



# Collapsing Structures and Public Mismanagement

Wolfgang Seibel

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## Collapsing Structures and Public Mismanagement

“In what is certain to become an indispensable book on public failures, their origins, and consequences, Wolfgang Seibel builds piece-by-piece a unique contribution to the study of rare events and the search for resilience in public policy. Bridges and buildings are perhaps the best real-world synonym for rational design and deliberation; proper construction and maintenance is the first and primary goal of entire professions. This book demonstrates how accidents happen, how social processes are fundamental to their occurrence, and how learning and inference about their causes is a core public management function. Along the way, Seibel masterfully musters evidence from a multitude of sources to painstakingly document both bridge and building failures and the organizational pathologies that accompany them. This is a must-read for those who want to better understand such “black swan” events and the search for resilience.”

—Andrew B. Whitford, *Professor at the School of Public and International Affairs, University of Georgia, US*

“A must read for practitioners and scholars, Wolfgang Seibel’s latest book provides profound insight in the intersection of public administration mismanagement and the absence of responsible leadership. Through a series of devastating cases, he provides a forensic analysis of how and why disasters occur, showing us what happens when we ignore warning signs and fail to act. His work challenges us all to step up, embrace a more strategic approach to learning, and prevent these catastrophic disasters from happening. An exceptional contribution to the field.”

—Janine O’Flynn, *Professor of Public Management, The Australia and New Zealand School of Government, Australia*

“Wolfgang Seibel convincingly demonstrates that learning from collapsing structures should not be left to the engineers only. The governance path to disaster needs to be addressed in order to learn and avoid future disasters. Seibel’s book provides both the theoretical and methodological underpinnings and a roadmap for learning from accidents.”

—Stavros Zouridis, *member of the Dutch Safety Board and Professor of Public Administration, Tilburg University, The Netherlands*

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and Public  
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## PREFACE

This book was written in the year of the great pandemic, 2020, a phenomenon connected to this book's subject in more than one way. The pandemic raised the awareness of how important capable and reliable public agencies are when it comes to the implementation of governmental action. The pandemic crisis also made us aware that good government is not only a matter of good decision making but also, even to a decisive degree, a matter of sound and reliable implementation by public administration. Whether or not public authorities were working properly and effectively impacted immediately on public health conditions and, ultimately, death tolls. The general importance of public administration for human safety is, basically, the very subject of this book. Moreover, one banal consequence of the pandemic was that it facilitated the book's production. Confined to my home office for months, the range of distractions and excuses shrank considerably (Palgrave staff may object).

This book is about the threats to life and limb as a result of public mismanagement. Conversely, it emphasizes the importance of good governance and a sound sense of responsibility outside the well-known risk zones of critical infrastructure or acute crisis management. Much of what goes wrong in public administration at the expense of safety and human security is enrooted in standard pathologies of the bureaucratic organization such as lack of flexibility due to hierarchized governance and horizontally fragmented division of labor, the proverbial red tape and rigid standard operating procedure. By the same token, however, these pathologies are known and, in principle, manageable so that their undesirable

effects are usually kept under control, especially when human safety is at stake. This book focuses on cases and circumstances where that control failed. It therefore addresses two questions: What explains the unlikely failure of professional public agencies to protect human safety? What can be generalized on the basis of exemplary case for the sake of learning and prevention?

The research on which the book is based is part of the project “Black Swans in Public Administration: Rare Organizational Failure with Severe Consequences” funded by the German Research Foundation (DFG) in the framework of the DFG Reinhart Koselleck program. I would like to express my gratitude to two more institutions whose hospitality and highly stimulating intellectual environment greatly mobilized my physical and mental energy in preparing and writing this book. One is the Stellenbosch Institute for Advanced Study (STIAS) where I had the privilege of being a Fellow from February through April 2019. The other one is the Utrecht University School of Governance (USBO) where I spent a very productive sabbatical as a guest scholar ages ago, i.e., in the pre-pandemic Fall and Winter of 2019/2020. I am particularly indebted to Mark Bovens and Paul ‘t Hart for making this possible and to the wonderful staff—Inge Bakker-Simon, Esther Verheijen and Liliane van der Vaart in particular—who supported me and my work. I also would like to thank Stavros Zouridis and the Oderzoeksraad voor Veiligheid (Dutch Safety Board) as well the Tilburg Institute of Governance and my dear friends Patrick Kenis and Joerg Raab for the opportunity to discuss the analytical concept of this book in various meetings and discussions. Moreover, I am profoundly grateful to Annette Flowe without whose enduring support and patience the manuscript would not exist and to Paulina Ulbrich who relentlessly assisted me in creating figures, tables and lists of all kinds and carefully coordinated all related activities. Finally, I would like to thank my editors, Nicholas Barclay and Stewart Beale, of Palgrave Macmillan for his consultancy and support and Ruby Panigrahi and Nirmal Kumar GnanaPrakasam for their diligence and patience in editing the manuscript. I alone am responsible for all remaining flaws and errors.

Konstanz, Germany  
November 2020

Wolfgang Seibel

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## ABBREVIATIONS

AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ARCE	Alan M. Reay Consulting Engineer
ARCL	Alan M. Reay Consultants Ltd.
ASSC	Industrial Construction Division
BARS	Bridge Analysis and Rating System
BGH	Bundesgerichtshof
CBD	Central Business District (Christchurch)
CCC	Christchurch City Council
CEAS	Consulting Engineers Advancement Society
CF	Contributing Factor
CJ	Critical Juncture
CPG	CPG New Zealand Ltd.
CRB	Country Roads Ward
CRC	Canterbury Regional Council
CTV	Canterbury Television
ETABS	Integrated Analysis, Design and Drafting of Building Systems
FF & P	Freeman, Fox and Partners
FHWA	Federal Highway Administration
GPM	Gray Plant Mooty (law firm)
HCG	Holmes Consulting Group
HCL	Hyland Fatigue and Earthquake Engineering
JHC	John Holland Constructions Proprietary Ltd.
LYCA	The Lower Yarra Crossing Authority
MnDOT	Minnesota Department of Transportation
NC	Necessary Condition

NDE	Non-destructive examination
NTSB	National Transportation Safety Board
OBS Or “Central Bridge”	Office of Bridges and Structures (Minnesota Department of Transportation)
PCI	Progressive Contractors, Inc.
PGC	Pyne Gould Corporation
QUANGO	Quasi-nongovernmental organization
SC	Sufficient Condition
SSL	Structure Smith Consulting Engineers
TP	Turning Point
URS	URS Corporation Inspections and Reports
USAR	Urban Search and Rescue
WSC	World Services and Construction Co. Ltd.

