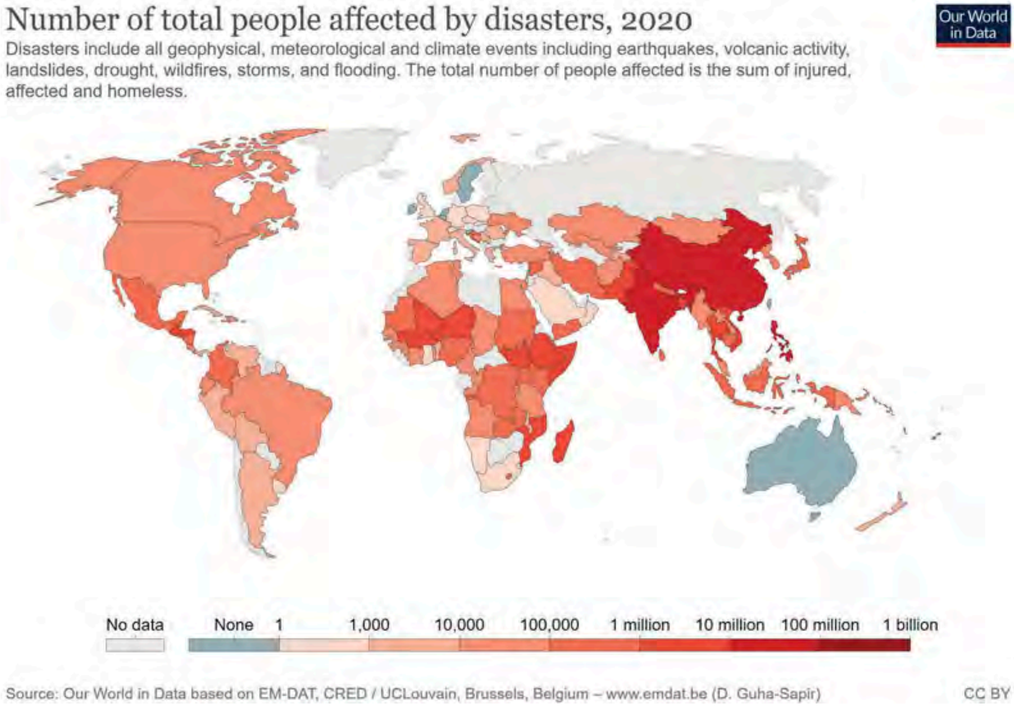
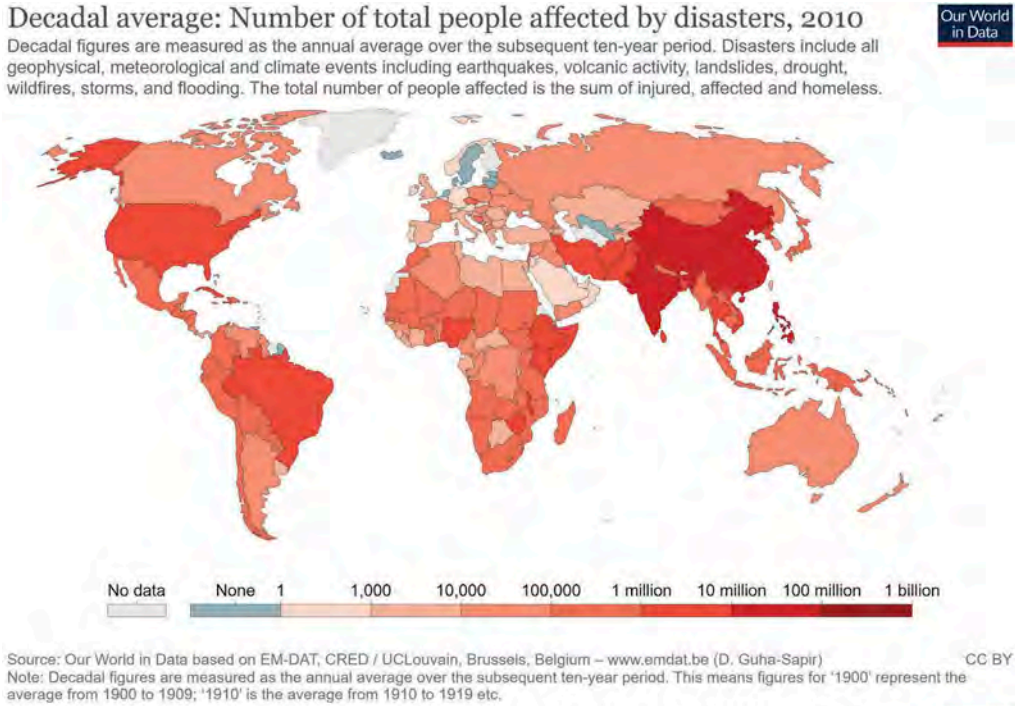


Figure 2. The two graphs represent the totality of people affected by disasters, the first in the decade 2000-2010, while the second in 2020.



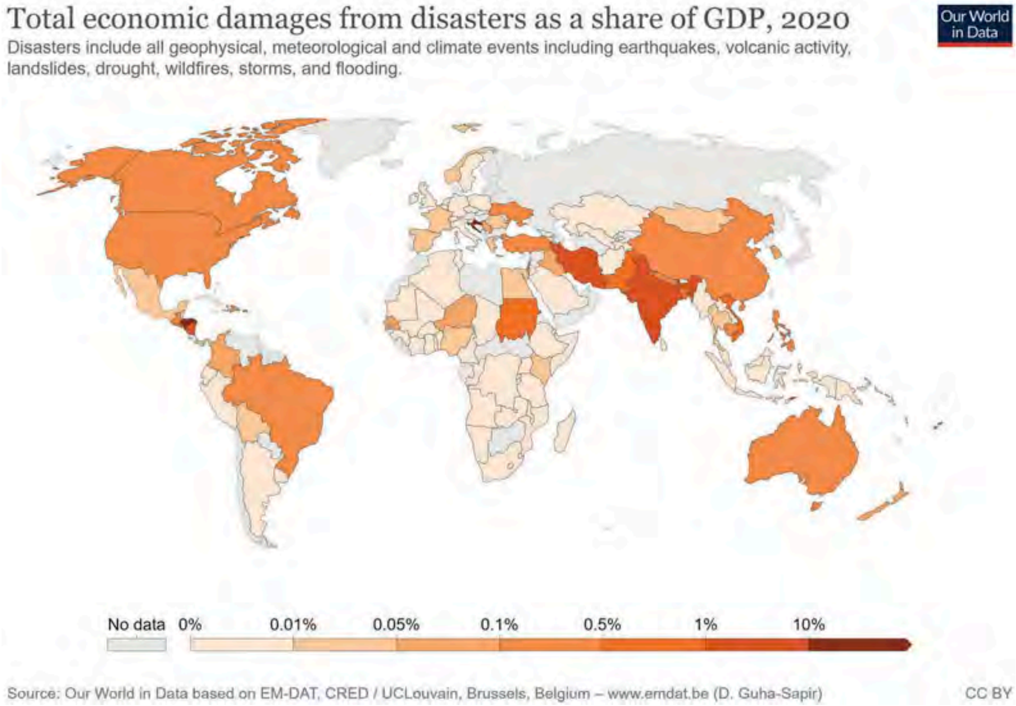


Figure 3. The two graphs represent the economic impact that disasters have had on the areas, the first in the decade 2000-2010, while the second in 2020.

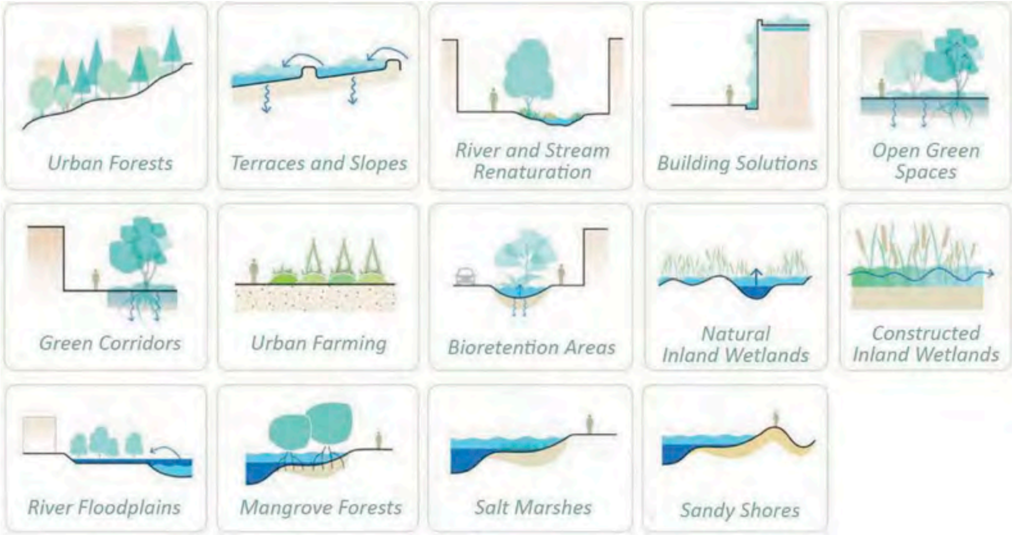


Figure 4. Some samples of nature-based solutions for urban application (GFDRR, World Bank Group, Global Pro- gram on Nature-Based Solutions for Climate Resilience. 2021. A Catalogue of Nature Based Solutions for urban resilience).

Figure 5. Areas of application of the NBS (GFDRR, World Bank Group, Global Program on Nature Based Solutions for Climate Resilience. 2021. A Catalogue of Nature Based Solutions for urban resilience).

2 GREEN URBAN AREAS AS AN ELEMENT TO SUPPORT RISK MITIGATION

A calamitous event, by its nature, determines a change in the territorial context in which it occurs, leaving many times, areas destroyed or heavily affected. In these areas a void is physiologically generated, often occupied by rubble, taking shape in a place that has lost its previous meaning. In many urban centers, full of buildings (Furuya, Munenari Inoguchi, et al., 2012), that have been created over time as a result of building processes without careful planning on the issues of climate change and seismic phenomena, the void can represent an opportunity rather than a lack. "Architecture and planning have traditionally been based on an additive idea: to create, erect, build, add, use. Today we need to plan the emptying. Removing does not mean either demolishing, abandoning or letting go, but rather planning the shape of the void in a flexible way, giving it a meaning, a use, a character, a sequence". (Web-6) It therefore seems necessary to reflect on possible intervention logics capable of converting areas, transforming them into catalysts for change. Designing a safe city that mitigates natural disasters is one of the important criteria in urban planning. Large cities and historic centers often suffer from calamitous phenomena such as earthquakes, fires and floods. The planning of green open spaces can be a valid support to counter the spread of a fire, or the seismic reverberation on buildings[1]. An important example is the urban planning of Japan that began in 1919.

Figure 6. Reconstruction plan after Kanto Big Earthquake (1923), (Ishikawa, 2001).

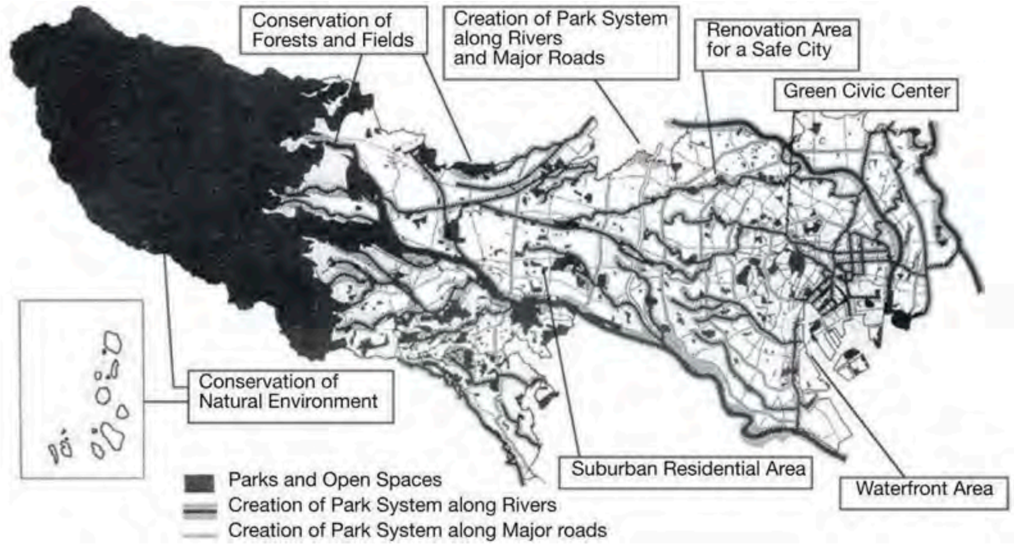


Figure 7. The Park System in Tokyo (Tokyo Metropolitan Government, 2001), (Ishikawa, 2001).

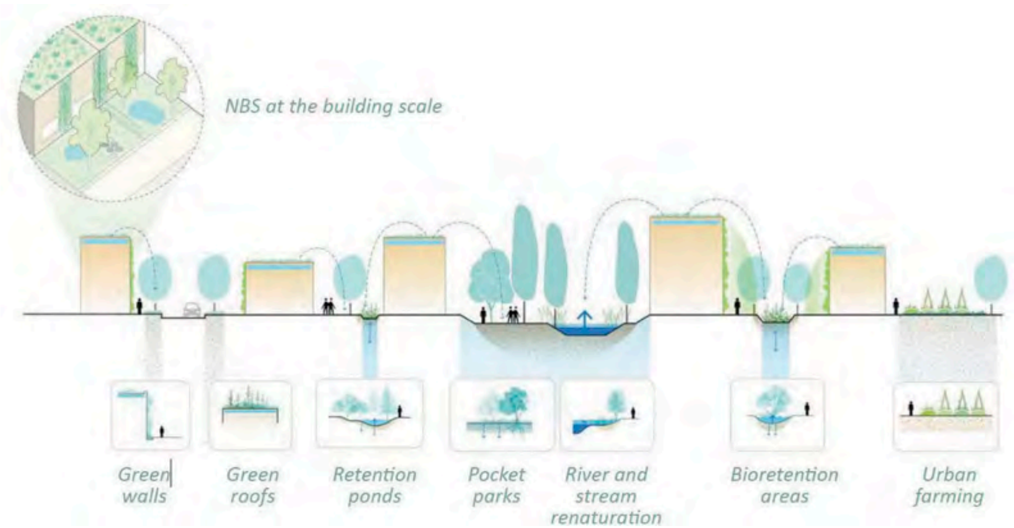


Figure 8. Schematic section of NBS at the neighborhood scale. (GFDRR, World Bank Group, Global Program on Nature-Based Solutions for Climate Resilience. 2021. A Catalogue of Nature Based Solutions for urban resilience).

Japan in those years suffered from a major seismic event, the 1923 Kanto earthquake, which affected 1,484,000 people (the city of Tokyo consisted of 2,309,000 people). The need for planning became necessary to mitigate the effects of the fire generated as a result of the earthquakes and the main objective of the Government was precisely to create dense and separate empty areas consisting of greenery, parks, green paths that contrasted the spreading of the fire and they became safe areas where people could take refuge for their lives. This method was called “the park system”, urban voids designed to interrupt the fire and to create human rescue areas. The methodology was soon exported to other countries and was also adopted by the city of Chicago after the fire of 1871 (Ishikawa, 2002).

The planning system of the city of Tokyo continues to foresee the “park system” as a rescue strategy, going to implement green areas, create green corridors and insert water paths and tanks, also introducing the opening system of the cemetery making it a great open public park and redesigning the seafront area by implementing the presence of green areas. From the careful analysis of the historical facts previously exposed it is clear that the strategies used in the past can be considered as precursors of the solutions characterizing the contemporary approach, therefore green corridors, urban gardens, green facades, large green spaces, renaturalization of urban canals and rivers, areas of bio-retention remain fundamental tools for the prevention and mitigation of the risk associated with disastrous phenomena.

3 NATURAL AND TOURIST AREAS - ACCOMMODATION, RISK MITIGATION STRATEGIES TO PROTECT ECOSYSTEMS AND PEOPLE

Numerous environmental risk mitigation strategies are in place today to allow for the coexistence of buildings, human activity, and landscape. A current example of hurricane emergency management for a resort town is the American Gulf State Park, which has always been the point of contact for the Alabama coastal communities of Gulf Shores and Orange Beach. When Hurricane Ivan in 2004 irreparably damaged the park and the existing structures, wiping out decades of local tradition, but also a great economic engine. (Web-7) Within a very short time the land was destroyed, becoming one of the victims of the same rapidly accelerating climate change. Local administrations therefore had to intervene in the reconstruction, however, using the catastrophe as an opportunity to be more sustainable, more resistant to catastrophic weather events and more in harmony with the natural environment that surrounds them. Action was taken to re-establish the ecosystem and rebuild hotel facilities. The new buildings have shown that they can withstand a Category 5 hurricane, in fact, when Hurricane Sally occurred, in 2020 as a Category 2 storm in the region all basic services were interrupted, but instead the new center did not it was never closed and was used as a building capable of protecting and hosting refugees.

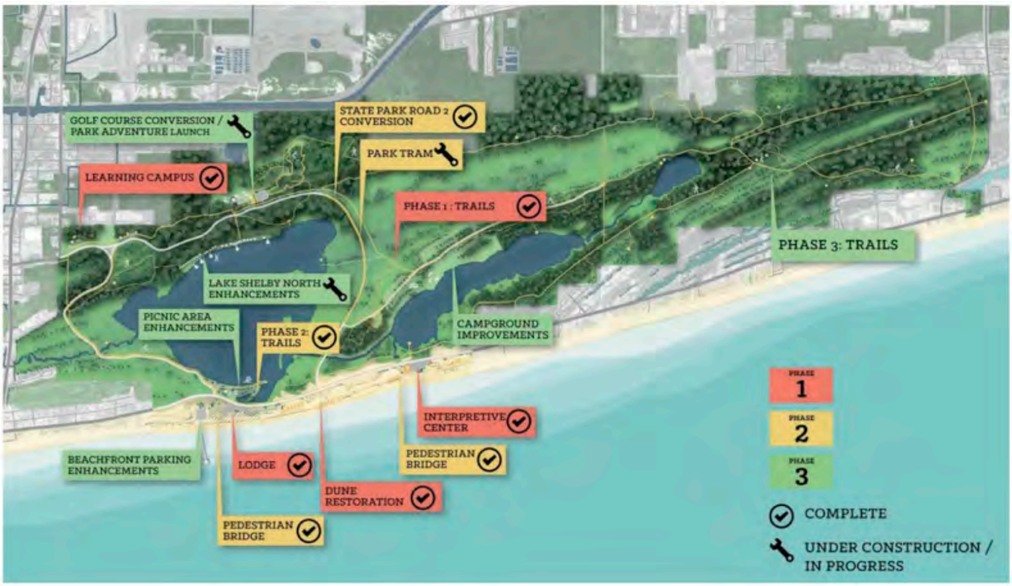


Figure 9. The new Master Plan of the Gulf State Park, project by SASAKI (https://mygulfstatepark.com/wp-content/uploads/2016/10/160823_GSP_MasterPlan_Final_lowres.pdf).

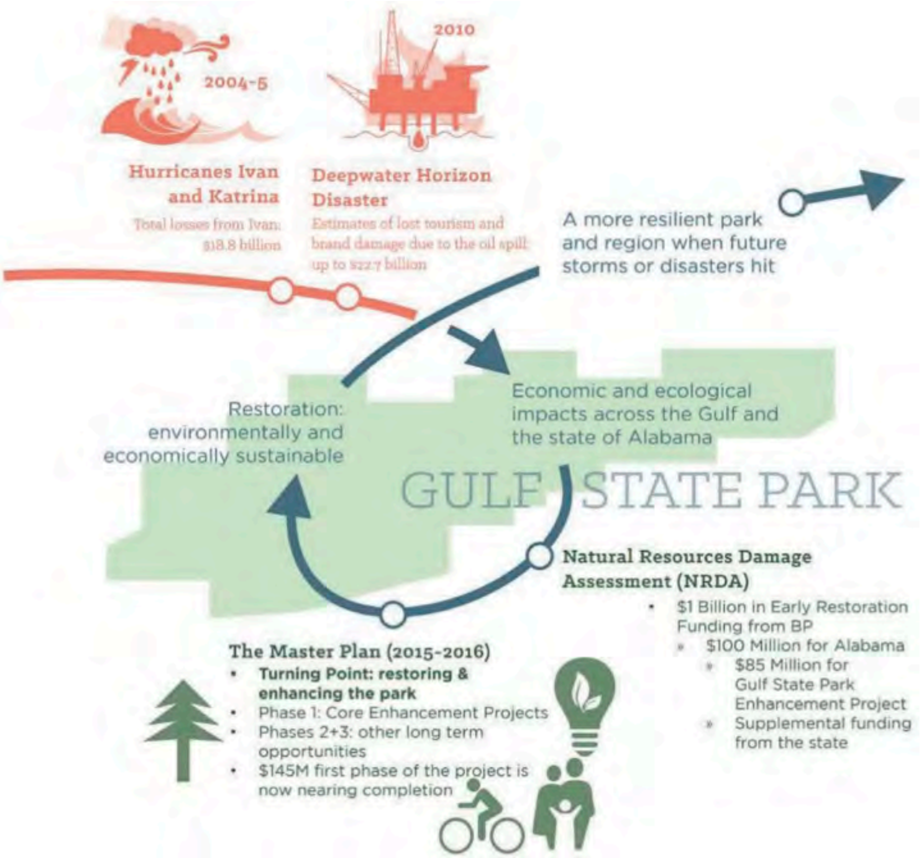


Figure 10. The new Master Plan of the Gulf State Park, project by SASAKI. (web-8).

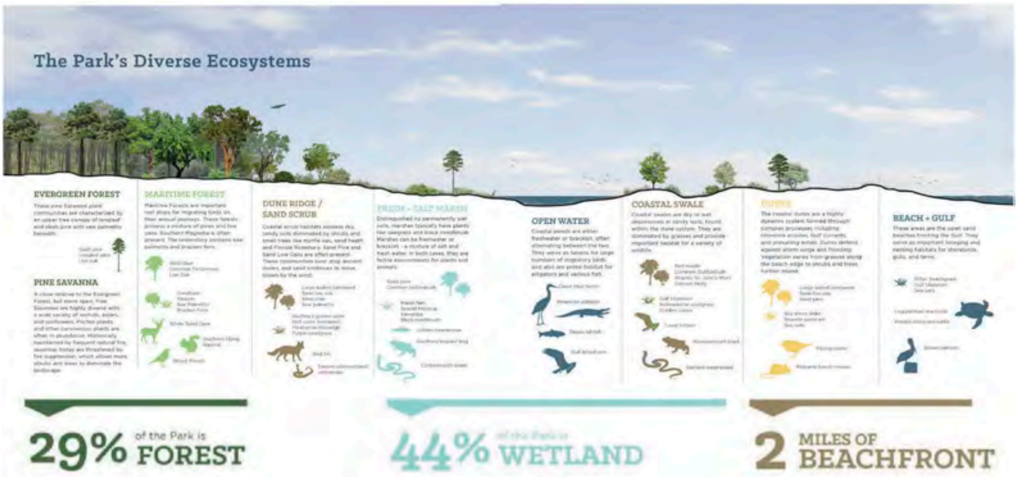


Figure 11. The new Ecosystems of the Gulf State Park, project by SASAKI, (https://mygulfstatepark.com/wp-content/uploads/2016/10/160823_GSP_MasterPlan_Final_lowres.pdf).

The project for the new master plan created by the American studio SASAKI (Web-8) is divided into various operational phases and defines a roadmap to arrive at an integrated vision by transforming the park into a sustainable tourist destination in which pedestrian, tourist, cycle, educational and sports routes are perfectly integrated into the new ecosystem through raised elements. An innovative system of double sand dunes allows the park to be kept distant and protected from potential dangerous waves that can damage the ecosystem again. From this project it is therefore possible to deduce that climate change must be mitigated with environmental strategies that integrate with the landscape. It is also necessary that the intervention actions are as much as possible in line with environmental principles, inserting themselves within a mechanism of systematic integration between intervention and the environment. For this reason, application strategies such as Nature-Based Solutions are currently considered necessary.

4 CONTRASTING PHENOMENA OF URBAN FLOODING

By 2050, 68% of the world's population will live in cities. (Web-9) One of the problems to be solved is linked to heavy rainfall in urban areas with low drainage, representing one of the most frequent flooding phenomena. This problem overwhelms water infrastructure systems, resulting in overloading of the system that exposes city residents to health risks. With the growth of the urban population and the climate, rainfall is increasingly frequent in many areas of the world where it was previously sparse and, when it occurs, it has a high water flow rate. The rapid urbanization of new peripheral settlements leads the population to find themselves in areas at high risk of flooding, such as floodplains and river banks. At the base of this problem, Nature- Based Solutions can be valid solutions. The general aspect that must be achieved is to favor the drainage of urban areas. Some intervention strategies are then reported: green roofs, permeable floors, open spaces, parks and green corridors, bio-retention areas, including rain gardens, built wetlands. In Sri Lanka, in particular in the metropolis

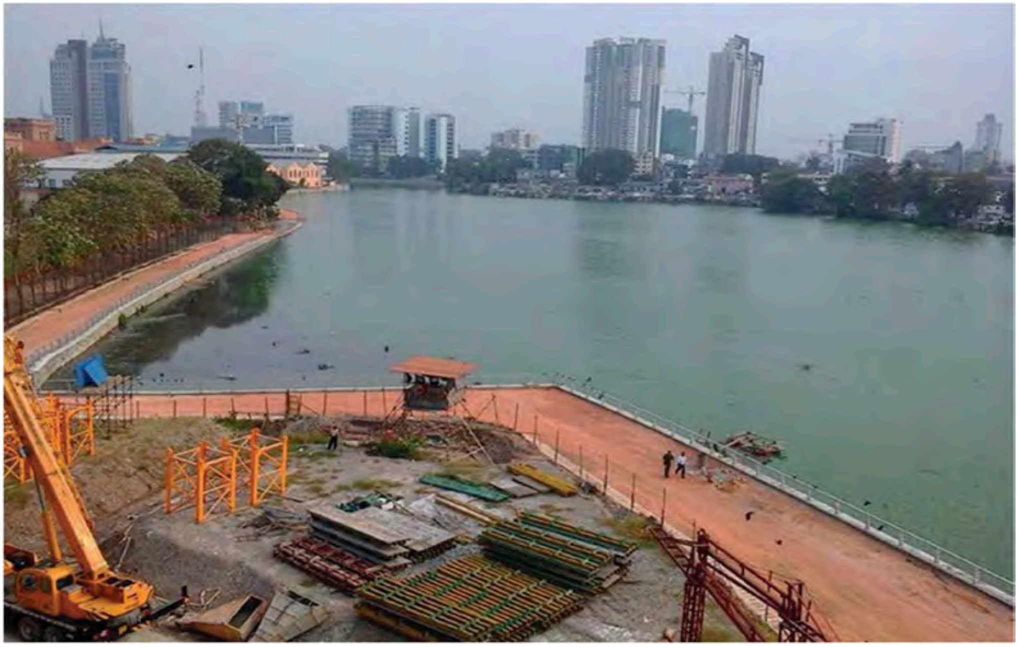


Figure 12. Sri Lanka, construction of Bank Protection works of Eastern Bank of East Beira Lake - 1.2KM.

Colombo, there is an urbanized area surrounded by vast natural wetlands and interconnected with each other, which allow to retain alluvial waters. However, rapid urbanization in recent decades has led to a 30% reduction in the water holding capacity of the surrounding wetlands. For this reason, in 2010, the city suffered a series of record floods that caused unprecedented damage. To reduce flood risks, the Sri Lankan government has implemented the Metro Colombo Urban Development Project (Web-10), which combines green and gray infrastructure: wetland conservation, flood retention parks and traditional concrete bank protection walls. The integration of wetlands and floodable parks allows rainwater to infiltrate slowly, decreasing the volume of water that has to be moved through the overloaded built system. Territorial studies have found that the more wetlands are preserved, the higher the level of flood protection.

5 CONCLUSIONS

To address the challenges associated with climate resilience, health and well-being in urban areas, current policies are shifting their focus from ecosystem-based solutions to Nature-Based solutions (NBS), generally defined as solutions to inspired societal challenges and supported by nature. NBS therefore translate into a low-impact strategic element for improving the attractiveness of places, health and quality of life and the creation of jobs. The Global Program on Nature-Based Solutions for climate resilience provides a platform for monitoring projects and investments in progress, especially in developing areas, where this system is proving to be increasingly useful and promising. (Web-14) Currently, economic frameworks to assess the potential of such co- benefits of NBS and to guide the design and implementation of cross-sectoral projects and policies demonstrate that they are truly beneficial and that they promise a real improvement in the living conditions of our planet and its inhabitants (Raymond, Frantzeskaki, Kabisch, et al., 2017).

Figure 13. An example of a very interesting intervention: a wetland park of 34.2 hectares in the middle of this new town of Harbin, China, planned by Turenscape. (web-24).

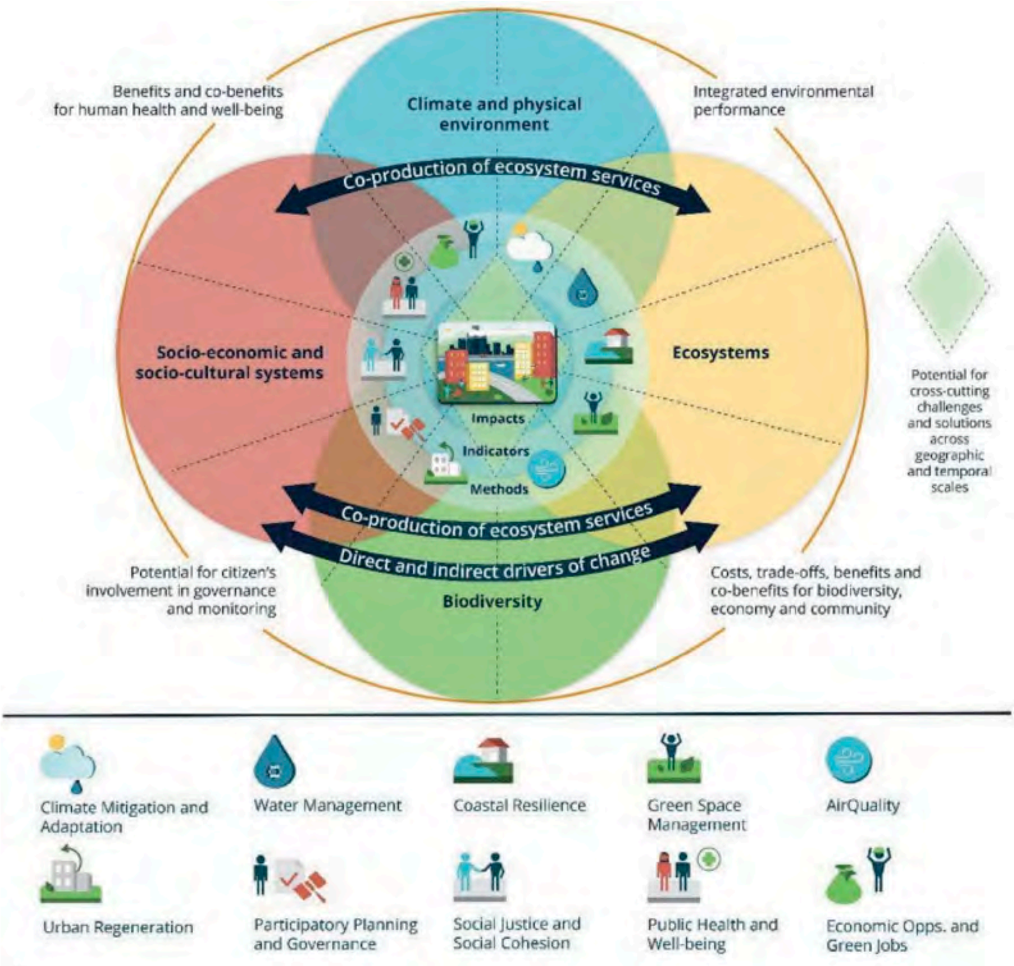


Figure 14. The NBS Scoreboard. The different elements of the system are considered: 10 challenge areas, indicators and methods for assessing the impacts of NBS in urban areas. (Raymond, Frantzeskaki, Kabisch, Berry, et al., 2017).

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NOTES

[1] "In Japan, the first city planning law was enacted in 1919. However, ironically enough, the first omprehensive city plan was carried out as the reconstruction plan after the Kanto big earthquake which occurred in 1923. About 1.484.000 people were affected, whereas the total population in Tokyo at that time was 2.309.000. The most important goal of this project was how to build a fireproof city. Considering economic and cultural standards, it was impossible to construct stone or brick buildings. The government chose the method of separating dense urban areas by open spaces such as parks and parkways. People knew the fact that trees and open spaces prevented the spread of fires, since 1570000 people escaped into parks and saved their lives." (Ishikawa, 2002)

Built Heritage in post-Disaster Scenarios – Balzani et al. (Eds)

Protocol for an integrated 3D survey for cultural heritage at risk

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ABSTRACT: The digital documentation concerning the cultural heritage and existing built heritage at risk due to natural or anthropogenic events is an area of growing interest and experimentation, in order to develop integrated tools and strategies for risk prevention, mitigation and management, as well as protocols that are optimised to support decision- making processes in the different phases of damage assessment, damage evaluation and reconstruction project.

The 2012 Emilia-Romagna earthquake offers an opportunity to establish and consolidate the partnership among the University of Ferrara, the DIAPReM Centre and the TekneHub laboratory, and the Agency for Reconstruction - 2012 Earthquake, within the framework of a line of research for the development of integrated digital methods and tools for the documentation of intervention on existing built heritage has been in progress for over twenty years. The project, comprising a set of research projects and post-graduate training, is part of a line of research that investigates, in the context of the complex relationship between "matter and memory", the role that new "graphic models", maps, diagrams, infographics and integrated digital platforms are the result of the application of integrated enabling technologies.

Keywords: environmental disasters, public spaces and urban void, urban regeneration, landscape, nature-based solutions

1 INTRODUCTION

Individual or collective (Leroi-Gourhan, 2018) the memory project (Balzani, 2014) requires selecting, conserving and reconstructing meanings, even before representing the perception of matter (Bergson, 2009). Memory implies perception, and vice versa, and the duration (Bergson, 2009) of systems of relations that return perceptions, images and graphic models (Cardone, 2015) to the possibility of being transferred. Transmission and transfer expand the memory (Leroi- Gourhan, 2018).

Matter, memory and project are closely linked in the reflection that follows the occurrence of calamitous events to the concept of identity (Bini, Bertocci, 2017), and of security with respect to which for a long time, and still today, the main lines of research have been conducted, both on an architectural and an urban scale (Parinello, De Marco, 2018).

The consolidation of the possibility of preserving digital images of a damaged or partly lost built heritage has already been an effective tool for memory design, but not only, for a decade, thanks to greater accessibility to and improved usability of the 3D survey technologies, to include terrestrial laser scanners and drones. However, it is the advent of integrated digital collaborative platforms that opens up the possibility of representing, conserving and diachronically comparing digital models that refer to different evolutionary phases of a building, the urban fabric (Centofanti, Brusaporci, 2013), a city and a landscape (Docci et al., 2007). Representation guides and orients, in this sense, through the processing of three-dimensional models, within complex data structures (Gaiani, 2011), and makes available new forms of representation, becoming an integral part of the information and communication

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DOI: 10.1201/9781003253730-33

process. Consequently, cultural heritage and built heritage at risk due to natural or anthropogenic events become the context for experimenting with the development of an optimised protocol for 3D digital documentation, and not only of the intervention. The methodology developed and illustrated in this paper defines the aims of the intervention to be of primary importance, together with the metric and morphological characteristics of the cultural heritage and existing built heritage under consideration.

In fact, the cultural heritage and the built heritage present characteristics of uniqueness and complexity not only in relation to geometry and material characteristics. The multiple sources of information, the plurality of investigations, the historical documentation and the representations necessary to support the intervention on built heritage require, on the one hand, that the information be accessible to more specialised users with diversified skills and, on the other, that synchronic readings of diachronic scenarios be allowed.

This paper delves into relevant case studies concerning the sites affected by the 2012 Emilia-Romagna earthquake, as well as others on the national territory.

2 INTEGRATED DIGITAL TOOLS FOR CULTURAL HERITAGE AT RISK

Following the 2012 Emilia-Romagna earthquake, the TekneHub Laboratory and the DIAPReM Centre of the University of Ferrara set up a set of post-graduate training and research projects in partnership with the Agency for Reconstruction - 2012 Earthquake, Emilia-Romagna Region, in order to create a common framework for the development of protocols and integrated digital tools for the documentation of cultural heritage and built heritage damaged or at risk. The interdisciplinary research group includes scholars and experts in a variety of fields related to cultural heritage, from the governance of complex events, to the protection and conservation of cultural heritage, and the application of integrated technologies for

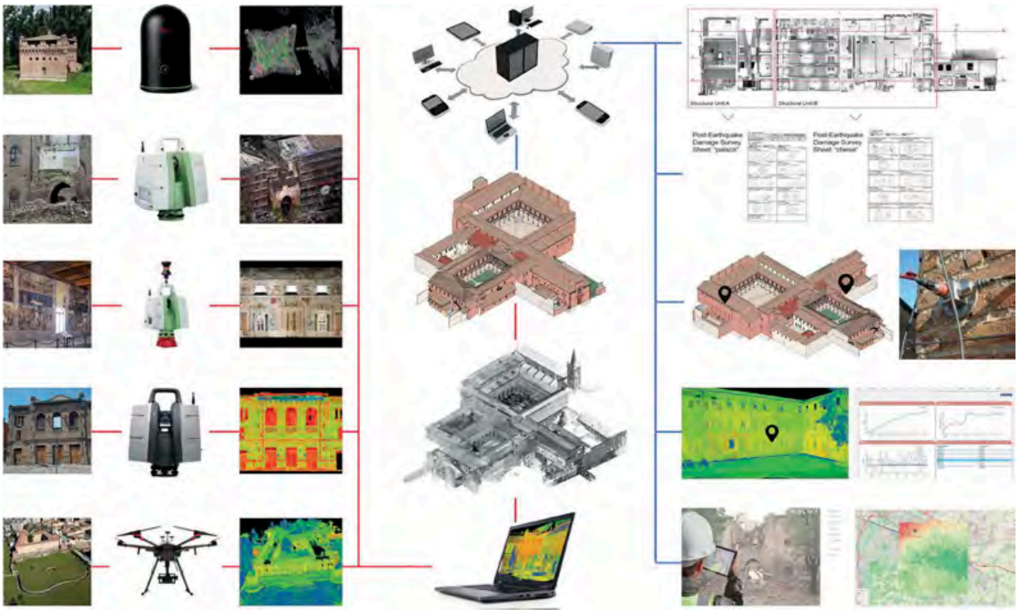

Figure 1. Integrated documentation procedure layout developed for the definition of a protocol for the survey of cultural heritage at risk. The geometric morphological characteristics of the heritage investigated as well as of the site lead, along with the aim of investigating the seismic vulnerability of the cultural heritage, the choice of integrated three-dimensional digital technologies. The operational phases range from the acquisition phase to the definition of the overall 3D data model and the HBIM model capable of being correlated to different data sources and available for multi-scalar analysis.

survey, digital documentation and project, and addresses strategic innovation objectives of the construction supply chain in the regional context: promotion of digitisation of the value chain of intervention on existing built heritage by contributing to the adoption of tools to support decision-making and intervention processes, including through Big Data.

The actions implemented within the framework of common objectives are: doctoral projects focusing on specific types of cultural heritage damaged by the earthquake; post-graduate training projects, in the form of international summer schools dedicated to built heritage at risk as a result of natural or man-made events; joint participation in international research/cooperation calls financed on a competitive basis. Overall, the initiatives are aimed at identifying solutions and best practices for enhancing cultural heritage resilience (United Nations, 2015).

Overall, the actions implemented and partly in progress aim at: (a) optimising protocols of expeditious survey of cultural heritage damaged by calamitous events; (b) optimising 3D digital survey protocols concerning cultural heritage at risk; (c) optimising scan-to-BIM protocols for the digital documentation of cultural heritage at risk; (d) developing integrated digital solutions and platforms, within which digital models allow users to orient themselves through a complexity of information query paths, starting from a semantic approach (Pauwels, et al, 2013); (e) updating the state of the art vis-à-vis documentation supports required in the supply chain and technological innovations, as it pertains to the relationship between the purposes of the intervention and the integrated protocols and digital representation, in a national and international context.

The interdisciplinary comparison for the definition of the various indicators at the basis of data acquisition protocols (phases “a” and “b”) for the subsequent implementation of semantically enriched HBIM models and the checks on the first case studies have been completed; on the other hand, the development phases concerning models and design of the architecture of platform for risk management (phases “c” and “d”) are either in progress or in the start-up phase.

3 A PROTOCOL FOR 3D SURVEY OF BUILT HERITAGE AT RISK

Renewed technological availability, starting from the advent and diffusion of Building Information Modeling and scan-to-BIM technologies, does not exceed the limit of providing partial information if unrelated to the set of knowledge required by the project intervention on built heritage.

Similarly, the 3D survey alone provides metric information necessary but not sufficient for the conservation or restoration project, if not adequately hierarchised and segmented [De Luca, 2011] in order to be placed in relation to the set of information on aspects concerning material, conservation, technology, history, performance and maintenance of artifacts being assessed.

Moreover, the huge amount of data produced by the current 3D digital survey campaigns integrated with terrestrial or aerial laser scanners makes it necessary to consider the point cloud model produced as one of the fastest spreading Big Data sources in the context of the construction supply chain, both nationally and internationally.

Indeed, although not yet widely added to standardised verification and testing processes and not yet considered a direct source of information, therefore questionable, the point cloud model clearly represents a digital asset of growing interest, in view of the objectives described.