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# Introduction: Black Swans and Sinatra Inferences

When, on 14 August 2018, the Morandi Bridge in Genoa, Italy, collapsed, it killed 43 people and made some 600 homeless whose dwellings were crushed by the impact of the debris. Obviously, a bridge does not collapse just out of the blue. In the case of the Morandi bridge, “investigations indicated poor design, questionable building practices, and insufficient maintenance—or a combination of these factors—as a possible cause of the collapse.”<sup>1</sup> Whatever the individual reasons in an individual case—the basic fact is that the collapse of bridges and buildings remains a highly unlikely event. After all, building under public oversight and control is one of the oldest collective activity of humankind. The practical purpose of building would be pointless without adequate safety, and the concern for safety emerged not only into professional standards of architects, engineers and public officials but also in the existence of governmental agencies supervising construction in accordance with relevant regulation. To that extent, collapsing bridges and buildings represent a Black Swan phenomenon<sup>2</sup>—one whose irregularity and rareness make it hard to predict but whose high impact requires knowledge-based prevention. The puzzle is that the dramatic consequences of failing bridges and buildings imply a

<sup>1</sup>Massimiliano Burlando et al.: Investigation of the Weather Conditions During the Collapse of the Morandi Bridge in Genoa on 14 August 2018 Using Field Observations and WRF Model. *Atmosphere* 11 (2020): 724.

<sup>2</sup>Nicholas Nassim Taleb: *The Black Swan: The Impact of the Highly Improbable*. New York: Random House 2007.

quest for solid and generalizable knowledge while the irregularity and rareness of such failure seriously limits the basis of generalization.

It is here where this book sets its focus. It analyzes four spectacular cases of collapsing structures, two bridges and two buildings: The West Gate Bridge in Melbourne that collapsed on 15 October 1970 when still under construction, the I-35W Mississippi River bridge in Minneapolis that collapsed on 1 August 2007, the Canterbury Television (CTV) Building in Christchurch that collapsed on 22 February 2011 after an earthquake and the Ice Skating Rink in the Bavarian city Bad Reichenhall whose roof collapsed on 2 January 2007. What made these accidents true disasters was the loss of human lives. Thirty-five people were killed in the collapse of the West Gate Bridge, 13 people died in the I-35W disaster. Even more dramatic was the death toll claimed by the collapse of the CTV building in Christchurch where 115 were killed, many of them international students of a language school located in the multi-story building. The collapse of the ice-skating rink roof in Bad Reichenhall claimed the lives of 15 people, among them 12 children skating in the arena during New Year's vacation.

What these cases have in common in the pragmatic perspective of research is that they are well documented, either through reports of investigation committees or judicial proceedings. While, accordingly, the empirical basis for causal analyses is solid, the question of representativeness and generalization remains valid in more than one sense. Does what applies to the conditions of failure in Australia, New Zealand, the USA and Germany also apply to conditions in China, Bangladesh or Nigeria? Moreover, how can we generalize from just four cases or “observations” anyway?

## 1.1 RARE INCIDENCES AND THE QUEST FOR INFERENCE AND LEARNING

Civil engineers will take it for granted that each individual case of collapsing bridges and buildings, however rare and unique, entails instructive lessons for the construction and building community around the world. It is always about a particular type of bridge, a particular type and composition of material and particular proceedings in the course of construction. So there are structures and processes that are unique and exemplary—thus generalizable—at the same time. Which applies to every single case analyzed in this book, whether it was the wrong choice of glue for a wooden roof structure, poorly designed gusset plates connecting steel truss members or insufficiently stabilized diaphragms connecting the floors of a



building to supporting beams. What sounds uncommon and incomprehensible for laypeople is easy to understand for the expert. Moreover, the expert will also spontaneously generalize. He or she knows about the peculiarities of particular structural designs, their strengths and weaknesses, their advantages and disadvantages because those peculiarities are systemic in nature. Gusset plates stabilizing the nodes of a steel truss are a common phenomenon, every wooden roof structure needs water-resistant glue and everywhere the stability of bridges and buildings relies on diaphragms connecting the various parts of their primary structure. Accordingly, generalization from a single case of failure is not only possible but imperative when it comes to serious issues of stability and safety.

By contrast, the non-technical causes of failure are, at first glance, non-generalizable. Why and under what circumstances existing regulation and professional standards remain unobserved, why contractors and consultants are unable to coordinate their action or why local building authorities do not enforce the relevant safety regulation seems to be contingent and unpredictable. In reality, however, the non-technical causes of failure share the characteristics of their technical counterparts. They too are systemic in nature. Public authorities have their own structural and agency-related risk zones. This applies to information asymmetries in a hierarchical setting known as principal-agent-problem,<sup>3</sup> unresolved problems of coordination,<sup>4</sup> goal displacement in the sense that standard operating procedures and routines become an end in themselves,<sup>5</sup> the “normalization of deviance” in the form of counterproductive routines become engrained and thus are taken for granted in an organization’s everyday life,<sup>6</sup> “bureaucratic politics” and inter-agency rivalry that makes public authorities more concerned with themselves than with the concerns of their clientele<sup>7</sup> or the

<sup>3</sup>Sanford J. Grossman and Oliver D. Hart: An Analysis of the Principal-Agent Problem. *Econometrica* 51 (1983): 7–45.

<sup>4</sup>James D. Thompson: *Organizations in Action: Social Science Bases of Administrative Theory*. New York: McGraw-Hill 1967.

<sup>5</sup>Robert K. Merton: Bureaucratic Structure and Personality. *Social Forces* XVII (1940): 560–568.

<sup>6</sup>Diane Vaughan: *The Dark Side of Organizations: Mistake, Misconduct, and Disaster*. *Annual Review of Sociology* 25 (1999): 271–305; Vaughan, Diane: *The Challenger Launch Decision: Risky Technology, Culture and Deviance at NASA*. 2nd ed., Chicago and London: The University of Chicago Press 2016.

<sup>7</sup>For the phenomenon of “bureaucratic politics” cf. Graham T. Allison and Morton H. Halperin: *Bureaucratic Politics. A Paradigm and Some Policy Implications*. *World Politics* 24 (1972): 40–79.

proverbial red tape in the sense of over-regulation that undermines the compliance of both staff members of public authorities and their clientele.<sup>8</sup>

However, precisely because these pathologies are ‘standard errors’ they are usually kept under control in a properly managed organization and, accordingly, properly managed public authorities as well. This, in turn, leaves us with an ambivalent diagnosis. It is not particularly convincing to assume the failure of public bureaucracies to exercise proper and effective control over building and construction to result from well-known deficiencies. After all, the hazards involved are not only known but subject to strict regulation. Division of labor between building authorities, contractors and consultants is inevitable, yet at the same time entirely manageable as long as fault lines and potential loss of information is soberly recognized as a risk factor and neutralized accordingly. By the same token, a conflict of interest exists between contractors and consultants vis-à-vis public building authorities when it comes to the desire for expeditious processing of applications for building permits and the indispensable diligence of reviewing and recalculating the structural design of bridges and buildings. Yet, public building authorities are usually robust and experienced enough to resist a pressure to accelerate the review of applications for building permits at the expense of professional diligence. Finally, there might be a ‘horizontal’ power asymmetry among the clientele of building authorities. It makes a difference whether the applicant for a building permit is a future homeowner or a contractor running a large-scale building project that one way or the other is also important for urban development. But even this is not uncommon and, accordingly, it is virtually unlikely that local authorities when dealing with consultants and contractors of major construction projects make concessions at the expense of compliance with safety regulation. Rather, there is good reason in acknowledging that, when it comes to human safety, a zero tolerance principle shapes the mindset of regulators, public officials and professionals of the architecture and engineering community.

This implies that, for the sake of ontological realism and methodological parsimony, the causal analysis of the non-technical origins of disasters in the realm of building and construction can be focused more narrowly. The question is, specifically, what counterincentives make human actors neglect or suspend the very professional and institutional routines that usually neutralize the impact of standard pathologies of formal organizations under the condition of risks for human life and limb. Which also is

<sup>8</sup> Alvin W. Gouldner: *Patterns of Industrial Bureaucracy*. New York: The Free Press 1954.

the key to generalization. It should be possible to identify typical mechanisms that make public officials, architects and engineers neglect their professional standards and/or existing regulation. Consequently, those mechanisms can also be defined as risk factors in their own right since they are powerful enough to cause failure in the restrictive environment of otherwise sound accountability structures, incorruptible bureaucracy and high professional standards of public officials, architects and engineers. Accordingly, those mechanisms can be assumed to be even more powerful—thus detrimental—under less restrictive conditions. Which is known as the “Sinatra Inference”: If a causal mechanism is strong enough “to make it” under restrictive conditions—i.e., when causal leverage is supposed to be low—it is likely to have even more of an impact under less restrictive conditions.<sup>9</sup> For instance, when and where accountability structures are weaker, professional standards lower, public bureaucracies more corruptible and, last but not least, when and where less vital issues are at stake than the protection of human life and limb.

## 1.2 CAUSAL PROCESS TRACING: TURNING POINTS AND CRITICAL JUNCTURES, NECESSARY AND SUFFICIENT CONDITIONS, AND CONTRIBUTING FACTORS

Detecting the counterincentives that make human actors neglect or suspend professional and institutional routines that usually neutralize the impact of standard pathologies of formal organizations requires causal process tracing.<sup>10</sup> Unlike the conventional causal analytic technique of defining independent variables and testing hypotheses referring to the impact on a predefined dependent variable, process tracing has the potential of detecting causal mechanisms rather than just causal effects expressed through correlation or regression coefficients. This, in turn, not only requires a careful and fine-grained longitudinal analysis of relevant events

<sup>9</sup> Referring to Frank Sinatra’s “New York, New York” song with the key phrase, “if I can make it there, I’ll make it anywhere”. Cf. Jack S. Levy: *Case studies. Type, designs, and logics of inference. Conflict Management and Peace Science* 25 (2008): 1–18 (12).

<sup>10</sup> Out of the burgeoning literature on causal process tracing cf. Derek Beach and Rasmus Brun Pedersen: *Process-Tracing Methods: Foundations and Guidelines*. 2nd ed., Ann Arbor: University of Michigan Press 2019; Andrew Bennett and Jeffrey T. Checkel: *Process Tracing. From Metaphor to Analytic Tool*. Cambridge: Cambridge University Press 2015; Nicholas Weller and Jeb Barnes: *Finding pathways: Mixed-method research for studying causal mechanisms*. Cambridge: Cambridge University Press 2014.

and decisions but also a definition of turning points and critical junctures at which the mechanisms became relevant in shaping the causal process.<sup>11</sup> Turning points and critical junctures not only mark the points in a timeline at which causal mechanisms are activate but also the situational setting in which necessary and sufficient conditions of the ultimate disaster were fulfilled. The definition of necessary and conditions is complementary to the differentiation of turning points and critical junctures. A factor or “condition” without which the consequence in question could not have occurred marks a turning point in the sense that from that point on the outcome was likely to occur but not yet inevitable. A causal factor, on the other hand, that would have triggered the outcome under any circumstances marks a critical juncture in the sense that from that point on the outcome was virtually inescapable. The occurrence of a single sufficient condition is rare while several necessary conditions may be jointly sufficient for the outcome in question to occur.<sup>12</sup>