If we consider, in the medium term, an increase in the need and ability to store data produced by integrated 3D surveys in order to make them available through dedicated platforms, and, at the same time, an indispensable increase in knowledge for querying, implementation and management of the digital information produced, the optimisation of the acquisition, calculation and recording of any relevant data is a priority. A recent event conducted by a group of professors and researchers of the TekneHub laboratory and the DIAPReM Centre of the University of Ferrara from 2019 to 2021, as scientific managers and coordinators of the activities of integrated 3D survey, scan-to-BIM modeling and two-dimensional representation concerning over 600,000 square metres of state-owned buildings, shows the growing interest in the extensive use of the technologies described, although such knowledge of their effective use is still inadequate.

As a result, representation through traditional two-dimensional surveys is the main tool that provides some guidance within the eBIM and HBIM model, while the 3D point cloud database is not yet leveraged as a direct source of information.

However, the paradigm change taking place is evident, promoted in part by statutory provisions but, even more, by the willingness of public operators to rely upon digitisation and innovation processes.

The objective of defining a protocol for 3D surveys and the digital documentation of cultural heritage at risk must, first and foremost, consider the different contexts in which the survey can be conducted: damage survey, following a calamitous event, or survey of existing built heritage to identify the risk category.

Indeed, although decisive for both contexts described, the time factors involved in the conduct of a survey and of calculation of the overall data model are a priority when it comes to damage survey, as they must allow the timely planning of reconstruction.

At the same time, a survey of cultural heritage and of built heritage at risk, such as the urban fabric of minor historic centres (Raco, 2019), must allow multiscale readings that can be implemented over time, which only a high quality survey can do (Balzani, Maietti, 2017).

Therefore, the prerequisites of the research protocol are:

- context in which the survey is conducted (damage survey or survey for risk assessment);
- objectives for which the survey is carried out, in addition to purposes related to safety issues (documentation, recovery and re-functionalisation, evaluation of energy, etc.);
- possibility of implementing the survey over time, or making it comparable with surveys carried out at a later time;
- possibility of conducting multiscale surveys through the overall data model and its hierarchies;

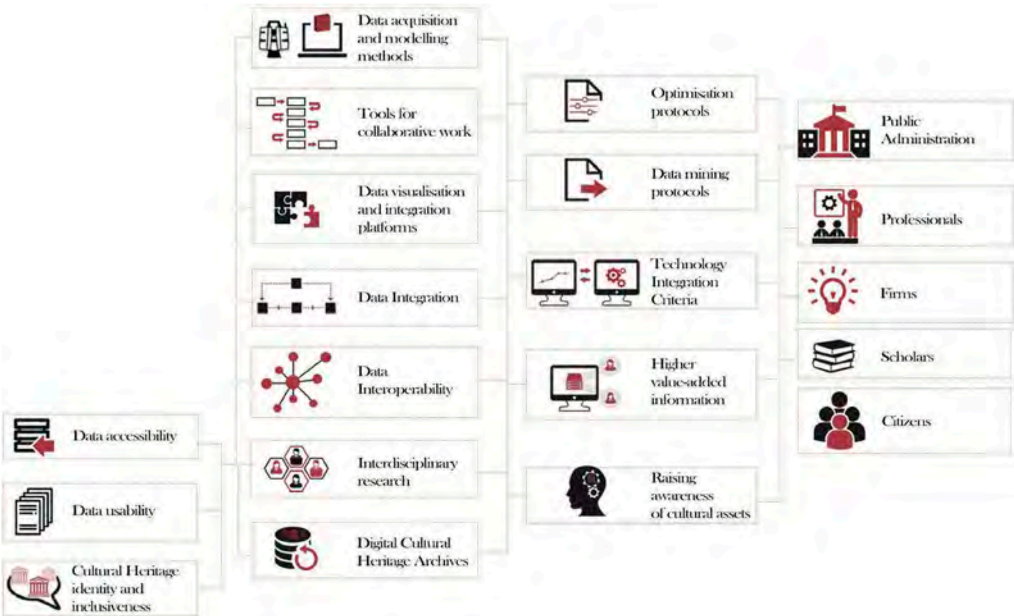

Figure 2. Summary outline of the priorities addressed by the project based on the main emerging challenges and purposes of information use related to cultural heritage at risk.

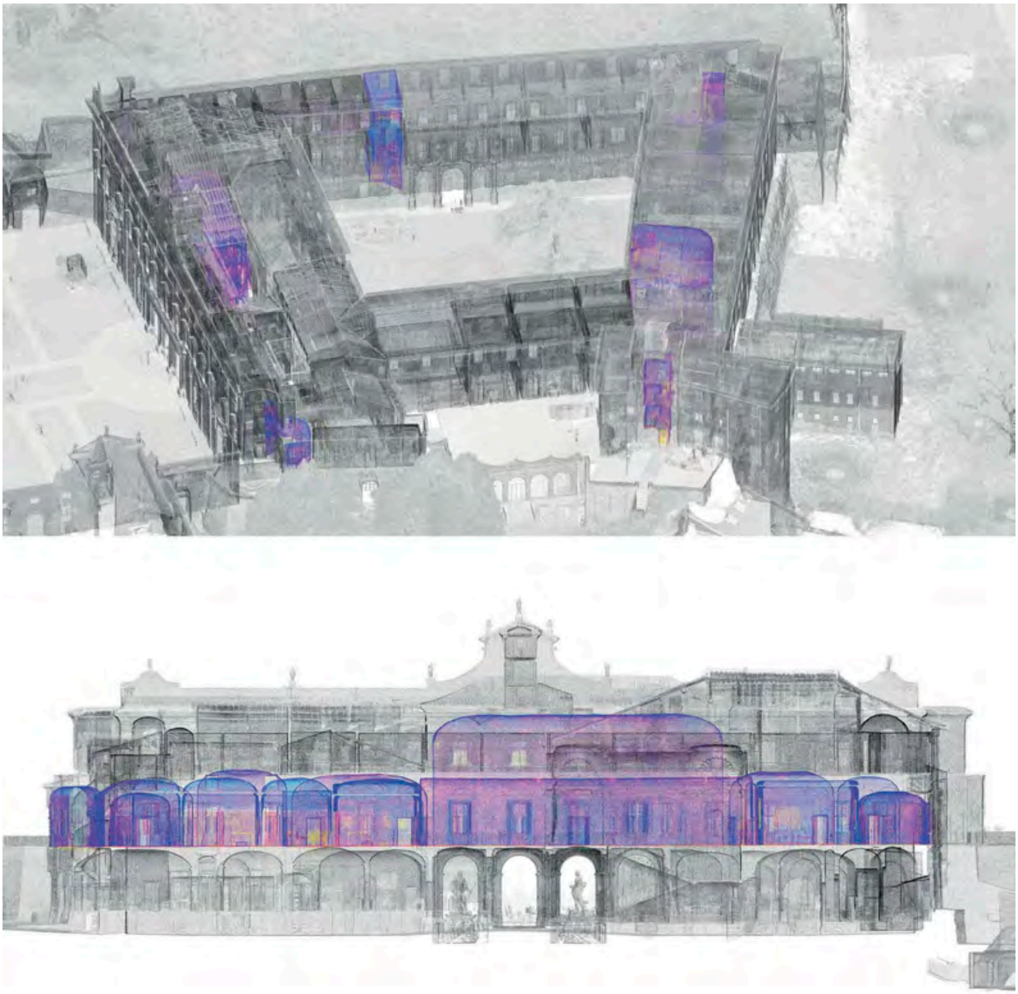

Figure 3. Scan to bim protocols for existing buildings at risk: Palazzo Ducale di Sassuolo, Modena, 2012 Emilia- Romagna earthquake. The survey design and acquisition phases allowed the recording of an overall point cloud data model hierarchized by: intervention purpose; structural units; functional distribution.

– optimised use of different 3D, terrestrial, drone and photogrammetric survey technologies, available at the time of the survey campaign.

Considering the different conditions and multiplicity of purposes for which the risk assessment survey is conducted, the evaluation of the structural, static and dynamic behaviour, remains a priority that guides the morphological metric survey right from the survey project phases. Therefore, the following prerequisites are considered to be essential for the acquisition, recording, calculation and segmentation phases of the overall data model:

– subdivision of the building, sector or urban fabric, into structural units;
– consistency or possibility of comparison between the hierarchy of the 3D survey and the damage survey tools adopted.

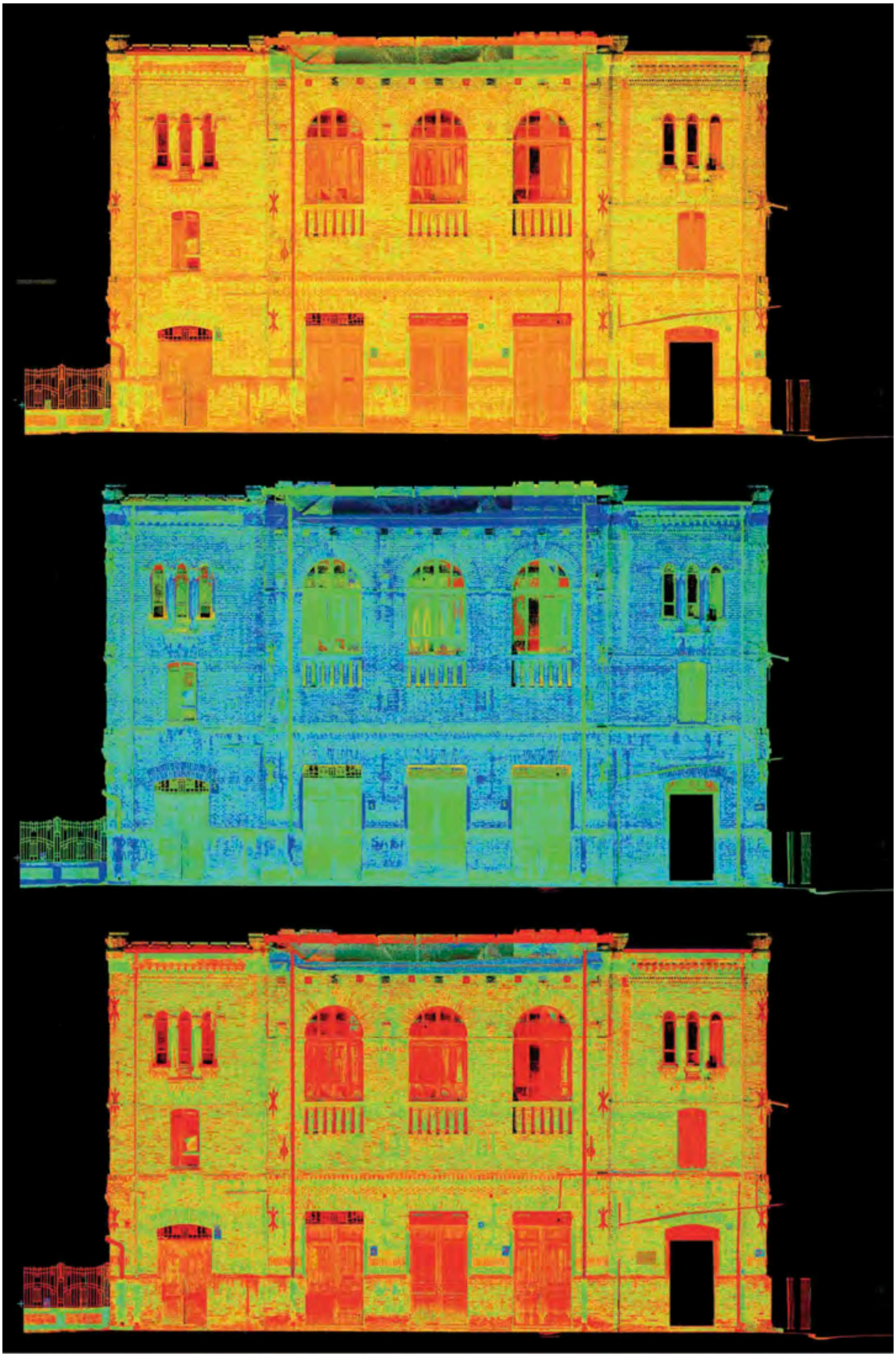

Figure 4. Cultural heritage damaged by the 2012 Emilia-Romagna earthquake. Social Theatre of Novi di Modena. Processing of the overall 3D point cloud data model. The different hue values allow the subsequent segmentation of the model available for semantic analysis.

4 OPTIMISATION OF DATA ACQUISITION AND PROCESSING PROTOCOL

It follows that the operational flow comprises phases constituting the prerequisites on the basis of which to verify and validate the intermediate products of the survey conducted through integrated digital acquisition, and the registration and calculation of the point cloud data model, and in particular: 1) definition of the purpose of the survey; 2) analysis of the site characteristics; 3) identification of integrated digital technologies to conduct the activities; 4) survey project; 5) health and safety; 6) primary control network; 7) secondary control network; 8) tertiary control network; 9) detailed photogrammetry survey; 10) registration of the overall data model; 11) model optimisation; 12) model segmentation; 13) processing of the model for specific analysis and processing; 14) archiving.

The experience conducted on more than 600,000 square meters of state-owned areas surveyed and on specific types of buildings damaged during the seismic events of May 2012 in Emilia-Romagna, such as the Novi Theatre, underscore the relevance of specific purposes, like assessment of the damage or of the risk level, require an answer to all the indicators and questions, previously defined, regardless of the number of operators involved and the set of technologies used.

A survey designed and implemented within this framework also allows, as supported by previous experiences, comparing information with data sources of a different nature such as, for example, the damage survey cards.

In the more specific case of damage to cultural heritage, it is important to consider as prerequisites of the survey project the specific tools adopted and the skills and responsibilities of the data acquisition procedures that follow the emergency management and safety phase, in addition to the specificities and complexities of the heritage asset in question. The "Sheets for the detection of damage to cultural heritage", which replace the Aedes sheets in the specific case of cultural heritage under evaluation, constitute both a useful reference to verify the structural units mentioned above, and an essential constraint due to some intrinsic limitations of the instrument itself, which have yet to be successfully addressed.

Available only for "churches" and "palaces" categories, the damage survey cards require tracing the reading of the damage, and, consequently, a metric morphological survey of a variety of existing cases, theatres, cemeteries, castles, for example, to the instruments used. The result is a general ineffectiveness and inefficiency of the information acquired, which has repercussions on the subsequent processing and implementation phases of the information system (Bianchini, 2014). It is necessary to consider all the different sources of information in order to define and implement an integrated digital information system that is capable of translating or integrating real collaborative platforms over time.

5 CONCLUSIONS

In a similar way to what is happening following the ever wider dissemination of Building Information Modeling tools, the need for operators in the value chain of the intervention on cultural heritage and built heritage, to apply operating standards for the evaluation of the quality and effectiveness of the survey activities is directly related to an increase in the value and duration of the design and data calculation phases, aimed at optimising the implementation phases in the field, as well as data segmentation and usability.

The definition of an integrated digital 3D survey protocol aimed at assessing damage or seismic risk is also the foundation for subsequent segmentation phases of the point cloud database in order to support the phases of: HBIM modeling of the built heritage; informative implementation of HBIM models (Logothetis et altri, 2015); automation processes for the semantic segmentation (De Luca, 2011) of the overall data model supporting critical survey processes.

Indeed, with a view to a wide application of the technologies for analysing and reading built heritage, as the tenders issued by the State Property Agency have shown over the last four years, it will be strategic to adopt automation procedures that, through a semantic approach, allow the segmentation of point cloud models by classes of characteristic elements; structural elements and construction techniques; and stratigraphic units and connection points (Giuffrè, 2010). Consequently, it is possible to gather methods, images, maps, graphic models, and information query paths through which the digital model of the building is situated in relation to historical, material, structural, technological, functional, maintenance and energy information, which, in turn, guides the integrated information system project, demonstrating how the prejudice of the neutrality of technique [Heidegger, 2017] is, once again, yet to be overcome by greater technological availability.

ACKNOWLEDGMENTS

The author gratefully acknowledges Dott. Dir. Enrico Cocchi, Arch. Antonino Libro, Ing. Davide Parisi and all the members of the working group of the Agenzia Regionale per la Ricostruzione Sisma 2012 for their contributions in terms of discussions and materials.

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Built Heritage in post-Disaster Scenarios – Balzani et al. (Eds)

The post-disaster legacy in Italy and the effects unfolded by the reconstruction plans

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ABSTRACT: The focus of the paper is to demonstrate, briefly a nd without a ny hints of historiographic systematicity, the legacy represented by some fundamental stages of the post-earthquake reconstructions that occurred in Italy over the span of almost sixty years. Some of these processes serve as paradigmatic turning points in both technical knowledge and action in the face of the enigma of natural disasters, illustrating the significance of what happens immediately after a natural disaster in determining not only the strategies for reconstruction of the damaged built heritage but also the more general turning points in the formation of new technical regulations. Earthquakes cause devastation to the buildings and the lives of those who are impacted, while the reconstructions, between successes and failures, offer hints at a new way of thinking about the interaction between the built environment, the territory, and the landscape, highlighting what a community is and, more relevantly, what it intends to become.

Furthermore, the document centers the attention on the Emilia-Romagna reconstruction, which is seen, after previous ineffective experiences, as a positive approach to pursue a reconstruction based on participative governance of decisions. It was established through a bottom-up discussion and participatory process. It had a democratic factor in the use of public resources since it was orientated by civic attention at different levels of re sponsibility, from th e ce ntral state governance to the last municipality in the crater. This approach guaranteed the highest levels of safety for residents and, above all, the use of endogenous reconstruction models, which, developed within the affected communities, reveal a strong sense of empathy for the territory and its historical and cultural identities.

Keywords: prevention policies, reconstruction plans, AeDES assessment survey

1 INTRODUCTION

An old Hebrew saying states that “saving one life is like saving the whole world” (whoever saves one life, saves the entire world. Yerushalmi Talmud, Tractate Sanhedrin 4: 9). In Vermicino (Italy), it was not possible to save a life, that of Alfredino, and it is as if the whole of Italy that day had a backlash, a loss of hope, trust, security. Faced with this tragedy, the protagonists’ reaction was precisely that of ensuring safety for others could be born from a misfortune. The transformation of this tragedy, not into an element of personal torment but into energy aimed at ensuring that other tragedies do not happen, was significant, ethically and civilly. The testimony of this inspiration heads to ensure that what happened there does not happen again and address the rescue operations to be better organized, faster and technologically more structured, and less conditioned by media pressure. This can no longer happen because prevention elements have been strengthened since then: knowing, learning, preventing, and helping are the core of Civil Protection.

A few months before June 1981, in November 1980, there was the Irpinia earthquake, a catastrophic event with thousands of deaths, and television showed the incredible disorganization of the relief efforts. The then President of the Republic, Sandro Pertini, managed to

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DOI: 10.1201/9781003253730-34

hold together a nation that showed all its organizational limits thanks to his charisma. If we asked any Italian over his thirties which tragic event he remembers with greater clarity, the answer in many cases would be the Irpinia earthquake: because among those survivors, there were all of us, because the many broken lives did not mean to end up under the curious gaze of the cameras. After all, at that moment, and for many years to come, a link was formed between the lives of the survivors and those of the rescuers. This bond went beyond the traditional dimension of the news in the life of each citizen. When the media television arrived in those places hit by the earthquake, for the first time in the history of communication, it transformed a news story that happened to a part of Italy into a collective event. From that moment, that story becomes a watershed with all the contradictions of the watershed because it is clear that the emotional load of that story was powerful.

For objective reasons, the Irpinia earthquake introduces a word that the Italians had almost completely forgotten since 1945 (even though the Florence flood or the Friuli earthquake almost came out), namely the word "fear", which is a scary word. It was a word backed by the worst catastrophes that happened with psychological, social, and political consequences when it became established. Fear is the awareness of the threshold one can reach, but this is personal. Collective fear is something different. Collective fear disarms, tends to close in a position of individual protection, tends to create armored doors, and leans to escape the rational and less emotional culture of knowledge and information. For example, nowadays,

Figure 1. The municipality of Teora, Avellino, Italy. On the left, the aerial photo of the urban framework immediately after the earthquake of November 23, 1980. On the right, the aerial view cruelly documents the demolitions that took place to secure the area, severely affected by the earthquake, but which still testifies the typological process of the urban inplant. What was done a few years earlier in Gibellina, Trapani, or more recently in Amatrice, Rieti, denounces a simplistic approach to solving the problem.

talking of "virus killer" pushes people, who perhaps, do not know the nature of the first word but know the meaning of the second, to stay at home, under the covers, close in on themselves to protect themselves. So it is essential to retrace the process that led to the creation of the Italian Civil Protection Department, with particular attention to the crucial contribution of Minister Giuseppe Zamberletti and how this should be included in a broader strategy, including the updating of Italian seismic legislation. After the experience of the Irpinia earthquake and after a critical parliamentary discussion, the minister understood that there was no need to create a new ministry, as it would have determined, in case of emergencies, conflicts in the management of resources. Consequently, Zamberletti moved towards creating a supra ministerial department with its own coordination and direction force. Another important intuition of Minister Zamberletti was that, still valid today, setting up four major lines of Civil Protection. In the first place, the coordination of a table with the presence of all operational structures, all components, institutions, ministries, and public and private entities. Secondly, the constitution of the national volunteering committee, to give organizational freedom to citizens, the so-called horizontal subsidiarity: citizens take autonomous initiatives and participate in decisions, manage typical administration activities. Hence, funds were granted to the scientific community to study the risks' reduction in Italy and establish the Great Risks Commission. Finally, the enhancement of local autonomies: it was clear that there could not be a Civil Protection that started from above, but it was necessary to create a system of coordination and direction starting with the local authorities in a bottom-up approach.

2 THE NORMATIVE LEGACY AND THE DEVELOPMENT OF THE LEGISLATION FOR ANTI-SEISMIC CONSTRUCTIONS IN ITALY

The following survey highlights the evolution of Italian legislation in the construction sector, revealing that it is in full swing. On the one hand, this is undoubtedly an indication of an adaptation of the law to the contingent and practical demands of professionals; on the other hand, it represents an apparent difficulty to identify a specific and detailed reference for the projects and the construction sites to be carried out. The regulations for constructions in seismic areas constitute the tool with which the Italian governments have pursued the objective of ensuring the safety of structures and infrastructures in seismic events, an objective directly connected with the protection of the administered communities and the continuity of productive activities involved. The most recent anti-seismic regulations consist of two distinct components: on the one hand, the seismic classification of the site, and on the other, the design rules for the structures. The seismic classification aims to indicate where seismic events can occur and their extent. The design rules list the requirements for the correct design and organization of the structures, define the construction details, and recommendations on the most suitable analysis tools for predicting the building's behavior during earthquakes. The anti-seismic regulations derive from the studies developed and the experiences accumulated after the most catastrophic Italian earthquakes, but also from the research activity developed in peacetime.

2.1 *The evolution of the legislation for the re-construction*

In Italy, the first decree concerning anti-seismic constructions dates back to 1627 following a very intense earthquake that hit Campania, describing a new construction type based on timber-framed masonry, known as "Sistema baraccato alla beneventana" (Figure 2), arranged by a wooden frame with pillars, beams, and St. Andrew's cross to perform the bracing function. The empty faces of the frame were filled in masonry to give support against the vertical actions and coated with plaster but were almost entirely free from any resistance to the horizontal actions, for which the wooden frame was specifically designed. At the time, the foundation frameworks were composed of a masonry base, while wooden beams supported attics and roofs.

In 1784 after the earthquake that the previous year struck Messina and Reggio Calabria, Ferdinand IV of Borbone issued the decree "Instructions for the reconstruction of Reggio", in which the use of the *barracato* system was settled by adding some new details such as the height of the foundation plinth and the requirement to create a restrain curb at the top of the walls to serve as a connection between masonries and the roof in order to guarantee a constant movement of the building bearing structures in case of an earthquake. The tragic earthquakes of 1857 in the Principato Citeriore of the Kingdom of the

Two Sicilies (Figure 3) and 1859 in Norcia prompted the Pontifical Government of Pope Pius IX to issue a new building regulation whose primary directives consisted in limiting the new building constructions to a maximum of two stories and not to exceed 8.5m in height.

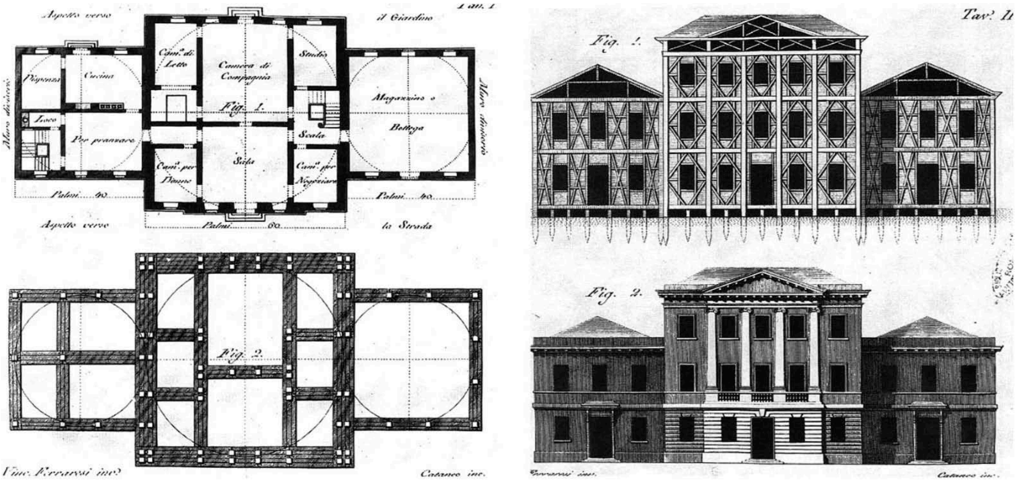

Figure 2. The use of temporary structures consisting of a timber frame with a raw earth infill or clay bricks (the casa baraccata or casa a gaiola, derived from the roman opus cratiucium) spread in the Kingdom of Naples after the earthquake of November 1, 1755 in Lisbon. Trough the insertion of transversal bracings, the framework developed into a mature construction type conceived as a complete and compact structure with good seismic energy dissipation behavior and adaptation to plastic deformations imposed by the earthquake.

Figure 3. The young Irish engineer Robert Mallet experimentally verified his theories on the dynamics of earthquakes by conducting an on-site survey and analysis of the damages caused by the seismic events of December 16, 1857, in the territories of the higher Val d'Agri, Potenza, and the Vallo di Diano, Salerno, in the Kingdom of the Two Sicilies. Engravings elaborated from the stereoscopic pictures of the photographic reportage commissioned to Claude Grillet support the illustration of the phenomenological investigation.

In 1883, the Casamicciola earthquake addressed the Royal Decree n. 2600 of August 29, 1884, limiting buildings' overall heights to 10m while prohibiting the construction of pushing roofs and limiting the cantilever projections to 0.60 m.

The tragic earthquake of Messina and Reggio Calabria in 1908 led to the issue of the "Technical and hygienic standards required for repairs, reconstructions and new constructions of public and private buildings in the places affected by the earthquake of December 28, 1908, and other precedents listed in the Royal Decree of April 15, 1909, and designates the Municipalities known at a juridical level as Royal Decree n. 193 of April 18, 1909, accompanied by

Circular note n. 2664 of April 20, 1909, “Technical instructions”. These decrees prescribed many indications still present in construction’s present technical regulations. These include the inadmissibility of pushing structures, the effective connections between the structural elements with the specification of clamping and the obligation to arrange curbs (made of wood, steel, or reinforced concrete) at the base and top of the masonry and the limitation to a maximum 5 m distance between two load-bearing walls. In addition, for the first time, attention is paid to the issue of soil quality by specifying the ban on building new structures in clayey soils, rough or at risk of landslide. It was also clearly specified that the distance of the openings from the edges of the masonry had to be greater than 1.5 m, and each opening had a steel or reinforced concrete frame to generate an unloading arch.

2.2 *The scientific approach to the development of construction legislation*

The Law Decree n. 1526 of November 5, 1916, quantified the seismic forces and defined their distribution concerning the height of the building. The weight and overload forces were increased by 50% to take into account the jolting effect of the earthquake, while the horizontal ones were considered by multiplying the weight and overload forces by a coefficient C which assumed values of 0.125 on the ground floor and 0.167 on the upper floors.

The seismic categories were defined with the Royal Decree n. 705 of April 3, 1926, as a consequence of the earthquakes in Siena and Grosseto. For reinforced masonry buildings, in the first category, the maximum height of buildings was limited to 10 m and two stories high, while 12 m and three stories in the second category areas. In no case it was possible to exceed the inter-floor height of 5 m.

The Royal Decree-Law n. 431 of March 13, 1927, extends the concept of seismic zoning and differentiates the requirements according to the category of the site, imposes the size and minimum strengthening for reinforced concrete pillars, and defines the values of the C ratio between the equivalent static forces acting on floors and the weights corresponding to the masses of each floor:

- in class I areas: C = 0.125 on the ground floor, C = 0.167 on the upper floors, 50% for vertical actions;
- in class II areas: C = 0.100 on the ground floor, C = 0.125 on the upper floors, 33% for vertical actions;
- buildings higher than 12 m: C = 0.167 applies on all floors.

It was evident that most seismic laws aimed to define increasingly restrictive criteria over time. The Law n. 1684 of November 25, 1962, requires that any building higher than seven stories to be built in reinforced concrete or steel and establishes that any traditional masonry building should be supplied with a reinforced concrete curb at the level of each floor and roof. Then, the Law n. 1086/1971 regulates reinforced concrete constructions (regular and pre-stressed) and metal constructions, while the Law n. 64 of February 2, 1974, as consequence of the Ancona’s earthquake, provides specific provisions for constructions in seismic areas and outlines an updated seismic map of the country and new technical standards for constructions.

The possibility of issuing improvement and updating previous decrees offered by Law n. 64/’74 caused many reforms in the 1980s. The Ministerial Decree of March 7, 1981, based on a study conducted by the Italian Research Council, defined the seismic zones of Basilicata, Campania, and Puglia, with the specificity that this study was based for the first time on a probabilistic survey and will be, later on, the basis of the Ordinance of the President of the Council of Ministers n. 3274 of March 20, 2003, which will define the seismic classification of the Italian territory. The Law Decree n. 75 of March 19, 1981, which later became Law n. 219 of May 14, 1981, marked provisions in favour of the populations and issued directives for reconstructing the municipalities affected by the Irpinia earthquake. The Ministerial Decree n. 515 of June 3, 1981, again through a probabilistic survey by the CNR, introduced the third seismic category with a coefficient C = 0.040. The approval of the Ministerial Decree of January 24 characterized the 1986 start, issuing “technical standards relating to anti-seismic constructions". With the Circular note of the Ministry of Cultural and Artistic Heritage, n. 1032 of July 18, 1986, recommendations were provided for interventions on the monumental heritage in seismic areas. Further executive instructions for masonry constructions were issued on January 4, 1989, in the Circular note of the Ministry of Public Works n. 30787. Hence, the Ministerial Decree of January 9, 1996, "Technical Standards for the calculation, execution, and testing of reinforced concrete structures, normal and pre-stressed, and for metal structures", was issued based on the indications of Law n. 1086/1971 to replace the Ministerial Decree of February 14, 1992, concerning the limit state assessments and allowed the use of Eurocodes 2 and 3. Based on the indications of Law n. 64/1974, the Ministerial Decree of January 16, 1996, relating to technical standards for buildings in seismic areas and technical standards regarding the criteria for verifying the buildings' safety, as well as their loads and overloads. The Umbria - Marche earthquake of May and September 1997 led to further developments of the regulations in force and *ad hoc* decrees for the affected areas, such as the Law Decree n. January 30, 1998. It aimed to address urgent interventions to be implemented in favour of the areas affected by earthquakes, which later became, with some modifications and additions, the Law n. 61 of March 30, 1998. The part dedicated to earthquake defence of the European legislation for structural design dates back to 1998, namely "Eurocode 8". The tremors and, consequently, the damage and the state of emergency persisted until mid-1998, making further legal acts and extensions necessary, including the Order of the Minister of the Interior n. 2947 of February 24, 1999, and the Ordinance of the Presidency of the Council of Ministers n. 2991 of May 31, 1999. The Law Decree, n. 300 of July 30, 1999, assigns to the Civil Protection Agency, a recently established legal body, the responsibility of identifying, training, and updating seismic areas, while the law on the reconstruction and repair of damaged buildings is enacted remotely ten years after the seismic event.

On June 6, 2001, the President of the Republic's Decree n. 380 "Consolidated text of legislative and regulatory provisions on construction" issued, particularly in Chapter IV, "Provisions for constructions with express prescriptions for seismic areas". Equally crucial for the organizational goals of the Italian Civil Protection is the Law Decree n. 343 of September 7, 2001, which regulates urgent provisions to improve the logistical and functional structures for communication and coordination of civil defence. Another year full of reforms was 2003, with many innovations in the construction field. The Ordinance of the President of the Council of Ministers n. 3274 of March 20, 2003, established the "First elements regarding general criteria for the seismic classification of the national territory and technical regulations for constructions in seismic areas". With it, the contents of the Eurocodes officially became part of the Italian technical regulations, making mandatory both the limit state semi-probabilistic calculations and the dynamic analyses with response spectrum. Ordinance n. 3274/'03 initially joined the seismic legislation of 1996 and, only after a due process characterized by many changes and additions, replaced the latter almost two years after its enactment. In addition, the Italian Regions were given the right to enforce the obligation of anti-seismic design. With this, they returned to being responsible for identifying the seismic zones within their territory, after which, since 1999, this had become the competence of the Italian Civil Protection. In particular, Article 3 provided the obligation to verify within five years for buildings of strategic importance and infrastructures which, in the event of a seismic event, are of fundamental importance for the purposes of Civil Protection. This ordinance marks the transition between the old and the new conception of legislation, no longer prescriptive but based on an approach aimed at guaranteeing performance and achievement of specific standards and objectives, with the commitment to declare also how to achieve this purpose. Following the L'Aquila earthquake in April 2009, the Ministerial Decree of January 14, 2008, containing once again "Technical standards for construction" (i.e., NTC 2008), came into force on July 1, 2009. It is considered Italy's most effective and lasting legal document so far. Circular note n. 617 of February 2, 2009, gave the instructions for the use of the NTC 2008. The Directive of the President of the Italian Council of Ministers issued on February 9, 2011, for the "Assessment and reduction of the seismic risk of cultural heritage" with reference to the Technical standards for buildings referred to in the Decree of the Ministry of Infrastructures and Transport of January 14, 2008, proposed a synoptic descriptive template of the seismic repair and the improvement intervention to be carried out on an asset of significant historical-cultural importance.

Furthermore, the document described a significant number of instructions and safeguards to consider when carrying out works on cultural built heritage. On April 30, 2015, the Ministry of Heritage, Cultural Activities and Tourism issued the Circular note n. 15, which invites Regions, Superintendencies, and General Direction of Fine Arts and Landscape to take a look at the "Provisions on the protection of the Architectural Heritage and mitigation of the seismic risk". The new NTC 2018, pending from 2010, has recently been approved, bringing clarifications and minor changes regarding seismic adaptation and improvement interventions.

3 RE-CONSTRUCTION AND PREVENTION POLICES

The role played by governance in adopting the most effective policies in a period of peace should be interpreted in relation to the threats that can impact the historic built heritage. Therefore, prevention is the theme placed at the centre of contemporary attention, assuming the definition of prevention as "the adoption of a series of measures to protect oneself from a future threat, and therefore the action or set of actions intended to achieve this purpose".

It is possible to refer to measures that follow or diverge from those enacted in the post- disaster government response, one component of which is the promulgation of technical rules. Prevention in the experimental process of the reconstruction plans is manifested through measures aimed at mitigating the seismic risk, for example, and consequently reducing damage to the built heritage. Prevention also has its effects on a social scale by pursuing the common good of a community, favouring full employment, recognition of rights, and satisfaction with the needs of services, housing, and access at every level of the territory. From the analysis of the governance that, in the last fifty years, guided the reconstruction in Italy following every catastrophic event, the shared awareness of the interrelations between phenomena that threaten the unfolding of life in historical contexts can be seen, favouring the formulation of policies to prevent multiple threats.

The exercise makes it possible to identify the strategies implemented from time to time between the various subjects, institutional and administrative bodies of the State, to share the actions to be taken, foresee their effects, the implications in the management of reconstruction, the monitoring of conditions that are determined, the resilience of the territorial systems affected by the event. The review, necessarily synthetic, highlights different contributions to a reconstruction strategy aimed at safeguarding the values of the territory and the conservation of the triple nature of our historic frameworks (i.e., settlement - community - institution), so well represented by Ambrogio Lorenzetti with the Allegory and Effects of Good or Bad Government in the Room of Peace in Siena Town Hall. In the quest for justice and peace among the members of the community, the municipality identifies the theological virtues, and its representatives who serve in assembly organs exercise good governance, while the citizens, with the exercise of their arts and crafts, can benefit from the results of good governance, pursued in a complex system of artifices rich in corporate symbolism.

3.1 *The path towards reconstruction*

After the emergency phase, in which the competent institutions work together to provide timely relief and respond quickly to the needs of the affected population, risk management places reconstruction at the centre of the process. Different approaches, ideas, and paradigms converge in this phase and shape the coordinated pathway. The comparison of the different processes that have been put in place over the last sixty years in Italy lets to estimate the evolution in the approach to reconstruction intended not only as the restoration of the previous conditions of something that has been destroyed but, above all as the opportunity to improve the settlement dynamics of communities in the affected areas. *Reconstruction* is a new route indicated by the implementation tools of local planning, along which communities are the

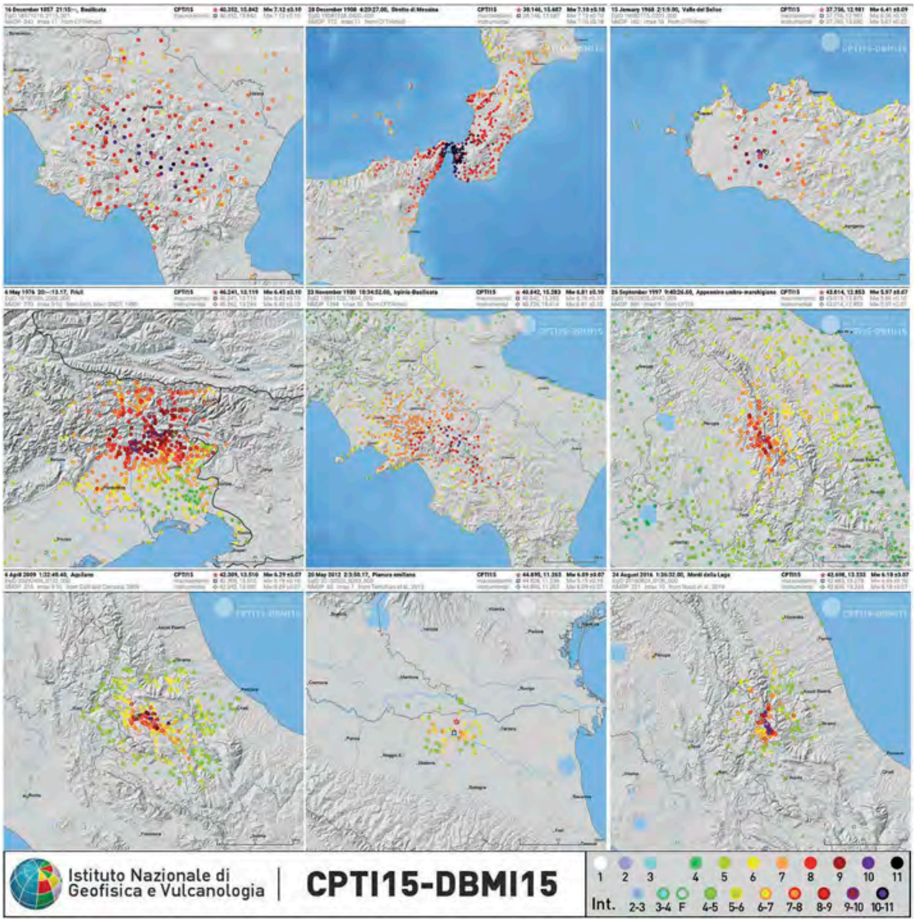

Figure 4. For more than 150 years, the principal Italian anti-seismic design codes were developed according to a prevention strategy based on a unified approach involving: the seismic classification of the territory, the anti-seismic design of new buildings, and the improvement of existing ones. Anti-seismic design standards have progressed following the devastating earthquakes above represented (web-1), establishing a clear cause-effect relationship between seismic events and corresponding updated regulations. The first-generation standards (pre-1960) are purely prescriptive and require structures to withstand a stress state composed of static equivalent lateral forces representing the dynamic effects applied to the building masses due to seismic action. The second-generation standards (1960 to 1980) have a single-level performance character, which, outlining the elastic response spectrum, focuses on violent earthquakes with a return period of 475 years, and requires the preservation of human lives as a performance, i.e., avoidance of building collapse. The third-generation standards (from 1980 to 2000) are double-level performance, taking as reference two seismic events: the service earthquake, characterized by a return period of 70 years, and the destructive earthquake, with a return period of 475 years. Two distinct performance levels and design objectives are associated with these events: the damage limit state and the ultimate limit state. Finally, fourth-generation standards (post-2000) follow a multilevel performance approach that, combining life-saving considerations with economic concerns, introduces intermediate levels of safety based on Performance Based Design.

active players in determining choices. At the same time, highly specialized technical professionals have the task of guiding the process aimed at ensuring the effective return of populations to their places of origin. The risk around the corner is the inefficient management of the process, which, as time passes, triggers, through a domino effect, processes that are difficult to reverse and can cause the socio-economic regression of places, as has unfortunately happened in more than one case.

The reconstruction plan has a prescriptive nature and involves the transformation of the territory through the use and possible land consumption, considering these processes in their entirety and projecting them in the medium to long term. The regulations may be transitory, such as those concerning rescue operations. However, above all, they will be definitive, such as expropriation for the construction of strategic infrastructures, for areas destined for temporary housing, or the formation of new settlements. The drafting of the guiding instrument is implemented following the actual damage estimate, carried out in the first months after the seismic event, and the more accurate the data collected, the more the instrument increases awareness of the methods and hierarchy of interventions. The Plan governs the territory in a non-neutral manner, deciding what to rebuild first and what should wait, thus becoming the sole interpreter of the urgencies of the territories, depending on each context, according to an approach that will condition all intervention. The boundaries of this process resemble the logic of 'all the same' or 'all different' in terms of restoring everything that has collapsed, where and as it was before, or rebuilding from scratch each element to form a new settlement, a mirror copy of the destroyed one. Every past reconstruction outlines a model, whether positive or negative, which in the common understanding seems to have contributed to a good reconstruction or a bad one, with the consequence, in the first case, that the model applies to any context, at any time and any latitude, in the plains or the mountains, in small towns or huge metropolitan cities.

On the contrary, it is impossible to define a single modality for different areas with noncomparable local traditions and dynamics. Consider, for example, the Friuli model, the reconstruction that took place successfully and in a short time, which was repurposed a few years later, in 1980, in Irpinia. Mr. Zamberletti, the commissioner for the reconstruction of both earthquakes, proceeded in the same way, but the result was certainly different, far from that progressive theoretical model capable of being implemented in the short term.

3.2 *Post-earthquake reconstruction in Italy between 'as it was, where it was' and 'new towns'*

In the Italian earthquake records, the political and cultural approaches that addressed the reconstruction process reflect the different territorial, economic, and social experiences. Beyond the failures, two essential models have been set up about strategy and planning, according to the *new cities* approach and the *where it was, as it was* paradigm.

The new city, usually built on sites other than the original ones, dates back to the catastrophic pre- unification earthquakes experienced in the Kingdom of the Two Sicilies. The Enlightenment reformism of the time promoted urban development projects in areas often on the margins of the social and economic life of the Kingdom of Naples, with new settlements characterised by wide, orthogonal streets and new buildings conceived according to previously never used dimensions and symmetries. To rebuild 'as it was, where it was' in seismic and hydrogeological prone areas is a mere play on words, given the need to use better quality materials according to earthquake-proof building techniques while respecting up-to-date building rules compared to previous ones. In practice, the ideal of remaining faithful to the original design is scaled down by safety considerations and other requirements needed to revive the affected territories.

In deciding where and how to rebuild, the central issue is the future of the communities, linked to the productive structure and demographic dynamics in the affected territories. For instance, rebuilding small mountain villages as they were but without services in progressive abandonment could lead to depopulation. In Belice, hit by the earthquake of 1968, the structural and demographic decline was so advanced even before the destructive event that no attempt was made to reform the old villages, focusing on new settlements without identity, but 'enhanced' with avant-garde artistic interventions, as in Gibellina. Earthquakes were the stimulus to innovate technical and management tools for emergency and reconstruction. Models ranging from total state centralisation to the delegation and subsidiarity of local authorities were applied from time to time, with a regulatory consequence of specific laws and exceptions to existing ones.

Figure 5. Above, Istituto Superiore per l'Edilizia Sociale, Marcello Fabbri, 1969. The Project for the relocation of the Gibellina population provides indications for the new areas to be allocated for building and represents a detailed plan completed by projects from architectural scale (1:50) to detailed scale (1:20). Below, Dimensional comparison between Gibellina Nuova and Gibellina Vecchia, in the box (Badami, 2019).

The earthquake that hit western Sicily on January 14-15, 1968 was the first highly destructive earthquake following World War II. Support to evacuees arrived late, and emergency management immediately presented mismatches and difficulties. In 1968 there still needed to be a central structure such as Civil Protection or an organic regulation defining the methods of intervention in the event of an earthquake. Following the initial phase of tent camps, the population was accommodated in less precarious conditions pending the completion of reconstruction and their return to their homes. Under the advice of the local mayors, the Genio Civile identified the locations of the temporary villages.

The location choice followed the state's centralistic approach to reconstruct most of the urban sites from scratch. The many temporary villages, fragmented in the valley, were almost all born far from the destroyed centres, halfway between the old village and the new foundation site, closer to the communication axes in favour of future urban and territorial reorganization and development. In addition, the urban layout of the new transitional town will be completely different from the one that characterized the centres in this area: a rectangular concrete plan will house numerous shacks made of corrugated iron sheets. This will be another disruptive factor defining the break with the past on a social and cultural level, considering that the population will remain in the shantytowns for 14 years.

The strategy used for the Belice reconstruction is to rebuild the centres according to a centralised self-referential approach. The formation of new towns is considered the ideal choice, in line with the state's development policies for the entire Mezzogiorno at that historical moment. All this is justified by the new urban planning theories of those years based on the utopian ideal of the garden city. Although Sicily has been a region with a special statute since 1946, in which competence in urban planning matters is in the hands of the region, in the exceptional case of natural disasters, management passes to the central state. The latter believes that in the event, there is an opportunity to demonstrate the central capacity to transform a backward territory into a territory opposite to the previous one.

Three pivotal objectives back the process: the de-rurrialisation of the territory through the transition to an industrial production system; the launching of construction for the infrastructure and reconstruction of the cities; and finally, the rejection of any restoration for the remaining buildings, rich in history and culture, followed by the demolition of everything that is deemed irretrievable. Reconstruction becomes the springboard for higher goals (in theory) and the territory is a blank sheet of paper where avant-garde theories can be applied, presumptuously considered as solving problems and as the only way to create opportunities and development.

The exception is the municipality of Santa Ninfa, which, almost destroyed by the earthquake, had a completely different fate from the other municipalities because the shantytowns were located in an area bordering the old centre, so the inhabitants maintained relations with it. In addition, the mayor at the time categorically opposed the relocation of the town elsewhere.

Eight years after the Sicilian event, in 1976, Italy faced again a devastating earthquake that struck the autonomous region of Friuli Venezia Giulia in the northeast. The first and most destructive seismic event of May 6, 1976 was followed by two tremors of equal magnitude that struck the same territory on the late afternoon of September 11 and the morning of September 15. As a result, the damage to those still standing buildings increased, thus completing the process of annihilating the territory while simultaneously further exhausting the population's mood. As a result of such close episodes, all the procedures to grant compliance with safety standards started in the summer months had to be restarted, forcing the population to retreat to the coast. This risked inverting the reconstruction process as initially planned, in which the population controls its own choices. Unlike in 1968, the government and the management of reconstruction were entrusted to the regional administration, which became the interlocutor with the central government in favour of the local municipal administrations, to which it, in turn, delegated the reconstruction planning and intervention projects. After subdividing the municipalities according to the three damage classes, the region's strategy is immediately restoring lightly damaged buildings that do not require too much processing time. The issued law had the sole purpose of speeding up the reconstruction process and the return of displaced persons, confirming the institutional choice to bypass temporary villages in favour of the slogan 'from tents to houses'. The pragmatic decentralisation approach used for the reconstruction of Friuli represents a change of direction in emergency and reconstruction practices and influences the management of succeeding earthquakes. As a result of the failure of the Sicilian experience, central governance delegated the entire process to those bodies closer to the territory and subsequently instituted a process from below that encompassed the most extraordinary form of national participation up to that point. It also produced concrete and less pretentious choices and objectives that, in contrast to Belice, relaunched the territory by mending the past without erasing it. The 'Friuli model' is the product of the reactions in the aftermath of the earthquake, coined in the famous motto *Com'era, Dov'era* (i.e., as it was, where it was), with which the population intended to act quickly to restore the territory, mindful of the Sicilian experience. The people's will is translated into the prioritisation of reconstruction prerogatives, found in the slogan 'First the factories, then the houses and finally the churches'. In fact, the operational strategy is based on the abrupt restoration of productive activities, then the reconstruction of houses and all related services, and finally, the reconstitution of the territory's cultural or historic built heritage.It is evident how the post- earthquake approach is opposite to Belice's one. The earthquake becomes an opportunity to relaunch the territory along a fille rouge in continuity with the past but projected towards the future, where interventions are not dropped from above and imagined on a blank sheet of paper.

The 1980 earthquake in Irpinia is remembered as one of the most devastating events since the post-war period in terms of area, intensity, and victims, but above all, because of the management of the entire reconstruction process, which definitively highlighted the gap between North and South. On the evening of November 23, 1980, a violent tremor hit a vast area of the southern Apennines, specifically Irpinia and the neighboring areas of Salerno and Potenza provinces. It is only in the first light of dawn that the catastrophe becomes apparent. The locals provided first aid, and, at first, the extent of the phenomenon was unclear. As the first days passed, the institutional machinery took shape, and, given the catastrophic nature, national and international aid began to arrive. However, the relief effort is uneven, with some countries waiting days for help to arrive. The difference and singularity of this emergency compared to the previous one is the perverse and unstoppable admission of many municipalities to the list of beneficiaries of funding. Even centers of considerable importance, like Avellino, Naples, Salerno, and Benevento, were marginally impacted by the effects, in comparison to the worst-hit area. This led to increased challenges in the recovery process and the provision of recovery tools. The first delimitation, made one month after the event, included 283 municipalities in the Campania and Basilicata regions, but after one year, the crater included 687 municipalities. This caused the decentralisation of the forces deployed, diverting attention to the real earthquake villages and disproportionately increasing public expenditure (e.g., the inclusion of Naples).

The proximity to the Friuli event necessarily meant that the institutional actors adopted the approach used in 1976 due to the successful results obtained a few years earlier. As with every earthquake in Irpinia, there is a debate between possible alternatives (i.e., reconstruction on site or ex novo), but from the outset, the choice seems clear. The initial plans perfectly followed the decentralization approach used in the Friuli earthquake, but without taking into account the differences between the two territories and their socio-economic dynamics. The result attempts to link experiences, objectives, and methods considered successful during previous reconstruction processes. As in the Sicilian case, the assonance can be found in the institutional will to bring social and economic upheaval and reorganisation to the areas affected by the earthquake. Meanwhile, the identification of the local administrative level as the key to the effectiveness of interventions represents an analogy to the Friuli strategy. However, unlike in Friuli, where the population loudly expressed and defended reconstruction in situ, in Irpinia, the municipal administrations were given the option of choosing where to relocate, that is, whether to rebuild in the expansion areas of the old centres or kilometres away from the original sites. In response to the crisis, the State delegated to the regions the coordination between the government and the municipalities through Regional Development Plans that intended to start an organic rebirth of the south region through the modernisation of the agricultural sector, the development of infrastructure within and outside the affected areas, the development of tourism, and the growth of small businesses. In order to respect the desire to use territorial planning as a frame of reference, the municipalities were responsible for revising urban planning instruments. However, the legislation has a perverse mechanism that produces two negative results. Ex novo reconstruction was rewarded by the law with an economic stimulus to the detriment of the recovery of the historic heritage. At the same time, the population planning to renovate their homes in the destroyed built-up area was penalized by a 20% reduction in contribution.

Consequently, it is easy to guess what the citizens' choice was. On the one hand, the law legitimized the abandonment of many Irpinia towns in the hope of improving living conditions; on the other hand, it guaranteed the same rights of expansion and development, without any level of contribution to the economy, even for the minority of the population that wished to remain. The result is, in both cases, the abandonment of pre-existing buildings, the redesign of the layout, and the establishment of entirely new social dynamics.

The 1997 earthquake can be considered the first test of the National Civil Protection system, established by law n.225/1992, which gave it a fundamental role in managing emergencies and assisting populations. As a result of the first activities, some criticism regarding the definition of roles and competencies accompanied the effective preparation of the institutional framework. In fact, the municipalities at seismic risk should have identified possible areas where temporary accommodation could be placed as early as the circular issued in 1987 by Minister Zamberletti. However, this had not yet taken place at the time of the event. The approach identified for post-seismic event reconstruction reverses many of the dynamics implemented up to that time, refining and overcoming already implemented models. As with other events, decentralisation of powers takes place, in which the fundamental role is played by popular sharing and participation. The most significant damage included important historic and cultural built heritage.

For this reason, in addition to the appointment of two delegated commissioners (i.e., the presidents of Umbria and Marche regions), a third commissioner was also appointed with the task of managing the interventions concerning these assets. It is immediately clear that two priorities dominated the approach: reconstructing the dwellings in the shortest time possible in order to avoid depopulation phenomena, and restoring all those churches, monuments, and historic buildings that addressed local identity. A crucial fact to note is that concerning the production sector. In this reconstruction, no attempt is ever made to distort the spirit of the area and its socio-economic dynamics with ex novo industrial development plans while encouraging small production and neighbourhood craft activities.

The L'Aquila earthquake is remembered sadly not only for the deaths and the extensive devastation of its artistic and historical legacy, but also for its management, which, in spite of plenty of previous experience, completely erases background and knowledge by following an approach that has many short-term, medium-term, and long-term negative effects. After six months of uninterrupted seismic episodes and numerous warnings and polemics from the population, the earthquake of 6 April 2009 turned the clock back on reconstruction governance. The emergency approach was managed in two subsequent stages as part of a revised operational process. In the case of L'Aquila, Civil Protection and the Italian government were verticalising management after years in which the decentralisation policy proved successful. The strategy echoes the Friuli slogan 'from tents to houses'. While this did not come true in Friuli, in 2009 the formula was not only proposed again but strengthened even more. In fact, the phases involve initial accommodation in tent camps pending the transition to permanent housing. No more temporary solutions were designed, but a complex urbanisation plan for the territory produced 19 new towns, temporary for the evacuees but definitive for the city. Parallel to life in the tent camps, site personnel worked day and night to build the C.A.S.E. (Complessi Antisismici Sostenibili Ecocompatibili) project, in other words, the 19 new towns that would allow the transition "from tents to houses". Reducing delivery times as much as possible requires a centralised process for smoother management. This is how the head of Civil Protection was identified as the pivotal figure in the reconstruction, who, with special powers, became the extraordinary commissioner for the reconstruction of Abruzzo. These special powers concern not only the relief part but also the construction part of the C.A.S.E. Project.

The project fails to fully meet the housing needs, so temporary spaces are set aside for the installation of MAPs (Temporary Housing Modules) to house the last remaining evacuees. Compared to other past managements, the emergency phase has restored the situation in unprecedented times, to the detriment of the territory that has been irreparably transformed. Soil has been consumed and dormitory quarters built that have nothing to do with the sense of inhabiting a place.

The aftermath of L'Aquila led to different approaches for different periods. The centralised approach to the first emergency phase, in which administrative bodies and the population were identified as beneficiaries, was replaced by a more decentralised approach to the reconstruction phase.

In addition, the emergency management process was implemented on the basis of decisions that were not shared by all. This was done in derogation of the entire regulatory system because of the state of emergency. With the completion of the new towns in January 2010, the decisive role of the State and Civil Protection also came to an end, and at the same time a new phase began, with the appointment of the President of the Region as Commissioner for Reconstruction. In this decentralisation, municipal administrations are recognised as subjects with specific roles and tasks, albeit not at the same level as the superordinate bodies.

3.3 *The Emilia-Romagna post-earthquacke reconstruction experience*

The Emilia-Romagna regional governance sought to provide a regulatory framework of practical reference for reconstruction activities with the Emilia-Romagna regional law of December 21, 2012, n.12 "Regulations for reconstruction in the territories impacted by the earthquake of May 20 and 29, 2012", by striving to combine the need to simplify procedures due to urgency with the need to improve seismic performance and the architectural and landscape quality of the urban area, settlements in the rural areas and places of identity for local communities. The regulation is developed to foster reconstruction by encouraging settled communities to pick up where they left off and revitalizing living and working conditions. This required, first and foremost, the conclusion of reconstruction, as well as assuring that all repair, recovery, and reconstruction work came with an increase in seismic safety. In addition, the reconstruction is also seen as a chance to enhance the quality of cities, both in terms of restoring or creating the public spaces and services that define the character of any urban centre and in terms of the quantity and quality of shared spaces, facilities, and transportation infrastructure that are entirely usable by all residents, regardless of age or condition.

Therefore, reconstruction had to focus on safeguarding historic urban centres, redefining the rural environment, and giving people their houses back and companies their spaces. Cultural built heritage and historic sites were actually the most severely damaged by the earthquake, with severe impacts on both the cultural and testimonial values of the individual structures and, above all, on the significance these sites held in the territorial context. The primary objective of this reconstruction is to redesign the relationship between the territory and the community. To achieve this, the regulations consider essential issues like the revitalization of historic centres, the core of daily identities and relationships, and the connexion between these elements and the new polarities formed on the outskirts of cities, as well as new locations for all public functions (e.g., schools, town hall, library, shopping centres). In order to pursue these objectives, the law introduced a special regulation that called for streamlined procedures and different routes that could address even the most diverse requirements. This ensured an earlier start to the reconstruction process while simultaneously allowing to go forward with planning tools for the more challenging circumstances.

Hence, building work could begin straight immediately when the conditions were ideal. Both the opportunity for categorizing minimum intervention units (i.e., UMIs) to be recovered through an overall plan, either for structural reasons or energy efficiency goals achievement, and organizing the city planning framework are examples of this specific legislation. It enabled the reconstruction plan to be used as an operational city planning tool that combines all available instruments, offering general project rules and criteria to enhance the city's safety and quality. Under the established planning standards, the plan provides for adjustments in expectations related to the earthquake's impacts, ensuring legal assurance in streamlined procedures with rapid, assured timescales.

Indeed, the plan's specific contents comprise variations on the city planning instruments already in use, deemed appropriate for interventions of repairs, renovation with seismic enhancement, and rebuilding, pertaining, in particular, to:

- the regulatory modification of city planning - building rules that directly affect the consent to building licences, or those relating to the revision of restrictions with modifications to the category of intervention in buildings protected by city planning rules that have collapsed or been demolished, or that through the proper assessment have demonstrated a level of structural or functional damage that does not allow reconstruction (i.e., art. 12, subsection 4);

- the modification of urban morphology and city planning frameworks, such as the design of new UMIs that incorporate entirely or partially new volumetric plans (i.e., art. 12, subsection 2);
- the relocation of building capacity for the reconstruction of buildings that have collapsed due to the earthquake, been demolished as a direct consequence of municipal orders, or been damaged to such an extent that they are classified as operational level E3 under the ordinance n.86 of December 6, 2012, attributable to: buildings situated in buffer zones for streets or waterways (i.e., art. 4, subsection 7), or feasibility corridors for public works (i.e., art. 9, subsection); buildings spread across rural areas that are no longer functional for agricultural activities (i.e., art. 9, subsection 5, letter b); inappropriate buildings (i.e., art. 12, subsection 6, letter c) or buildings that, in urban areas, require to be relocated in order to enhance the infrastructure or services for the current mobility networks (i.e., art. 12, subsection 6, letter b). As a result, the reconstruction plans should identify and specify the city planning regulations for the area in which the reconstruction will take place and, in the event of relocations, prioritise the use of abandoned buildings or areas located within the urban sites, favouring processes that increase the density of the existing fabric (i.e., art. 12, subsection 7). Only on a conditional basis, the new location should be planned in areas identified as prone to urban development by the city planning regulations in force or, in the absence of provision, in new areas adjacent to or continuing the existing urban fabrics.

The plans should also involve city-planning incentives and reward measures to promote the prompt implementation of the interventions. In addition, the reconstruction plans should fully engage all private parties involved in ensuring the effectiveness of the relocation work, either through compensatory agreements under the regional legislation in force or by demonstrating the provision of the financial resources required to complete the work within the validity term of the expropriation agreement. In the same way, whenever UMIs, intended as urban planning factors to be integrated into the plan, are identified and formulated, as well as on occasion significant changes address the urban morphology, city planning frameworks, or new significant investment projects are identified, the reconstruction plans should establish the project-based and regulatory aspects of the urban implementation plan (e.g., structural systems, overall project dimensions, the most appropriate project characteristics, and every other detailed regulation) in order for construction to begin immediately with direct interventions. This is an intentional, systemic position made by the legislation to ensure the immediate feasibility of the reconstruction, without any need for further steps, through operational planning.

The reconstruction plan stands out as the city planning tool requisite to imagine and design the reconstruction in the long term. It addresses the issue of regenerating consolidated urban areas, revitalising historic urban areas and their relationship with the new polarities that emerged in response to the earthquake, and the need to reallocate public functions and temporary housing. As a result, the Emilia-Romagna governance entrusts significant goals and tasks to the regional reconstruction plan. Though, this framework and the set of goals that the Emilia-Romagna governance sought to establish have a significant impact on national legislation and financial contributions for reconstruction, which are all based on the axiom of "as it was, where it was" and do not take advantage of opportunities for regenerative processes, potentially weakening the provisions of regional laws. In this regard, the set of decrees passed by the President of the region, serving in the capacity of deputy commissioner for reconstruction, and the amended guideline of the stability law (i.e., Law n.147 December 27, 2013) provide a few options in the direction of the regional law.

The municipalities in the crater area thus had the opportunity to design an organic plan to restore the conditions of daily life, resume economic activity, and reduce vulnerability at both the building scale -single or in aggregate- and the urban scale. Within the plan, it was possible to articulate the funds set aside by the national legislation for reconstruction, also allocating resources to the acquisition of building areas essential for the relocation of damaged buildings that could not be rebuilt on the same site or for the reconstruction of damaged properties that the owners did not intend to repair. The regional governance strengthened this new perspective with the financial decree n. December 28 20, 2013, which determined that, in order to

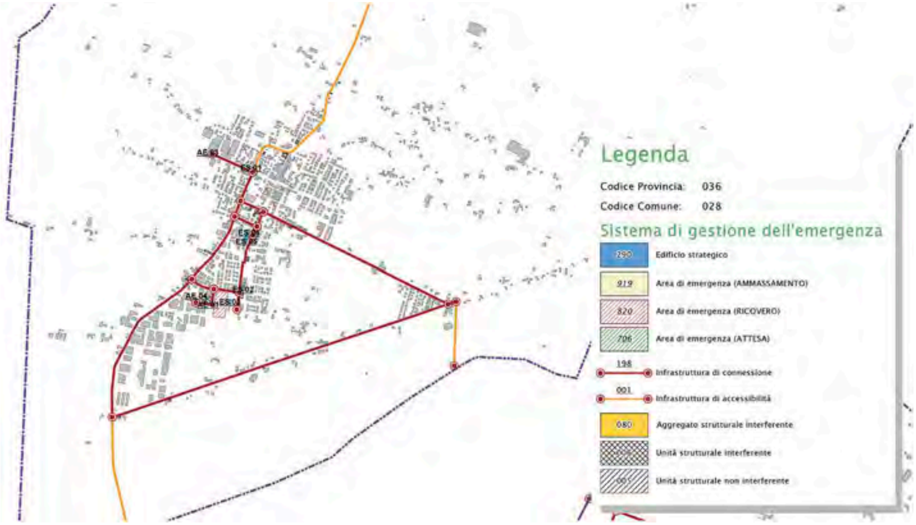

Figure 6. Novi di Modena, classification of elements belonging to the emergency framework addressed by the urban settlement's limit condition for emergency.

Figure 7. Concordia sulla Secchia, Modena. Definition of the Minimum Intervention Units (i.e., U.M. I.); in red the results of the inagibility assessment according to the AeDES methodology.

promote the reconstruction of historic centres and sites hit by the earthquake on May 20 and 29, 2012, the reconstruction plan takes on the contents and produces the effects of an urban redevelopment program (i.e., art. 37 subparagraph 1).

In accordance with Ordinance n.60 of May 27, 2013, most earthquake-affected municipalities developed the reconstruction plans in several sections, addressing their contents in an improvement process that allowed the most urgent projects to be promptly launched while adopting the most suitable solutions for the more complex ones. As a result, the first issues that all the towns had to deal with were the damage to the structures and the revision of the constraints of the urban planning instruments in force. Backed by the AeDES assessment survey reports, it was feasible to generate damage maps that reflect the damage degree of all the buildings and support the analysis of the amount of damage present in all the plans and the identification of the practicability findings. In order to direct the reconstruction interventions and promote urban planning options linked to the reconstruction plans, taking into due consideration what happened and implementing seismic risk mitigation strategies, it was necessary to prepare seismic microzonation for the identification of the areas subject to greater amplification and soil liquefaction, as well as the classification of elements belonging to the emergency framework addressed by the urban settlement's limit condition for emergency (i.e., CLE) intended as the point at which, in the wake of a seismic event, even in the face of physical and functional damage, each urban settlement resumes to operate most of the strategic functions for emergency management (i.e., Ordinance n.4007 of the President of the Council of Ministers, February 29, 2012). These subjects are integrated into the reconstruction plans by introducing the topics of safety and sustainability in the urban planning instruments. However, municipalities that did not need to draw up the reconstruction plan adapted their urban planning tools so that actions were taken to reduce the seismic risk in the entire area of the seismic crater, albeit with different timescales.

4 DISCUSSION

The topic of reconstruction following catastrophic events has found the interest of researchers for many years since it became clear that there are critical limits to the capacity to reduce the damage resulting from various extreme phenomena drastically.

As part of the assessment and management of natural risks, it is necessary to rethink prevention policies for the entire disasters cycle, including the response to the emergency and that necessary first to start and then conclude the reconstruction processes, as endorsed by the Sendai Framework for Disaster Risk Reduction 2015-2030 which constitutes the guideline of all the United Nations countries that have signed it. The occasion offered by the "After the Damages" project helps bring the reconstruction topic to the centre of the attention of experts, highlighting the most up-to-date decision support models to prepare plans before the calamitous event occurs, representing a guide and a canvas for action. The present paper intended to highlight that each reconstruction was considered a case in itself. Models and intervention schemes were planned as if past experience had taught almost nothing each time.

This is evident in the experience of a country which, like Italy, has unfortunately experienced many disasters events in the last 50 years, including several earthquakes, from Belice, Friuli, Irpinia, L'Aquila to Emilia, without forgetting those that struck in the recent past, in 1979 and 1997, in Umbria and the Marche, both part of the area affected by the seismic sequence of August 2016 in Central Italy.

On the one hand, each event indeed has unique and peculiar characteristics specific to the context in which the phenomenon occurs, both in terms of the seismic force and the response methods of the affected territory); on the other hand, as experience and literature teaches, there are many constant elements of similarity, even between areas that are very different from each other both culturally, economically, and politically. A look at these invariants provides the basis for developing intervention models to avoid contradictory programs, which always start from scratch, with robust political interference whose goal is not is not the construction of collective choices, but a tool to obtain electoral consensus and use the tragic event as a showcase to exhibit the ability to channel resources to the affected territories.

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Part 3

Multiscale application and simulation Workshop

Built Heritage in post-Disaster Scenarios – Balzani et al. (Eds)

Knowledge for conservation. Methods and technologies to preserve the cultural heritage

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ABSTRACT: Heritage takes on various forms, whether tangibles like locations, buildings, and landscapes or intangibles like memories, emotions, beliefs and practices. Nowadays, digital documenting of cultural assets is critical for heritage research, preservation, documentation and distribution with diverse experts in the area and beyond.

The purpose of this work is to analyze and compare different case studies from around the world to propose various strategies for preserving and enhancing an architectural heritage that is much too frequently abandoned and left to deteriorate due to natural and cultural harm.

Keywords: Documentation, Virtual Tour, Augmented Reality, BIM, Reconstruction

1 INTRODUCTION

The national heritage and identity of a country are representative structures of the past that must be preserved and disclosed, which is why it would be interesting to analyze and document their historical evolution. But, on the other hand, to identify methods for preserving and disseminating them, both through the use of traditional methodologies and cutting-edge technology.

It is possible to know the past and our heritage through the classic analysis of historical archives documents and through new methods such as Virtual Tours to navigate and observe the site, BIM containing historical information of the building, 3D models. All mentioned tools and techniques represent the virtual reconstructions of ancient aspects and augmented realities to spread the knowledge of the heritage to people with different levels of expertise, thereby increasing the integration of citizens. Thus, in this research, we did bring different methodology of documentation, maintenance, valorization and dissemination used by various countries to preserve heritage and present it to the world.

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DOI: 10.1201/9781003253730-35

2 THE IMPORTANCE OF HISTORICAL SOURCES

The knowledge of a building, likewise the relief and representation, is an essential prerequisite for any conservation intervention (Lombardini, Cavalleri and Achille, 2010). Starting from a historical and archival analysis and on-site surveys, it's possible to know the techniques and materials used for the construction of historical buildings in order to plan maintenance and ensure their conservation over time. This is the methodology at the basis of a complex research about constructions with reinforced concrete floors built in Salerno at the beginning of XX century (Department of Civil Engineering, University of Salerno, Italy).

The study of ancient books and theoretical and practical manuals of premodern treatise together with laws and archive materials have allowed a short historic excursus about the reinforced concrete development, from the origins to the most recent prestressing technique, and an exhaustive classification, description and analysis of the main floor patents with a reinforced concrete structure, beginning with the solid slab ones, passing through the ribbed slab ones up to the bricked ones, mainly the "special" types, realized using the diffusers in glass, pumice or other materials.

Very interesting is the usage of the first patents (Cannovale e Dellepiane floors, Stimip, Hulhanec e Leemann, Zeni and Provera types and others) to realize reinforced concrete floors in the most important Salerno buildings, for example the "Torquato Tasso" Gymnasium (Ribera and Del Regno, 2012). The results of this study have been summarized in some graphs and schedules with all the types of elements found in the Salerno local area, making a comparison (light, height and interaxial distance): this is an archive easy to be consulted and updated.

Figure 1. A photo and an archival document – "Torquato Tasso" Gymnasium (1932), Salerno, Italy.

The research focused also on reinforced concrete floors' weaknesses, due to technologic and building lacks, and the possible deterioration elements in order to suggest some ways to rescue.

By applying this approach on a large scale it's also possible to document the main techniques used to rescue the reinforced concrete slabs, describing the operative modalities in order to find out the most suitable ones for the preservation of the elements' authenticity and respect of their originality.

3 VIRTUAL TOUR FOR THE KNOWLEDGE OF REMOTE SITES

The possibility of traveling and getting to know sites in various parts of the world today is easy to achieve thanks to the creation of Virtual Tours (VT) that allow people to visit monuments even remotely, virtually "walking" through the sites of interest and often correlating the visit with historical and/or technical information. In the era of the pandemic caused by COVID-19 and as consequences of the quarantine, which has limited movement and travel, interest in digitization and VT has increased more and more, bringing people closer to this innovative way of enjoying spaces (El-Said, 2021).

The possibility, in fact, to share on the Internet ensures the enjoyment of sites even remotely, allowing to live experiences in various parts of the world and to increase interest in fascinating places on our territory, often also lesser-known. Although it is impossible to replace live visits, these tours are very effective for the dissemination and knowledge of heritage. In fact, in recent years, many museums have adopted this technology to encourage visits, allowing them to observe their collections from anywhere in the world (Carvajal, Morita and Bilmes, 2020). An additional advantage of such technology is the great accessibility that they can guarantee, allowing any person (even those with disabilities) to access and visit places in various parts of our territory.

In this way, moreover, it is not only possible to document the tangible aspect of heritage, such as structures or monuments, but also to archive information of various kinds such as historical and cultural information (Ping Mah et al., 2019). Therefore, the attention in addition to the single building is direct to the entire site, allowing, to an increasingly wide audience, to live exciting experiences.

The realization of a VT is particularly suitable for the study and dissemination of the defence system of the coastal province of Salerno, particularly for the one that arose in the 16th century with the Spanish viceroyal dynasty (Figure 1). The foundations of this system have ancient origins, the necessity of the province of Salerno to defend itself from the continuous attacks by sea brought to the birth first of towers displaced discontinuously on the coast and later of actual defensive plans (Morena and Talenti, 2019). The intent was to ensure a visual connection between different towers to signal the attacks, as well as, to provide a strategic location for sighting. In order to spread the knowledge of the defensive system, therefore, it is necessary not to focus the attention only on the single building but on the entire strategy that led to the realization of the project. In fact, knowing how the towers were conceived and used allows a better understanding of the cultural value of the site (Champions, 2018). Although the "network of gazes" turns out to be one of the most important aspects of the defensive system, it is still little known today (especially to the less experienced public) and certainly one of the most complex information to convey. Based on the studies conducted on

Figure 2. Panoramic photo of the Tower of Paestum and the index panel.

the ancient cartography written in 1613 by Nicola Antonio Stigliola (1546-1623) and by Mario Cartaro (1540-1620), it was possible to identify the existing visual connections between the towers of the defensive system and to create a comparison between the connections once existing and those remaining. Of the 111 towers planned along the coasts of the province of Salerno, about half are in a good state of preservation, while the remainder have disappeared or are in a state of abandonment.

The application phase involved a series of acquisitions near the towers, taking 360° photos (and working in HDR to solve overexposure and underexposure of the images) through the Panoramic head instruments (Department of Civil Engineering, University of Salerno, Italy). The shots captured in this way were combined with appropriate software in order to guarantee the return of high-definition panoramic images.

Finally, the virtual tour was created, correlating the panoramic photos of additional information panels. The possibility to create a VT among the various towers located along the Salerno coasts would allow us to restore, albeit virtually, the visual connections that existed between towers. correlating it with additional information (animations, panels, historical photos, archival documents etc.) necessary to comprehend the strategy behind the defensive plan.

4 A PROJECT TO REVEAL THE HIDDEN CULTURAL HERITAGE

The new technologies based on virtual and augmented reality make it possible to bring to light the historical and cultural heritage that has changed over time or, as in the case treated in this chapter, no longer visible due to the urban transformations that have taken place over the centuries. . Today computer graphics offer a huge contribution to the discovery of those places that are not easily accessible and that, in order to be visited, would require radical transformations of the surrounding urban fabric. The 2018 project entitled "Pd-Invisible PaDova INnovative VISions - visualizations and Imaginings Behind the city Learning", financed by a European social fund and made possible by the work carried out by the Department of Cultural Heritage and the Department of Civil, Construction and Environmental Engineering of the University of Padua, is an ambitious project whose main objective is to develop an application of augmented reality to visualize the archaeological remains present in the Padua area hidden by the stratifications of the city over the centuries.

Augmented reality allows users to view artefacts "in situ" through the screen of their mobile device. The first phase of the project involved the active participation of the Department of Cultural Heritage in the consultation of documents and historical photographs of Roman Padua.

The State Archives of Padua, the Altinate San Gaetano Cultural Center, the Superintendency and the Civic Museums at the Eremitani were involved and gave access to the material in their possession (Carraro ed al. 2019). The research group, on the basis of the documents acquired, has selected the most important archaeological artefacts of the Roman age present in the area such as the Arena, the remains of the walls, the necropolis, Ponte San Lorenzo, Ponte Altinate and the Zairo Theater and uploaded their spatial coordinates in a database for the elaboration of a GIS map (necessary element for the App to guide the user within the city). In the second phase, the laser scanning and (in some cases) photogrammetric survey of the artifacts was performed. Particular attention was given to the remains of Ponte Altinate and Ponte San Lorenzo. Ponte San Lorenzo is in a fairly good state of conservation and consists of three arches below street level accessible by an underpass; thanks to the easy access, both the laser scanning survey and the photogrammetric survey took place.

The laser scanning survey allowed the creation of the BIM model of the building, useful for cataloging the bridge elements, as well as for identifying critical issues and the state of decay (Bonetto te al. 2019). Two photogrammetric surveys; one performed with a reflex camera and the other performed with two Go-Pro 5.0, made it possible to structure a workflow to obtain correct management of the photorealistic 3D model for viewing in AR. The fourth phase concerns the optimization of the models generated by the point clouds, the conversion of complex meshes into

Figure 3. Ponte Altinate displayed in augmented reality - Riviera Ponti Romani, Padua Italy.

simple meshes and the restitution of the level of detail by means of the "baking" - process aimed at transferring the level of detail of the complex object (complex mesh) on the simple object (simple mesh) - indispensable for a fluid visualization of the models (Perticarini et al. 2020).

The fifth phase involved the creation of the App, developed in Unity and which contains the GIS map, all the technical and historical information acquired during the preliminary research, the BIM models that can be interrogated by the user and the photorealistic models that can be viewed both in remote, and "in situ" using augmented reality.

This type of project, aimed at the enhancement of cultural heritage, triggers a process of discovery of the city and forgotten places; a transversal process that involves the enhancement of the urban center, intended as a landscape and not just as an urbanized place.

The GIS map, in which the artifacts are indicated, guides the user through the streets of the city and allows the discovery of different corners and views.

Therefore, technology, in addition to showing virtual and actually intangible objects, favors the rediscovery of a real and tangible environment that otherwise risks being forgotten (Figure 3).

5 BIM TOOLS AND HERITAGE CONSERVATION

Building Information Modeling (BIM) is a relatively new technique that is rapidly gaining traction in architecture, Engineering, and Construction. It enables the Assembly of virtual architectural models associated with numerical data, text, pictures, and other kinds of data (Pocobelli et al. 2018). Nowadays, architects have to think about restoring cultural heritage and becoming an essential subject rather than constructing new structures; as well as, all individuals engaged in the building process may renew their methods of operation through the BIM concept (Del Giudice, Osello, and Sciences 2013).

Erbil. One of the largest cities in northern Iraq, it is located approximately 350 kilometres (220 miles) north of Baghdad. The latitude of Erbil, Iraq, is 36.191113, and the longitude is 44.009167. Erbil city located in Iraq country, the Cities place category with GPS coordinates of 36° 11′ 28.0068″ N and 44° 0′ 33.0012″ E. The city of Erbil has a long history. The city of Erbil had a great civilization; it has a tradition comparable to rich history countries. Erbil stands as the best example of this ancient cultural tradition in the Kurdistan region in Iraq.

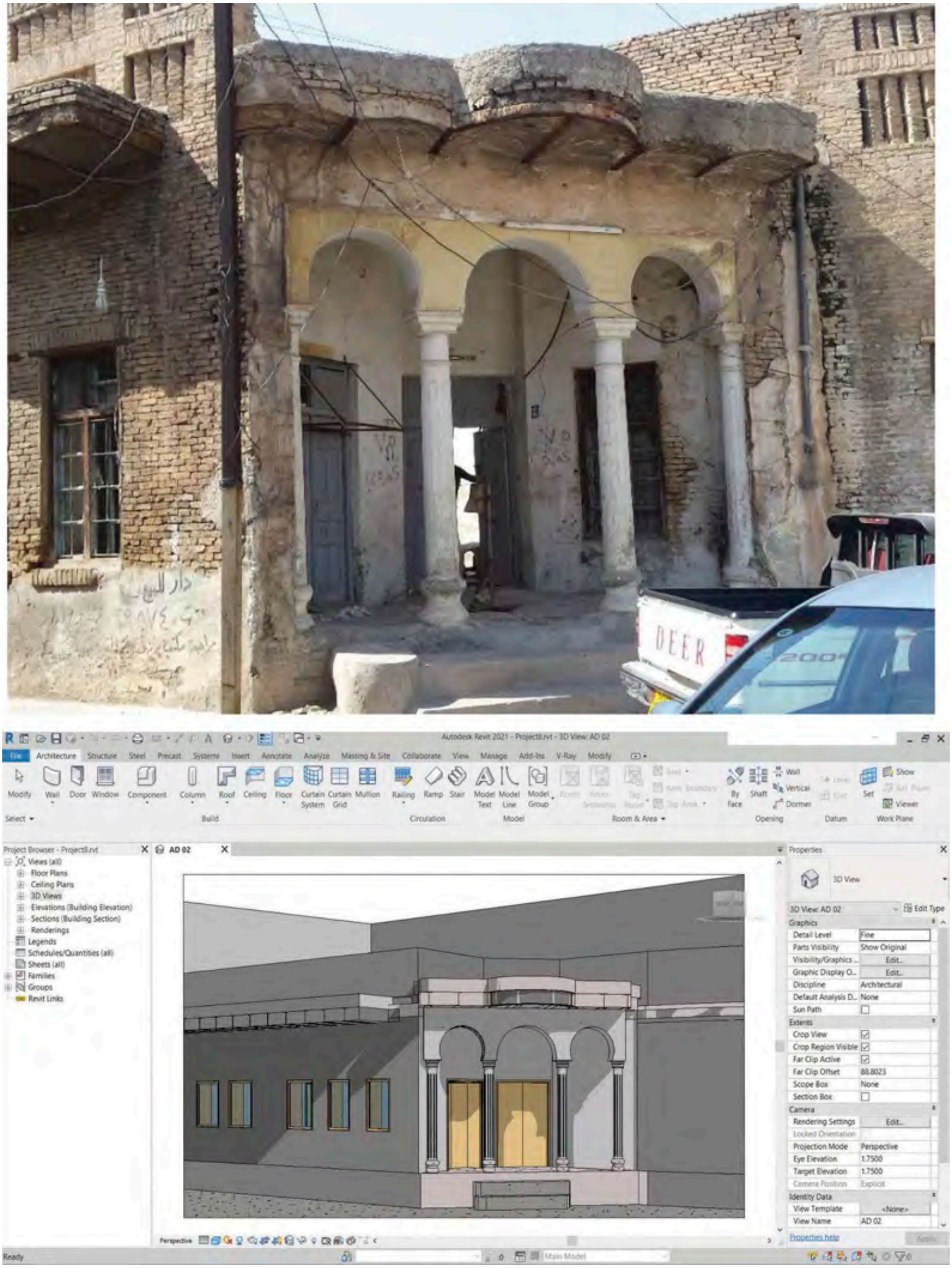

Figure 4 . Realistic view and 3D model for a traditional house located in Erbil, Iraq, created by BIM.

This city is one of the earliest inhabited settlements, in the middle of Erbil city, indicating the old citadel of Erbil that was built more than 6,000 years ago. Around the old citadel, there are two critical areas selected as buffer zone A and B. The mentioned area around the ancient places can create new life in the middle part of Erbil city (Abbas 2017).