There is a gray zone, however, beyond necessary and sufficient conditions that may be termed “contributing factors”.<sup>13</sup> Contributing factors are similar to what in criminology is known as “permissive environment” or “permissive conditions”,<sup>14</sup> i.e. factors that work in favor of particular (undesirable) actions but still leave considerable discretionary leeway for personal decisions. Indirectly, the notion of contributing factors/permissive conditions refers to one distinct difference between the analytical and the normative dimension of causal process tracing. Analytically, the purpose of process tracing is the reconstruction of the causal chain with rigor and accuracy. That accuracy just reflects the deterministic logic of causality whose actual shape and occurrence needs to be analytically reconstructed. By contrast, normative conclusions address risk factors and are, thus, probabilistic in nature. Factors that contribute or just *may* contribute to an undesirable outcome are a risk factor in their own right and therefore need to be

<sup>11</sup> Giovanni Capoccia and Daniel R. Kelemen: The Study of Critical Junctures. Theory, Narrative, and Counterfactuals in Historical Institutionalism. *World Politics* 59 (2007), 341–369; Gary Goertz and Jack S. Levy: Causal Explanation, Necessary Conditions, and Case Studies. In Gary Goertz and Jack S. Levy (eds.): *Explaining War and Peace. Case Studies and Necessary Condition Counterfactuals*, London 2007: 9–45 (29–31); David Hillel Soifer: The Causal Logic of Critical Junctures. *Comparative Political Studies* 45 (2012): 1572–1597. The distinction between *turning points* and *critical junctures* is emphasized by Goertz and Levy.

<sup>12</sup> Goertz and Levy: Causal Explanation, Necessary Conditions, and Case Studies, 24–26.

<sup>13</sup> *Ibid.*, 10.

<sup>14</sup> Soifer: The Causal Logic of Critical Junctures.

addressed as such, which in real life means to eliminate them or at least to restrain their detrimental effects. It is not necessary, for instance, to assess with rigor and accuracy the exact impact of speeding and reckless driving in order to define speeding as a risk factor that should be eliminated anyway.

In this very sense, the case analyses presented in this book serve a double purpose. On the one hand, they reassess actual causalities. On the other hand, they identify general structural risk zones and risk increasing behavioral patterns. This is done on the basis of three components, namely an analytical narrative that addresses turning points and critical junctures at which crucial actions or omissions occurred; the definition of necessary and sufficient conditions and ‘contributing factors’; the identification of typical causal mechanisms with the potential of generalization.

### 1.3 CAUSAL MECHANISMS, NEAR MISS SCENARIOS, AND POINTS OF INTERVENTION

The analytical narrative addressing turning points and critical junctures as well as various types of causal conditions is inductive in nature. It requires the reassessment of actual processes so that formative actors and decisions become gradually identifiable. By contrast, the definition of generalizable causal mechanisms requires theory-based deduction. The mechanisms themselves are not “visible”, they only can be conjectured.<sup>15</sup> The diagnosis of coordination problems, loss of information, persisting misperceptions etc. remains a matter of theoretical interpretation the basis of which are ontological premises concerning the “system” at hand.<sup>16</sup> We expect social mechanism in social systems or bio-chemical mechanisms in ecological systems, etc. Which implies that the range of actually relevant mechanisms that shape individual or collective behavior is limited according to the nature of the system itself. Relevant mechanisms on a commodity market, for instance, are demand, supply and competition. There might be further mechanisms like networking in a supply chain or brand reputation but they are of no or limited relevance for the core mechanisms of a market. Similar with authority connected to formal hierarchy or bargaining as the driving mechanism of negotiations.

<sup>15</sup> Mario Bunge: Mechanism and Explanation. *Philosophy of the Social Sciences* 27 (1997): 429–436; Mario Bunge: How Does It Work? The Search for Explanatory Mechanisms. *Philosophy of the social sciences* 34 (2004): 182–210.

<sup>16</sup> Bunge: Mechanism and Explanation; Bunge: How Does It Work? The Search for Explanatory Mechanisms.

Yet, to what extent human action and interaction is being aggregated to the outcome in question remains to be assessed on a case-by-case basis. Insufficient control and oversight over maintenance of public infrastructure, a bridge for example, may or may not be conducive to poor maintenance itself. And even when maintenance is indeed poor this does not inevitably result in a loss of stability and safety of the bridge. Poor maintenance is certainly a core mechanism which, however, is embedded in permissive conditions and connected to additional factors that may or may not trigger a disastrous outcome. One may thus assume a triplet of mechanisms according to the one introduced by Richard Swedberg<sup>17</sup> and Peter Hedström and further developed by Hedström and Petri Ylikoski in “Causal mechanisms and the social sciences”.<sup>18</sup> These authors distinguish action-formation, situational and transformational mechanisms (Fig. 1.1).

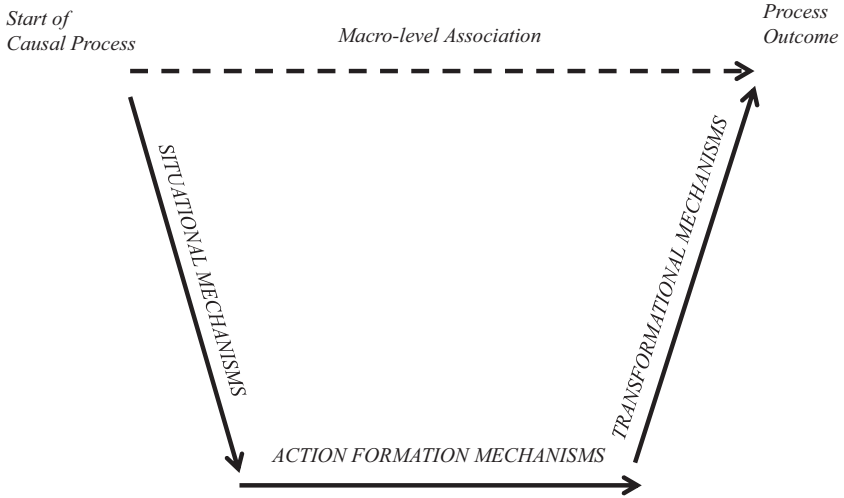
This differentiated concept of causal mechanisms is, on the one hand, a more elaborate version of actor-centered methodological individualism, represented by “action formation mechanisms” known from James S. Coleman’s bathtub metaphor.<sup>19</sup> On the other hand, the Hedström and Ylikoski concept of causal mechanisms also makes salient that, in principle, not only various types of causal mechanisms are linked to each other but that the “links” signify potential points of intervention. One of those points is located at the interface between situational mechanisms and action formation mechanisms and one at the threshold between action formation mechanisms and the actual occurrence of the outcome.