From 2015 academic group, most of the members consisted of engineers and architects started by measurement, surveying and photographing the main parts of mentioned places;

the results of the work used for articles, master theses and PhD dissertations, the work covered by Tishk International University, From Iraq, Hasselt University in Belgium, Near East University, and Cyprus International University from Cyprus (Jawhar 2018).

The group made interviews at various levels, including ordinary, moderate, and expert, and then used photographs of the old citadel with the most significant places in ancient places and Buffer Zone A and B around the historical parts. Unfortunately, The primary issue of mentioned places is facing them by neglecting the relevant institutions; the group did the recording and archiving to preserve the main important heritage places inside the city. Recording data provided an excellent effort for the old city, and it protects the remains of ancient areas in the city from permanent destruction.

To encapsulate the topic, After surveying, the group started to collect vast amounts of pictures, references and notes and then collect data used inside MicroStation and AutoCAD software to create 2D details and generate accurate plans, elevations, and sections.

Based on 2D drawings and assembled data, Autodesk Revit utilized the advanced BIM software to recreate popular places in 3D form. Authors used the 3D model to perform modern techniques; most 3D forms used to generate modern analysis by the advanced method inside BIM software. On the left side of Figure 4, there is a real photo for the case study in the Arab district in Erbil city. On the right side of the exact figure, the computer model of the same building is illustrated inside the BIM application.

6 HERITAGE CONSERVATION AND ITS IMPACT ON SOCIAL LIFE

With the new technologies and the development of BIM, which is shown in the latest research, the virtual technique presents the heritage of a country to the world more efficiently and in detail. However, built and urban heritage can also contribute to the development of a country in different environmental, social and economic aspects. Rehabilitation of heritage can be direct (targeting the building) or indirect (targeting its infrastructure and landscape). For this approach, research was made on the rehabilitation of an old public square in the city of Fes in Morocco, the public place of Lalla Yeddouna.

First of all, the indirect rehabilitation technique, the Lalla Yeddouna project aims to relaunch the handicraft sector, reconstruct the Square, a strategic space in the old Medina. This site transformed into spaces dedicated to artisans, shops, educational cycles, restaurants, and cafes with spaces including residences to develop the craft sector. After its inauguration at the end of 2019, the Lalla Yeddouna Square became a dynamic urban centre with mixed uses that benefit residents and visitors of Medina. This large-scale project began in 2014 to boost economic activity through the enhancement of heritage by targeting the sectors of crafts, tourism, and cultural activities. The project focused on the square's buildings, residents, and infrastructure.

Previously, Lalla Yeddouna was in a very advanced state of disrepair. The craftsmen working in very precarious conditions led to a decrease in visits from tourists and locals due to its state of pollution and construction. The adopted architectural proposal sets up a variety of workshop-houses for local artisans. It creates an interconnected urban model which, with the relocation of the polluting activities of the tanneries located in the old medina, the water of the river located in the centre of the Place Lalla Yeddouna Square will regain its natural beauty.

Secondly, for the direct rehabilitation, it consists in intervening on the heritage, inspired by using vernacular architecture, the model adopted for the design of the courtyards and buildings constructed with local materials to improve the thermal mass, thus offering protection against the hot climate of the city. Its facades optimised to maximise passive cooling clad in the age-old local tiling technique. Still, its pattern brings a modern touch to the decorations and highlights the traditional craftsmanship.

The distinctive colour of each courtyard gives a sense of place in each block and provides a landmark for navigation (Figure 5).

Finally, these heritage rehabilitation techniques improve the condition of the heritage and be a significant factor in the city's economy by improving the place. Shops and handicraft facilities have been added, which increase work opportunities and attract tourists in large masses worldwide.

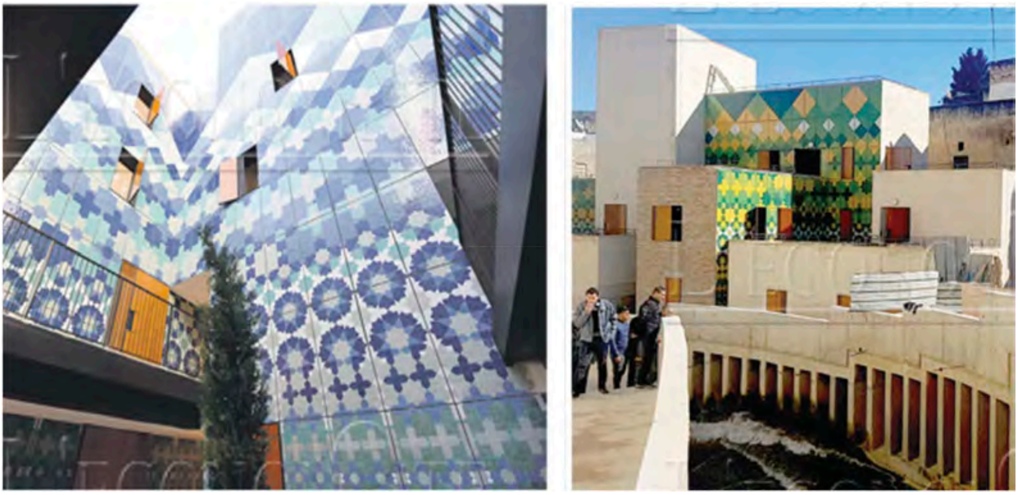

Figure 5. Panoramic photo of the Tower of Paestum and the index panel.

7 DISCUSSION

The collaboration between professional engineers and architects expert in conservation and preservation of built heritage has made possible a small collection of some of the main strategies currently applicable in the historical and architectural area: historical documentation, virtual tour, three-dimensional reconstructions and design hypotheses of buildings or spaces.

The study and analysis of our roots are critical to preserving our culture; indeed, it is only through an appreciation of the past and the history of civilizations in every part of the world that we can foster respect and dialogue between diverse cultures.

AUTHORS CONTRIBUTION

This paper is the result of a collective effort. During the International Summer school After the Damages the various components of The Roots group had the possibility to collaborate and discuss. For this paper the drafting of the sections “The importance of historical sources” is attributable to Rossella Del Regno; the section “Virtual Tour for the knowledge of remote sites” is attributable to Sara Morena; the sections “A project to reveal the hidden Cultural Heritage” to Maurizio Perticarini; the sections “BIM tools and Heritage Conservation” to Shad Sherzad Jawhar and, finally the section “Heritage conservation and its impact on social life” to Zineb Megouar. The introduction and discussion are collective.

ACKNOWLEDGMENTS

The Roots group would like to extend the best wishes to the organizers of After the Damages and express special thanks to Dr Alessandro Camiz, who supported the group as supervisor.

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Built Heritage in post-Disaster Scenarios – Balzani et al. (Eds)

Team-driven documentation of civil structures

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ABSTRACT: This paper explores precedents in Amatrice and Padua as a point of departure for an ideal documentation and survey project for the Circumetnea, a minor Sicilian railway system. This transportation network includes several bridges due for structural review, offering an opportunity to apply best practices informed by an interdisciplinary lens through which to explore the history of the circuit's construction, its structural behavior and potential cultural value for local stakeholders and visitors alike.

Keywords: Cultural heritage enhancement, documentation, H-BIM, prevention, slow mobility

1 INTRODUCTION

Recognizing the resounding importance of civil structures, a team of authors from different backgrounds share their experiences in the field of documentation and conservation of cultural heritage. This analysis evaluates the weaknesses of salient precedents to propose best practices in Heritage-Building Information Modeling (H-BIM) and to highlight the quiescent potential of collecting and managing data and documents. This approach advocates for the development of shared knowledge repositories and the collation of interdisciplinary findings which share the same landmark or territory as their focus. By digitally centralizing documents and studies, generations of calculations, images and findings could bolster prevention, restoration, and enhancement strategies, rendering cultural heritage more relevant to a broader range of stakeholders.

This multifaceted paper considers the case study of a minor Sicilian railway system, called Ferrovia Circumetnea (FCE) (Figure 1a), which has circumnavigated long tracts around Mount Etna since 1895. This route is a narrow-gauge, regional railway that connects Catania to Riposto, passing through several towns on the volcano's slopes. Due to its architectural, structural, historical, and cultural implications, the Circumetnea railway is an opportunity to foster both disaster mitigation and heritage enhancement strategies. Furthermore, multiple natural hazards characterize the geographical location of the Circumetnea railway, such as the

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DOI: 10.1201/9781003253730-36

Figure 1. On the left, circumetnea railcar with mount Etna in the background (Source: Web-1); on the right, Giacinto Platania, fresco of Etna's 1669 eruption seen from Catania, located in the vestry of Catania's cathedral. (Source: Web-2).

high seismic risk of Sicily's northeastern tip and the additional uncertainty of Europe's largest volcano. For example, a painting in Catania's cathedral recalls how lava flows reached the city walls and the Ionian coast in the 1669 eruption (Figure 1b). This image documents a wide-scale disaster and hints at the underexplored connections between documentation, disaster planning and heritage enhancement.

To leverage past experience, the first half of the paper will present two case studies: (1) Amatrice as a worst-case scenario regarding the lack of structural documentation regarding the town's civic tower in the aftermath of a series of devastating earthquakes and (2) PD-Invisible, an interdisciplinary research project for Padua's San Lorenzo Bridge which employed Heritage/ Historic Building Information Modeling (H-BIM). The latter project produced a formidable Augmented Reality (AR) tool yet discarded interdisciplinary findings which could one-day prove vital. The second half of the paper focuses on the Sicilian train route and introduces ongoing research about its masonry bridges. Converging models then set the foundation for an H-BIM platform in which experts can record data, collect documentation and research about the Circumetnea railway, thus monitoring, preserving, and bolstering the cutting-edge potential of Etna's heritage and its potential resources.

2 RECURRING SEISMIC DAMAGES

2.1 *After the damages: Amatrice's Civic Tower*

In 2016-2017, a series of devastating earthquakes hit the regions of Lazio, Marche, Umbria and Abruzzo in the central area of Italy, one of the most seismically active zones of southern Europe. The seismic events occurred on August 24, October 26, and October 30, 2016, and January 18, 2017, causing 299 casualties and severe damage to residential buildings and historic monuments (Figure 2). The first shock, occurred on August 24, 2016, with epicenter close to Accumoli and Amatrice (in the province of Rieti, Lazio) and magnitude Mw = 6.2, had a very destructive impact on these small medieval towns due to the almost total collapse of their built heritage. Focusing on Amatrice municipality, the historical center was generally destroyed: three historical masonry towers (the Civic Tower and the bell towers of Sant'Emidio's and Sant'Agostino's churches) and few new buildings remained damaged, but still standing after the first shock. Since then, provisional safety interventions have been implemented on the damaged structures by the Civil Protection Department and the Department of Firefighters in order to preserve the structural integrity in the face of possible seismic events before the onset of definitive restoration interventions. Debris- clearing operations have been arranged, recoverable elements have been selected and stored in specific depots awaiting a reflection on their use in reconstruction plans.

Figure 2. The Civic Tower of Amatrice in 2008 (left), 2017 (center) and 2018 (right). (Photographers: Francesco Gangemi, Francescco Gangemi and Enrico Fontolan; Source: Francesco Gangemi, Rossana Torlontano and Valentina Valerio in collaboration with the Photographic Collection, Focus on Amatrice, Bibliotheca Hertziana – Max Planck Institute for Art History, 2020. Source: Web-3).

At the same time, many experts have carried out studies (Poiani et al., 2018; Jain et al., 2020) regarding the structural response shown by the damaged buildings during the seismic sequence, so as to identify vulnerable points in the structure and give useful hints for the reconstruction plans. In order to fully understand the structural behavior of a building, studies aimed at reconstruction purposes should be based ideally on a significant amount of information dealing with several aspects of the building, from its geometry and constituent materials to its history and architectural features. In the case of buildings located in seismic zones, data availability plays a paradigmatic role for a successful reconstruction plan.

For instance, access to a building's reliable geometrical survey is a key component for any further investigation, such as the realization of models for sophisticated structural-numerical simulations. Consequently, the importance of digitized information appears quite evident as a "digital twin" of physical materials can safeguard information lost through collapse mechanisms and other disaster-related damage. Vice versa, physical documents in their original form "back up" digitized information, a body of knowledge that has its own, rather underestimated conservation concerns relating, but not limited to calamities. Focusing on the engineering research activity carried out on the medieval Civic Tower in Amatrice after the 2016-2017 seismic events, very little data and few documents of engineering interest were found, despite the tower's strategic position at the intersection of the two main streets of the town, namely Via Roma and Corso Umberto I, and its role as one of the most important historic symbols of Amatrice's city center. Due to the lack of technical information, it was necessary to formulate some assumptions in order to characterize the tower from an engineering point of view and to realize a numerical model for computer-aided seismic simulations (Figure 3): the geometry of the building was deduced from photographic evidence gathered before the earthquakes. The material properties were hypothesized by comparing masonry fragments with the mechanical properties proposed by the Italian Building Code. Due to the lack of technical documentation from restoration work carried out on the tower in the 1980's, the reinforcement intervention was modelled in a rather simplified way. Nonetheless, this reinforcement was decisive in limiting damage and preventing the tower's total collapse.

In the engineering activity, the lack of technical information about existing buildings of historic interest is quite common, and this situation is often overcome through hypothesis- based approaches. In this sense, buildings located in seismic areas provide an interesting opportunity for the scientific community to understand the causes of seismic vulnerability of the buildings and to confirm hypotheses developed in the computer-modelling phase. Indeed, seismically damaged buildings provide the opportunity to compare numerical results obtained from computer-aided simulations with the structural behavior observed after a seismic event. In this scenario, photographic documentation is essential not only to narrate a town's past and seismically damaged present, but also as a valuable source of information which may support architects and engineers in faster and more precise reconstruction projects.

Figure 3. 3D Finite Element model of the Civic Tower (Source: Magrinelli E.).

2.2 *Recording the past, planning the future*

Through the absence of historical documentation, one recognizes the importance of merged data and documentation like that brought forth in the 2020 online exhibition Focus on Amatrice. Earthquakes and photography—recording the past, planning the future (Figure 2; Web-3). This project converged the Photographic Collection of Rome's Biblioteca Hertziana with art historical research conducted at US and Italian universities. Moreover, these studies were conducted with scientific and technical support from territorial authorities at the national Ministry of Culture. Using an easily consultable webpage, the team curated a selection of photographs dedicated to local monuments, including Amatrice's civic tower. The photographic evidence attests to safeguarding efforts spanning from 1908 to 2018 in a digital catalogue dedicated to local heritage, seismic activity and the history of the recent disaster. The value of this documentation and research becomes self- evident in hindsight, spurring the preemptive need for such interdisciplinary collaboration and shared tools in routine structural maintenance and disaster planning and mitigation.

2.3 *Untapped potential: The technological enhancement of Padua's San Lorenzo bridge*

PD-Invisibile is an interdisciplinary project carried out in 2018-2019 by the Department of Cultural Heritage and the Department of Civil, Environmental and Architectural Engineering of the University of Padua. A team of archaeologists, architectural engineers and architects collaborated, with different knowledge sets, to give new strength and "make visible once more" the great heritage of the Roman Age Padua, hidden and partially destroyed due to the city's growth over the centuries (Bonetto et al., 2019). The original aim was to create an AR app for mobile devices with a broad range of data capable of showing various outcomes and information depending on the audiences' broad range of desires and intents. The target had to be wide, to include not only tourists and a general public but also specialists from different professional fields.

This multidisciplinary approach gave life to a complete project based on both technical and cultural points of view. Research was divided into two main phases as suggested by the ideal methodology, largely discussed in literature. The cognitive phase gave important indications on artefacts regarding their geometric configuration and the relationship with the pre-existing structures. It is ideally accompanied by documentary and archival research, while being integrated with digital surveys executed with TLS and SFM technologies. The Information Modelling phase aimed at creating parametric components filled with data in order to create H-BIMs stating form surveys. The cognitive phase of PD-Invisible regarded general data collection: archival and documentary research, a precise detection of archaeological remains and the selection of some interesting key points on the maps of the city, the inspection when possible and the geometrical survey with both laser scanner and photogrammetry, other survey methods of diagnostic and non-destructive tests on the structures. At first sight, San Lorenzo Bridge offered the possibility to explore each of the aspects listed above. It is a Roman bridge,

Figure 4. BIM informative and parametric model on the left, visually accurate 3D model with texture on the right. Both are representations of San Lorenzo Bridge. (Source: Callegaro C. and the PD-Invisible team).

located in a narrow, yet accessible chamber under Riviera dei Ponti Romani, a street with a corresponding tram line. The geometrical surveys, executed through laser scanning and photogrammetry, were carried out in the early stage of the research. This process led up to the structure's digital clone with a high level of accuracy and details, colored textures and materials, that provide a solid base for the development of the desired 3D model repository of the knowledge (Figure 4). As the research progressed, it became clear however, that the original aim of a complete and complex project was nearly impossible. The BIM model was put aside at an early stage to give more attention to the realistic model: this choice was driven by the lack of information and time. The best solution was to create a simple AR app showing a visually pleasant reconstruction of the bridge with few details about the structural elements and some historical images with short descriptions. Ultimately, one of the greatest obstacles was the difficulty in obtaining permission to access and use archival documents. Therefore, the team shifted focus; the visual deliverable became PD-Invisible's new emphasis. The historical research ceded precedence in favor of the project's relevance for tourism.

The need for greater coordination is another lesson learned. To maximize the potential of the project's human resources and scientific know-how, the team lacked the time to develop shared strategies to achieve each partner's objectives. Ultimately, short-cut planning led to a lack of interdisciplinary dialogue and the loss of important data regarding the history and physical structure of San Lorenzo Bridge.

3 PROPOSAL FOR A KNOWLEDGE-BASED APPROACH

3.1 *The Circumetnea's masonry bridges*

With the railway's advent, straddling the 19th and 20th centuries, masonry arch bridge design and construction experienced a great boom; railways deeply transformed the territory and marked the landscape with valuable civil structures. Over the years, the value of these assets has increased, despite the widespread neglect that often characterizes them. A strategy for their expeditious health monitoring is needed in order to preserve masonry arch bridges and mitigate potential damage identified by several vulnerability assessments. As Italian guidelines for monitoring and management of existing bridges (MIT, 2020) suggest, the knowledge of these structures is a crucial step in the comprehensive approach to understanding the constructions' behavior. Over time, several approaches for defining protocols and methodologies have called for the creation of informative models that integrated grained and heterogeneous information. While bridges and buildings have similar features, they differ significantly in terms of construction, operation, and classification of parts; this distinction leads to the rise of Bridge Information Modeling (BrIM) (Costin, 2016), an extension of BIM that helps manage data through the life-cycle specific of bridges and facilitates collaboration and interoperability between a variety of stakeholders. Furthermore, consolidated pipelines are designed around concrete or metal bridges, yet there is an increasing interest in masonry bridges as well. These require a more enhancement-oriented approach. With this target, Circumetnea railway masonry arch bridges are an ideal case study. These bridges are characterized by heterogeneous typologies (number of arches, materials, geometry). Furthermore, it is an endangered heritage in the face of changing road requirements and due to the modernization of the train line. The methodology followed in Circumetnea's bridges study is structured following the well-known procedure illustrated in the case of Padua's San Lorenzo Bridge, with a comprehensive cognitive phase succeeded by an information modelling phase (Garozzo, 2021). The first step involved in-depth documentary research at the State Archives of Catania and the FCE archives. This phase yielded original drawings and documents dating back to the Circumetnea's construction. This key documentation enabled the investigation of unknown technological features and a better understanding of the entire project (Garozzo et al. 2021). Coupled with that, a digital survey campaign was conducted. The integration of laser scanning, photogrammetry (ground and drone-assisted) and videogrammetry was required due to the peculiarities of the under-investigation case studies (Figure 5).

A total of 37 bridges were identified along the route, 11 of which were surveyed using the above-mentioned techniques. The in-development scan-to-BIM process considers several aspects. When bridges are modelled as accurate triangulated surface meshes and then converted in the interoperability standard IFC, this process preserves the geometric peculiarities of bridges (Sánchez Rodríguez et al., 2020), but parametric modelling (León-Robles et al., 2019) offers a more comprehensive approach as it enables the management of both geometrical and information assets. In this direction, the next step in this research foresees coalescing this type of models within a infrastructure BIM platform so as to contextualize the bridges in the Circumetnea and allow for a holistic analysis of the whole railway system.

3.2 *Merging domain expertise with the inherent values of Etna's cultural landscape*

This Sicilian railway finds itself before an important opportunity in light of its recent revision, the University of Catania's ongoing structural studies and BIM-models dedicated to the bridges' building techniques, structures, behavior and state of conservation. In tandem with these studies and measurements, researchers have collected archival materials dedicated to the works' history, a chapter of 19th-century industrialization worthy of further investigation.

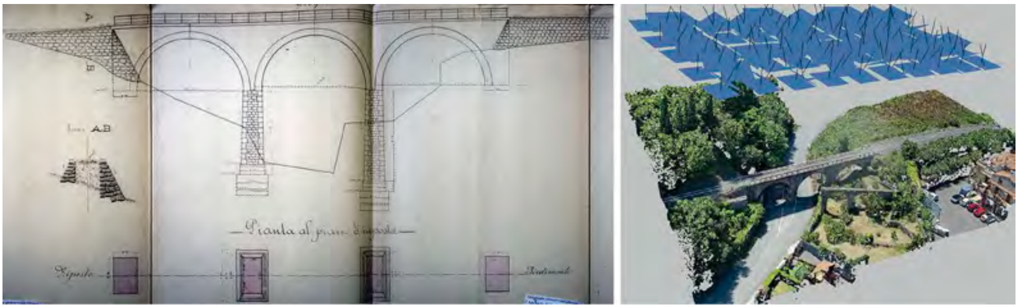

Figure 5. Three-arch bridge in the municipality of Mascali (CT). (Left) Part of the archival documentation (Source: Archivio di Stato di Catania); (right) Results of the survey campaign conducted with a DJI MAVIC 2 PRO (Drone operator: Antonio Ferraro) (Source: Raissa Garozzo, PhD thesis).

The Circumetnea constitutes an active role in local transport and tourism, its value as a heritage asset remains largely underappreciated as a form of slow mobility and sustainable tourism (Bozzato et al. 2017). Today it constitutes an important model for "green" travel both as a low-emission form of transportation and through its low-impact, sinuous design against the black, lava slopes. Aware of its landscape's value, the local transport authority already offers four themed itineraries based on wine-touring, bicycling, a cultural itinerary dedicated to local castles, and another dedicated to observing the igneous landscape (Web-4). These itineraries seek to enhance an underappreciated destination of the Grand Tour, immortalized by Goethe's 1787 description of this cultural landscape and its "smoldering, snow-covered cone". Today, Mount Etna could again act as laboratory for humanistic and technical dialogue by making the effort to merge domain expertise on an H-BIM platform dedicated to FCE's bridge health assessments alongside forms of documentation traditionally relegated to scholarly research.

Collated, interdisciplinary data on the Circumetnea can work in tandem with routine monitoring and maintenance while offering unexplored possibilities for disaster mitigation and cultural activities. Historic photographs, like those seen in the Hertziana's Focus on Amatrice, provide data useful for both technicians and cultural operators. Photogrammetric technologies, their resulting digital models and drone imaging provide substantial resources for railway workers, the tourist industry, education, and vocational training. Experiments like the award-winning Research@ Volterra-Detroit Foundation (Web-5) demonstrate successful partnerships which bring together engineers, architects, GIS-experts, industrial partners, international students, the local municipality, and the national Ministry of Culture in scanning the archeological vestiges of a Tuscan town thus co-producing high-definition, open-source models, and documentation.

When research coalesces in shared platforms, experts harness the innovative potential of H-BIM technology and limit knowledge dispersion. The Circumetnea's ideal information platform could graft information gathered from routine maintenance and monitoring, infrastructure upgrades, historic research and cultural initiatives. This documentation could form an active resource for a variety of daily operations and, in extreme circumstances, could provide essential data needed for disaster mitigation and reconstruction. In order to integrate this technology into routine operations, this sort of model necessitates investments in IT upgrades and transversal training sessions for personnel like local officials, railway employees, local archivists, etc. to enable stakeholders to share semantic guidelines and domain expertise. H-BIM thus offers an innovative modality to resolve long-standing obstacles to safeguarding Etna's railway system, a civil structure worthy of being enhanced and reevaluated for the railway's inherent sustainability.

4 CONCLUSION. VISION FOR THE FUTURE

This paper promotes a holistic model for documenting the Circumetnea railway to thoroughly document the technicalities of the railway system while storing related data, images, digitized historic sources and virtual models through H-BIM models. This shared, interoperable platform would offer an effective tool for routine care and long-term conservation of a valuable, but little recognized part of Sicily's cultural heritage and stratified cultural landscape. Natural hazards and their destructive potential underscore the many ways technical and historical knowledge intersect. Due to its light environmental footprint, this railway merits particular attention and promises a capillary economic impact geared towards long-term, community wellbeing.

Team-driven H-BIM models can help harness the potential encapsulated in case studies like Amatrice's post-disaster studies as well as the documentation campaign and knowledge gathered by PD-Invisible. H-BIM models offer a missing link in creating deeply interdisciplinary networks and facilitating dialogues between technical experts, historians and administrators in their common aim to conserve and enhance local heritage like the Circumetnea railway system. Documentation of civil structures - and not only that of famous landmarks - best managed from multiple standpoints. Collaboration among professionals with different expertise and sensibility (including, but not limited to architects, engineers, art historians, archivists, and administrators) is a must. Heterogenous documentation systems can help engage policymakers and community members in meeting safety and serviceability while transmitting collective memories to future visitors and citizens.

AUTHORS CONTRIBUTION

Conceptualization, C.C., R.G., E.M. and Y.M.; investigation, C.C., R.G., E.M. and Y.M.; writing—original draft preparation, C.C., R.G., E.M. and Y.M.; writing-review and editing, Y.M. From a strictly editorial point of view, the paragraphs were divided as follows: 1 and 4 all authors, 2.1 E.M., 2.1.1 Y.M., 2.2 C.C., 3.1 R.G., 3.2 Y.M..

All authors have read and agreed to the published version of the manuscript.

ACKNOWLEDGMENTS

The authors would like to thank: the team of the project FSE 2105-18-11-2018 "PD-Invisible: PaDova INnovative VISions – visualizations and Imaginings Behind the city Learning", Esfahani Ali Dalalbashi as a part of the project team and, lastly, Professor Stefano Bertocci and Matteo Bigongiari for their mentorship. Thanks go to the following institutions for their permission to publish records and photographs in their collections: the Archivio di Stato della Provincia di Catania; the Ferrovia Circumetnea; Francesco Gangemi, Enrico Fontolan and the Photographic Collection Bibliotheca Hertziana – Max Planck Institute for Art History.

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Built Heritage in post-Disaster Scenarios – Balzani et al. (Eds)

Floods and heritage: Comparison of cases and observations

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ABSTRACT: Floods are some of the main threats for the existing built heritage and Cultural Heritage, occurring with an increasing frequency, due also to the climate change, and involving countries and territories all over the world characterized by different features (climate, morphology, level of urbanization), as this paper shows. The common point between the different study cases is the presence of a source of flooding (such as a river) or a big amount of rainfall (the monsoon season, for example), a route for the flood water to take, and a particular contest (urban contests, in this case) that is affected by the flood. In front of these wide risks, local governments adopt some punctual and general strategies aimed at environmental, social and economic resilience to face the floods and to reduce the future risk. The aim of this paper is to compare the different approaches in different countries and continents (India, Morocco, Brazil and Italy), to show how it is possible, starting from the knowledge of the features of each particular site - to draw and define a list of good practices related to policy models to support emergency and risk management. Since flood risk is now something that can be estimated, thanks to the study of past experiences and with the help of modern technologies (data collection, documentation and monitoring activities), and its effects are generally predictable, actions should be based on a holistic approach, and focused on the development of a flood mitigation policy reduction, with some specific measures for the protection of the cultural heritage (old cities, monuments and archaeological sites). These policy models to support emergency and risk management can also be seen as an opportunity to enhance a sense of community and belonging, through environmental awareness initiatives at the regional and national scale and a new and deeper interest in local cultural heritage.

Keywords: flood, heritage, knowledge, ecology, mitigation

1 INTRODUCTION

Flood risk is a vast and global challenge: it involves a lot of countries with features as different as the consequences of this calamity. The study of flood risk becomes essential to better prevent and respond to the problem.

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DOI: 10.1201/9781003253730-37

The choice of the topic, consisting of the problem of the flood and comparison of different study cases, is based on the will to show how this natural phenomenon has a great impact on the deterioration of the cultural heritage worldwide and lead to the development of strategies and mitigation policies.

Each author selected a site case from his studies or direct experience, thanks to his specific cultural and study background. As architects, it has been possible to analyse and interpret the risk in terms of vulnerability and resilience of territories and populations of different geographic contexts. Each author has given his contribution to analyse a case, with the specific point of view of his professionality and studies, focusing on the resilience of the territory, the population, the cultural heritage and how this approach could have been changed over the years. The comparison of different approaches, methods and technical tools used in different territories (India, Italy, Morocco and Brazil) is a way to share experiences, knowledge, strategies for risk management, and to widen the possibilities of intervention, respecting the peculiarities of each site.

The risk and the consequences are there observed through the several cases under a territorial and also a local point of view. In this way it has been possible to produce outcoming observations for the management of the risk, in long but also short times, in terms of plans but also punctual action. It is evident how, in presence of different heritage's values and expositions, it is more convenient to lead operations of punctual or landscape design operations to face the flood risk. In every case study there has been the observation of "before damages" and "after damages" policies and actions, under an architectural or planning point of view. Going to conclusions, there are exposed common "before damages" and "after damages" operations through the cases, outlining how best practices are quite the same also for a different region of the world. Long term goals and short term goals should be the same in order to guarantee the best flood risk management all over the world.

2 METHODOLOGY, AIMS AND TOOLS

2.1 *Aims*

The main aims of this current study is to understand the impact of flood on various scales, analyze the reasons behind the emergence of floods and take measures to reduce the impact, compare the risks of flood on the heritage, in order to show various strategies employed across four different continents and categorize the best measures to overcome the damages in before and after scenarios of the actual disaster.

2.2 *Methods and tools*

In order to establish this current study and achieve its aims, almost similar cases were identified in India, Morocco, Brazil and Italy, and diagnosed the events and the consequences that lead to the hydro-meteorological disaster. Maps and reports have been used on the individual cases to categorize further observations. The study presented the classification of preventive measures required to reduce the magnitude of the disaster on the cultural heritage, as well as the application of the after damage approaches that lead to mitigate the loss of cultural heritage (including tangible, intangible and movable assets).

Thereby, the main goals of this study consisted in the identification followed by the adoption of these tools that include vernacular wisdoms, documentary skills, participatory efforts and new technologies to sustain the life of conservation.

3 INDIAN CASE: KERALA STATE FLOODS

In Indian literature, the monsoon is literally depicted as the season of love. Mother nature renews herself and gives a precious new lease of life. (Anil Agarwal 1997, 25) From bringing bliss to the lives parched by the summer to relieving the drought affected regions. A cheerful

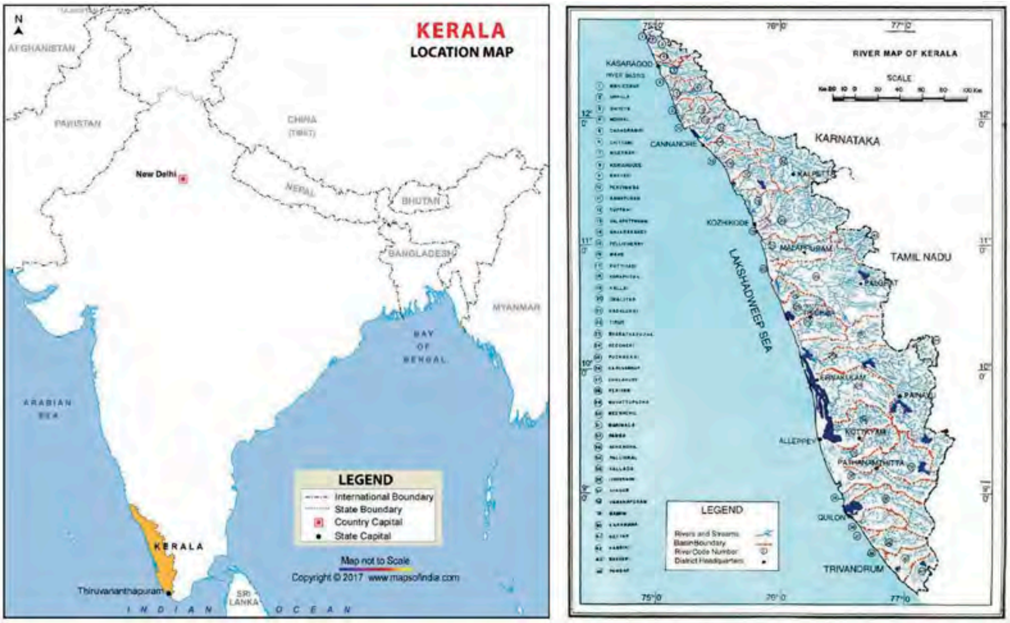

Figure 1. Map of India locating the state of Kerala on the extreme South-West part of the nation, exposed to the seasonal monsoon direction (left) (source: Maps of India). Map of Kerala representing the amount and location of rivers present in the state (right) (source: CWRDM, Govt. of India).

transformation of the atmosphere. However, it has also been responsible for a number of natural disasters, particularly in the region of Western Ghats. The state of Kerala occupies the southern portion of this region (Figure 1), thus being seemingly most susceptible to such hazards due to its exposure to the monsoon direction and the steep slopes of the terrain on the East. Floods are the most common natural disasters in the state.

3.1 *Cultural heritage of the state*

Kerala is one of the most well-known states for its variety of its natural habitats. But it is also rich in terms of traditional arts, festivals and crafts. These traditions have settled and flourished themselves in this place because of the diverse riches of raw materials available naturally. These, together with the particular performances have become an intangible identity of the state. Tangibly, the region also bears testimony to a wide range of history with its temples, forts, palaces and other heritage structures. They are unique as compared to the rest of the nation due to the architectural elements, construction materials and response to the climate. With all these forms being present, the state itself exhibits an abundant and prosperous cultural inheritance. The 2016 Kerala State Disaster Management Plan was prescribed to ensure proper early warning mechanism and monitoring for flood prone waterbodies. It claimed that encroachment of river banks and infilling of paddy lands and wetlands are the major cause of the increase in the vulnerability to floods. The disaster preparedness directives pronounced the Kerala Conservation of Paddy Land and Wetland Act 2008 to be strictly implemented, as they are flood buffers, and their protection will ensure reduction of flood magnitude. It further suggested conserving ponds & open wells to allow rainwater harvesting. (Centre 2016, 116)

3.2 *2018 Floods disaster*

Between June 1 and August 18, 2018, the state experienced the worst ever floods in its history since 1924. During this period, the state received cumulative rainfall that was 42% in excess of the normal average. The torrential rains triggered several landslides and forced the release of

Figure 2. Flood affected areas of the state. One can see monuments of religious and cultural importance as well as common houses and agricultural fields under the influence of the floods (source from left to right: AFP, Thrissur; Tobin Augustine and Anamika Edathara).

excess water from 37 dams across the state, aggravating the flood impact (Figure 2). Nearly 341 landslides were reported from 10 districts. (Kerala 2018, 12) The devastating floods in Kerala have had a serious impact on the following cultural heritage of the state. (Kerala 2018, 152)

- Tangible heritage (monuments and archaeological site)
- Intangible heritage (traditional crafts, rituals and performing arts)
- Movable heritage (Museum articles and manuscripts)

3.3 *Cultural heritage of the state*

The monuments and archaeological sites in Kerala have weathered the floods to some extent, and in most cases, the extent of damage is moderate. Their geographical location and material protected the monuments and other sites of cultural importance, enabling them to withstand the floods. Despite the far-reaching effects of the floods, the people of Kerala have shown remarkable resilience in recovery and rebuilding, engaging in cleaning and salvaging living spaces and buildings. (Kerala 2018, 154)

4 ITALIAN CASE: HYDROGEOLOGICAL INSTABILITY AND RIVER FLOODS

Today in Italy, about 10% of the national territory is considered in high hydrogeological risk, as for floods and for landslides (Web-1) (Figure 3). In the present paragraph are presented cases of two cities, Matera (MT) and Pisa (PI), and the causes why they suffer the flood risk differently, because of their historical assets and geographic conditions.

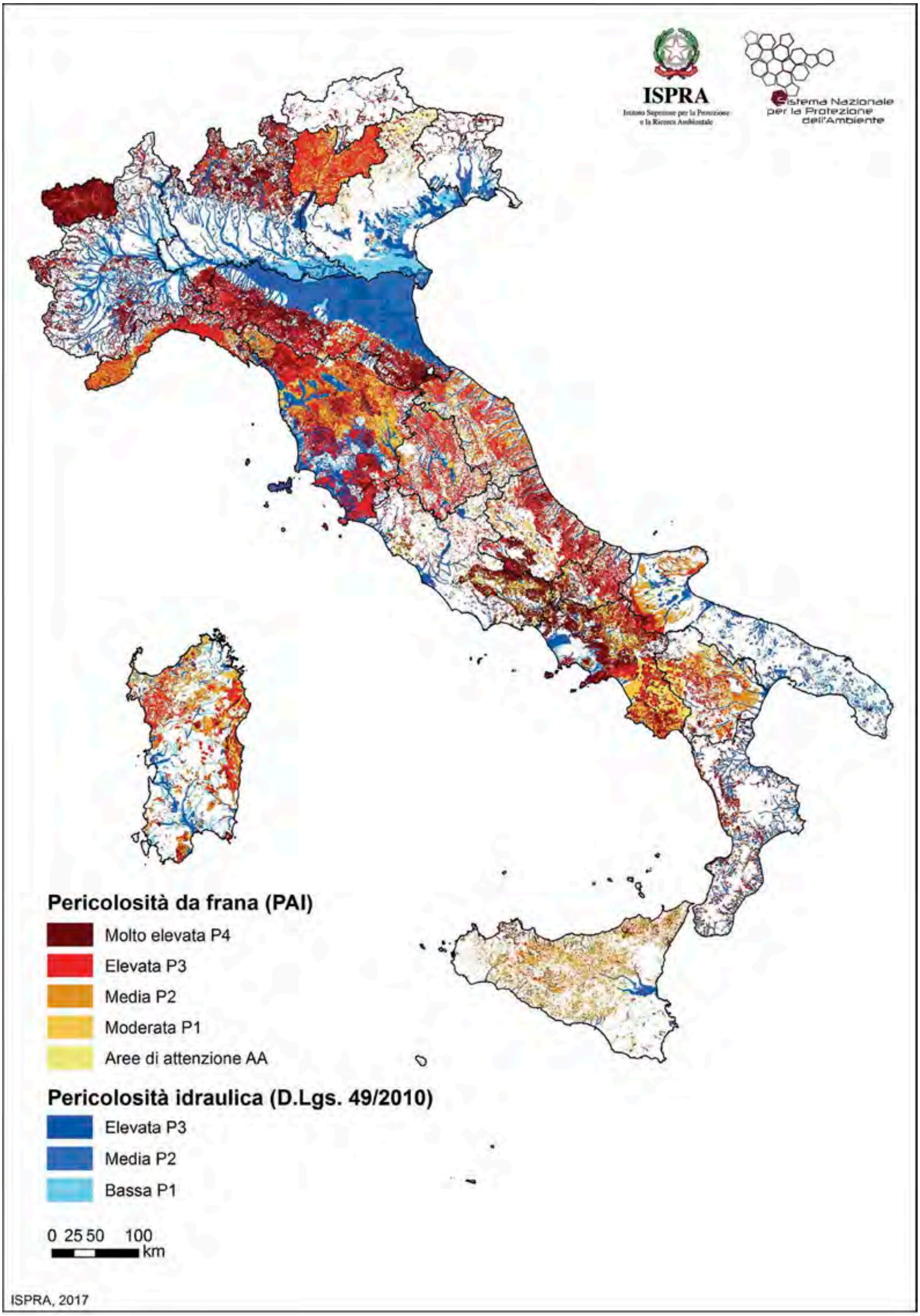

Figure 3. Map of landslides and hydraulic hazard, from www.isprambiente.gov.

4.1 *The city of Matera and its hydrogeological instability*

Matera (MT) is a small city in the south of Italy. Its peculiarity is that the anthropic presence there has always been continuous since the neolithic until nowadays. The old town named Rioni Sassi of Matera is the result of a technology for the exploitation of resources and for the preservation of the environment facing the erosive phenomena.

The lack of water, completely absent in rivers and present only in concentrated rains, has made the practice of meteoric collection and underground conservation essential. During the violent rains, terraces and water collection systems have always protected the slopes from erosion and conveyed the waters by gravity towards the cisterns in the caves.

This system, that could be considered a "before the damages" situation, has been broken by the last century development of the modern city above the Rioni Sassi, because of the use of materials, as bitumen and waterproof grounds, that changed the permeability of the ground so making the water difficult to flow. In addition, the contemporary human-being don't contemplate the use of cisterns to store water anymore, because of the introduction of the aqueduct, so they have been abandoned and now the water flow is deviated from the ground.

It is now easy to observe the situation like November 2019, when the Rioni Sassi of Matera were affected by a violent flooding with damages to the constructions and the commercial activities. This event impressed the public thanks to a huge resonance within media, however the cause has not to be caught in the hazard of the event, but in the current vulnerable condition of the Rioni Sassi and the upper town, because of a wrong alteration of a centennial balance. (Figure 4).

4.2 *Pisa and the Arno river floods*

Pisa is the last major city that the Arno river crosses before reaching the sea. The floods of the Arno river, especially in the XX century, showed the vulnerability of a territory characterized by a wide cultural heritage. In the same days when a flood affected the cities of Venice and Matera, November 2019, the city of Pisa was threatened by the risk of flooding of the river Arno. The Arno River basin in Italy is a quite particular case because most of this territory is prone to frequent flood hazards, with high levels of risk due to the vulnerability of a unique artistic and cultural heritage.