What one may reasonably assume is that a large amount of the risk potential of situational mechanism is neutralized already at the interface between situational and action formation mechanisms. Which is exactly what regulation of risk prone systems does that emerged in a historically protracted process of learning, decisively accelerated by the industrial

<sup>17</sup>Peter Hedström and Richard Swedberg: *Social Mechanisms. An Introductory Essay*. In Peter Hedström and Richard Swedberg (eds.): *Social Mechanisms. An Analytical Approach to Social Theory*. Cambridge: Cambridge University Press 1998, 3–32.

<sup>18</sup>Peter Hedström and Petri Ylikoski: *Causal mechanisms in the Social Sciences*. *Annual Review of Sociology* 36 (2010): 49–67 (59).

<sup>19</sup>James S. Coleman: *Foundations of Social Theory*. Cambridge (Mass.): Harvard University Press 1990, 10. The wording “bathtub” does not actually appear in Coleman’s book but it has become popular due to the shape of the graph on that very page in support of the claim that the analysis of both social structure and social action has to conceptualize the linkage between the “micro”-level of human action and the “macro”-level of aggregate effects. Hedström and Swedberg, in their 1998 book chapter, referred to the “bathtub” and gave it a more nuanced characteristic while maintaining its basic shape.



**Fig. 1.1** Typology of Causal Mechanisms (adapted from Peter Hedström and Petri Ylikoski: *Causal Mechanisms in the Social Sciences*. *Annual Review of Sociology* 36 (2010): 49–67 (59))

revolution since the early 19th century. Still, those precautions might be too weak, they might not be enforced, they might be ignored or deliberately circumvented. At any rate, these weaknesses pertain to the level of action formation mechanisms.

But even if they do occur those weaknesses and risk increasing behavioral patterns do not necessarily trigger undesirable outcomes. A municipal building authority may be tempted to accelerate the issuance of a building permit in an effort to do justice to the legitimate interest of the applicant and, maybe, the local business community at the expense of diligence in checking structural design issues. That impulse might be the consequence of situational mechanisms in the form of local pressure group influence. Yet, that impulse may be neutralized by senior officials so that the threshold between action formation mechanisms and transformational mechanisms remains intact.

This refers to the general phenomenon of a near miss or close call situation aptly described by Scott Sagan in his seminal book *The Limits of Safety* of 1993.<sup>20</sup> Many “accidents” do not happen because of last moment

<sup>20</sup>Scott D. Sagan: *The Limits of Safety: Organizations, Accidents, and Nuclear Weapons*. Princeton, N.J.: Princeton University Press 1993.

interventions as Sagan described for cases of nuclear weapons storage and transport and the failure of strategic missile early warning systems. There is no equivalent analysis pertaining to the construction industry but it is beyond reasonable doubt that in that risk prone environment serious consequences of neglect or outright blunder are frequently being prevented by resolute intervention at a very late stage. What the cases analyzed in this book have in common is that those ‘last moment’ opportunities existed and, yet, were missed.

#### 1.4 ‘NORMAL ACCIDENTS’ AND LACK OF MINDFULNESS

The differentiated concept of causal mechanisms is helpful for both explanatory and normative purposes when combined with two prominent concepts of disaster analysis and prevention, namely Normal Accident Theory (NAT) and High Reliability Theory (HRT). Normal Accident Theory<sup>21</sup> became prominent as the first contribution of organization theory to disaster research. What Charles Perrow in his trailblazing book of 1984 stated was that a particular type of organizational structure is toxic.<sup>22</sup> Organizations that combine tight coupling of sub-units and complex interaction among those units face an unsolvable dilemma, Perrow argued. Complex interaction requires decentralization since coordination under such circumstances requires constant exchange of ideas and deliberation which cannot be organized on the basis of hierarchical control. Centralization and hierarchical control is, however, exactly what keeps tightly coupled organizational systems viable (the railway system is a typical example). Since decentralization and centralization are mutually exclusive organizations that combine complex interaction with tight coupling are not viable either, Perrow stated. They may survive for a while but only as a particularly risk prone structure.

Scott Sagan, in his book on “Organizations, Accidents and Nuclear Weapons” obviously had more than one reason to take Perrow’s perspective seriously and yet went one step further when addressing the very question why, despite the undeniable risks aptly characterized by Perrow, risk prone organization structures dealing with particularly dangerous tasks do not constantly create disasters. Which led to an important contribution to what became known as High Reliability Organization Theory or

<sup>21</sup> Charles Perrow: *Normal Accidents: Living with High Risk Technologies*. New York: Basic Books 1984.

<sup>22</sup> *Ibid.* See also Perrow: *Complex Organizations. A Critical Essay*. 3rd ed., New York: Random House 1986, 119–156.



just High Reliability Theory (HRT):<sup>23</sup> Human agency is, after all, a key factor of mitigation and control in a high risk environment of any kind. This is why, Sagan stated, catastrophic accidents with nuclear weapons had not really happened, so far. However, they definitely could have happened and Sagan pointed to incidents at which a disaster had been averted only by a hair's breadth as nuclear 'close calls'.

The very combination of Normal Accident Theory and High Reliability Theory is used in the case analyses of this book in an 'enriched' version that integrates the differentiated concept of causal mechanisms developed by Swedberg, Hedström and Ylikoski.<sup>24</sup> It is quite in the vein of Normal Accident Theory that particular "structures"—for instance organizational and contractual arrangements—can be identified as particularly risk prone and, yet, not unmanageable. After all, one might assume, in accordance with High Reliability Theory, that the interface between situational mechanisms and action formation mechanisms can be stabilized through mindful control and that the threshold between risk increasing action formation mechanisms and transformational mechanisms can be raised sufficiently in order to prevent a disaster from being triggered. By the same token, however, both 'filters' may be perforated. Which is the logic characterized by the Swiss Cheese metaphor widely in use since its introduction by James T. Reason in the 1990s<sup>25</sup> to disaster research.<sup>26</sup> The case analyses of this book make the "slices" identifiable as missed opportunities of intervention that could have neutralized the risk increasing effects of situational

<sup>23</sup>Emery Roe and Paul R. Schulman: *High Reliability Management: Operating on the Edge*. Stanford: Stanford Business Books 2008; Karl E. Weick and Kathleen M. Sutcliffe: *Managing the Unexpected. Resilient Performance in an Age of Uncertainty*. 2nd ed., Hoboken: John Wiley & Sons 2007.