One of the most catastrophic floods occurred on 4 November 1966, because of anomalous climatic conditions. On that occasion, the city of Pisa was spared from flooding thanks to the

Figure 4. Images by author: scheme of the ground impermeabilization of the upper modern city of Matera and the consequent flood of Rioni Sassi, avoiding the ancient cisterns.

adoption of some measures that were able to divert a big amount of water in the countryside around the city of Pisa, thus protecting the city and its artistic and cultural heritage.

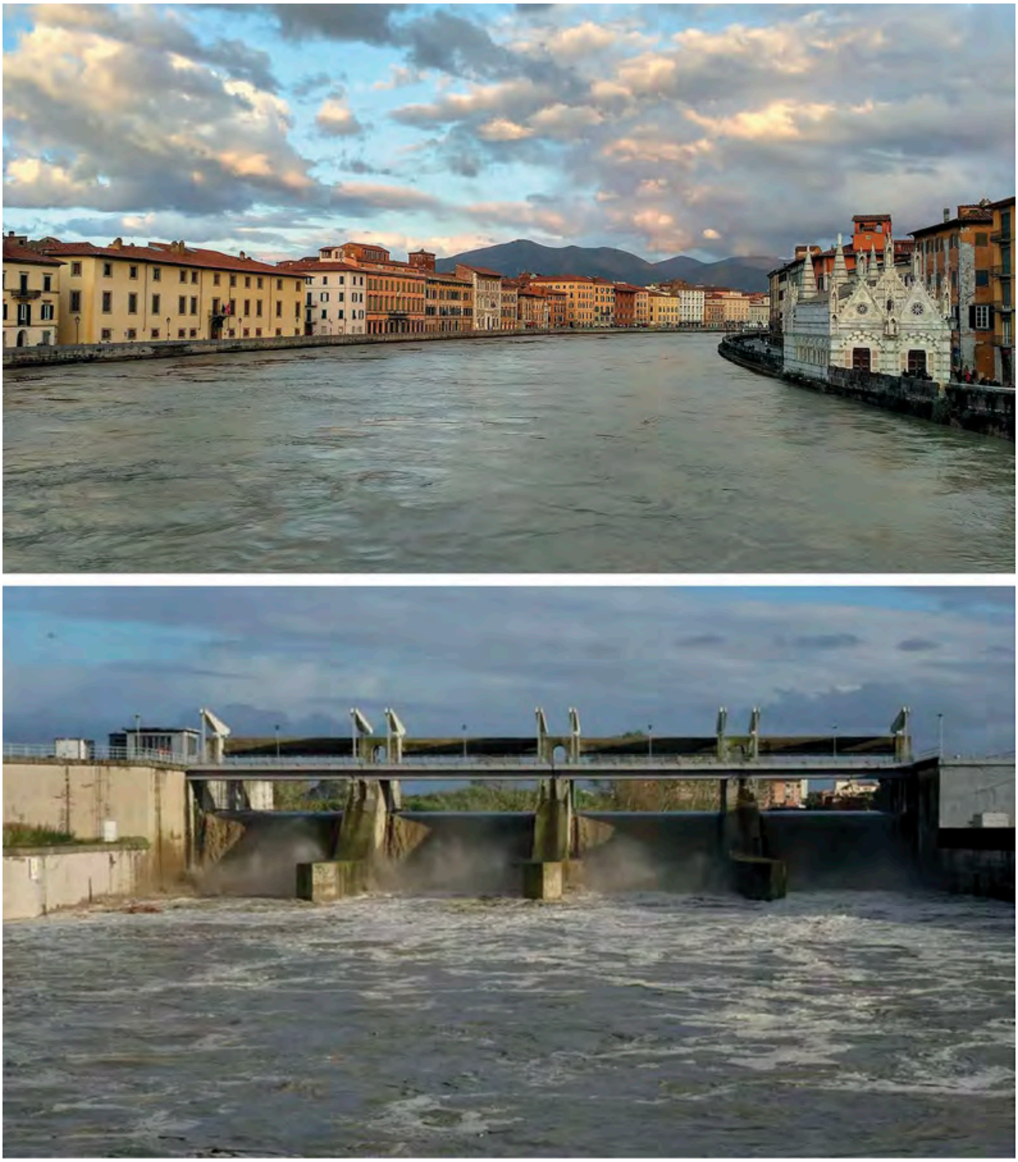

Figure 5. Image of Pisa during the last flood in November 2019; example of flood mitigation systems in the Pisan area.

In 1966, the Arno flood struck the public feeling. This event led to:

– systematic data collection and analysis of flood risks (a recognition of the Arno river basin size and the importance of the human activities on the territory).
– the development of a flood mitigation policy. Several laws were shaped and approved over the years.

That's the reason why along the years structural interventions for flood risk mitigation were adopted in order to mitigate the risks of flooding. They consisted in:

– the realization of flood control areas along the Arno River and its tributaries (by-pass canal to divert water directly to the sea south of Pisa, etc..);
– the increase of the retention capacity of the river bed and landscape, by means of keeping the riparian vegetation and preventing the reduction of the waterproofing of the soil; most of these objectives are now part of the regional urban policies, showing how important is the connection between urban planning tools and territorial protection guidelines (Figure 5).

In contexts like Pisa, Florence, Matera (Unesco sites), it would also be important to adopt some specific measures for the the cultural heritage protection as a strategy of resilience to face the "after damages" situations:

– cataloguing the artistic artefacts, which due to their location could be damaged in the event of a flood;
– developing the safeguard programs in case of an alarm (how to physically protect the building, how and where to move these artistic artefacts (in case of museums, archives, libraries, collections).

5 MOROCCAN CASE: AGADIR

After its destruction by a deadly earthquake in 1960, the city of Agadir has been completely reconstructed with a brutalist architecture that represents today the actual modern cultural heritage of Agadir.

During the past few years, the cultural heritage of Agadir has been threatened by the risk of flooding that affected the population and its properties, as the city is located in a piedmont mountain area, and is crossed by important rivers that promote exposure to torrential hydrological risks (Figure 6).

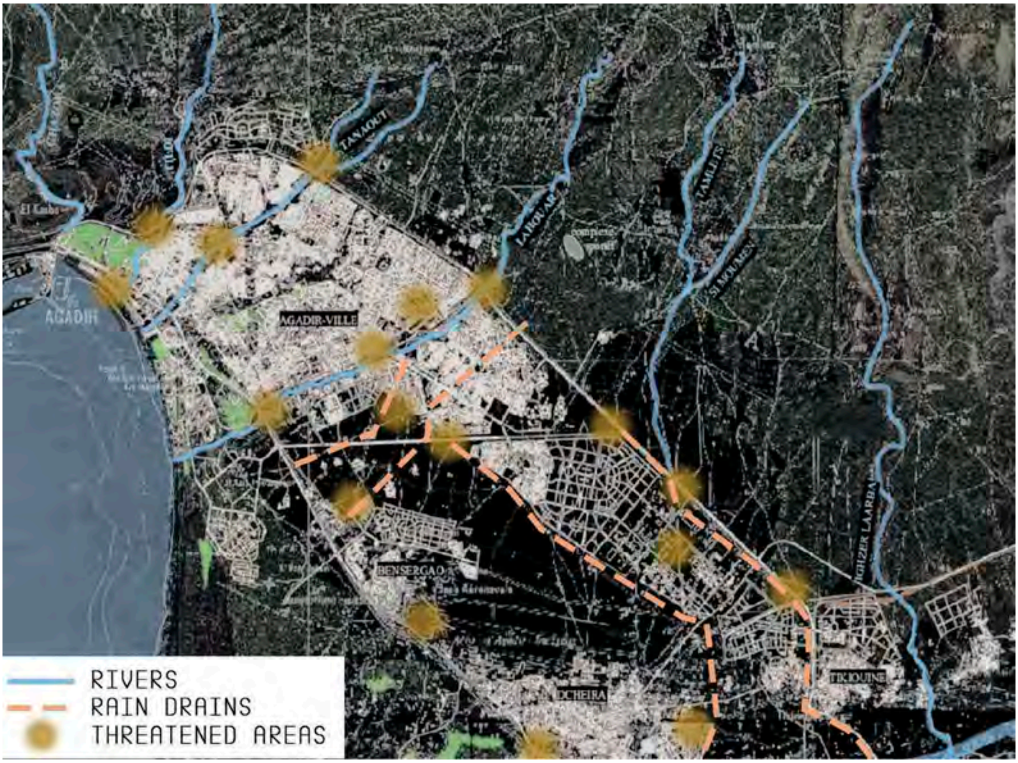

Figure 6. Map showing the risk of flooding in Agadir.

5.1 *The Moroccan approach to the risk of flooding*

In order to prevent this problem and reduce the floods damages, the government of Morocco has elaborated a plan that takes into account two ways of intervention: before and after the natural catastrophe. Before the damages, the Kingdom of Morocco approaches the issue from two different angles: indirect and direct protection.

The indirect protection consists in intervening far from threatened sites by reforestation, increasing the permeability of the pavement, constructing dams and regulating flows, setting up an area of deviation of rivers responsible for floods to other rivers located outside the areas to be protected. The direct protection consists in intervening directly on sites threatened by limiting the extension of the stream bed, canalizing the river (pipelines), strengthening the sanitation network, controlling the urban expansion of highly threatened habitats by the flood, and setting up rain stations, hydrological observation stations and dams to regulate the water courses and reduce damages to urban areas.

Throughout and after the natural catastrophe, the Morrocan approach consists in evacuating the population and securing the area, decongesting the canalization network, cleaning up the mudflow from the urban area, analyzing the impact of floods on the structures of buildings affected and then reinforcing them, reconstruction operations, and analyzing the situation to intervene in advance for the upcoming damages to better respond to them.

6 THE BRAZILIAN CASE: SÃO LUIZ DO PARAITINGA

São Luiz do Paraitinga is a municipality in the eastern part of Sao Paulo in Brazil. Its historic centre represents a national heritage site and its local cultural heritage makes the city a major tourist destination of the Paraiba Valley region.

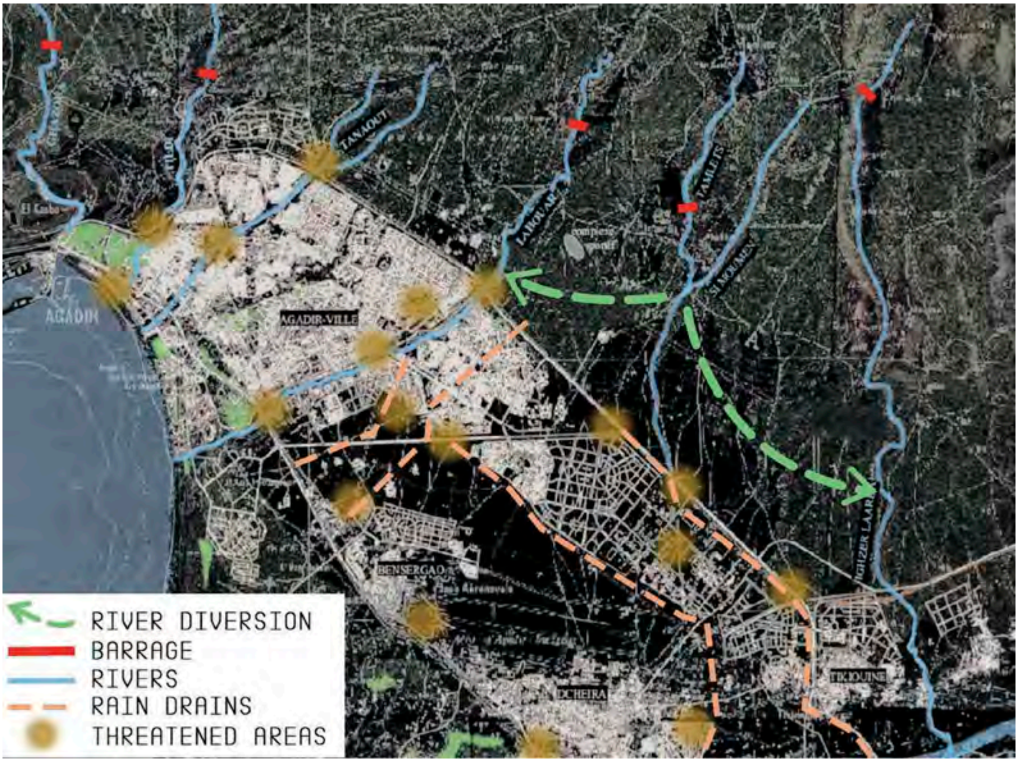

Figure 7. Map showing the morocan approach to risk of flooding in Agadir.

The historic centre of the city contains more than 450 Portuguese colonial architecture. It reflects the city's former prosperity due to coffee farming and gold mining in the 19th century.

The city of Sao Luiz do Paraitinga in Brazil was highly affected by floods in 2010, which have resulted in the destruction of eight historical constructions, including the São Luiz de Tolosa Church, the city's main church that was built in the 19th century.

6.1 *The Brazilian approach to the risk of flooding*

The situation was held in different stages: the interruption of electricity and water supply and rafting rescue teams, as well as cleaning the streets and removing the constructions' debris.

The third stage was the inspection of buildings, and the fourth stage was defining the reconstruction process by maintaining the same volumetry of the original building, using tiles in ceramic material only, as well as restoring frontage and side walls with similar doors and windows.

6.2 *Proposal of other solutions*

In order to considerably reduce and prevent the damages, there are several proposals of other measures like setting up a cross of sandbag embankment. Amphibious buildings (Figure 8) can also be an interesting solution for the new constructions by introducing a floating building system.

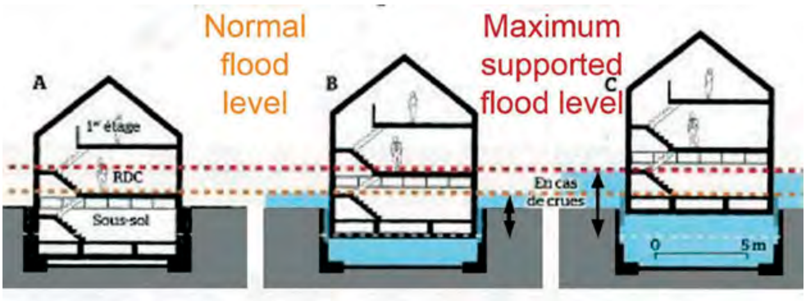

Figure 8. Example of an Amphibious building: floating building system.

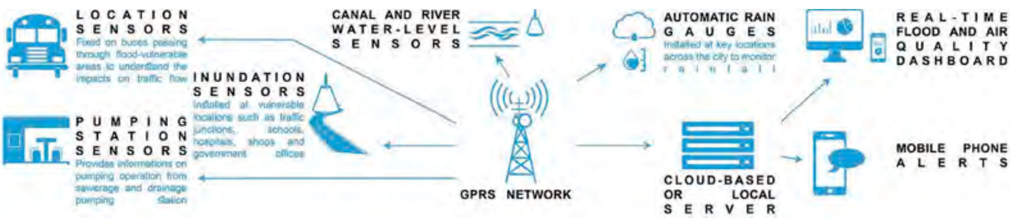

Figure 9. Example of news technologies that can be used in flood risk management.

7 CONCLUSION

Despite all cases belonging to contrasting pairs of climatic zones and topographies, it is noticed that the impact of the flood on the local heritage has been extremely severe. The collective analysis across different continents suggests numerous multifaceted approaches that respective cultures and stakeholders have taken while countering the calamity.

The study explicitly demonstrates both anticipatory preparation as well as responsive action post floods. Preliminary efforts to allow excess water absorption by regulating the existing waterbodies or wetlands and increasing permeability of pavements will substantially control the magnitude of the future floods. Periodic structural measures and historical data research can also aid for a similar purpose. Post disaster study of damages and resistance offered by heritage techniques also throw light on the lesser known traditional wisdom and ways to form a certain immunity to such events. Crowdfunding, community participation and collective memories of the heritage jointly can boost the efforts of restoration effectively.

The introduction of new technologies in flood risk management can make us more responsive in order to reduce the damage caused by floods and save many lives (Figure 9).

Thus, advanced planning and effective reaction post disaster both together can minimize the damage due to such hazards to the crucial heritage of the society.

The perception of damage risks has a crucial impact on the process of human decision-making. Although the disasters come with huge material losses and community trauma, they can be seen as an opportunity to enhance a common sense of community strength and a sense of belonging, through environmental awareness initiatives at the regional and national level, so as to implement effective policies.

AUTHORS CONTRIBUTION

Abstract, M.I.L.; Introduction, C.T.; Methodology, I.A. and L.E.M.; Indian case, S.M.; writing—original draft preparation, C.T.; Matera case, C.T.; Pisa case: M.I.L.; Moroccan case, L. E.M. and I.A.; Brazilian case, L.E.M. and I.A.; conclusion: C.T., L.E.M., I.A., S.M., M.I. L. writing-review and editing, C.T., L.E.M., I.A., S.M., M.I.L.

All authors have read and agreed to the published version of the manuscript.

ACKNOWLEDGMENTS

The paper is developed based on the final work of the International Summer School After the Damages July 2020. The research was presented by the group consisting of all the authors. The authors would like to thank Prof José Geraldo Simões Junior for his guidance towards this assessment. A special note of thanks to the organisers of the Summer School at the University of Ferrara and all the partners involved.

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Built Heritage in post-Disaster Scenarios – Balzani et al. (Eds)

ME.MO.RIA - monuments essence, materials observation, risk interpretation & analysis

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ABSTRACT: When planning for any building conservation project, one must start with the understanding of the existent and be willing to accept the constraints this may create. In order to enable effective preservation of the built heritage it is important to start from meaningful data, reliable information and valid analysis.

As a case study for the final workshop presentation of the International Summer School "After the damages – Prevention and safety solutions through design and practice on existing built environment", the group ME.MO.RIA selected Fortaleza de Santo Amaro de Barra Grande in Guarujá, Brazil. The site was chosen for an evaluation of the compatibility between the building and the collection housed. Specifically, all preservation goals for the historic building conservation were analysed while striking the balance with those of its collection. It is essential, in historic sites like this one, that the significance of the place is preserved together with the local communities' identity.

The fortress, along with 18 others, has been elected by the National Historic and Artistic Heritage Institute (Iphan-Brazil) for the UNESCO World Heritage List under the name of "Brazilian Fortresses Ensemble". After a first analysis of the structural preservation state and a collection care survey, authors propose some reasonable and flexible approaches aiming at solving accessibility issues and context identity relevance as well as building improvements, space allocation and a new collection interpretation and long-term conservation plan.

Keywords: flood, heritage, knowledge, ecology, mitigation

1 INTRODUCTION

At this moment, the National Historic and Artistic Heritage Institute (Iphan - Brazil) is currently working on preparing the nomination of the "Brazilian Fortresses Ensemble" for

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DOI: 10.1201/9781003253730-38

the inscription on the World Heritage List by the United Nations Educational, Scientific and Cultural Organization (UNESCO). This historic set is understood as a serial property, including 19 forts and fortresses, built between the 16th and 19th century, and distributed over 10 of the 26 States of the country. These fortresses are representative of the defensive constructions implanted in the Brazilian territory. Specifically, in those sites that served to define the maritime and fluvial borders that ended up creating the largest country in Latin America: Brazil, which today covers 8.516.000 km^2.

Despite the nearly five decades of the existence of the Convention Concerning the Protection of the World Cultural and Natural Heritage, defined by the UN in 1972, most of the nowadays recognized sites are still located in economically developed countries, implying a gap in the representativeness of cultural heritage of the various regions of the World. While the current "UNESCO's animus" already represents many historic cities, it is now also necessary to bring to its attention a cultural heritage of other nature. Therefore, in this case study there is an innovative approach to the ideological construction of a set of socially selected fortified architectural artifacts, beyond the integration into a broader network of cultural meanings as a heritage of outstanding universal value. Such a cultural network makes built heritage available to this community, enhancing wider dissemination and promotion of cultural heritage overall and its values, contributing to a broad affective appropriation, and allowing a deeper sense of belonging.

In order to build an application focused on transcend national boundaries and to be of common importance for present and future generations of all humanity, as World Heritage, it is essential to reflect on a sustainable preservation practice that guarantees the Outstanding Universal Value of the heritage, as well as its protection, conservation, management, monitoring and promotion. In order to foster articulations within civil societies, public and private organizations, so that a shared heritage preservation management plan can be developed, State Technical Committees were instituted in addition to the commitment signed by the "The Charter of Recife" in April 2017. Thus, establishing guidelines, concepts and other actions for the elaboration of a nomination dossier.

The outstanding value proposed for this heritage ensemble encompasses a variety of works of military architecture, with different designs, styles and construction techniques that mark the ingenuity and local creativity that provided conditions to define the borders of Brazil in the past. The "serial properties" definition means that all 19 fortresses are located in a single country, taking into account manageability and coherence aspects. However, properties can be located in different States to reflect local, cultural and social links. In the case of Brazilian Fortresses Ensemble, each building has a unique shape, construction typology and structural features. Thus, each of them contributes to the overall outstanding value of this ensemble.

2 FORTALEZA DE SANTO AMARO DA BARRA GRANDE - GUARUJÁ

Between the 19 fortresses involved in the Brazilian Fortresses Ensemble, Fortaleza da Barra Grande has been chosen as a study case. It is located in Guarujá, it is a federal property that currently operates as a municipal museum – under Guarujá Municipality management. It has Federal protection since 1964 and State protection since 1980.

Made of wood and mud, the fortress was built in 1584 when Portugal and Brazil were part of the Iberian Union (1580-1640), and lately attributed to the Italian architect Battista Antonelli. Three generations of the Antonelli family worked as architects and military engineers and served in Europe, Africa and America for almost ninety years in the service of the Spanish Crown. This construction was built as a defensive response to a 1583 attack by the English privateer George Fenton. The fortress, however, was not yet ready when another Englishman, Thomas Cavendish, sacked the town of Santos in 1588.

Its format is of two overlapping rectangular batteries with a long curtain defending the coast and an auxiliary battery on top of the elevation where it is located.

The fortress, the main defense of Santos, was kept in operation until 1905, after which it lost its strategic position to Fort Itaipu, situated on the southern counterfort of Santos Bay. It came back into activity between 1956 and 1969, when it became the headquarters of the Santos Military Circle. After this period, the building was abandoned and ruined (Figure 1).

Figure 1. The Fortaleza de Santo Amaro da Barra Grande (source: web-6).

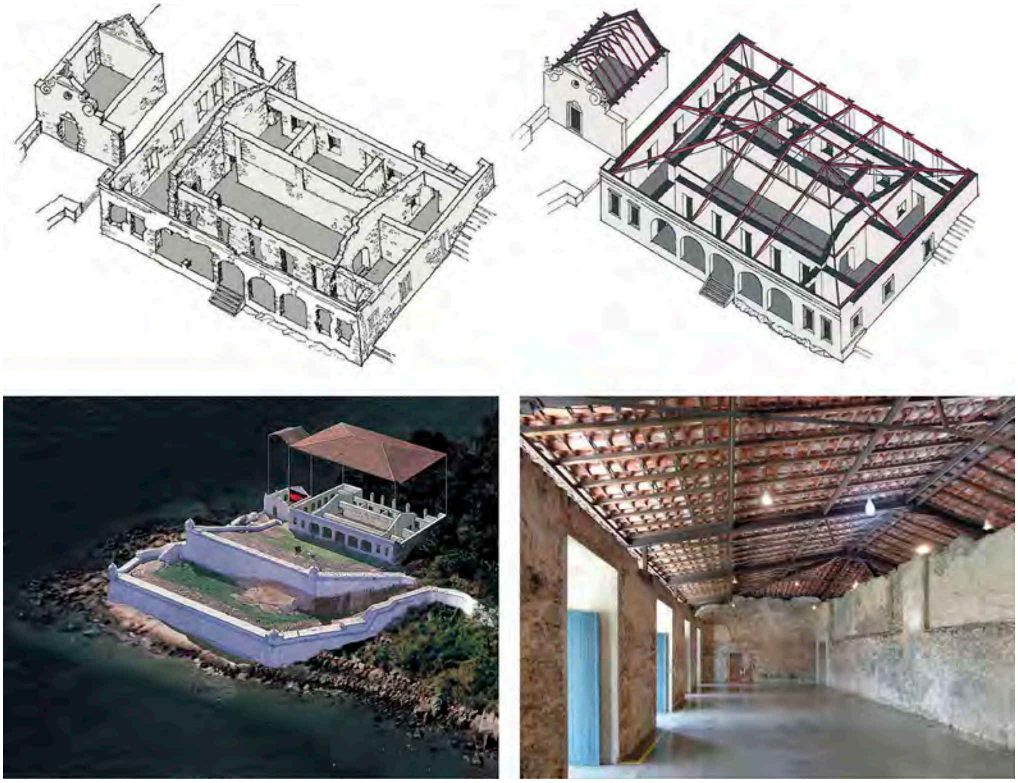

Figure 2. A,b: axonometric drawings before and after the restoration project; c: sketch of the new ceiling structure; d: the steel roof of nowadays (source: [a,b,c,d] Mori, Victor Hugo. 2003. Arquitetura Militar – Um panorama histórico a partir do Porto de Santos).

In the 1990's the recovery campaign began and in 1995 the architects of Iphan, Luiz Dias de Andrade e Victor Hugo Mori, developed the very first restoration project for the entire property. The concept of the intervention was emblematic at the time and limited itself to protecting the quarter with a new roof, allowing distinction and reversibility, with a structure of Corten steel structure with 40 meters bay leaning on perimeter walls. The conservation work included both artillery batteries and chapel. The restoration process was finished in 2000, the same year of the celebrations of the 500th anniversary of Europeans landing in Brazil (Figure 2 a,b,c,d).

In 2014 the Fortaleza da Barra Grande Historic Museum was established and has been managed by the Guarujá municipality ever since. The fortress currently hosts a permanent collection of archaeological artifacts excavated on site, and some panels that tell, through texts and images, the history of the city from the colonial period to today.

The context around the Fortaleza is divided in two different areas, in a way to remark and protect the close area of the architecture and the landscape: the core zones and the buffer zones. The core zones include the fortress and the hill behind it, while the buffer zone includes the two small communities on the surroundings. Detached from the protected area, there is the coast of the city of Santos, whose harbor is located in front of the fortress, accessible in ten minutes by boat (Figure 3).

3 BUILDING PRESERVATION APPROACH

Following the main topics of the International Summer School, this paper aims to analyze the building according to the different points of view related to strengths, weakness, opportunities and threats aspects. The proposed methodology in all fields creates possible and specific solutions for the single case study, reaching best practice in the building preservation (Carbonara, 1997), with safe condition, as well as a new usability plan. Beginning with assessing the main risks and issues of the site and then working together towards suggesting mitigation strategies, the various approaches came from the authors' different backgrounds: the multidisciplinary approach became the strengthening point of the research. The key aspects on which the research was

Figure 3. Satellite picture with highlighted core and buffer zones (source: IPHAN-SP, 2019).

conducted are correlated and developed accordingly to their importance as well as for the restoration strategies proposal.

3.1 *Strengths*

The first step to study the building structure is related to strength aspects of the architecture. The Fortaleza de Santo Amaro is one of the most important monumental buildings of its territory, which characterizes the entire context with its relation to the city of Santos, as well as the natural elements: sea and the behind hill. The fortress creates the identity of the entire context. Therefore, identity and authenticity were underlined and valorized during the restoration project, creating a strong relation among the natural and human elements.

3.2 *Weaknesses*

As other monumental architectures, the fortress presents some issues on which it is necessary to focus on. Even though it is close to the city and to the main entrance of the harbor, the building is not easily accessible: the only possible ingress is from the southern side, the new city, with a natural path not nimbly approachable. In this way, the entire area is not sufficiently valorized, with lot of not improved opportunities. The maritime traffic in the last decades increased radically with bigger ships and cargo vessels creating problems, not only to the relation of the building with the natural elements, but also by increasing the collapse of the foundation level with the waves' expansions. Furthermore, the absence of environmental monitoring increased an incontrollable corrosion of the roof elements, thus exposing the interior area of the building to more structural risks (e.g., collapse).

3.3 *Opportunities*

The first step to study the building structure is related to strength aspects of the architecture. The Fortaleza de Santo Amaro is one of the most important monumental buildings of its territory, which characterizes the entire context with its relation to the city of Santos, as well as the natural elements: sea and the behind hill. The fortress creates the identity of the entire context. Therefore, identity and authenticity were underlined and valorized during the restoration project, creating a strong relation among the natural and human elements.

3.4 *Threats*

The threats to which the building is exposed can't be ignored in order to pursue the proposed strategies and limit possible future site problems. Some of the aspects are related to natural impacts such as the sea level rise of the last decades, involving lot of the architecture and artificial context close to the sea to be exposed to a serious risk with it tide cycles. Moreover, the use of modern materials or different treatments of the structural material limit corrosions' effect due to the sea.

The project goal, sketched in the following image (Figure 4), includes a series of analysis, solutions and methods uniquely targeted to the building preservation, its access and valorization in order to be appreciated again in the present and the future.

4 ANALYSIS OF THE EXISTING: SURVEY AND SENSATIONS

Risk management and damage prevention arise from an in-depth knowledge of the fortress and a decisional database that supports the relevant information. The methodology starts from a digital survey of the case study and the archaeological sites as well as the surroundings. Thanks to the Scan to BIM process, it is possible to start implementing an information database that stands as a data collector: for example, describing the configuration, the relations between the objects, the materials, and their performances. It is useful to represent and map in the 3D model both, the state of conservation of the fortress, and the previous interventions, as the Corten structural framing, can be visually reconstructed and then monitored. Due to the specific features of the fortress, qualified and trained staff should be involved to assure a correct development of the digital reconstruction phases. The level of information needed is established to map the existing data, define the required geometric shape, and plan the future activities in order to meet the different and effective goals. Finally, to predict the behavior of the fortress, it is possible to use the BIM model within both urban simulation and analysis of the single building environments. The results could then be integrated with the data collected by monitoring.

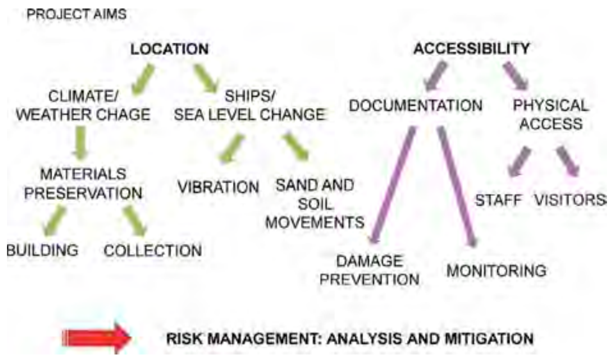

Figure 4. Project process diagram (authors).

There is a third artillery battery on the top of the hill, that is ruined and partially covered by the forest. Recently, a photogrammetric survey of it was undertaken and the 3D model now allows us to understand the structures remaining (Figure 5 a,b,c). The acquired data can be used in two different and complementary approaches. Firstly, as data to prevent the risk of damages, and secondly as a tool to involve tourists and the community in the fortress discovery process through virtual applications and installations.

The recognition of the building has also been reached by the “sensation map”, which aim reflects the involvement of local communities and their “perception bond” to the architecture. The map has been elaborated by local students from the University of Campinas and it illustrates the point of view of the communities that live close to the fortress (Figure 5d).

5 ACCESSIBILITY AND DAMAGE PREVENTION

Considering the issue of accessibility, to improve the number of visitors it is necessary to create an easier and more comfortable path to reach the fortress, that can currently only be reached by boat. The improvement of the actual access to the area can be pursued with some new paths differentiated by type of users: staff vs. visitors. Furthermore, other footways can be planned to connect the fortress to the archaeological area, still today not easily accessible and the creation of another pathway can create new linking opportunities with the city of Santos (Figure 6 a,b,c). According to the actual conditions of the context, other studies can be referred to the structural aspects, also evaluating the impact of the maritime traffic to the architecture. Because of the presence of the Santos’ harbor, one of the biggest in Brazil, the coasts on which the fortress is located are exposed to several cycles of tides, with the variation of the sea level. This phenomenon exposed the foundations of the building to alternative waves which removed the foundation ground, causing the subsequent instability of the wall’s foundations. The possible insertion of micro-poles, which guarantee the stability of the foundation ground, can solve the problems related to accidental base failures; while, with the purpose of limiting the effect of the waves, the breakwaters represent a non-invasive and efficient intervention (Borri, 2010; Varagnoli, 2010).

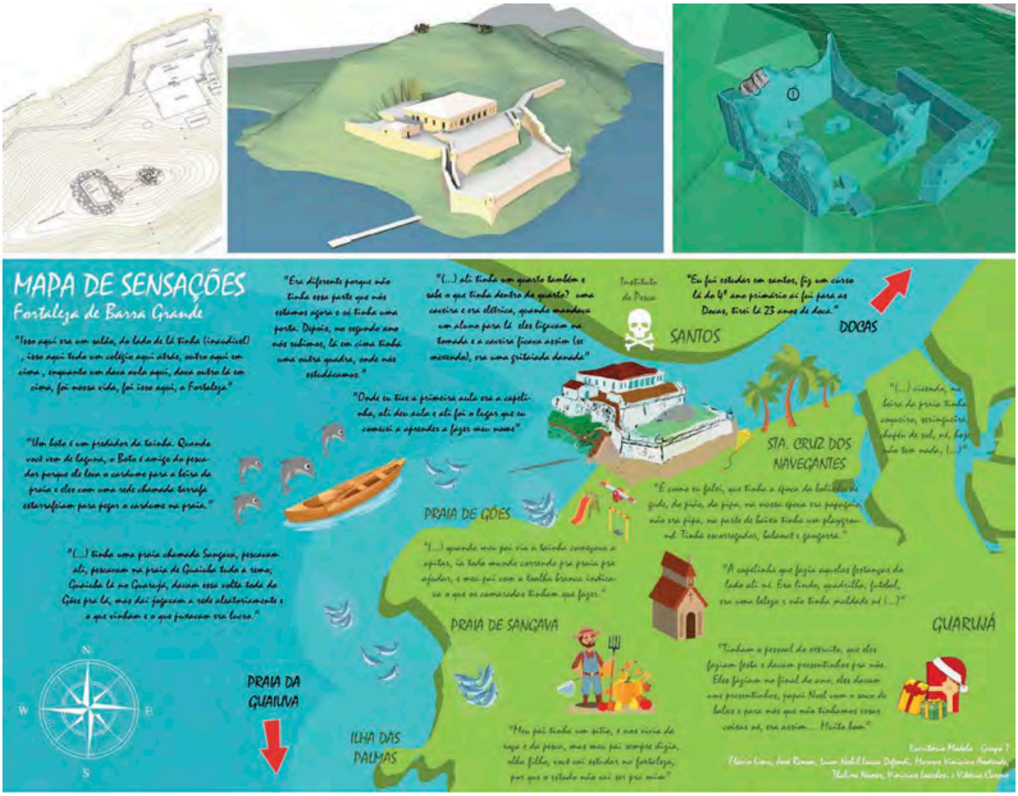

Figure 5. a: plan of the archaeological area; b: sketch of the fortress with the archaeological area; c: 3d model of the archaeological ruins; d: Sensation map (source: [a][b][c] Unicamp, 2019; [d] FIAM-FAAM, 2020).

Beyond the foundation study, the architecture, and in particular the new steel structure of the roof, must be protected from corrosion phenomena that can cause iron degradation decreasing the bearing structural capabilities. The specific application of anti-corrosion treatment on the steel elements can limit the above-described decaying phenomena (Figure 7).

6 MATERIALS PRESERVATION: COLLECTION AND EXHIBITION SPACE

Considering that preventive conservation should always be targeted to its institution, its collection and its environment, one should remember that planning for long term care of a heritage site includes both the building and the collection. Therefore, for an evaluation of the compatibility of the collection and the building together, along with the possibility of moving new artifacts in the existing exhibition spaces, it is necessary to establish all hazards

Figure 6. a: The existing path to the Fortaleza; b-c) plan and 3d model of a possible new path (source: FIAM-FAAM, 2020).

Figure 7. Resume of the different structural applications (authors).

for each object in each area and context. Thus, even identifying the local risks is essential. To do so, a collection care survey should be undertaken. As a semi-quantitative observational approach, it helps relate objects, hazards, deterioration processes and context while describing preservation needs to the whole collection and assessing the state of art. This can be done via simple observation, photo documentation, physical measurements and scientific tests.

Such a systematic approach should then be integrated with a risk assessment plan in order to predict collections future potential for deterioration from the identified hazards. Working as an expectation of the effects from causes to which the collection is exposed, it uses existing theoretical framework of damages to different materials.

Then, planning for an environmental monitoring campaign would be beneficial in order to establish the internal condition by considering temperature, RH, light levels, and pollutants in relation to the envelope layers analysis (passive vs. active control systems) as well as cyclical maintenance. As part of this phase, emergency preparedness and response plans as well as security procedures should be written.

Finally, along with the space allocation plan, an interpretation plan to evaluate the best use of each internal space should be prepared.

The historic museum of the Fortaleza de Santo Amaro da Barra Grande brings together archeological objects found in the fortress and its surroundings, as well as panels that tell through texts and images the passage of the city from the colonial period to the present day, and replicas of ships from the colonial period.

The fortress also hosts the abstractionist mosaic panel The Red Wind (Figure 8), made by Japanese-Brazilian artist Manabu Mabe. Created in 1997 during the building conservation process, it is located inside the chapel right where an altar should be, and it is very appreciated by visitors thanks to its modernity.

At the time of writing, authors only had the possibility to undertake a remote virtual assessment of the collection, establishing that among all hazards, the most dangerous to wooden objects already located in the exhibition spaces of the fortress, are relative humidity (RH) and dust. The first, mostly due to salty air coming from the sea, is causing mechanical change in the ships' replicas resulting in material cracking and surface salt depositions leading to crystallization. Dust, caused by particles deposition, and a fine black powder related to cruises and ships pollution, are an issue especially for the non-archeological objects that are not preserved into air tight vitrines. Another concern was raised when considering a special part of the collection located outside the building: cannons. Even though, they currently do not show major damages, they should be investigated more into details for a long-term preservation plan. Therefore, the next phase of the collection preservation project will be organizing a monitoring campaign while running a comprehensive on-site collection care survey, also including The Red Wind, who's conditions could not be assessed yet because of its size and the lack of existent documentation.

Figure 8. Resume of the different structural applications (authors).

7 CONCLUSIONS

This work, that originated from the merger of the various authors' competences, is the result of a multidisciplinary approach to the complex context of Fortaleza de Barra Grande and its preservation goals. The analysis of the issues and the proposed solutions in all research fields are related to the main preservation aim including the physical analysis of the site, the study of the context and the local identity, as well as the structural solution and re-use purposes.

The project's vision for the future includes both a medium to long term perspective, and an imminent impact on the site preservation and valorization.

The proposal for a new exhibition plan, more comfortable accesses and the creation of connections to the archaeological areas can increase the number of visitors; the sensation map can reinforce the identity relation between the fortress and the local communities; the structural improvement solutions can protect the architecture from decay processes related to sea level phenomena. Finally, the environmental monitoring campaign can help assess for collection needs. All outcomes target different preservation solutions: cultural heritage preservation, natural and built heritage valorization, damage prevention, risk analysis and mitigation strategies, social belonging and integration, local memory and identity interpretation as well as enhancing resilience. Therefore, having a comprehensive overview of the Fortaleza da Barra Grande preservation state through an approach that analyzes the building, the collection and the place identity, will have a fast positive impact on the entire context, helping the site fruition and valorization as well.

AUTHORS CONTRIBUTION

This paper is the result of different contributions: authors elaborated each paragraph according to the various topics. Specifically, Olivia Buscariolli and Haroldo Gallo wrote about the context of the nomination and the fortress' history; Marco Felli elaborated the paragraph related to the preservation strategies; Bartolomeo Letizia put down the section related to the structural actions; Rachele Bernardello proposed the BIM modeling analysis and the possible application for the case study; Emma Gaia Ziraldo contributed as editor and wrote the paragraph on material preservation for the collection and exhibition space.

ACKNOWLEDGMENTS

The authors would like to thank the Summer School Committee who made this project possible by bringing us together. In particular, we would like to express our gratitude to Arch. Claudio Varagnoli who acted as our tutor during the live workshop project' presentation in 2020 and Claudia Pescosolido for the administrative and technical support. Thanks to Emilia Romagna Region for their sponsorship and financial support.

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Built Heritage in post-Disaster Scenarios – Balzani et al. (Eds)

Faster! Platform: Fast assessment and survey of the territory for evaluation and restoration

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ABSTRACT: The paper presents one of the works resulting from the Summer School "After the Damages" course, offered during July 2020 and organized by the Architecture Department of the University of Ferrara and its research laboratories. Focusing on the urgency of dealing with post-disaster situations in cities and territories, the group of students developed a methodology of fast response, based on the collection, storage and distribution of data that supports the recognition, maintenance and intervention of buildings and places of relevant interest for preservation. As a result, the Faster! platform emerges - Fast Assessment and Survey of the Territory for Evaluation and Restoration.

Based on a holistic approach, integrating varied and integrative knowledge that aids in the perception and understanding of the pre-existences under various aspects, the platform would provide quick and easily accessible information, ideal for a post-disaster situation - but not only. Considering the importance of implementing Conservation Plans, the Faster! platform is able to be continuously updated, providing crucial and supported information for maintenance and future intervention actions. Other fact of great relevance is the possibility for various actors to have access to the data, such as owners, professionals, public bodies and researchers, either to consult it and/or feed it with new information. It also provides rigid access control, so there is confidentiality or general public access (open data resources), depending on the document.

In this paper, the main argument of this proposal is presented, which is the relevance of concentrating these databases in a specific online location, as well as the methodology proposed by the group for its operation. Then, the specifics of data collection and the possible consequences of adopting Faster! is considered. Finally, the evaluation of benefits and obstacles is done, as well as a critical analysis of the proposal presented by the group.

Keywords: conservation, holistic approach, open data, survey, vulnerable places

1 INTRODUCTION: REASONS

The guiding lead of the proposal of the platform Faster! came from the opportunity to develop a joint proposal based on the different backgrounds of the team members, which were

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DOI: 10.1201/9781003253730-39

tangential on some aspects. Faster! stands for "Fast Assessment and Survey of the Territory for Evaluation and Restoration", which is exactly what it proposes: to act quickly with grounded knowledge collected in time and made easily accessible.

The results of this interdisciplinary experience were elaborated and presented during the After the Damages Summer School, and are now the main object of this article. The Faster! project also echoed the spirit of the course, which had an international approach and sought to bring up for discussion the best and most recent risk management and prevention practices related to the effects of environmental and man-made disasters on territories. Thus, the motto of the proposal presented hereafter reflects the intense debates, the presentations of case studies and the reflections provided by several specialists and researchers in the area. The group of participants of the Summer School "After the Damages" that formulated the proposal presented is composed of Renata Campiotto, Giorgio Matis, Cilísia Ornelas, Nicolò Pini and Flavio Ridolfi.

Understanding the limitations of the time available for effective action to take place in the event of a disaster, especially when it involves assets with cultural value, including buildings, cities and landscapes, the group focused on pre-disaster preparation that could stipulate guidelines for quick and efficient responses. The definition of a strategy applicable to the most diverse cases started from a concept of holistic approach, as reinforced by several authors - one of the main references on this subject today is the "The Seventh Edition Conservation Plan", a method developed by architectural historian James Semple Kerr (2013). Furthermore, this guideline that in-depth knowledge must guide all decisions to be taken, especially when it comes to cultural heritage, is present in several heritage charters, endorsed by governmental bodies and international councils (ICOMOS, 1964; KÜHL, 2010).

In this way, the Faster! platform aims to be a tool that does not necessarily offer immediate responses, but provides paths to be followed in the most diverse situations - including cultural heritage. It could also work as an extension or addition of a Conservation or Management Plan, for example, but aimed at risk situations that could result in a substantial loss and endanger territories and places - by the rupture or loss of its materiality.

2 METHODOLOGY AND TOOLS

The beginning of the discussions towards the conception of a platform that could manage specific information about a given asset involved what would be the data to be collected. Even though each building or place has its own peculiar characteristics and values, with different forms of approach and apprehension, the team started to list some of the main means of survey that could assist in this stage of data collection to be carried out. The understanding of survey procedures as fundamental not only to intervene, but essentially to know and guide decisions, was indispensable to justify the proposal. It must be stressed also that the data collected, intended to be continuously updated, constitutes a memory of that site - in this sense, the Faster! platform could also be seen as a time machine, where data on different moments and situations can be accessed for any usage. Taking into account the theme of post-disaster solutions in cultural heritage, the proposal is structured in the following context: before, during and after an adverse event, as illustrated below (Figures 1–2). However, it is worth noting that this methodology would be applied in the most diverse cases, both in vulnerable places and where there is no foreseen disaster.

The main categories of data to structure a database on the Faster! platform are: Archival and Cadastral data; Surveys data; Common people's data.

For this, the methodology proposed by the MARBH program (Methodology for the Assessment of the Residential Built Heritage - created at FEUP/ Portugal in a Ph.D research and continues to be developed as a user-friendly digital app) was used as a reference (Ornelas et al., 2020 and 2016). The MARBH methodology offers quantitative assessment of items and/ or indicators on the following dimensions: Heritage, Technical and Social (Table 1), providing innovative, systematic and updated information that contributes to a cohesive assessment and monitoring of the built heritage at different scales and dimensions. In particular, if integrated or combined with ICT tools, MARBH can become a user-friendly assessment tool

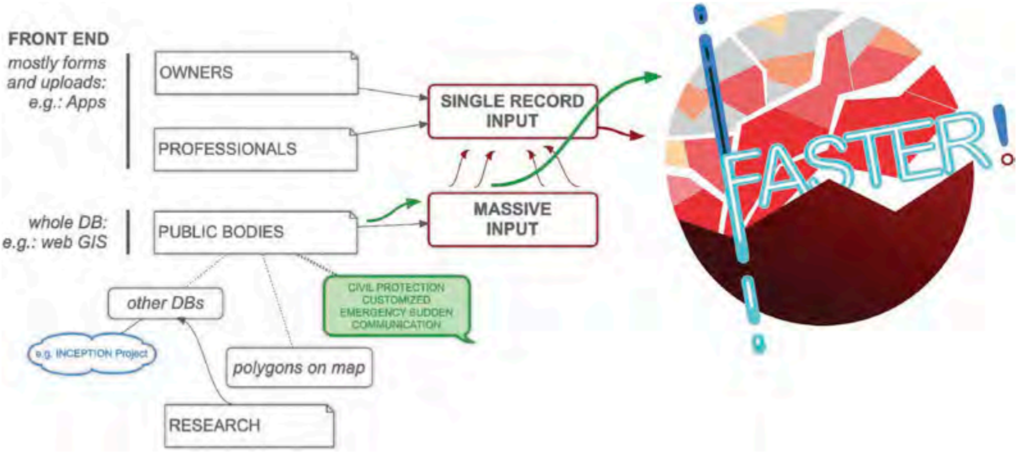

Figure 1. Scheme showing ways to feed the platform with inputs: contributions from owners, professionals and public bodies, in addition to other pre-existing databases. These data are continually added to the Faster! platform, which becomes more complete over time - pre-disaster situation. Elaboration: Flavio Ridolfi, 2020.

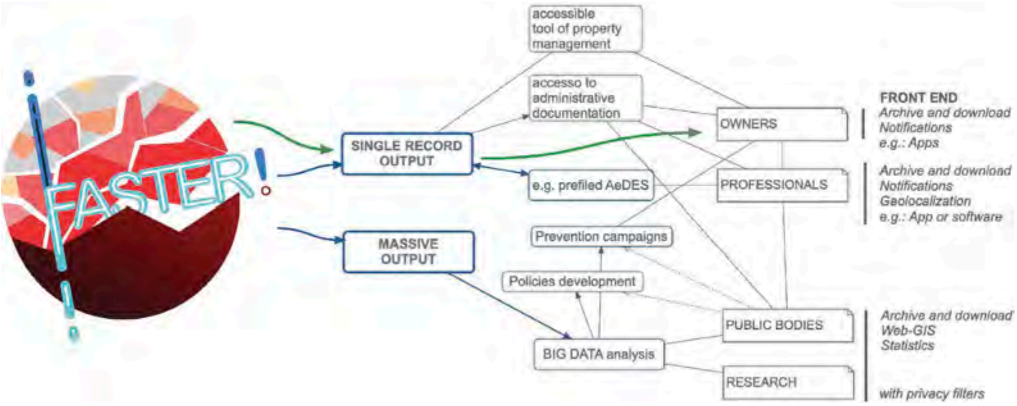

Figure 2. Scheme showing the outputs of the platform: in this case, both for a quick response in a disaster situation, as well as for eventual maintenance, intervention and research needs. Elaboration: Flavio Ridolfi, 2020.

for technicians and experts in the field of the rehabilitation and intervention on urban and built heritage, able to support digital databases. Finally, MARBH's characteristics make it also an interesting methodology to be included in a future HIA procedure, in a knowledge step, helping monitor the effect of the rising urban threats in World Heritage sites – and can also be embedded in the Faster! platform.

From the continuous updating and evaluation of these data, a synchronous monitoring of different buildings, places or landscapes could be carried out, providing clues for possible and eventual disasters (when comparing different results arising from structural analyses, for example), and even devaluation due to lack of maintenance.

Another aspect taken into consideration during the development of the platform concerns the different levels of access, whether to feed data or to disseminate it. At first, four main levels of access were defined depending on the user category, corresponding to four different modalities of viewing and exporting data, depending on the scopes:

Table 1. Adaptation of the MARBH tool (Methodology for the Assessment of the Residential Built Heritage – FEUP/Portugal, Cilísia Ornelas). The multiplicity of different types of surveys, such as the ones adopted by MARBH program was used as a reference to create the database to feed the Faster! platform system.

Part 1 – Heritage Dimension	Part 2 – Technical Dimension	Part 3 – Social Dimension
Particular Characteristics of Buildings	Safety and Housing Conditions	Residential Satisfaction
• Morphology/ Typology	• Structural Safety	
• External Elements	• Fire Safety	• Residents' Profile
• Interior Elements	• Safety to Normal Use	• Residents' Perception of Buildings and Dwellings
• Materials Techniques	• Housing Conditions and Comfort	• Residents' Perception of Residential Area

Source
Adapted from Ornelas, Cilísia & Guedes, João & Sousa, Fernanda & Breda-Vázquez, Isabel. 2020. "Supporting Residential Built Heritage Rehabilitation through an Integrated Assessment". *International Journal of Architectural Heritage*. 1-14.

Another aspect taken into consideration during the development of the platform concerns the different levels of access, whether to feed data or to disseminate it. At first, four main levels of access were defined depending on the user category, corresponding to four different modalities of viewing and exporting data, depending on the scopes:

– Level 1: Owners (common user) → access to web pages, apps, forms, questionnaires;
– Level 2: Professionals → access to web pages, apps, dedicated softwares;
– Level 3: Public administration → access to dedicated softwares, massive database statistics;
– Level 4: Research → access to all of the above (with privacy/disclosure filters).

The approach of the "Italian Protezione Civile" towards urgent data management was also taken into consideration and is somehow intended to be integrated in the larger database of Faster!. The AeDES ("Agibilità E Danno nell'Emergenza Sismica") method allows to standardize the collection of post-earthquake damage surveys, as well as to make results unified. "Erikus" software allows to prepare the ground for such surveys and to put the data on a GIS database making them easily accessible from different locations. In this manner, Faster! database accommodates and unifies data and keeps a modular approach towards other systems in order to fit into existing methodologies and to be customized for different usages (Figure 3).

When thinking about a post-disaster situation, fast solutions for the recovery of a place or an entire territory are needed and respective information about the affected area must be immediately available, in order to support the actions with a technical basis. This is also why it is essential that this system be allocated in a digital repository.

3 OUTCOMES

From the implementation of the Faster! platform, people request in the emergency is simpler, possibly without a paper form, and it's not needed to collect them by employees or volunteers. Since it is programmed as a reliable system based on different types of integrated surveys, investigation and analytical techniques (avoiding the problem of discordant Cartography tables), its front ends are customized depending on the public - such as different kinds of institutions, professionals and private subjects.

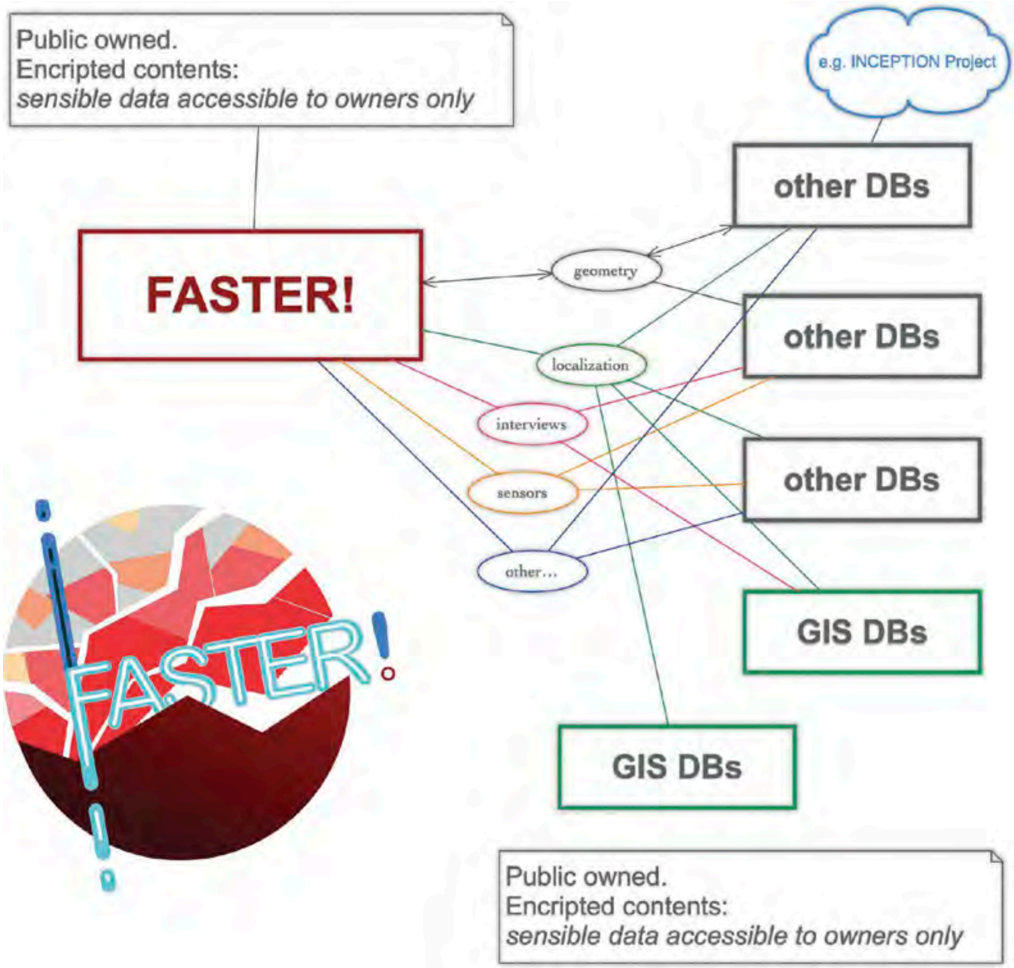

Figure 3. Scheme of the modular integration of Faster! with pre-existing databases. Elaboration: Flavio Ridolfi, 2020.

It allows a multi-scale analysis with different and complex graphic and thematic charts being generated as outcomes. At the same time, it is a shared storage of detailed and precise information and data for better knowledge, functioning as a time machine - always updated. In the case of damage survey, Faster! data management provides an improved DPC system (Figure 4).

4 DISCUSSION

The Faster! platform represents an attempt to develop a methodological and practical tool to manage already existing knowledge and increase data available on different levels within a single system, embracing both landscape and built environment.

Its possible applicability to different scopes - from prevention to research - is certainly a major pro, opening for its adoption but a wide plethora of professionals and unspecialized-users. The automatization of process as well as the modularity of the information help the platform to be a user-friendly tool, in accordance of course with the different goals for which it is employed and to the expertise and experience of the user. Faster! ultimately represents the

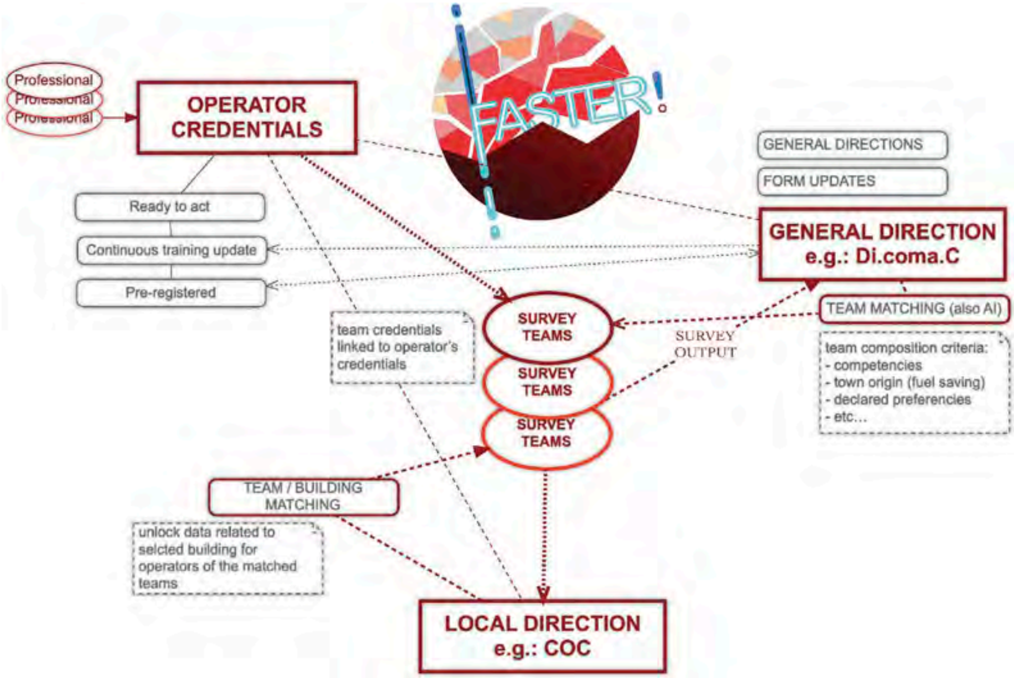

Figure 4. Scheme showing a model of Faster! emergency management for what concerns large scale damage survey. Elaboration: Flavio Ridolfi, 2020.

opportunity of unifying the documentation process, also integrating statistics and big data within a single platform. At the same time, being accessible to different profiles of users, it is potentially an important asset to implement policies and campaigns and enhance participatory processes.

Clearly, a similar platform presents different potential weaknesses which require careful analyses. A first, more technical aspect is the application of universal standards codes: this is an element which potentially would limit the loss of information, making data more accessible. The following issues are more related to the proper implementation of the platform and the engagement of different “actors”.

In fact, the data collection process is highly dependent on users: gathering and maintaining the database up-to-date requires a constant and organized effort, and should not be left as an individual initiative. Parallelly, data collection might also generate privacy issues, if owners of lands or buildings are not directly involved in the processes. To this concern, the definition of a precise legal framework, and eventually its adaptation to specific contexts, is of primary importance.

It is evident that the involvement of public bodies is vital, either in terms of interest in the adoption of new tools and in the formation of specialists. As mentioned, the implementation and adoption of the platform cannot rely entirely on individual initiatives, and consequently the role of public administrations is crucial to its success. If the platform is not systematically adopted and is not regularly updated, the risk is to have a frozen picture, preventing us from effectively monitoring natural and human processes taking place. Similarly, if its use is limited to extremely specific purposes or tied to a flattened approach, it might cause an irregular application of the methodology and of the tool, resulting in a lower amount of data collected and once more, importantly affecting the effectiveness of the platform. In any case, Faster! adaptability and holistic approach make it an extremely valuable tool to pursue different goals. In a shorter term, its “preventive” nature is most evident, contributing to limit the loss of information in case of destruction following natural or human hazards, as well as to mitigate damages. In the medium- term, it would help develop proper prevention plans, not only to mitigate eventual damages, but to potentially avoid certain types of emergencies.

Furthermore, it could represent an important tool to increment "historical" knowledge in local building techniques and landscape exploitation strategies. This latter aspect appears to be particularly interesting for its long-term potential: in fact, it might well contribute to trigger local community activities through the implementation of more sustainable socio-economic development plans.

To this concern, the contextual promotion of the platform by International Organizations (e.g., UNESCO or ICOMOS) could be taken into consideration. Faster! would represent a useful instrument to evaluate potential new World Heritage cultural landscapes or identify potential dangers to already enlisted sites. Indeed, as a consequence of climatic change and unsustainable exploitation practices, more and more geographical regions are exposed to increasingly frequent natural hazards which could lead to the complete loss or widespread destruction of important landscapes and settlements, either ancient or modern. As mentioned, Faster! is though primarily as a preventive tool, aiming to prevent or limit damages and information loss, but is an important support to develop - and or in certain cases integrated/update - valorization and conservation plans. Moreover, it would represent an important tool for International Organizations and States to better manage and coordinate the candidature process to WH Tentative List and WH List, prioritizing those properties more exposed to human and natural hazards.

To conclude, Faster! represents an important asset for different users and different purposes. It could surely find an important application in the immediate aftermath of natural and human hazardous events, but it would be an even more precious resource as a preventive tool, to limit damages and develop a more sustainable future.

AUTHORS CONTRIBUTION

Given the multidisciplinary nature of the Summer School "After the Damages", the different backgrounds of the authors contributed so that the proposal presented addressed different perspectives. In this way, after several meetings and brainstorming sessions, the group jointly decided to deal with a theme that was the common point among their academic and professional experiences, which is the need for accurate documentation of cultural heritage and sites. The personal experience of each of the authors was fundamental for the theoretical approach, methodology and applicability of the proposed platform.

In this paper, the vector illustrations of the methodology were made by Flavio Ridolfi; the writing-original draft preparation was done by Renata Campiotto and Nicolò Pini; and the writing-review and editing by Flavio Ridolfi and Cilísia Ornelas. All authors have read and agreed to the published version of the manuscript.

ACKNOWLEDGMENTS

The participation of all authors in the Summer School "After the Damages" 2020 Edition would not be possible without the support of all partner institutions: the Department of Architecture of the University of Ferrara, the DIAPReM Centre, the Labora.R.A., LEM and TekneHub research laboratories, the Department of Engineering and Architecture of the University of Parma, the "Enzo Ferrari" Engineering Department of the University of Modena and Reggio Emilia, the Regional Agency for Reconstruction Sisma 2012, the Authority for Archaeology, Fine Arts and Landscape MiBACT and the Institute for Artistic, Cultural and Natural Heritage of the Emilia- Romagna Region.. This paper was carried out with the support of the São Paulo Research Foundation, FAPESP (Direct Doctorate Scholarship - Process no. 2019/10406-0 of Ph.D Candidate Renata Cima Campiotto).

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Built Heritage in post-Disaster Scenarios – Balzani et al. (Eds)

Contemporary approach to ancient walls

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ABSTRACT: When we researched a theme to develop, we thought about our personal studies and professional experiences. Therefore, we realized that a common topic had been studied by all of us and linked our paths: the city walls, with their fortifications, conformation, history, memory, past and present.

Consequently, we asked ourselves what could be a scientific approach to the analysis of the surrounding walls of historical cities and we asked ourselves some questions: what identity and value do they have for the community? What is the level of knowledge necessary to approach their restoration? How can conservation, structural reinforcement and enhancement be combined through a contemporary language?

Through an analytical method we then compared three case studies (Istanbul in Turkey, Agadir Oufella in Morocco and Durres in Albania) that allowed us to deepen the methodological aspects developed.

What we have achieved is a methodological and holistic approach that can be replicated to other historical buildings and "border" artifacts, without neglecting the relationship between the people who will experience the monument and the monument itself, after the conservation and enhancement interventions applied on it.

Keywords: contemporary language, critical, identity and value, inclusive, knowledge, structure

1 INTRODUCTION

Ancient town walls are often boundaries between the old and the new town, so a sort of limit in the urban texture that nowadays acquires a different meaning for the city. If in the past urban life was embraced and surrounded by walls, in contemporary cities old walls are often in between the built environment. In many cases, however, the fortified circuit still marks the limit between the ancient and the modern city, embodying the psychological border between

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DOI: 10.1201/9781003253730-40

two worlds that often have conflicting relationships. On the other hand, the fortified walls assume the role of an outstanding repository of cultural values for the historical city. In addition to the intrinsic historical value of their structures, their symbolic and identitary value is indisputable, as in them the city itself has placed, during the centuries, the security of its existence.

If in the early modern age, that of the city walls was an uncomfortable and cumbersome presence, of which we often wanted to free ourselves, also for their symbolic implications and in the name of new urban forms and functions, today their value is recognized and we strive for their preservation.

So, when dealing with damages on this type of structures, we should address to some questions related to how we perceive them: first of all what is the historical testimonial value that the community gives to this architectural elements? In some cases, in fact, walls are neglected and forgotten, but in others the community still interacts with them, having found different functions, purposes and ways of using them. For this reason, the question "what do we do with them when they get damaged?" can't be answered without first understanding their meaning for the city to which they belong to.

2 BACKGROUND OF THE STUDY

The strength of this proposal is giving importance to restoration in aim to know, thus providing more stability to the structure and preserving the consolidated image of the historical city in a symbolical dimension. It is important to consider damages as a 'project opportunity' which can provide recognition by the inhabitants of an often-forgotten heritage by means of a visually appealing solution. But the quality of the appearance of the adopted solutions depends on many factors and it will have to deal with problems related to the historical authenticity. Furthermore, establishing a relationship between ancient structures and contemporary additions can be difficult in both symbolic and material sense. The proposal of this study is to solve the problem of aging in supporting elements by using a contemporary architectural language.

3 METHODOLOGIES

In the face of a disastrous event, which leads to the collapse of a relevant section of a fortified circuit (Figure 1), we can intervene according to different approaches. These different methods can be exemplified, but they all require a preventive path of analysis, knowledge and awareness. First of all, as usually said, 'we must know before restoring'. Within this context, the role of the survey disciplines, declined in the morphological, structural, diagnostic and archaeological aspects, is certainly central. The survey must lead to critical investigation and assessments, which must also take into consideration the data from historical and iconographic sources. These processes of 'knowledge increasing' don't constitute a neutral operation, however, they are necessary in order to justify an intervention. If critically oriented, they introduce sometimes unexpected and fruitful design themes, which can lead to the discovery of latent meanings or to the rise of new vocations. In the light of the streams within the theory of restoration, we can succinctly exemplify and summarise the main approaches to the theme of the walls' recovery, according to three different models. We premise that this is a rough simplification, since each individual case requires in- depth reflection, the results of which can easily determine the need for a hybridization of these methods. In fact, we must not confuse dogmatism, to which uncritical adherence to a theory leads, with methodological coherence. In the first example (Figure 2) the damage is treated as a wound to be healed, by restoring the elevation of the wall. In this case, obviously, we can opt for an à l'identique restoration using the same materials and the same texture as before, or by using different solutions to make recognizable the recovery intervention.

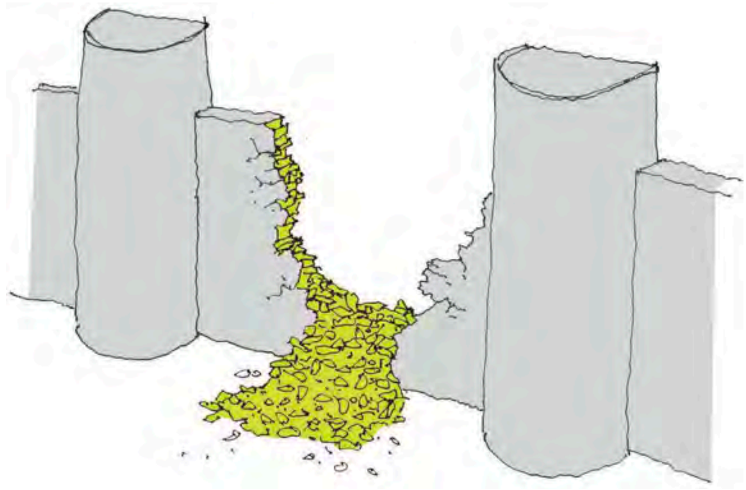

Figure 1. The collapse of a relevant section of a fortified circuit.

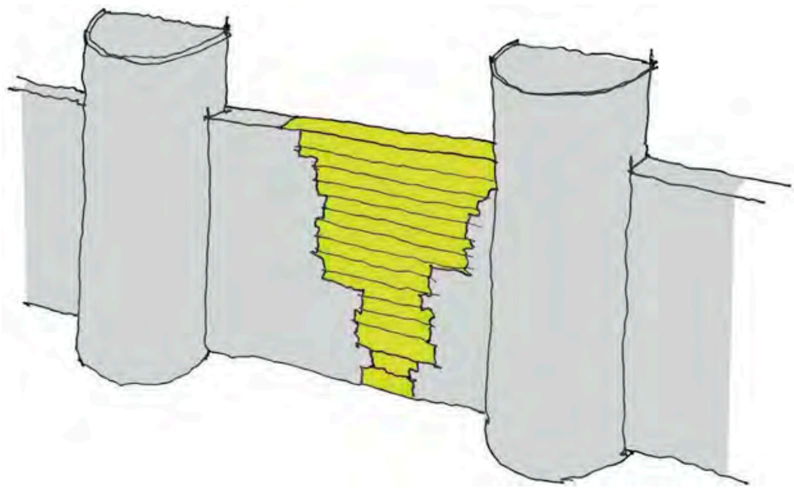

Figure 2. The damage is treated as a wound to be healed.

This type of intervention can vary significantly depending on the design and technological solutions and on the underlying objectives. This method can aim to erasing the disastrous event from the memory, at least in terms of image, or to highlighting the palimpsest character of the walls.

In the second example (Figure 3), we show how the void, or rather the lacuna, can be treated as a permanent archaeological yard, consolidating the surviving structures and developing an accessible path that leads to their knowledge. In this case the injury is an opportunity for a closer contact with the matter, in order to be able to learn constructive features of the structure or to explore hidden and unusual visions. Otherwise, the shape can be crystallized intentionally in the state resulting from the event, by carrying out only a simple consolidation of the adjacent sections.

The damage, in these cases, becomes an integral part of the monument's history. The last example (Figure 4) considers the damage as a design opportunity, by inserting an element of contemporary architecture. The figural unity of the walls is recomposed, but a 'new door' has been created. The contemporary door is aimed to improve the awareness of the people experiencing

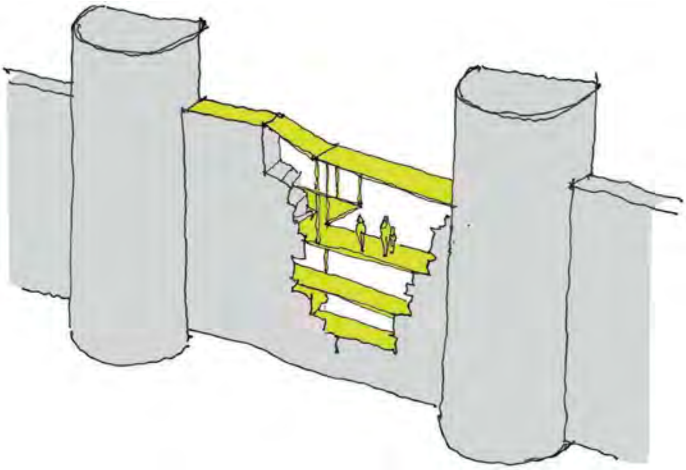

Figure 3. The void, or rather the lacuna, is treated as a permanent archaeological yard.

this monument and to allow the re-appropriation by the community of the spaces around and through the wall. The new gate provides thus some answers while raising many questions. In any case we can say that 'we restore to know or re-know the walls'.

The new architectural sign compares itself with those of the past and intends to dialogue with the historical urban landscape. Of course, the respectful or prevaricating nature of this relationship is a variable that is strongly affected by the designer's sensitivity, constituting a potential risk of damage for the manufact.

4 CASE STUDIES

This part of the paper offers some examples to explain our approach in action. Each case is selected to generate solutions for damages in ancient city walls that have different relations with the urban tissue. We wanted to implement the approach to three cases of city walls that have different relationships with their urban context and that are in need of recognition and stabilization.

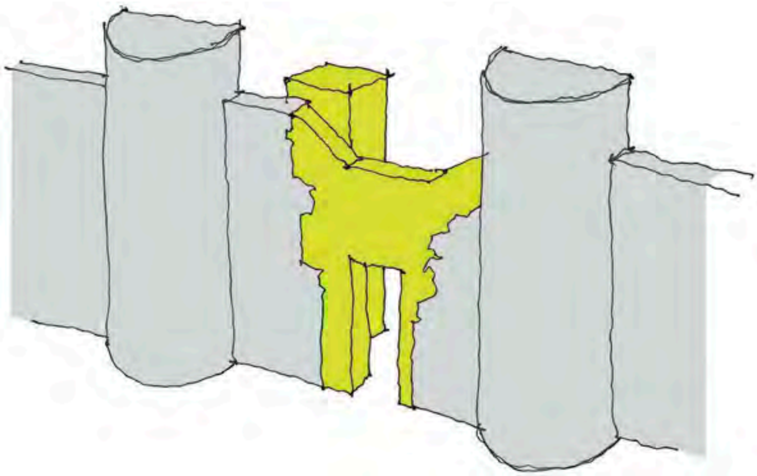

Figure 4. The damage is considered as a design opportunity.

Figure 5. The hypothetical reconstruction plan of strong houses and defense walls in Galata, İstanbul. Graphic is prepared regarding information from Sağlam, 2018.

Source: Sağlam H. Sercan. 2018. *Urban Palimpsest at Galata & An Architectural Inventory Study for The Genoese Colonial Territories in Asia Minor.* PhD Thesis. Politecnico di Milano.

4.1 *Genoese Walls of Galata, İstanbul*

The damaged Genoese fortification in Galata, Istanbul, is placed in the city center (Figure 5). Galata, which was called "Sykai" (Eyice,1969) is located in the east coast of Golden Horn and has a history that dates back to the 2nd century. The first fortification of Galata was for securing the entrance from the sea and placing the chain extending between the castle and the coast where the imperial palace of Byzantium was. The Genoese settled to Pera in 1267, therefore the Venetian fleet attacked Genoese settlements along the Aegean Sea and Galata, during the Byzantine- Venetian War of 1296 – 1302. Following this event, the Genoese demanded to have security in Galata and gained the right to build houses with necessarily strong and secure walls in 1304, but constructing any kind of defense wall or a castle was not allowed. In 1316, the Genoese gained the right to build surrounding moats, but they violated the articles by building walls among strong houses and encircled Galata in 1335. What remains today from this fortification is only a number of strong houses and thin masonry stone walls connecting them. This research focuses on the largest piece, due to its heavily damaged current situation.

The need of interventions is very urgent due to the The North Anatolian Fault zone (NAF), affecting Adapazarı and the surrounding settlements. This is seismically one of the most important active faults in Turkey (Figure 6). The western segment of the NAF extends as a single line until Dokurcun and divides into two main branches. It passes through Arifiye,

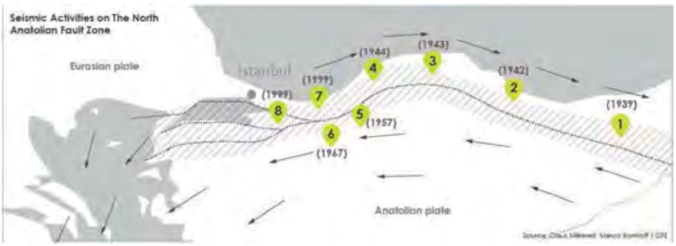

Figure 6. The hypothetical reconstruction plan of strong houses and defense walls in Galata, İstanbul. Graphic is prepared regarding information from Sağlam, 2018.

Source: Bulut Fatih, Bonhoff Marco, Ellsworth William L. Aktar Mustafa, Dresen Georg. 2009. Microseismicity at the North Anatolian Fault in the Sea of Marmara offshore Istanbul, NW Turkey. J*ournal of Geophysical Research*, Vol. 114.

Figure 7. Location of the Genoese defense walls in İstanbul. The remaining walls are connected to Galata Tower on the left and reaches down to Bankalar Street.

Source: https://3d.beyoglu.bel.tr/.

Sapanca, İzmit and reaches the Saros Gulf through the Marmara Sea. Especially in Adapazarı, numerous strong and small earthquakes have been recorded since 1943. The major earthquakes that affected the region are respectively Ms = 6.6 in 1943, Ms = 7.1 in 1957, Ms = 6.8 in 1967, Mw = 7.4 in 1999 and Mw = 7.2 in 1999. Especially 1999 Marmara Earthquakes affected İstanbul and caused significant loss of life and property.

The fortification walls in Galata are mostly demolished and the remaining parts are damaged by the calamities and by the buildings that have been attached to walls in the past. The foundations of the selected section of the wall are heavily damaged due to the lack of support from the soil, that has been taken away for the construction of a new building. Infilling the soil back or shoring with structural scaffoldings may help to keep the stability of the wall. Yet, unless the wall became a part of contemporary city in a proper way, it is hard to provide a long term solution.

Figure 8. This section of the wall has been documented by the team led by prof. Giorgio Verdiani and Doruk Peker in 2019. The outcome is used for the preparation of the stabilization proposal for the defense wall.

Source: Peker Doruk, Spallone Roberta, Camiz Alessandro and Vitali Marco. 2021. TLS survey and architectural representation of a Genoese tower for the Museum of the city and territory of Galata. Cities in Evolution: Diachronic Transformations of Urban and Rural Settlements, VIII Architecture, Archaeology And Contemporary City Planning Symposium, Istanbul 2021.

The recommended intervention is the stabilization and strengthening of the structure, first by infilling the soil to cover the exposed foundations, then preventing possible landslides and ruptures on the wall by means of scaffoldings. The missing part of the foundations is considered as a wound to be repaired, but removing the remains of the demolished structures that were attached to the walls could cause further physical damage. The intervention proposal includes opening the gate near the tower, for gaining this desolated heritage as a part of the contemporary city (Figure 8).

4.2 *Agadir Oufella, the upper Agadir*

The city of Agadir is today one of the major components in the urban structure of Morocco. It is the capital of the southwest territories of the country, endowed with an important tourist and economic attractiveness.

The progress of Agadir today is however an uprising that the city makes of a sad event that took place during a night in the holy month of Ramadan, on February 29, 1960.

An earthquake of a magnitude of 5.71 on the Richter scale hit Agadir, leaving behind 12,000 (a third of the city's population) dead and 25,000 injured. Great international solidarity came to the aid of the citizens of Agadir. Because of the earthquake, the city suffered severe damage in its materiality, while the Kasbah of Oufella, built in 1540 (the old city of Agadir), almost entirely collapsed and only the surrounding walls partially survived (Figures 9, 10).

The walls of the Kasbah of Oufella, of 1110m in total linear length, survived partially the earthquake's disaster, but their height was reduced by a remarkable amount (dropping from 6m to 2m of height). The towers resisted remarkably and played a significant role in reinforcing the wall, preventing from its total collapse. The fortification walls showed great robustness and resistance to the disaster (compared with the total collapse of the inner-city walls) thanks to their build, their thickness, which exceeded 1m, and the material they were made of (stones). All these qualities prevented the walls from totally collapsing (Figure 11).

Oufella's walls geometry:

– Lenght: 1100 m
– Height: 5 to 6 m
– Thickness: 0,5 to 1.6 m

Nowadays, the walls of Agadir Oufella have been partially reconstructed. Conversely, the city inside has not been rebuilt, because it's considered a Muslim cemetery, thus prohibiting its restoration. The walls of Agadir Oufella is today made of some restored sections and others, left untouched, that testify to the disaster of the earthquake. Agadir Oufella, on the hill, is today a place visited by tourists, which offers a panoramic view of the modern city of Agadir, which has been completely rebuilt.

Figure 9. Agadir Oufella, The Historic Kasbah, Before the earthquake 1957.

Figure 10. The Kasbah of Oufella after the earthquake.
Source: https://www.alamy.com/stock-photo/agadir-earthquake.html.

Figure 11. The Walls of the Kasbah, before and after the earthquake.

«Agadir became a big city (680 000 inhabitants in 2004), with its huge harbor composed of a commercial port, a fishing port and a marina. Agadir was the first port for sardines in the world in the 1980s, and has a famous beach, stretching over 10 km with one of the most beautiful seafront promenades in the world. With its white buildings, its large flowered boulevards, its modern hotels and its European style cafés, Agadir is not a typical and traditional Moroccan city, but a modern town, active and dynamic, definitely open to the future.»

4.3 *Durres walls after the 2019 earthquakes*

In 2019 a series of three earthquakes of magnitude higher than 5.5 Richter has hit the provinces of Durrës, Alessio and Tirana in Albania. In the same year, the Department of Engineering and Architecture of the University of Parma has focused its studies on the damaged historical city walls of Durrës.elements: sea and the behind hill. The fortress creates the identity of the entire context. Therefore, identity and authenticity were underlined and valorized during the restoration project, creating a strong relation among the natural and human elements.

The ancient town fortifications consisted of crenellated walls and towers that were built in different ages. However, of this original system of walls only a part is still standing today (Figure 12). The remaining structures clearly show the variety of interventions they have undergone in the centuries and the different wall typologies, styles and systems they were made of. As a matter of fact, while the Ottoman portions of the walls are made of bricks and thick layers of highly resisting mortar, other parts of the fortifications consist of stones and date back to the Venetian period. The foundations instead are built with big blocks of square rocks positioned on round stones cemented with mortar (Figures 13, 14).

This mixture of properties in the build translates into a more delicate structure, that in case of an earthquake, could be prone to easily damage in correspondence of these discontinuities. Another cause of vulnerability in many portions of the walls is the presence of shrubs and trees, whose roots have already damaged the masonry. Nonetheless, the walls being squat and short, with a height of 6-9 meters and a width of 3.5 meters, haven't suffered serious damage following the earthquake of 2019 and just some old cracks have reopened. The crenellations have also survived thanks to the quality of the mortar of the wall, none of them has collapsed and only a few have shown signs of rupture at the base (Figure 15). While most of the towers have suffered minor damages, a big portion of masonry in the tower C has collapsed, despite the good quality of the brickwork in this part of the fortification. The collapse was caused by the overturning produced by the earthquake in a portion of masonry that lacked anchoring to the rest of the structure and that was affected by the presence of vegetation and roots.

The recommended interventions consist of the stabilization and strengthening of the walls: touch ups (scuci-cuci) for the deteriorated parts of the masonry, supports and polyester fibers bandages for the crenellations and steel hoops for the circular towers. For the tower C, it would be recommended to consolidate the standing fractured wall adjacent to the collapsed part, by anchoring it with tie bars to the more solid portions of the tower in the background (Figure 16). To avoid further damages, unrelated to the earthquake, another important intervention would be removing the vegetation on all the walls and applying biocide to prevent its growth.