<sup>24</sup>The mutual complementarity and cross-fertilization potential of NAT and HRT has been addressed repeatedly in the relevant literature. Cf. Sagan in his 1993 book as well as Shrivastava, Sonpar and Pazzaglia in their article "Normal accident theory versus high reliability theory: A resolution and call for an open systems view of accidents" (*Human Relations* 62 [2009], 1357–90). None of related contributions refers to causal mechanism analyses though.

<sup>25</sup>Starting with James T. Reason: *The Contribution of Latent Human Failures to the Breakdown of Complex Systems*. *Philosophical Transactions of the Royal Society of London B Biological Sciences* 327 (1990): 475–484, and elaborated in James T. Reason: *A Systems Approach to Organizational Error*. *Ergonomics* 38 (1995): 1708–1721. See also James T. Reason: *Managing the Risks of Organizational Accidents*. Farnham: Ashgate Publishing 1997.

<sup>26</sup>Justin Larouzeec and Jean-Christophe Le Coze: *Good and bad reasons: The Swiss cheese model and its critics*. *Safety Science* 126 (2020), 1–11.

mechanisms and/or made the threshold between action formation mechanisms and transformational mechanisms impenetrable.

The collapse of the West Gate Bridge in Melbourne in 1970 was essentially the consequence of a mismatch between an innovative and ambitious structural design and unusual building practice and sub-standard management tolerated by the responsible authority. The failure of the I-35W bridge in Minneapolis in 2006 resulted from the Minnesota Department of Transportation's unwillingness to finance costly structural analyses of the bridge's steel truss. The collapse of the CTV building in Christchurch in 2011 reflects the creeping erosion of professional integrity on the part of a local building authority while the failure of the ice skating rink in Bad Reichenhall whose roof collapsed in early 2006 illustrates the consequences of politicization of the non-politicizable which is human safety. While both the technical and the non-technical risk zones were identifiable for the key actors involved the risks themselves were not neutralized through human intervention. Why not is the very subject of the subsequent case studies.

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# Evaporated Responsibility: The Collapse of the West Gate Bridge in Melbourne on 15 October 1970

## 2.1 CHARACTERISTICS OF THE CASE

On 15 October 1970, at 11:50AM, part of the West Gate Bridge in Melbourne, span 10-11 of 367 feet length, disintegrated and triggered the collapse of the bridge. Thirty-five men were killed in the disaster. The bridge was still under construction, all those killed were workers or engineers employed on the construction site. What aggravated the catastrophe was that fuel tanks caught fire upon the impact of the debris so that workers died or were severely injured through the flames spreading across the construction compound. A Royal Commission was tasked with the investigation into the origins of the collapse.<sup>1</sup> It stated that “the disaster is probably the most tragic industrial accident in the history of [the state of] Victoria”.<sup>2</sup>

What makes the collapse of the West Gate Bridge an “index case”—i.e., a case that exemplifies crucial characteristics of a basically unlikely disaster

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<sup>1</sup>Report of Royal Commission into the failure of West Gate Bridge presented to both houses of parliament pursuant to section 7 of the West Gate Bridge Royal Commission act 1970 No.7989 (1971), henceforth quoted as Royal Commission, page number. For a compact overview see also Donald. E. Charrett: West Gate Bridge Melbourne (1970). Australian Construction Law Newsletter #120 (2008), 28–35.

<sup>2</sup>Royal Commission, 9.

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I thank Paul ‘t Hart very much for pointing me to this Australian tragedy.

triggered though by typical structural weaknesses and causal mechanisms<sup>3</sup>—was that it happened in an institutional and professional environment with high safety standards and high levels of auditing, control and transparency. Yet, the disaster resulted from mismanagement that was all but coincidental. The Royal Commission itself stated that “proper and careful regard to the process of structural engineering” were not in place,<sup>4</sup> a fact that had been left uncorrected by the quasi-public authority in charge, the Lower Yarra Crossing Authority. The main characteristics of the structural engineering of the West Gate Bridge were “unusual”<sup>5</sup> indeed. Which, however, only implied that “proper and careful regard” was imperative. Neither the overall design of the bridge nor the process of structural engineering itself caused the disaster but, rather, a lack of coherent control and diligent management.

## 2.2 FACTS OF THE MATTER

### 2.2.1 *Pre-history of the Bridge*

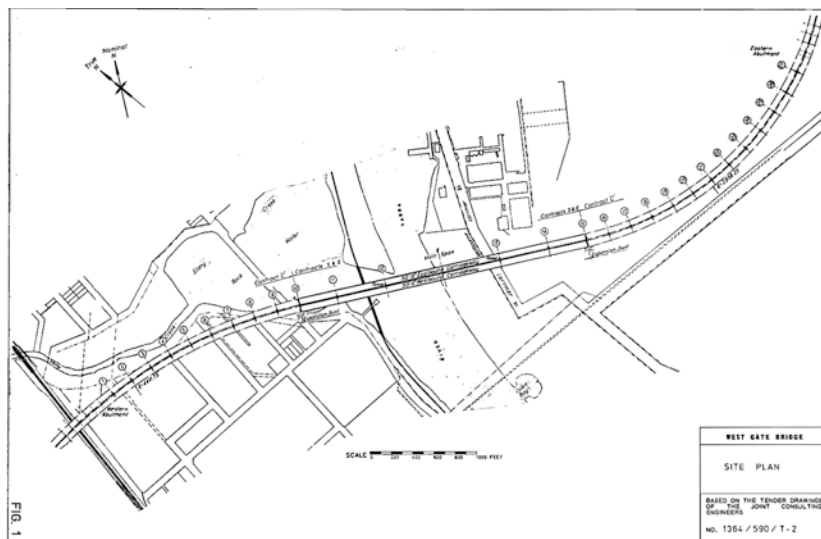
The West Gate Bridge was one of the main infrastructure projects of the city of Melbourne and the government of Victoria after World War II. Its purpose was to cross the Lower Yarra River between Port Melbourne and Williamstown. Both Port Melbourne and Williamstown are suburbs located on peninsulas but separated by the Yarra River. A crossing of the Yarra between the two suburbs was traditionally handled by ferries, a means of transportation that was considered increasingly insufficient in the 1950s so that the quest for a more convenient crossing of the Yarra river with substantially amplified capacity—either a tunnel or a bridge—became a pressing issue of urban development of the entire agglomeration and the state of Victoria (Illustration 2.1).