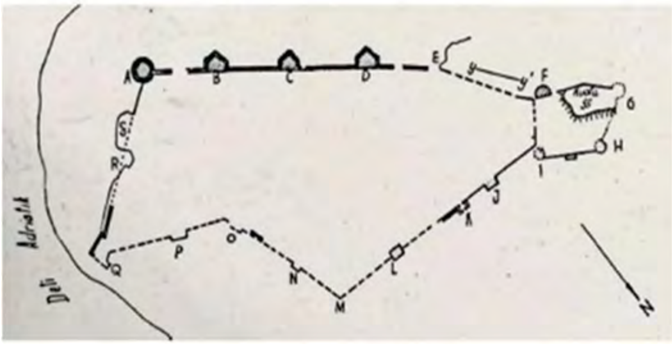

Figure 12. Plan of the walls of Durres.

Source: Eva Coïsson, Daniele Ferretti, Erica Lenticchia, *Report of joint inspections between the Superintendency of Durres and the University of Parma to historical-monumental buildings damaged by the Albanian earthquake*, Parma, 06 Gennaio 2020, p. 17.

Figure 13. Walls of Durres.
Source: Eva Coïsson, Daniele Ferretti, Erica Lenticchia, *photo taken during the inspection, December 2019*, graphic reworking by the authors.

Figure 14. Walls of Durres, mixture of properties in the build.
Source. Eva Coïsson, Daniele Ferretti, Erica Lenticchia, *photo taken during the inspection, December 2019*, graphic reworking by the authors.

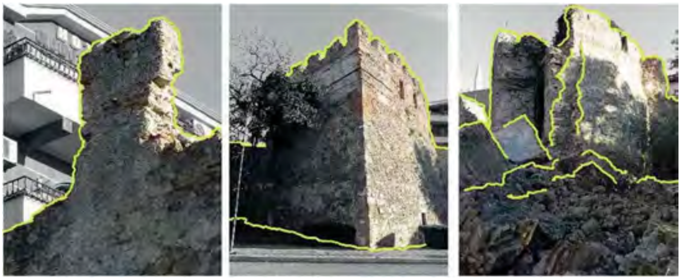

Figure 15. Walls of Durres, serious damage into crenellations.
Source: Eva Coïsson, Daniele Ferretti, Erica Lenticchia, *photo taken during the inspection, December 2019*, graphic reworking by the authors.

Moreover, the structures of the walls could also be integrated architecturally with a walkway that would allow tourists to visit the fortifications, while building an internal staircase in the towers, to reach the new gangway, could have positive effects on the stability of the structure.

Figure 16. Walls of Durres, recommended interventions.

Source: Eva Coïsson, Daniele Ferretti, Erica Lenticchia, *Report of joint inspections between the Superintendency of Durres and the University of Parma to historical-monumental buildings damaged by the Albanian earthquake*, Parma, 06 gennaio 2020, p. 21 (a) and 27 (b), graphic reworking by the authors.

Figure 17. Examples of walls' identity, study, structure, use and integration with contemporary language.

Identity and value – *In what way does the community identify with the architecture? How much is the construction used by the people and how important is it for them?*
Knowledge – *It is key of the whole process. Acquiring knowledge is needed to find the best intervention solutions and providing knowledge is important to enhance community interaction with the architecture.*
Critical – *Intervention can be decided after a critical thinking process that starts from knowledge.*
Structure – *There can't be restoration without structural intervention, being architecture an art made of matter.*
Inclusive – *Architecture should be inclusive to boost connection and attractiveness for the community.*
Contemporary language – *Restoration should be visible, understandable and translatable as a sign belonging to its time.*

5 CONCLUSION

To summarize the whole research we have come up with some key words to better address the most important features to consider when restoring boundaries. This method though can be applied also to other contexts and heritage manufacts.

AUTHORS CONTRIBUTION

Abstract, Giuseppe Camillo Santangelo. Introduction, Michele Cornieti and Ilaria Manetta. Background of the study, Özge Özkuvancı. Methodologies, Michele Cornieti. Case studies: Genoese Walls of Galata, İstanbul, Özge Özkuvancı. Agadir Oufella, the upper Agadir, Lamiae Ainine. Durres walls after 2019 earthquakes, Ilaria Manetta and Giuseppe Camillo Santangelo. Funding acquisition, all authors. Writing-review and editing, Özge Özkuvancı, Ilaria Manetta and Giuseppe Camillo Santangelo. All authors have read and agreed to the published version of the manuscript.

ACKNOWLEDGMENTS

We want to thank Prof. Eva Coïsson for her contribution to our research work, especially in reference to the case study of the walls of Durres, of which we have studied the *Report of joint inspections between the Superintendency of Durres and the University of Parma to historical-monumental buildings damaged by the Albanian earthquake*, that she has kindly allowed us to deepen and quote.

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Built Heritage in post-Disaster Scenarios – Balzani et al. (Eds)

A thrust on modern heritage conservation: The comparative cases of 20th century architecture in India, Italy and Turkey

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ABSTRACT: Modern heritage is relatively young and does not even fall under protected heritage in most countries. The biggest threat for Modern Heritage is incessant demolition and vandalism alongside material and structural decay and damage. Therefore the immediate concern would be the lack of awareness.

The identification and assessment of the significance of twentieth-century cultural heritage should use accepted heritage criteria. The cultural heritage of this particular century (including all of its elements) is a physical record of its time, location and use. Its cultural significance may rest in historical, social, scientific or spiritual associations and its tangible attributes, including physical location, views, design (for example, form and spatial relationships; colour schemes and cultural plantings; construction systems, fabric, technical equipment, as well as aesthetic qualities). Significance may also lie in use, evidence of creative genius, and/or in its intangible values (Approaches for the Conservation of Twentieth-Century Cultural Heritage 2017) The purpose of this article is to answer questions about what values to preserve, considering a relatively new architectural heritage. The research attempts to answer these questions from a general perspective through four different case studies and areas: IIM, Ahmedabad, India; İnönü Stadium, Istanbul, Turkey and the Nino Colombo Beinasco Library, Turin, Italy. The results of the comparison complete the conservation strategy and vision for the future.

Keywords: conservation, holistic approach, open data, survey, vulnerable places

1 INTRODUCTION

The modern movement came about as a reactionary move and as a part of simultaneous development with industrialisation. It later metamorphosed into a need during the post-war reconstruction. William Curtis observed in 1989 that '. . .major revolutions in the history of Architecture were all together rare and the changes that took place earlier in the century have altered the ground on which we stand. . .Such buildings render critical oppositions between form and function, image and structure, modern and ancient, irrelevant. They articulate deeply held beliefs about the human condition in a way that suggests inevitability rather than arbitrariness. And they possess the sort of symbolic prégnance that guarantees longevity.' (Curtis 1989).

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DOI: 10.1201/9781003253730-41

The Modern Movement did not develop singularly as a stylistic entity but as an encouragement of material, formal and regional expression. It, therefore, became an assimilation of the technological advances, application of theoretical and philosophical standings, and regional wisdom. The works of the modern movement need to be protected not only as symbolic heritage but also as 'lived-in' heritage.

This work aims to answer the fundamental questions of what and how to preserve while adapting to change when the issue is a relatively young architectural heritage. The key concerns are:

1. How to formulate management definitions regarding modern urban areas and cultural landscapes?
2. Which are the values to be preserved and transmitted to the next generations?
3. How to formulate social participation into a protection area?

2 THE ANSWER: CHANGE

Co-operation	establish a multi-disciplinary team to identify problem areas. architects, Engineers, Anthropologists, Historians, archaeologists, user/stakeholder representation
Heritage	tangible and intangible parameters; the cultural, societal, contextual impact of the architecture on the heritage
Analysis	of concerns related to human-made and natural disasters through damage survey and monitoring
Need	for immediate action or phase-wise/long-term action for sustainability (immediate concern of demolition and reconstruction) for the historic fabric (as today we were saying "every building lives and talks", so we need to hear it in order to know what to do with it)
Ground	actions on security + rejuvenation (save the heritage but also give a new and coherent meaning to its identity) + adaptive re-use
Establish	a legacy

3 CASE STUDIES

3.1 *Indian institute management, Ahmedabad*

Dubbed an institute of national importance by the Government of India was established in 1961. It was an essential part of the nation-building exercise in post-independence India. Designed initially by Louis I Kahn in association with Anant Raje, BV Doshi and Kulbhushan Jain, IIM is not only an embodiment of Modern architecture language but also an ode to the regional sensibilities. The building was designed as a load-bearing structure in brick masonry. Reinforced arches with RCC tie beams were one of the many unique structural and material innovations. Several experimental construction exercises were carried out before the actual construction of these arches.

Wear and tear due to continuous, uninterrupted use, dilapidation due to age and damages caused to a major earthquake in 2001 were the primary reasons for concern and need for restoration. There was a need to protect and enhance these buildings since they were seriously affected by age, degree of exposure to sun, rain and wind, and problems that arose from the original construction techniques, quality of workmanship and deferred maintenance. It was observed that the local bricks used for the construction of these buildings in the 1960s were porous and the cement mortar used was harder than the bricks. The reinforcement in the concrete had been laid without adequate cover. The vertical and horizontal mild steel (MS) reinforcements in the brick walls and arches corroded, leading to cracks in the brickwork. The defects also resulted in efflorescence, rising damp water seepage and brick spalling. The failure of terrace waterproofing had caused dampness in exposed concrete slabs resulting in corrosion of the reinforcement, and with inadequate concrete cover, resulted in spalling. (Bahga 2019) The campus restoration was carried out in phases by Somaya and Kalappa Consultants, starting with the Vikram Sarabhai Library from 2016-18. The conservation addressed the structural concerns and also the concerns of appropriations carried out during its lifetime and the need for updating and rejuvenation. More recently, the institute's management had decided to demolish 14 of 18 student dormitories on campus due to "unsafe" conditions and failure to effectively restore the structure even after several attempts. (Jha 2021) However, the expression of interest (to demolish) was later withdrawn by the authorities via a letter addressed to 'all the stakeholders of IIM, Ahmedabad'. The retraction came about after many awareness campaigns and protests were held by the architects across the country, the alumni of the institute and the citizens alike. What powerfully works in favour of IIM-A was the collective memory associated with the continuous and unchanging usage of the campus. The unique architectural language, innovation in construction techniques, spatial quality and the planning and hierarchy of spaces set an important example for the study of architecture. The campus also has a deep association with the image of the city and is a part of its historic rise to fame in the 60s and 70s.

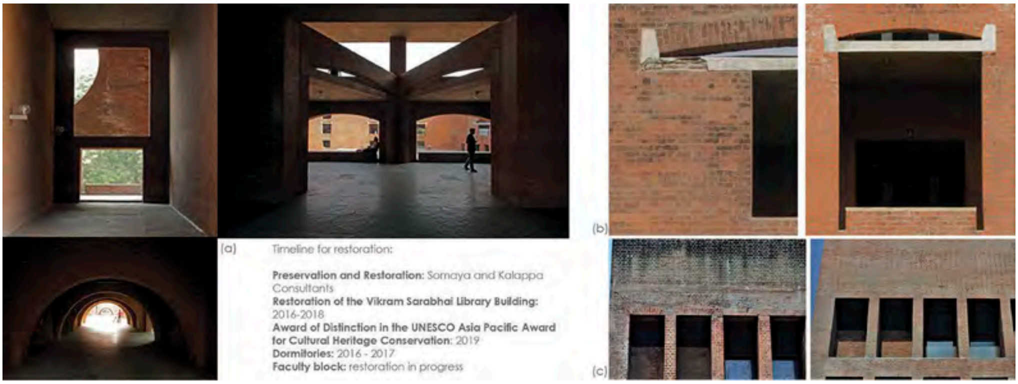

Figure 1. (a) IIM-A Spatial qualities (b) the tie beam before and after restoration (c) The facade before and after cleaning and restoration.

3.2 *İnönü Stadium, Istanbul, Turkey*

İnönü Stadium has been the home stadium of Beşiktaş Gymnastics Club since its inauguration in 1947. The building was designed by architects Paolo Vieli-Viotti, Şinasi Şahingiray and Fazıl Aysu. The construction work started in 1939, on the land behind Dolmabahçe Palace, next to the former Gas Plant, and the first phase of construction was completed in 1947. The stadium was enlarged with new open tribunes added in the 1950s on the west wing where the Gas Plant buildings were located. Since the stadium is located on the Bosphorus and in the vicinity of historic monuments such as Dolmabahçe Palace and Mosque, any renovation work needed to be approved by the relevant Regional Council on Conservation of Cultural Assets. In the 1970s, Beşiktaş Gymnastics Club had several requests to the Council to increase the stadium's spectator capacity. However, these requests were rejected due to the building's prominent position within the silhouette of the city. In 1978, the Council finally approved a renovation project that proposed adding two towers with additional seats between them and the entrance portico on the south wing at the Bosphorus side (Council decision no 10553 dated 8 September 1978). In 2004, the stadium underwent an extensive renovation in order to meet UEFA standards. Within the renovation project, the field was lowered to make room for additional seats. The open tribune that was added in the 1950s was covered with a metal roof, and the seating capacity was increased to 32145 spectators. The stadium was designated as cultural property in 2005 according to the "Law for Conservation of Natural and Cultural Properties" numbered 2863 (Council decision dated 31 March 2005). This decision was based on the expert views of DOCOMOMO Turkey and ICOMOS since only the buildings built until 20th century are considered cultural heritage by the law. (Turkish Law No. 2863 1983) Turkey underlying the significance of the building reflecting the Turkish modernism, being the first stadium built in İstanbul, preserving its authenticity and integrity with its main colonnaded entrance and is located within the boundaries of Dolmabahçe Palace conservation zone. (Salman S.Y. 2013)

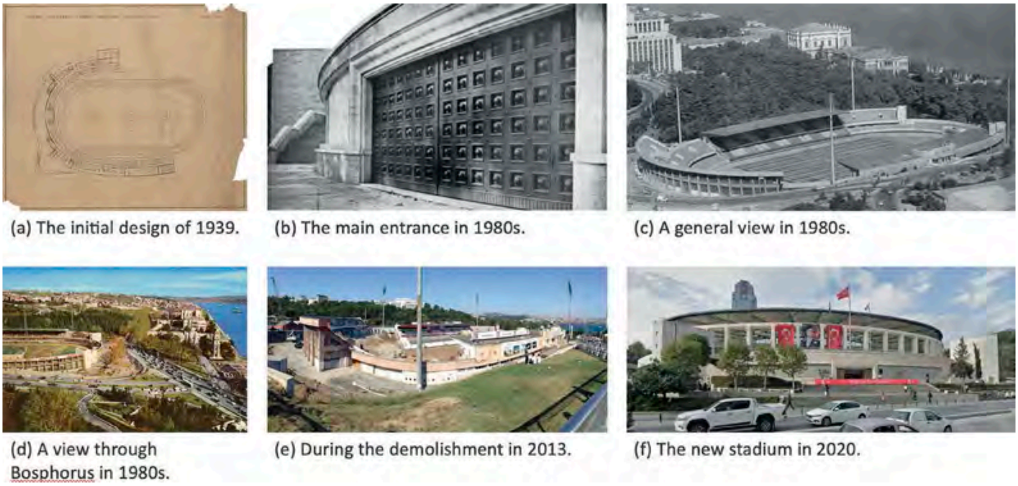

Figure 2. İnönü Stadium, Istanbul, Turkey. (a) (AHISTDOLM044 n.d.) (d) (ATFAISD0004 n.d.).

In 2013 the same Council that decided of listing the building as a cultural heritage decided that the additions to the first design are damaging the authenticity and integrity of the stadium. Furthermore, those of 2005 are not structurally safe according to the Earthquake Safety Regulation dated 2007 and do not meet the UEFA requirements valid for soccer stadiums (Council decision no 946 dated 7 May 2013). After this decision, the building was partially destroyed between 20132016, the main colonnaded entrance, the wall and tribune between two towers were kept intact with some additions on the upper level, and the rest is built from scratch.

3.3 *The Nino Colombo Library, Beinasco, Italy*

The former "Nino Colombo" Library in Beinasco, designed in the 1960s by Bruno Zevi, represents the union between the problem of the restoration of the Modern and the need for an adaptation to current efficiency regulations. Since the beginning of this century, the building was abandoned. It covers an important historical and cultural value: the structure, at the time of its construction, was proposed as a prototype for a widespread network of small libraries in smaller towns. This project was advocated by the Turin publisher Giulio Einaudi, who wanted a complete diffusion of culture at all levels of the population (THE CIVIC LIBRARY-Luigi Einaudi in Dogliani n.d.)

With its fully prefabricated structure, the building met the needs of functionality, economy and ease of reproduction. However, today it is also one of the few examples in Italy of the 60s use of prefabricated steel construction technologies in architecture. Due to this original feature, in 2019, the library, despite being built less than 70 years ago, was listed by the authority within the bounded asset in accordance with the Legislative Decree 42/2004.

In 2018 the Polytechnic of Turin was entrusted with the renovation project, and Professor Carlo Luigi Ostorero assigned it as a final workshop of this course. The result of this teamwork is seen here. As a first step, each element's geometric and photographic relief was done and codified in an abacus. After that, the main decays were identified. Most damages were due to the mismatch between the original design and the actual on-site applications, incorrect installations, and also the natural decay of materials and vandalism. The specific decays are missing parts, improper repair works, incoherent additions, dent, exfoliation, soiling, rust, superficial decay and loss of performance.

Figure 3. Picture of the actual State of the Library.

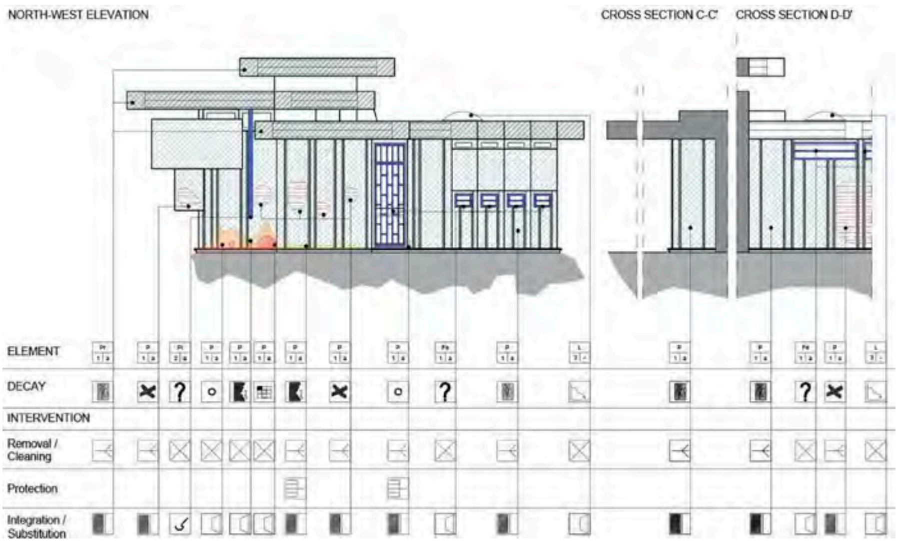

Figure 4. North-west elevation and cross sections of the Nino Colombo Library with the specific decays and interventions for each element.

The specific decays are missing parts, improper repair works, incoherent additions, dent, exfoliation, soiling, rust, superficial decay and loss of performance. As it is seen in the previous pictures, each element was assigned to the specific decay and the possible intervention, grouped as removal/cleaning, protection and integration/substitution. Then a project was

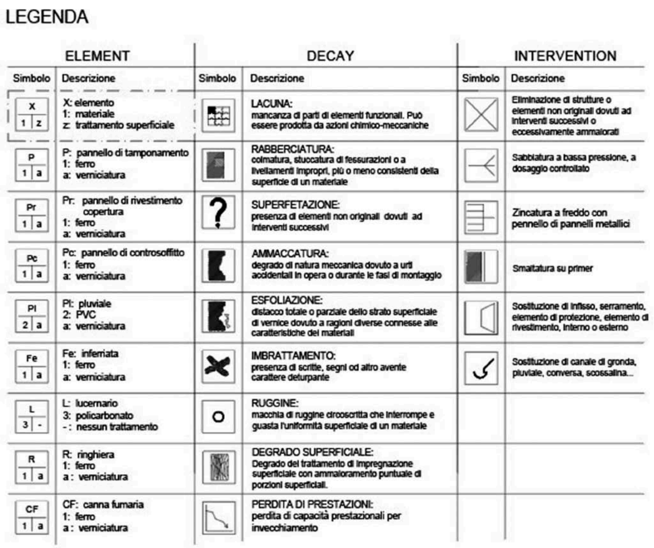

Figure 5. Description of elements, decays and interventions.

made, which focused on rebuilding the library's connection with the surrounding landscape by adding cultural spaces such as co-working areas and reading places outside. This was crucial to preserve its urban meaning and raise a sense of belonging in the users.

4 FUTURE VISIONS

Cities consist of layers shaped according to different socio-economic conditions, population den- sity, usage patterns and social needs in different periods and constant change and transformation. The planned and correct management of this change ensures both the protection and continuity of use of structures and areas. A systematic approach should include the planning and correct execution of the implementation process. The recent past places face a lack of appreciation globally. This is in part because modern architecture is relatively recent, and also its sig nificance is sometimes not understood by the general public.

The State, in partnership with the various stakeholders, is an integral part of this participatory process that is the preservation of the modern. In this scenario, the pivotal role played by the policies of land and built environment management in the allocation of funds to be assigned to their recovery and preservation is undeniable.

4.1 *The scenario in India*

Modern Architecture in India is an integral part of the post-independence national identity. The institutions, offices, commemorative monuments, government institutions, and the mass housing established after independence mostly speak the language of the Modern Movement. The 201920 annual report of ICOMOS. India acknowledges that 'Functional and aesthetic obsolescence and absence of protective legislation are the most common risks to our Modern Heritage.' (Kiran Joshi 2020) High expense, lack of awareness, lack of funding, missing legislation and recognition and most importantly, a lack of research and know-how regarding the restoration of the modern materials are some of the biggest challenges that will be seen on the way ahead.

Recently the Getty Foundation's 'Keeping it Modern' initiative and the World Monuments fund recognized the significance of the Sardar Vallabhbhai Patel Stadium, Ahmedabad. It was, therefore, placed in the 2020 World Monuments Watch, a selection of cultural heritage sites that conjoin "great historical significance with contemporary social impact." (Keeping It Modern: 2020 Grants Awarded n.d.) Initiatives such as these on an international platform and local awareness and immediate interventions by the citizens, professionals and the government bodies are a definite way forward.

4.2 *The scenario in Turkey*

Following a bottom-up approach and starting from local communities, forming a group of volunteers who care about preserving that community's recent past places and working together to save those places from rapid destruction may be a direction for future efforts. Contemporary Levent Association, formed as a volunteer group in 1996 against the urban pressure threats on the Levent Neighbourhood, built in the 1950s, had positive effects on municipal government. The process ended up with the declaration of the whole neighbourhood as an urban site in 2008. Offering tours and hosting special events and workshops at the academic level are valuable tools to raise awareness and educate specific audiences about this vulnerable heritage.

DOCOMOMO Turkey in co-operation with other organizations such as ICOMOS. Turkey tries to create an information and documentation centre by comprehensive inventory studies to define and keep on agenda the problems encountered in modern and 20th-century architectural heritage. As discussed before in the İnönü Stadium case study, these two organizations play a significant role in creating scientific opinion in the registration process, especially those buildings under threat of demolition. Once an area or a building is recognized at the local level and identified as a site merit protection, it is crucial the legal protection in order to benefit from economic assistance and tax immunity.

Within the scope of the "Regulation on Providing Assistance to Immovable Cultural Heritage", dated 27.05.2015 and numbered 29368, assistance is provided from the budget of the Ministry of Culture and Tourism for the protection, maintenance and repair of immovable cultural assets. The Ministry provides in-kind, cash and technical support for structures owned by real and legal persons subject to civil law. The owners can apply for project or implementation assistance through the Provincial Directorate of Culture and Tourism, where the asset is located. (Turkish Regulation No. 29368 2015)

4.3 *The scenario in Italy*

In Italy, for over twenty years now, tax incentives have been introduced to restore the building stock. The tax deduction was introduced by the Law of 27 December 1997, n. 449 (Measures for the stabilization of public finance LAW 27 December 1997, n. 449 1997) which had provided for expenses incurred in the tax period in progress on 1 January 1998 and the following, a deduction of 41 percent of the same. The standard was subsequently amended and extended and finally made stable by DL n. 201 of 2011 (DECREE-LAW 6 December 2011, n. 201 2011), which included in DPR n. 917 of 1986 (DECREE OF THE PRESIDENT OF THE REPUBLIC, n. 917 1986) the new article 16-bis. This provision confirmed the subjective and objective scope of application of the deductions and the conditions under which the tax benefit was due by consolidating the orientation of practices in this area. The measure of the Irpef (personal income tax) deduction was 36 per cent for the costs of building renovation incurred for an amount not exceeding 48.000 euros for each property unit. To date, for expenses incurred from 26 June 2012 to 31 December 2021 (DECREELAW 19 May 2020, n. 34 2020), the deduction is high at 50%, and the maximum expenditure limit is 96.000 euros. The deduction must be divided into ten equal annual instalments. There is also an Irpef deduction, up to a maximum of 96.000 euros, even for those who buy renovated housing buildings. In particular, the deduction is payable in the case of restoration, refurbishment and renovation of buildings, covering entire buildings, carried out by construction or renovation companies and housing cooperatives, that provide within 18 months from the date of completion of the work to the subsequent sale or assignment of the property.

Without claiming exhaustiveness, those mentioned are only some of the many incentives (among others energy requalification, facades bonuses etc.) put in place by the Italian State to encourage and support the recovery of the existing building heritage, including the modern one.

Among the manoeuvres put in place during the Covid-19 pandemic, the most significant is undoubtedly the introduction of the rate increased to 110% of ordinary tax deductions. Thanks to the so-called "Super bonus", Italy is experiencing a period of fervent building activity, in the name of eco-sustainable and energetically efficient design, based on implementing the principles of bioclimatic and green building. The future expectation is that this fervour will not be exhausted but will remain stable and grow, preserve and pass on to future generations the myriad of prestigious buildings, of which the modern heritage is a substantial part than hitherto acknowledged.

5 DISCUSSION

As aforesaid, the outcomes expected from this work consist of a thoughtful CHANGE, in the means of putting together an interdisciplinary team to organise documentation and analysis. There is also a need to establish heritage value because modern heritage should include individual monuments and planned areas, and landscapes scattered across the city or region. Most regulations approved following the major disasters see the structural weakness as the major threat, losing the view on the heritage values we mentioned beforehand. The future considerations that are made for safety should rise alongside those of the preservation of architectural characteristics and authenticity.

ACKNOWLEDGMENTS

The paper is developed on the final work of the International Summer School After the Damages 2020. The research was presented by the group consisting of all the authors and Architect Cristina Ciovati from Italy. The authors would like to thank her for her contribution. A special thanks to the organisers of the Summer School at the University of Ferrara and all the partners involved. The author Giulia Bufo would like to express gratitude to Professor Carlo Luigi Ostorero for his guidance and his endless passion in his work and to her colleagues in the project of Beinasco Library for their contribution.

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Built Heritage in post-Disaster Scenarios – Balzani et al. (Eds)

The dimensions of heritage as strategies for action plans for pre and post disaster intervention

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ABSTRACT: Developed as a cooperation project aimed at the construction of an action plan for, before and after disasters in the context of heritage preservation, this study is based on the experiences of a multidisciplinary team, highlighting different dimensions of heritage and the potential of establishing processes that build upon shared knowledge and cooperation. In order to do so, the study explored cultural dimensions of heritage within a complex ecosystem and the elements and specificities that are essential for designing an action plan to guide the preparation for 'natural' disasters that affect a community and its socioecological and cultural structure. By establishing a methodology which aims to identify common tools and interconnections, action plans can be designed to potentialize the efforts aimed at creating systems which are more resilient and prepared to deal with such impactful events.

Keywords: heritage preservation, socioecological system resilience, disaster planning

1 INTRODUCTION

Experiences related to heritage preservation and conservation derive from a history of devastating events (natural disasters such as earthquakes, or climate change such as floods, landslides, etc.), especially in the last century, and have allowed for the consolidation of a significant body of knowledge and the development of techniques, tools and procedures intended to prevent, prepare and act in such situations.

The complexity of dealing with disasters is comprehensive, as it addresses safety of people, the safeguard of resources and assets, the recovery and rebuilding of infrastructure, and beyond, as memory and identity are essential for the sense of belonging, purpose and community. Heritage, therefore, is both an object and an agent of preservation and restoration, as is not limited to a building, an artefact, etc. Place, people, buildings, artwork and history are

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DOI: 10.1201/9781003253730-42

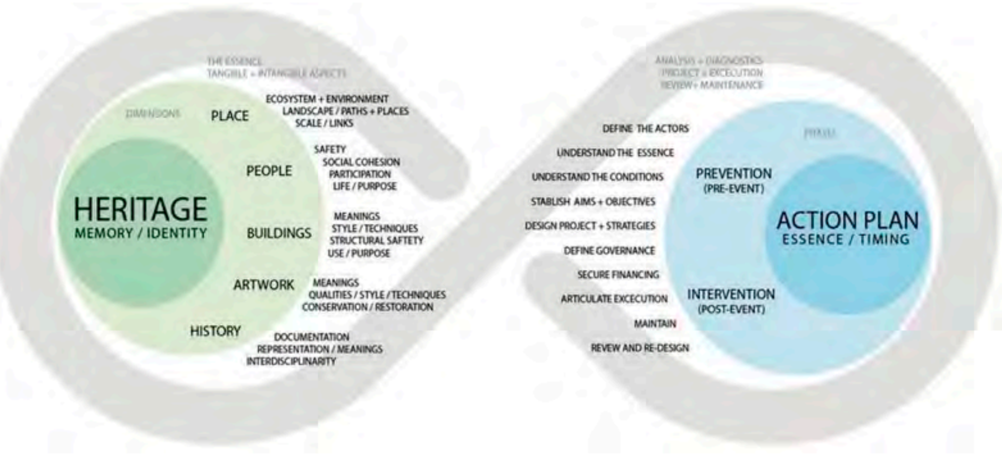

Figure 1. The different dimensions of heritage and their tangible and intangible aspects as a methodological approach to building an Action Plan for pre and post disaster intervention structured as an evolving process that accounts for design and preparation, application, review and redesign, through collaboration and experience, hence the symbol of infinity.

essential dimensions of heritage and are deeply interconnected. Identifying the essence and purpose of the different elements within a system is a way of making them part of its function, as explored in this paper. By approaching heritage as a fundamental component of a dynamic socioecological system, efforts to document and understand risks, as well as to prepare and recover from disasters have explored the notion of resilience and its application in heritage preservation. As defined by IPCC (Field, 2012, p.5), "resilience is the ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner, including through ensuring the preservation, restoration, or improvement of its essential basic structures and functions".

In order to create resilient systems and prepare for such impactful events, it is essential to establish the relationship between heritage and systems resilience, and further identify common tools and interconnections that can action potentialize the efforts and resources and minimize risks. Through careful analysis and diagnostics of a situation before disasters, it is possible to establish dialog and recognize strengths and weaknesses, actors and strategies (therefore agency and governance), which allows for the design of prevention projects and action plans for intervention during and after disasters.

2 THE 'DIMENSIONS' OF HERITAGE AND HERITAGE PRESERVATION

Identifying significant dimensions of heritage, such as place, people, buildings, artwork and history, and understanding their essential characteristics allows correlations to be established between them. In doing so, heritage preservation can also have meaning beyond the object itself, as new functions and appropriations may occur. Furthermore, it is by considering common aspects of tangible to intangible nature, as well as techniques and methods of interpretation and interventions, that resources can be shared and compose a comprehensive and transdisciplinary approach to pre and post disaster intervention in heritage.

2.1 *Place*

Effects of land occupation or urbanization have a direct correlation with intensification of climatic events or climate related conditions (such as floods, landslides, cyclones, droughts) that are threatening to the people, heritage and the environment. Such occurrences are often related to dynamics that go beyond the local conditions, framing them at a wider scale. In this sense, a socio ecological approach of an ecosystem can be very suitable, as can resilience, once it is linked to the ability of a system to adjust to the conditions and effects in order to manage risks and potential damage, but also take advantage of new opportunities when dealing with these factors, and further explore our expectations for the future. This requires integration, such as connectivity, speed, scale and diversity (Holling, 2001, Folke, 2006).

As ecosystem services are the functions provided by nature that we need to survive (such as clean water, fresh air, etc), in the same respect, cultural heritage also provides services, which are essential for social cohesion, as memory and identity are values that promote the sense of belonging and community (Zarnic, 2012). Recognizing their different features and its values (of indirect or direct use) is a way of understanding their function and meaning within the system, as well as their abilities do adapt. Buildings, for instance, which have adapted throughout history, tend to be more sustainable and have meanings and purposes that connect people to place in time, strengthened by the sense of place and belonging, intrinsic to cultural heritage.

In the dynamics of urban requalification, the approach of resilient socioecological system, disturbances have the potential to create opportunities to innovate but also expand to the ability to reorganize and evolve as well. Memory and identity embodied by the built and cultural heritage is a fundamental part of the system, as both the object of saving and the essence of a community.

Industrial sites of the XVIII and XIX century, for instance, are particularly compelling given the de-industrialization processes around the world in the last century. Its presence in the landscape, with building typologies that can accomodate new uses, as well as its sites characterized by large open space that can become functional environmental sites through brownfield regeneration. As cities strive to become more resilient, such spaces can be very strategic, for their location (often near downtown) and size, accommodating comprehensive socioecological systems that mitigate effects of climate change (for instance through the implementation of green-blue infrastructure that can better deal with the impacts of increasing events of extreme rainfall and floods as well as droughts, at the same time that it enhances the cultural landscape). Examples of interventions in post-industrial landscape such as in the Ruhr Valley in Germany, have illustrated the capacity of transformation at many different levels (economic, social, environmental) and scales through a sensitive heritage preservation approach that enhances the sense of place and identity.

The complexity of the dimension of place has to do with both tangible and intangible qualities of a place and at different scales. The resilience approach in socioecological systems requires integration, such as connectivity, speed, scale and diversity. Thus, a fundamental tool for understanding these system dynamics is mapping, layering and liking information, analysing the interconnectivities within the system. Georeferenced data can be very effective in establishing complex analysis of characteristics such as topography, geological and hydrological systems, morphology and infrastructure, building typologies, dynamics of use and economy, landscape and identity.

Furthermore, systematization and analysis through interconnected and spacialized information allows for the exploration of possibilities and complexities of the systems dynamics in the territory, recognizing patterns of occupation and transformation and understanding past, present and future impacts, an essential tool and process to inform decisions and projects.

2.2 *People*

In the context of rural or traditional communities, the greatest amount of cultural assets which can be considered representative of the society are the dwellings of the people. This vernacular architecture, the largest of the built environment (Oliver, 2006), may be also the one that takes the most time to recover because, for it to be done properly, it requires a social reconstruction: Together with housing, the bond to place and culture should be maintained, which implies considering issues such as identity, memory and a sense of belonging. The past remains latent in the place where the disaster has occurred (Hernandez and Beucher, 2005) and, therefore, reconstruction should not be a beginning from zero but a process conditioned by pre-existing social and cultural structures (Moatty et al., 2017).

In the dimension related to people and from the perspective of the maintenance of emotional ties with place, there are several risks arising from the damage threatening this social reconstruction. Some of the most noteworthy are related with administrative delays or insufficiency of the governmental capacity to take action and provide resources within the post-disaster time compression (Olshansky et al. 2012); temporary shelters that become almost permanent and break people's bond with their former home; mistrust on traditional materials and techniques and preference for new industrial materials and models which, in some contexts, are unaffordable and paralyse the process due to lack of budget; transfer of responsibility for reconstruction from the government to the individual, i.e., to the homeowners who, after having suffered the experience of the damages, are not in the best position to react. These risks can result in a slow response, the passage of time being one of the factors that most affects people's perception of space and their connection to it (Tuan, 1977; Nejati and Mahdavi, 2016).

In order to try to reduce these risks, and based on the lessons learned from the 2020 International Summer School After the Damages, three possible levels of action related to material, social and emotional issues are identified.

2.2.1 *At a material level: Working with available resources*

Locally specific building cultures often have their own mechanisms for dealing with recurrent disasters on a site. Problems often arise when these traditional solutions are no longer known, are abandoned or are modified by transformation processes resulting in a loss of their original meaning. Another problem can arise from the scale of climate-related disasters that are occurring with increasing intensity and frequency. In the light of these issues, the role of technicians must begin with a detailed knowledge of the pre-disaster construction situation in order to identify whether or not these traditional solutions are still maintained, whether or not local resources are still available after the disaster, and whether or not there is a need to improve constructive solutions. In answering these questions, technicians must be guided by the point of view of local actors, their job being to accompany, from a technical perspective, the recovery of the dwellings.

In carrying out reconstruction, working groups of masons, neighbours and facilitators can be organised. The role of the latter should be to enable the population to communicate effectively with the administration or to obtain funding. Training courses and workshops on building with local materials, for builders or volunteers, can provide the population with the necessary tools to start reconstruction. Moreover, this training can lead to the promotion of public employment and the involvement of the population in the reconstruction works. Ultimately, the aim should be to consider community members in the design of reconstruction and the resources to be used. Whether or not it makes sense to rebuild as before the damage occurred, is a debate in which technicians and neighbours have to participate since it cannot be forgotten the need of the population to choose the place where they want to live.

2.2.2 *At a social level: Working from the community*

At this level, one of the most important measures should be to try to avoid the dispersion of the population in the territory in order to maintain social cohesion, as far as possible. In addition, it is necessary to identify the actors who can intervene in reconstruction (professionals, families, neighbourhood associations, spontaneous aid groups, etc.) and to be aware of the role that each of them can play in the reconstruction process. Participation sessions or meetings are necessary in order to share knowledge and information on affordable and safe reconstruction methods, but also to identify the most vulnerable families and ensure their inclusion in the process.

The aim should be to promote the involvement of property owners and families in reconstruction as a means of strengthening community capacity and creating or taking advantage of already existing social networks among the population, a way of working from the ecosystem, and not from the individual element (Borin, 2020).

2.2.3 *At an emotional level: Working with people*

In this sense, intangible heritage can be considered a support and reinforcement when tangible heritage has been damaged and is in the process of recovery (Joshi, 2020). The aim would be to take advantage of customs, rites, traditions, celebrations, as a means of psychologically dealing with the impact of damage.

In addition to this, social recovery must also be based on an understanding of the general panorama of the situation, investigating the perception of the population before, during and after the damage, according to age groups (children, adults, elderly).

Finally, the relevance of communication as a recovery mechanism should not be forgotten. The measures related to expression and sharing of people's experiences allow for learning about their perception of the damage, being aware of the emotions of fear, sadness and anger; nostalgia and melancholy; pride, affection and feeling of "home" associated with damaged spaces (Marzot and Boielli, 2020).

2.3 *Buildings*

The analysis of historical masonry and construction techniques are fundamental knowledge to be acquired in anticipation of restoration and consolidation interventions aimed at the specificities of the individual construction techniques.

In masonry buildings, "construction" and "structure" coincide, because each part is required to collaborate in stability. The masonry material, taken in isolation, has a fragile behaviour but the structure as a whole is able to obtain great deformation and resistance performances. In order for the wall constructions to maintain their structural characteristics over time, it is necessary to ensure accurate and constant maintenance, not only to remedy the damage caused by wear, but also in anticipation of probable natural disasters such as earthquakes.

The study and in-depth analysis of the aids and construction techniques that have been developed in the various territories to protect themselves or mitigate damage, are fundamental to preserve the historical building, also in defence of the cultural identity of entire populations that are they recognize.

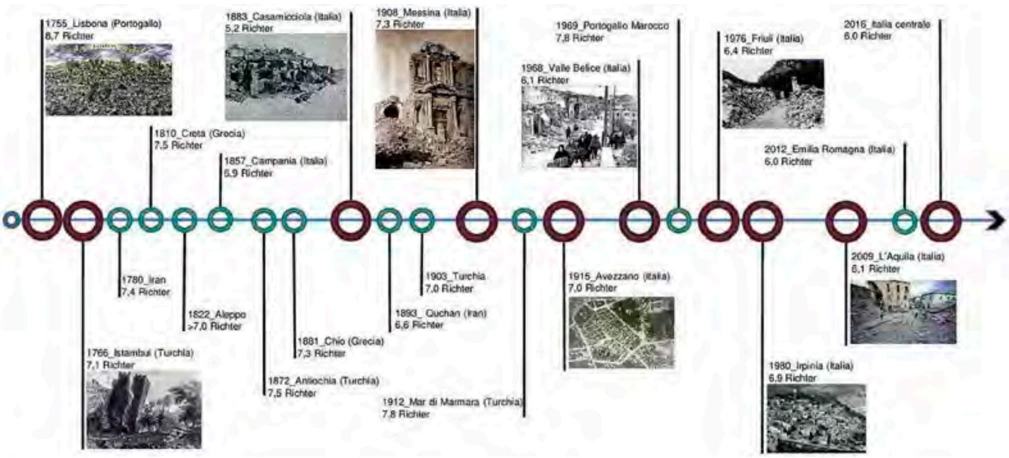

Figure 2. The time line of the major earthquakes that have occurred in Europe, starting from 1700. Source: Antonietta Milano. 2020.

A building can be considered reliable (anti-seismic) if following a disaster (earthquake) it is damaged but does not collapse. In light of this consideration, the ancient construction techniques are the result of what has been developed to counter and/or mitigate catastrophic events such as earthquakes, floods, fires, etc. Italy's cultural heritage, for instance, is full of buildings that survived disasters with almost no damage. In buildings, the causes of seismic damage are often due to old restoration interventions that did not take into account the intrinsic characteristics of the building, the construction and structural techniques and the materials with which they were built.

The time line of the major earthquakes that have occurred in Europe, starting from 1700 (Figure 2), allows them to be compared and to verify the contribution to the development of construction techniques resulting from the reconstructions.