While the desirability of a high capacity crossing of the Yarra River was undisputed between the government of Victoria, the affected municipalities and local businesses, the Minister for Public Works of the government of Victoria made it clear in discussions held in 1958 that no public funds could be mobilized for this purpose and suggested private funding as an

<sup>3</sup>John Gerring: *Case Study Research. Principles and Practices*. 2nd ed., Cambridge: Cambridge University Press 2017, 72–74.

<sup>4</sup>Royal Commission, 9.

<sup>5</sup>*Ibid.*



**Illustration 2.1** West Gate Bridge, Melbourne, as planned and partly erected before the collapse of 15 October 1970. (Source: Royal Commission, Appendix, p. 123)

alternative. From this emerged a public-private partnership in the form of cooperation between a newly created private company, the Lower Yarra Crossing Company Ltd., and the government of Victoria's Country Roads Board (CRB). The CRB, meanwhile in 1962, also started subsurface investigations into the geological conditions on the banks to the west and the east of the Lower Yarra River.<sup>6</sup> In 1964, the government of Victoria eventually decided that the crossing of the Lower Yarra River should be performed by way of a high-level bridge that would keep the river open for large scale shipping rather than by way of a tunnel.

The already existing public-private partnership was further developed and formalized in 1965 when the Lower Yarra Crossing Company was purposefully liquidated and replaced by a new company under the name Lower Yarra Crossing Authority Limited which with the approval by the attorney general of Victoria was later given the license to discard the word "Limited" so that the name eventually became "The Lower Yarra Crossing

<sup>6</sup>Cf. for the early history of the West Gate Bridge project Royal Commission, 10–11.

Authority” (LYCA), or simply—also in the report of the Royal Commission into the failure of the West Gate Bridge—“the Authority”.<sup>7</sup> By the Lower Yarra Crossing Authority Act of 1965, the Authority became a true hybrid institution since, on the one hand, it remained a company entirely comprised of representatives of private enterprises but on the other hand it was given regulatory powers. The general scheme of the relevant legislation was that LYCA was enabled to borrow money on debentures in order to finance the construction of the bridge. The government of Victoria, in 1966, became the guarantor of the repayment of the debenture funds. So, in reality, LYCA became what in British language is known as a QUANGO (quasi-nongovernmental organization).<sup>8</sup>

While the hybrid nature of LYCA already diluted governmental responsibility, the governance structure was especially fragmented on the private business side as well. Which implied predictable fault lines that weakened the effectiveness and accountability of the project management. Representatives of what later became the Lower Yarra Crossing Authority had contacted a British consulting and civil engineering firm with a branch in Melbourne, Maunsell and Partners, in 1964. Since Maunsell had “limited experience with major bridges of structural steel”<sup>9</sup> they contacted, in February 1966, yet another British consultancy and civil engineering firm of, at the time, world-wide reputation, Freeman, Fox and Partners (FF & P), with the intent of future cooperation. On 7 July 1967, LYCA signed an agreement with Maunsell and FF & P, now acting as joint consulting engineers. The agreement required Maunsell and FF & P to develop a detailed plan for the future bridge.

Based on qualification requirements defined in the course of consultations between Maunsell and FF & P a public tender was called with a closing date of 14 February 1968. The subject of the public tender was divided into three sections according to the main parts of the relevant works and laid down in related contracts whose designation referred to the nature of the works concerned: Contract F for Bridge Foundations, Contract C for Concrete Bridge Works and Contract S for Steel Bridge Works. Just as the

<sup>7</sup>Royal Commission, 11. The abbreviation LYCA used in this chapter is not an official acronym.

<sup>8</sup>The Report of the Royal Commission into the failure of the West Gate Bridge, while being precise and nuanced in its description of the pre-history of the construction of the bridge and the relevant governance structure, refrained from characterizing, let alone criticizing, the hybrid status of the Lower Yarra Crossing Authority.

<sup>9</sup>Royal Commission, 11.

details of the tender documents, the evaluation of the submitted tenders was done in substance by Maunsell and FF & P. LYCA followed their advice to award Contract S to World Services and Constructions Proprietary Ltd. (WSC), an Australian subsidiary of, according to the Report of the Royal Commission, “a company of international reputation having its base in the Netherlands”.<sup>10</sup> Contracts C and F were awarded, again according to the advice given by Maunsell and FF & P, to John Holland (Constructions) Proprietary Ltd. (JHC), a Melbourne-based company specialized in concrete work. The three contracts were signed in July 1968.

### *2.2.2 Delayed Construction and Risk-Increasing Contractual Re-arrangements*

By the very nature of the construction and the related time sequence, Contracts F (Bridge Foundations) and C (Concrete Bridge Works) were the first to be executed which happened by a single contractor, Melbourne-based JHC. These works had started even before the formal signing of both contracts as early as April 1968 and work under Contract F was completed on 25 September 1969 while work under Contract C according to the Report of the Royal Commission “also proceeded satisfactorily” and was supposed to be completed in March 1971.<sup>11</sup>

It was evident and certainly anticipated that the steelworks were the more complex, demanding and necessarily time consuming portion of the entire construction works. Nonetheless, practical completion of those works was envisaged for the end of the year 1970. They were assigned to World Services and Constructions Proprietary Ltd. (WSC), a Dutch firm represented in Australia by a subsidiary. Already at the end of 1969, the Royal Commission stated, “it was perfectly clear that WSC was behind in its programme”.<sup>12</sup> The main reason for the delay of the works to be performed by WSC was that, “this company had a great deal of trouble with labour, and there were many times when all work was stopped owing to strikes”.<sup>13</sup> The strikes were not that much stimulated by insufficient pay or work conditions but by quarrels between individual unions known,

<sup>10</sup> Royal Commission, 12.