The memory of the earthquakes is kept by the surviving historic buildings, where it is possible to trace the various phases of the restorations that have taken place. In these buildings, it is possible to read both the structural deficiencies of the building and the anti-seismic devices that have been used over the centuries to respond to the stresses suffered during earthquakes.

The Vitruvian principles of firmitas, utilitas, and venustas (constructive solidity, intended use and beauty) summarize the fundamental concepts of Roman culture in the architectural/monumental field, and over the centuries they have been critically applied and adapted to the specificities of the buildings and the territory.

By studying ancient construction techniques such as opus craticcium, opus gallicum, opus littatum, opus reticularum, etc., it is found that these are used, with adequate adaptations, in the areas most affected by strong earthquakes. For example, variants of the opus craticcium become the "pombalina" in Lisbon, the "shacked house" in Casamicciola, the "framed structures with confined walls" in Messina, etc. (Figure 3).

In safeguarding our cultural heritage, knowledge of construction techniques is essential so that we can work with targeted restorations in accordance with the intrinsic characteristics of each individual building. Intervening afterwards, when possible, leads to more invasive operations and not always in full agreement with the specific identity of the building.

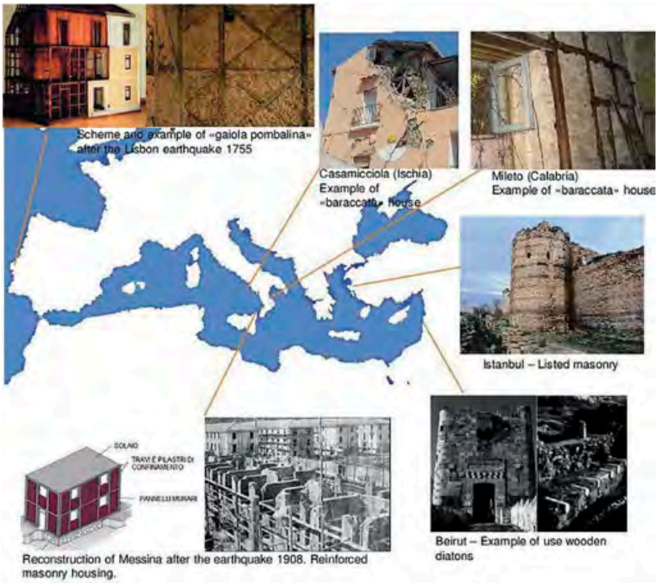

Figure 3. Historical anti-seismic safeguards widespread in the Mediterranean basin.
Source: Antonietta Milano. 2020.

Damage mitigation (in Italy in particular of seismic damage) also involves the conscious restoration not only of listed historic buildings, but also of the immense historical and historicized heritage, widely spread in small towns. In the event of an earthquake, the "minor" buildings are currently the ones most at risk because they are built with materials of lesser value than historic buildings, but still worthy of attention as it is a fundamental part of the identity culture of a country, where citizens recognize themselves in. Taking care of this heritage is equivalent to keeping it alive and usable by present generations and hopefully also by future ones.

The reconstruction initiatives in different areas affected by earthquakes should be coordinated by one sole but comprehensive conservation plan extended to the entire building fabric in order to preserve the authentic values of the historic nuclei as a whole and not of individual buildings.

2.4 *Artwork*

Preventive conservation applied to artwork is a very useful tool in terms of mitigation of risk, especially in potentially calamitous areas. The application of its principles brings to a deep knowledge of artworks on different levels, and in a context of risk prevention and damage reduction, the analysis of all relevant aspects of the surroundings in which the heritage asset is situated, has a fundamental role.

When intervening at this level, it is important to focus special attention on procedures which may help to better understand the local and cultural context, such as: estimating of the amount, type of artworks and their position; overlapping the artworks position to those areas which results statistically more vulnerable to damages; documenting on building and artwork materials and techniques; analysing conservation status of a big cross-section of artworks; evaluating all the needed interventions in order to reduce the vulnerability of cultural heritage; identifying the potential agent of loss and deterioration of artworks.

Furthermore, in order to support these procedures, digital tools have become essential in collecting and systematizing this type of information, such as developed by the Italian Ministry of Cultural Heritage (Mibact): in 1990, following the theory of Cesare Brandi (1963), with the concept of "preventive conservation" and Giovanni Urbani "Piano pilota per la conservazione programmata dei beni culturali in Umbria", the Istituto Centrale per il Restauro (ICR) started to set a cultural heritage database called Carta del Rischio (CDR) which is a SIT (Integrated territorial system). Based on GIS technology, it contains 100,258 records on cultural heritage divided into three categories: Architectural Heritage, Archaeological Heritage and Modern Containers of artworks, which has collected, geo-referenced each cultural heritage object and designed a vulnerability data sheet.

The main target of this program was to define a system able to quickly identify and locate cultural heritage objects and buildings considered as more vulnerable to damages, in order to plan interventions considered as more urgent. By using statistical elements and mapping, the CDR finds correlations between different cultural heritage characteristics, conservation status, location and the related potential deteriorating agents. An example of application of CDR was in the context of the earthquake that hit L'Aquila on April 6th 2009. This database was used to produce a map of the affected area and provide the listings and locations of the cultural heritage, which were given to the Civil Protection Agency and Fire Department for the recovery and assessment of the damaged artworks.

Among the actions that could be done in for preparation for such events is the construction or identification of spaces to be used as temporary artwork storage, as done in Spoleto (Umbria) before the earthquake of 2016. In this temporary warehouse, all artworks that arrived after the earthquake of 2016 were registered and if necessary, they were temporarily stabilized with an emergency treatment. The emergency treatment's main goal is to block the deterioration process with an intervention, which has to be reversible and re-treatable. Considering that under such circumstances artworks often remain for a long term in these spaces, treatments should be stable enough in order not to become a potential deteriorating agents. The same method can be extended to planning provisional structures for architectural elements that are part of a building restoration process.

Another fundamental aspect that must be considered is the role of the local community and administration. During research and documentation, historical memory of the community is always important in filling in the gaps of information of archives (private and religious etc.), personal memories, local newspapers etc. The community is a significant agent in the preservation of meanings and maintenance of cultural heritage, as depopulation may easily lead to decay of buildings and artworks. Furthermore, collaborating with the community and strengthening the shared identity and values of cultural heritage also requires involving the people in the process and communicating what is going on, which methods and procedures are chosen and why, what to expect when and why sometimes it takes a long time. Active participation and information is essential in order to keep active a two-way bond between the local community and its heritage.

2.5 *History*

For the study of heritage, we rely on documentation, as it is the testimony of the history of a place, site, settlement or cultural asset. Documentation can be regarded as part of analytical surveys, models, evaluations, structural drawings and calculations, but documenting traditions and rituals is also important. The data that is acquired must be connected with social habits in order to compose the history within the building, the artwork, or the place. It cannot be a static registration, but a dynamic system that is updated in order to monitor the cultural heritage assets, as well as the traditions and social changes, so it is important to involve as many actors as possible, and to use technology as an enabler.

Documentation is a vital tool in order to preserve not only the tangible elements, but also the intangible aspects of the heritage and the essence of a place, before and after disasters occur. It has to be used not as a simple or one way technique but as a pooling of resources. Knowing deeply a place, a building, rituals and traditions, ensure these aspects as the foundations and catalysers in the recovering process. Establishing a functional and effective documentation structure for heritage preservation in the context of disaster intervention benefits from collaboration and integration of both technical and societal knowledge. As documentation is not only intended to make a portrait of past times, it is essential that it is inclusive, leading to understanding of identity, which can help plan for a cohesive response to the challenges related to disasters, both before and after they occur.

Consolidated methods are benefited from technological advances that allow for systematization, integration and sharing of a very large amount of information. In this respect, interdisciplinary and transdisciplinary surveys can build a more comprehensive understanding of the history of a community, their meanings and ties in time and place, and thus, through a broader knowledge of risks and assets, establish priorities and connections that inform decisions in preparing for or acting in emergency situations. Furthermore, understanding the present as part of a historic moment that is connected to the past and the future, one that is rooted in previous achievements and that recognizes the needs of the people that will come after us. This approach is able to broaden the vision of heritage beyond objects, buildings or events, setting the notion of heritage preservation at a broader temporal dimension as well, deeply connected to the notion of the dynamics of a socioecological system.

3 DISCUSSION

The discussion regarding heritage preservation and restoration in the context of disasters is of foremost importance, given the intensity and frequency of such events due to climate change and its relation to human related occupation of the environment, the impact in communities and their resilience, that is, their ability to recover from such events and promote improvements. Experiences show how disastrous events change both the territory and the socio-cultural balance of the populations. We have learned that it requires the coordination of different specialists, addressing social and technical issues, trying to generate synergies that preserve both community identity and cultural heritage assets, sharing resources and information, working at different scales to improve the sustainability of our system in order to respond fast and effectively.

By framing heritage as a socioecological system that considers specificities of the local scale and implications at much broader scales of time and space and by recognizing the multiple dimensions of heritage and possible unfoldings, this paper intended to illustrate the potential of commonalities and connections that can be established between them and the tangible and intangible aspects, essential for building of an action plan for pre and post disaster intervention.

ACKNOWLEDGMENTS

The paper is developed on the final work of the International Summer School After the Damages 2020. The research was presented by the group consisting of all the authors and Architect Cristina Ciovati from Italy. The authors would like to thank her for her contribution.

A special thanks to the organisers of the Summer School at the University of Ferrara and all the partners involved. The author Giulia Bufo would like to express gratitude to Professor Carlo Luigi Ostorero for his guidance and his endless passion in his work and to her colleagues in the project of Beinasco Library for their contribution.

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Built Heritage in post-Disaster Scenarios – Balzani et al. (Eds)

Strategies to manage flooding risk in historical cities: The case of Paraty

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ABSTRACT: Over the last years, the risk related to natural disasters has become more severe due to the intensified climate change combined with the expansion of urban areas and increased land-use. Therefore, worldwide Governments and Civil Protection agencies have to deal with the definition of plans and policies for the prevention and the mitigation of risk. In this context, the protection of the so-called 'tangible heritage' such as buildings, infrastructures and monuments is of primary importance, together with all the strategies that guarantee the safety of populations. However, an important attention should be also driven to the preservation of memory, culture and local identity, the so-called 'intangible heritage'. In the current world subjected to a constant transformation process, which cannot be stopped, the survival of traditions assumes a significant role in the adaptation to everyday changes. While several actions to protect the tangible heritage applied nowadays, the fragile intangible heritage is frequently exposed to the risk of "amnesia", since there is little concern to this issue.

In this matter, an interesting case-study is represented by Paraty, an historical city located on the Atlantic coast of Brazil. The city has a peculiar history and represents an internationally recognized heritage, both for the architecture and the landscape. Paraty is subjected to a significant risk of flooding, mainly due to past modifications in the flows of the main rivers of the city, and an uncontrolled urban sprawl. The purpose of this paper is to analyse the case-study of Paraty, illustrating its heritage and history, but also examining the situation with respect to natural risks through climatic data and risk maps. The proposal of some possible strategies to manage the risk is outlined, with a discussion of the technical aspects beneath. Thus, this work offers a comprehensive analysis of threats and possible solutions, considering both the tangible and intangible heritage of Paraty, paving the way for a multifaceted plan to make a city more resilient to natural risks.

Keywords: climate change, cultural heritage, flooding risk, historical city, urban planning

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DOI: 10.1201/9781003253730-43

1 INTRODUCTION

Nowadays extreme weather events are more frequent due to climate change and the uncontrolled human impact on nature (IPCC, 2014). They represent a serious threat for the urban built environment, for populations, but also for the maintenance of cultural identity, traditions and history. In this context, the present challenge is to find robust and feasible plans to protect both the so-called 'tangible' and 'intangible' heritage. This does not only involves the identification of strategies to increase the strength of buildings through times, but also the organization of consistent actions to safeguard the memory of peoples and to find resilient solutions to face the new transformations of processes of this century.

In particular, due to the recent increase of the sea level, and the higher frequency of extreme rain events, many countries worldwide are suffering from flooding issues that are foreseen to become even more severe (Kulp and Strauss, 2019). An interesting case-study concerning the flooding risk and its management is the city of Paraty, an important touristic pole in South America. Paraty is a coastal municipality in southeast Brazil, located between São Paulo and Rio de Janeiro. This peculiar city was born as a village, and developed after European colonialism. Paraty was listed by 'Instituto do Patrimônio Histórico e Artístico Nacional' (IPHAN, Web-1) in 1958 and it received the 'Monumento Nacional' title eight years later. The architecture and landscape were also listed to encourage the preservation in 1974, moreover, part of the territory was declared as a Cultural and Natural Heritage of Humanity by UNESCO in 2019 (UNESCO, Web-2). Currently, the city is an important tourist destination, due both to the particular colonial style buildings, the traditions and celebrations, but also to the natural landscape integrating the Atlantic Forest, recognized nationally for its value. In the last decades, the process of urban expansion without adequate urban planning has caused severe damages in Paraty. The two main rivers crossing the city played a crucial role in history for the development of the city. However, irregular occupations in their surroundings altered the characteristics of their natural flow, boosting the intensity and the frequency of flooding events (CEPED UFSC, 2013). In addition, the decrease in soil permeability has led to more intense flooding in several urban areas of the city.

Due to this, different strategies have been adopted to avoid the water to reach the historic centre, and affect the population that depends on tourism to survive. Researchers have been simulating the problems and proposing resilient plans for this problem, as is the case of the works of Marins (2013), Battemarco (2016) and Barbedo (2016). According to the authors, a resilient urban planning might enable the city to resist and recover from unexpected extreme events, or natural disasters. The construction of a city resilient to floods can be achieved by adopting techniques that rationalize the relationship of urban space with water, with a focus on preventive actions that must be addressed in order to safeguard the existing built environment and the identity of the locals.

This paper discusses possible solutions to manage the flooding risk in the city of Paraty, whose preservation of tangible and intangible heritage is of great national interest. A synthetic examination of the main plans proposed to date is presented herein, with ad hoc graphs and maps schematizing the risks and the most effective strategies. A critical analysis of the heritage in danger is outlined in the first paragraphs, thus, all the aspects of the flooding risk are addressed under a technical point of view.

The main aim is to illustrate a comprehensive process of flooding risk prevention in Paraty, in order to enhance a resilient strategy that may help the regeneration of the built environment, the life of the inhabitants, the expression of the local culture and the traditions. A critical point of view on the main issues is expressed, contributing to define an effective and functional plan to face the flooding risk in the city.

2 THE CONTEXT OF THE CITY

The two main rivers crossing the city of Paraty are 'Mateus Nunes' and 'Perequê Açú'. They had an important role in the development of the city through time. The prevailing architectural typology in Paraty centre is from the colonial period. Most of the streets are orthogonal, and the buildings are aligned against each other, creating a compact built mass on each block.

2.1 *History of Paraty and relationship with water*

Before the European colonization of South America in XVI century, Paraty was inhabited by native people living close to rivers. After the first Portuguese expeditions, the main churches of the city were built (for example Santa Rita in Figure 1a), setting the location for the current position of the city center. After the discovery of the gold areas of 'Minas Gerais', the city growth thanks to the business of traders and merchants. Later on, due to the creation of new paths for commerce, not crossing the city, Paraty went through a period of economic de-growth. Over time, alternative routes were created, reducing the importance of the port and gradually isolating Paraty.

Only after 1954, Paraty became a touristic pole after the opening of a new road to the São Paulo state. The city was recognized national monument in 1958 and started to grow in importance and extension. In particular, its demographic growth exploded in the 1980s, when the new railway 'BR-101' was opened. Indeed, in 1950 the municipality had 9360 inhabitants, whereas in 1980 the number rose to 20626 (Battemarco, 2016). Today the city is an important touristic pole of attraction in the State of Rio de Janeiro, as well as in the whole Brazilian country. Since the beginning, there have been many changes in the flows and beds of the two main rivers, which have been fundamental in determining the development of the urban design of the city. For example, in 1728 the 'Perequê Açú' river, which had its natural mouth north of the hill of the fort, was transferred to the south, in order to bring drinking water to the residents. This modification had few consequences, indeed the port started to became lower and muddy, and the water to invade the streets during high tide events of the sea.

In 1804, the urbanization and the public health plan was proposed. Later on, in the second decade of 19th century, Paraty expanded to all directions, both towards the mountains and the sea. Many reports indicated that it was very difficult to build in the village, due to the very low and swampy soil condition: many places were invaded at the same time by water from high tides and rivers, or spaces were covered by mangroves where the sea penetrated (Battemarco, 2016).

The issue of frequent flooding interfering with the growth of the city stimulated the locals to search for solutions. The Chamber enacted a law to restore the mouth of the 'Perequê-Açú' river to its primordial bed, and to widen the mouth of 'Patitiba' river. Moreover, the streets were paved with round stones, known as 'pé-de-moleque', illustrated in Figure 1b, 1c. Streets were designed at 50 cm above the sea level, with a slight inclination towards the sea and rivers, provided with a central channel through which the tidal waters flow. Moreover, the houses were built about 30 cm above street level (IHAP, 2012). In this way, the entrance of the sea through the streets was conceived as a natural way to keep the city clean, also to protect the populations from cholera or yellow fever.

However, all these measures did not solve the flooding issues. Nowadays, still Paraty faces problems due to the lack of a proper urban planning, the inefficiency of drainage systems, the degradation of rivers and changes in land-use and coverage. Due the history of the city, the flooding of the streets in Paraty is a reason for admiration by tourists, even today. Anyway, the floods cause a lot of inconvenience to the residents of the region, not only in the city

Figure 1. Pictures of Paraty made by the authors: (left) one of the main churches of the city, Igreja Santa Rita da Cassia; (centre) street view of the facades; (right) layout of the street allowing the water to flow in the middle.

historic centre but also in many areas of the entire region. High tides events together with overflowing in the rivers are a significant problem: the great flood risks are associated with the occurrence of extreme rain events concomitantly with high tide events (mainly spring tides), and by winds coming from the sea towards the continent (Marins, 2013).

2.2 *Cultural heritage: Local identity versus tourism*

Paraty is a touristic destination recognized nationally for its historical and cultural heritage, with colonial style houses and churches, diverse cultural calendar, traditional religious festivals, celebrations and artistic manifestations, in addition to the beautiful beaches and islands, and the Atlantic Forest (IPHAN, Web-1). As already mentioned, the city of Paraty had its architectural and landscape ensemble listed by IPHAN, in 1958; in 1966 it received the title of National Monument and, in 1974, this was extended including the surroundings of the municipality. In recent years, the impact of floods has caused damage to the historical heritage, compromising touristic activities and commerce in the region, in addition to causing severe inconvenience to residents.

In 1965, UNESCO requested to the Belgian architect Frédéric de Limburg Stirum to outline a Master Plan aimed to protect, control and manage the urban development in Paraty (Freitas and Thompson, 2016). Up to that date, the local authority allowed new construction within the historical centre limits as long as these new buildings maintained the pre-existing alignments and adapted to the general context. The Master Plan developed by the architect proposed the inclusion of a landscaped terraced area between the historical centre and other areas: a physical boundary separating the areas to be preserved from those where the expansion was allowed (Leal, 1965).

In the same year, IPHAN requested UNESCO to reformulate the project in order to integrate not only cultural, but also economic factors under a consolidated approach. This so- called consolidated approach was developed following two main objectives: the recognition of the touristic potential of the cultural heritage, and the identification of cultural factors to support a proper development (Fonseca, 2005). Therefore, in 1972 the Integrated Plan for the Development and Protection of the Historical Centre was definitely published (Freitas and Thompson, 2016).

It is worth highlighting, setting aside any type of discussion regarding the merits of the preservation laws and guidelines subsequently issued, and ignoring the debate generated by the outcomes of the interventions, that the conservation of the historical centres still follows a path that is remarkably different than that of the monuments that are part of it. The restoration of the monuments and the conservation of minor architectural heritage is essential to preserve the traditional urban quality, to facilitate social exchange and promote the local economy.

A very significant risk threatening the historical centre of Paraty, like many other coastal areas, is related to climate change and the rise of the sea level, which is an issue to be addressed at a global scale. At the local level, a proper urban planning, taking into account the potential of disasters (natural and man-made) could be quite effective. To this purpose, minor interventions that are not excessively costly, such as drainage and appropriate use of land, could potentially prevent expensive restoration works in the future. Although not directly, the risks threatening the historical centre are connected to appropriate planning which encompasses safeguarding the local identity, aiming to avoid, mitigate and manage the impact of potential catastrophes on the built environment.

Actions addressed on minor architectural heritage restoration, after a catastrophic event, may not necessarily follow cultural reasons. It should be of primary importance to avoid the risk of losing some of the most significant characteristics of vulnerable small urban centres, in order to help local communities to control, as much as possible, the danger of alteration of landscape elements that represent collective identity.

A threatening factor for the local identity to consider is the transformation of many historical centres into "theme parks", as Professor José Geraldo Simões defined them (Maietti et al., 2020), which may be considered also for the case of Paraty. This economical operation generally aims at attracting as many visitors as possible and maximising profit with poor consideration of the inhabitants, local artisans, trades and culinary traditions. This approach tends to pave the way for the establishment of the large distribution, serial services and touristic products, moving towards globalisation threatening the loss of the local identity. In recent years, since travelling has become more accessible and relatively less expensive, mass tourism has embarrassed this threat in many places.

Although tourism is, without doubts, an essential resource for the local communities of Paraty, the intangible heritage that contributed to define the unique identity of the site needs to be protected. Local communities and the political leaders should be engaged to create a consistent approach of territorial planning based on a long-term vision (Baggethum and Barton, 2013).

The protection and conservation of a historical centre like Paraty should not be limited to the built environment, but extended to all the activities, traditions and expressions, to maintain the cultural identity alive and prevent the migration of the inhabitants. Moreover, the local landscape can be conceived as a widespread cultural heritage, a stratified asset of civilisation, in which the community recognized its identity (Feiffer, 2011), and thus should be protected. The preservation of a site's uniqueness, should be addressed by controlling the use of land, resisting the mass tourism forces and demands. A right balance between the preservation of the identity, the requirements of tourism and the benefits it brings to the community, should be fulfilled.

3 FLOODING RISK IN PARATY

3.1 *Analysis of the main risks*

As previously explained, Paraty is a city with outstanding, and internationally recognized, historical and environmental heritage. Despite this, the city faces problems related to the risk of flooding and landslides, which are becoming more severe due to climate change, and the urban sprawl towards areas in danger. According to data from the Brazilian Atlas of Natural Disasters (CEPED UFSC, 2013), between 1991 and 2012 the city of Paraty experienced eight natural disasters. The events officially registered in this period in the municipality were related to landslides (1), river flooding (6) and high sea tides (1): in the municipality 2300 people were affected (CEPED UFSC, 2013).

The high tide phenomena do not occur only in the historic center of the city, since other areas of the region are also affected. Besides the influence of high tides, Paraty is also affected by the floods of the two main rivers during extreme weather events. According to Battemarco (2016), floods have occurred with greater magnitude and frequency in Paraty in the recent years. Following the information for the preparation of the 2015 Threats Map of the State of Rio de Janeiro, released by the Civil Defense in 2016, floods are identified at the first place in the hierarchy of threats in the municipality, repeating the position of 2014. The author also observed that the effects of climate change intensify the impacts caused by flooding in the regions downstream of the railway BR-101.

In addition to the problems related to river drainage, the fifth report (AR5) of the Intergovernmental Panel on Climate Change (IPCC, 2013) argued that the global increase of the sea level would affect many coastal cities. It is worth saying that the likelihood of flooding events increases with the rising of sea levels. According to the special report of the Brazilian Panel on Climate Change (PBMC, 2016), the coastal flooding will affect the Rio de Janeiro State, and the six most vulnerable cities to the rising of sea levels are Paraty, Angra dos Reis, Rio de Janeiro, Duque de Caxias, Magé and Campos dos Goytacazes. The rising of the sea level is a critical issue recognized worldwide. In Figure 2a, the increase in the sea level since 1993 is reported as measured by NASA (Beckley et al., 2021): it depicts a constant increase which is likely to continue in the next years (Kulp and Strauss, 2019).

In addition, the whole municipality of Paraty is subjected to extreme tropical rainfall events, which cause an increase of the water flow in the two main rivers discharging in the Carioca Bay. When severe rainfalls hit the city at the same time with high tides, the water breaks into the streets of the city, which becomes canals. In order to comprehend the climatic condition of the area, two graphs are proposed in Figure 2b and 2c, showing the average minimum and maximum temperatures, and the average precipitations recorded between 1981 and 2010, respectively. The data have been registered in the meteorological station located in

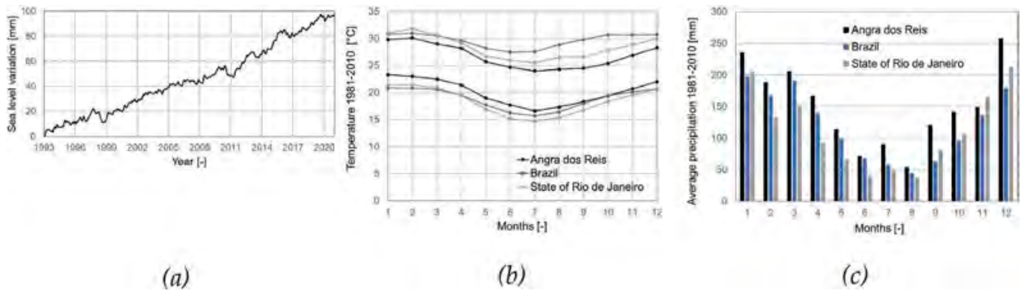

Figure 2. (a) Global mean sea level variation from 1993 to 2021, data taken from NASA (Beckley et al., 2021); (b) Average maximum and minimum temperatures in Angra dos Reis, in Brazil and in the State of Rio de Janeiro, between 1981 and 2010, data taken from INMET (Web-4); (c) Average precipitations in Angra dos Reis, in Brazil and in the State of Rio de Janeiro, between 1981 and 2010, data taken from INMET (Web-4).

Angra dos Reis (INMET, Web-4) which is very close to Paraty and characterized by similar weather conditions. The minimum and maximum temperatures in each month of the year have been less severe, if compared with the average values registered in the whole Brazil and in the whole State of Rio de Janeiro, probably thanks to the mitigation effect of the sea. However, the average cumulative precipitations registered in each month have been in general higher in Paraty, if compared with entire Brazil and the State of Rio. In this context, the event that occurred between January 9 and 10, 2009, deserves to be highlighted. On that date, a storm surge hit the mountainous region of Paraty, raising the water level in the Perequê-Açu River up to 8 meters, destroying many houses and leaving many people displaced, as reported by the newspaper ESTADÃO (2009).

In this context, this paper aims to explore strategies to manage the flooding risk in historical cities, based on the case of Paraty. To this end, the mapping of flood areas and main waterways in the central region of the municipality have been produced, using data from the Brazilian Institute of Geography and Statistics (IBGE, Web-3), the National Water Agency (ANA, Web-5) and the Geological Service of Brazil (CPRM, Web-6). The data were georeferenced with the aid of the QGIS tool (QGIS version 2.18, Web-8) over the Bing satellite photographic base (Web-7).

The map in Figure 3 shows the municipality of Paraty, its main waterways (colored in blue), the main roads (in black) and the areas in risk of flood, with emphasis on the historic center. The flooding risk is schematized with a colored scale, from more severe (red color) to low risk (green color). According to CPRM data, the areas that are not colored following this scale are not subjected to flooding risk. It can be observed that the historic center area surrounding the Perequê-Açu and Mateus Nunes rivers is classified with high risk, and it is one of the most densely populated areas. The map in Figure 4, with the same layout of Figure 3, depicts the risk of landslides in the municipality. In this case, the high risk (red color) of landslide is more concentrated in the mountainous areas, where the natural slopes increase the occurrence of this phenomenon. Indeed, the city center of Paraty is located in a planar area corresponding to the mouth of the two main rivers; however, the peripheral urban parts of the city are subjected to a medium-high risk of landslides.

Considering the cultural and historical heritage of the central area, and its high susceptibility to flooding, it is interesting to discuss some possible strategies for the mitigation of the flooding risk. By approximating the scale for the area of intervention and cross-referencing it with the information discussed in the other sections of the paper, points of strengths, threats, weaknesses, and opportunities have been identified, as shown in the Table 1.

3.2 *Strategies to prevent the flooding*

This type of risk can be prevented through direct strategies managing the water discharge through the main rivers, as well as indirect strategies of long-term urban planning. Indeed, the

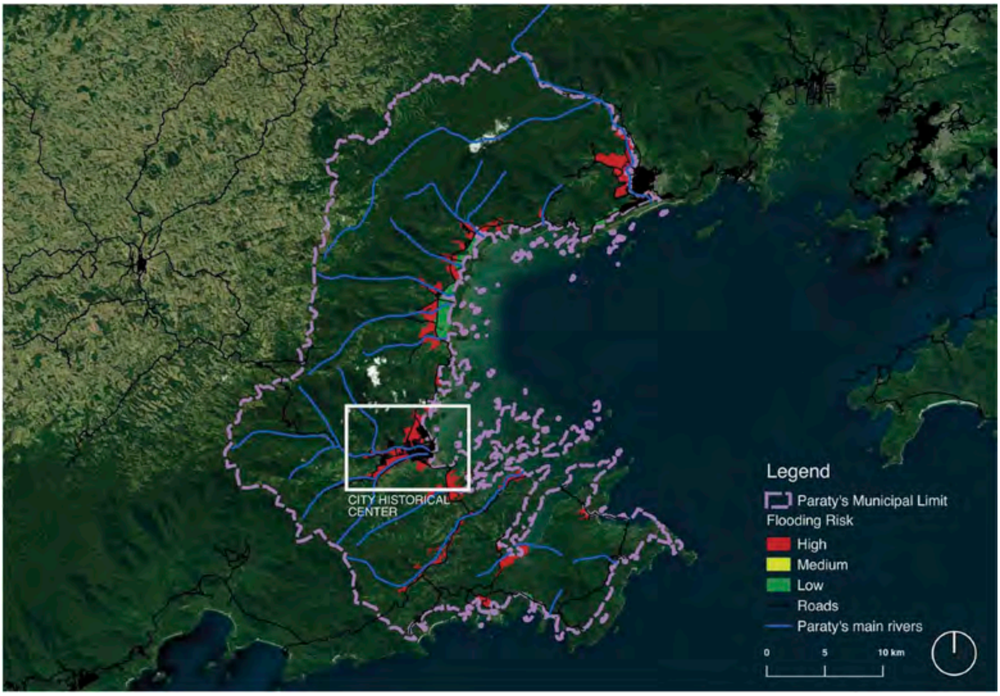

Figure 3. Flooding risk areas in Paraty, Rio de Janeiro State, Brazil. Prepared based on data from IBGE (Web-3), ANA (Web-5) and CPRM (Web-6). Satellite image: Bing (Web-7).

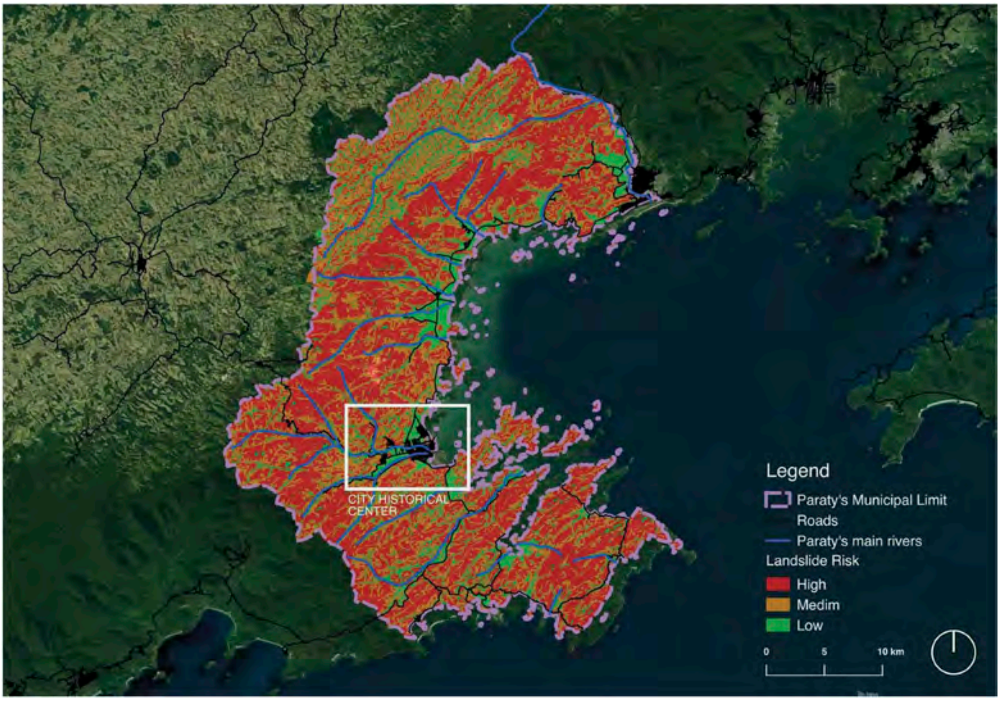

Figure 4. Landslide risk areas in Paraty, Rio de Janeiro State, Brazil. Prepared based on data from IBGE (Web-3), ANA (Web-5) and CPRM (Web-6). Satellite image: Bing (Web-7).

Table 1. Main strengths, threats, weaknesses and opportunities of Paraty, Rio de Janeiro State, Brazil.

Strengths	Threats	Weaknesses	Opportunities
• Historical heritage, architecture and landscape	• More frequent extreme rain events	• Build areas close to rivers	• Proper urban planning
• Tourism	• Demographic growth	• Migration of the locals	• Sustainable tourism
• Natural beauties like beaches and islands	• High tides	• Historical monuments in danger	• Adaptation to extreme events
• The city is resilient to 30 cm flooding	• Rivers overflow	• Inefficiency of drainage systems	• Strategies to improve drainage and water management

mitigation of the risk should be addressed with a long perspective considering the possible changes in the climate condition, and not just reducing the impact of an event in the short term. Considering the risk equation according to which the risk is expressed as the product of hazard, vulnerability and exposure (Society of risk analysis, Web-8), the mitigation strategies can be addressed to lowering exposure and vulnerability, i.e., the amount of elements, goods or assets that could be affected by hazard, and their tendency of being damaged or affected by hazard. Regarding this aspect, urban planning plays a key role in the adaptation and mitigation of natural disaster risks, including flood risk.

As already mentioned, a proper urban planning could be one of the most effective solution in Paraty, since the urban growth have spread without control in many areas in danger. In order to capture this phenomenon, Figure 5 reports an aerial view of the urban areas around the city centre of Paraty in 2001 and 2020, showing the increase in land-use (highlighted in orange) in twenty years, involving many parts next to the main rivers.

Several studies, such as the ones of Hough (2004), Cormier and Pellegrino (2008), Herzog (2013), have pointed out the importance of adopting nature-based solutions to make cities more resilient to disasters. Regarding the issues related to water, several approaches enhance the need to combine structural and nonstructural measures as well as to the control the land-use to mitigate flood risks, and to minimize the impact of urbanization (Barbedo, 2014). By crossing the main strengths and weaknesses of the area under consideration, some strategies to manage the flooding risk have been listed and mapped. The strategies have been formulated based on the concept of nature-based solutions, integrating urban planning and ecosystem services, promoting the reduction of flood risk. Table 2 offers an overview of the main direct strategies proposed, with reference to the works of Hough (2004), Herzog (2013) and Sanches (2014), and highlights the various benefits that can be derived. Moreover, these strategies may also bring other benefits to the population and local environmental quality. For example, the implementation of parks and green corridors not only promotes better storm water runoff and increases the permeability of soil, but also helps to avoid an uncontrolled urban sprawl, improves the air quality, connects natural remnants and serves as a recreational space, integrated with the cultural and environmental heritage of Paraty.

A schematic representation of the introduction of new parks and water basins in Paraty is illustrated in Figure 6. The new parks are indicated with a light-green colour, whereas the new basins and canals are in light-blue. Parks and green corridors have been installed based on the natural remnants in the territory, mainly located at the limits of the area in major flooding risk. Flood basins, wetlands, and new channels have been integrated to the aforementioned parks, aiming at improving the drainage of soil, collecting the surplus of water, and laminating the peak of the water flow during extreme events. The creation of new parks in order to limit the urban sprawl and the paved areas, as well as the introduction of new canals and flood basins, entails several benefits. In Figure 7, there is a schematic representation of the engineering process of lamination beneath these strategies. The main aim is to reduce (i.e., laminate) the amount of water flow through the main rivers of Paraty during an extreme flooding event, and to allow a gradual release of the water in time (Apollonio et al., 2021).

Figure 5. Google Earth (Web-10) aerial view showing the urban sprawl in Paraty in (a) 2001 and (b) 2020. The newly built areas are colored in orange.

The black curve represent the amount of water flowing over time during a rainfall (indicated with ‘Q’). The peak of water-flow (Qe) is reached in a few minutes, and the main amount of the whole volume of water is released in a short interval of time. The blue curve, instead, represents the modified trend of the water flow if strategies of lamination are adopted. Indeed, the peak of water flowing in the rivers is reduced significantly (Qmax), and there is a flattening and smoothing effect of the curve over time. Thank to this effect, a certain volume of water (W) can be stored in the basins during the peak intensity of the rainfall, and thus released at a second moment, or collected for public intended use (Pregnolato et al. 2021).

Through this process, the impact of flooding can be remarkably reduced in an urban area like Paraty, where water has a predominant character in the entire environment.

Table 2. Main strengths, threats, weaknesses and opportunities of Paraty, Rio de Janeiro State, Brazil.

Strategy	Objective	Benefits
Green parks and green corridors	• Avoid the urban sprawl;	• Elimination of standing water;
	• Increase the permeable area;	• Infiltration and groundwater recharge;
	• Improve drainage of soil;	• Better surface runoff of rainwater;
	• Public space for tourism/leisure.	• Health of vegetation;
		• Improvement of air quality.
Wetlands	• Improve drainage;	• Retention of rainwater;
	• Discharge the surplus of water;	• Reduction of water flow;
	• Decrease the impacts of flooding.	• Creation of new ecosystems;
		• Purification/filtration of diffused water pollution.
Flood basins and new canals	• Laminate the peak of water flow in rivers;	• Retention of rainwater;
	• Retention of the surplus of water.	• Reduction of the water flow in urban areas and rivers;
		• Disposal of water basins for public use.

Figure 6. Scheme of the strategies to manage the flooding risk in Paraty, Rio de Janeiro State, Brazil. Prepared based on data from IBGE (Web-3) and ANA (Web-5). Satellite image: Bing (Web-7).

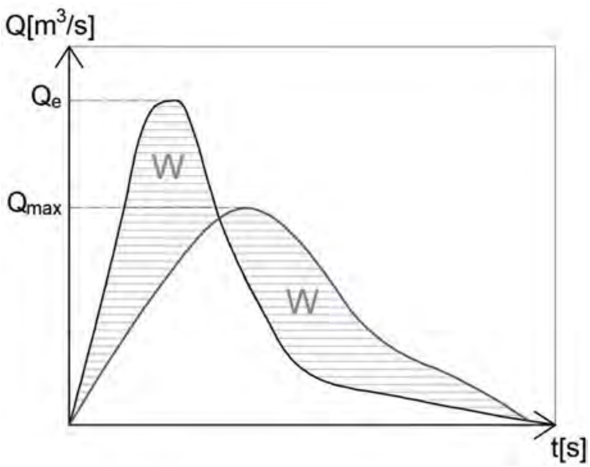

Figure 7. Graphical conceptual representation of the process of lamination of the water flow during a flooding event.

4 CONCLUDING REMARKS

This paper discusses possible strategies for the prevention of the flooding risk in historical cities, with a comprehensive analysis of the particular case-study of the city of Paraty, in the State of Rio de Janeiro, Brazil. The context of the city has been explained with reference to the deep relationship with water, and to the fragile balance between the preservation of the local identity and the exploitation of the touristic potential of the municipality. The main natural risks in the city have been presented base on several climatic and environmental data, and possible strategic solutions have been commented. The following conclusions can be drawn:

- The historical and environmental heritage of the city are recognized internationally and must be preserved, together with the culture and the identity of the local community;
- The touristic potential of the city should be exploited by governors to enhance the economic growth and bring benefits to locals, but with a strategic plan focused on the protection of the intangible heritage through sustainable tourism;
- The city of Paraty, as well as many parts of the municipality, is in flooding risk and have been subjected to many natural disasters; thus, an effective plan aimed at reducing the

vulnerability of the area should be outlined, considering the possible future evolution of climate change;
– Direct strategies of flooding risk mitigation like the creation of new parks, wetlands, flood basins and canals, may be a feasible solution to increase the resilience of the city;
– The lamination of the water flow in the main rivers combined with a proper and long- term urban planning may be an effective approach to foster urban environmental quality and cope with future climate hazards;
– Adaptation to climate change and the definition of multifaceted plans of risk mitigation should be encouraged in order to protect the tangible and intangible heritage of many places in risk.

4 AUTHORS CONTRIBUTION

Conceptualization, I.A. de Serro Azul, M. De Souza and M. Previti; methodology and definition of the problem, L. Praticò and A. Marques; investigation and research, M. De Souza and M. Previti; resources and draft of figures, A. Marques and L. Praticò, C.C.; writing—original draft preparation, L. Praticò, I.S. de Serro Azul, M. De Souza, M. Previti and A. Marques; writing-review and editing, L. Praticò; supervision, I.A. de Serro Azul. All authors have read and agreed to the published version of the manuscript. The authors cooperated as a group identified with the following logo self-made with Web-11.

ACKNOWLEDGMENTS

The support of the International Summer school After the Damages is fully acknowledged. The lectures given in the Summer School have been a true inspiration for the development of this research. The authors are fully responsible for the contents of this work, which do not necessarily reflect the position of the lecturers and organizers of the Summer School.

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Author Index