<sup>11</sup> Ibid.

<sup>12</sup> Ibid.

<sup>13</sup> Ibid.

according to the Royal Commission, as “Demarcation Disputes”.<sup>14</sup> As a consequence of the strikes and the delay of the completion of the steelworks, WSC came under pressure by its contract counterpart, LYCA. This took the shape of a formal initiative by LYCA requiring WSC to declare why a particular penalty clause of the contract applicable due to the delay of the steelworks should not be enforced. This conflict resulted in a settlement, reached on 16 March 1970, that decisively shaped the rest of the trajectory of decisions and omissions leading to the disaster of 15 October 1970.

According to the settlement between LYCA and WSC of 16 March 1970, WSC was to continue to fabricate the steel boxes that formed the core-components of the girders of the bridge span. The completed boxes would then be handed over to JHC which, according to the new agreement, “would be responsible for all further operations involved in erecting the boxes and completing the construction of the steel portion of the bridge, including all concrete work and black top for the roadway”.<sup>15</sup> Although a formal agreement finalizing the settlement of 16 March 1970 was signed only on 10 July 1970, WSC and JHC started to proceed on the agreed-upon basis as early as the second half of March 1970.<sup>16</sup>

The consequences of the settlement between LYCA and WSC and the resulting division of labor concerning the steelworks between WSC and JHC were heavily detrimental for the entire project management. What is more, the consequences could have been anticipated due to the very nature of the structural engineering concerning the steelworks and the difference in expertise and experience between WSC and JHC. At any rate, splitting up competences and control concerning what was clearly the most ambitious and demanding portion of the entire construction works could and should have been recognized as a grave mistake in the first place.

As a matter of fact, the method of erecting the bridge was both unique and particularly challenging. The structural design was based on box girders with a main span of 2782 feet total length. The steel boxes had to be assembled and connected to each other. Two techniques were available for putting up this core-structure. The conventional way was to assemble the boxes up in the air and having the segments of bridge cantilevered step by step. While this was termed by the Royal Commission the

<sup>14</sup> Ibid.

<sup>15</sup> Ibid.

<sup>16</sup> Ibid.



“straightforward method” it would have required temporary support structures many of which inevitably to be founded in the water of the Yarra river and, consequently, neither easily nor expeditiously to erect. Accordingly, it was a plausible and, from a professional vantage point, entirely justifiable alternative to have the individual boxes of the girder structure assembled on the ground and to have them subsequently lifted and put into position at the top of the piers.<sup>17</sup> At the same time, however, to assemble a span of several boxes on the ground and jack it up into place up in the air meant that, according to the report of the Royal Commission, “the total weight to be lifted would be some 1200 tons to a height of 170 feet”.<sup>18</sup> In the attempt to take advantage of connecting the boxes of the entire span on the ground while reducing the total weight to be lifted, engineers of the initially engaged contractor, WSC, had chosen to assemble each span in two halves on the ground separately, split along the longitudinal axis of the deck of the bridge.

While it was evident that, as always, accuracy and precision was of pivotal importance for every segment of this necessarily complex process of assembling, lifting and connecting the steel boxes, it also could have been anticipated that tight control and coordination was of the essence. Quite obviously, the settlement between LYCA and WSC achieved the opposite. Instead of neutralizing the negative impact of an already existing fault line the separation of competences and responsibilities between WSC and JHC aggravated the risk of insufficient coordination and control.

In this very sense, splitting up competences and control for what was a coherent and integral segment of the entire construction process was already risky and unwise enough. However, the selection of JHC as substitute contractor for the erection of the steel spans was an act of blunder in its own right. After all, JHC was a local corporation and the Lower Yarra Crossing Authority was a hybrid institution vested with regulatory powers and acting as quasi-public authority although it consisted exclusively of representatives of local businesses. The chief executive officer of JHC, Mr. C. V. Holland, was a successful Melbourne businessman and, unlike the representatives of WSC as a Dutch-based firm, socially well embedded in the local business community. Unlike WSC, however, JHC had no experience with steelworks, let alone with the type of sophisticated assembling and erection processes envisaged in the case of the West Gate

<sup>17</sup>Royal Commission, 16.

<sup>18</sup>Ibid.

Bridge. As the Royal Commission put it, “JHC’s experience with the assembly and erection of steelwork was limited”, only to make the real issue crystal clear:

No operation of this size and complexity of the West Gate Bridge steel structure had ever been undertaken by that company [= JHC]. Consequently, the ability of their personnel to handle a project of such magnitude remained untested and conjectural. (...) The expertise of the Holland group lay more with concrete than steel, and its management recognized that the nature of the design of the steelwork in this bridge was a field in which it had no experience.<sup>19</sup>

To make things worse and to dilute control and responsibility even more, the task to be assumed by JHC was limited to the mere physical erection of the steelwork while JHC “would have no responsibility for engineering decisions relating to final or erection stresses in the bridge”<sup>20</sup> which was mildly characterized by the Royal Commission with the wording that “the relative inexperience of JHC influenced them [JHC management] to seek, and the Authority [LYCA] to grant, some limitation of the usual the contractor’s responsibility”.<sup>21</sup>

The core of the matter was that LYCA as the supervising and ultimately responsible institution had tasked JHC with a job the firm was unfit to do. The entire new arrangement between LYCA and JHC was laid down in a new contract signed 10 July 1970 and labeled “Contract E”. Although the division of labor between WSC as the previous main contractor for the steelworks and JHC as the new substitute contractor had already started in late March 1970, the peculiarities and the unusual character of the new contractual arrangement were reflected, according to the Royal Commission, in the fact that “the legal advisers of both parties [LYCA, JHC] experienced considerable difficulty in arriving at a mutually acceptable form of contract”.<sup>22</sup>

The Royal Commission, in its report, was reluctant to address the obvious asymmetry in negotiation leverage that clearly disadvantaged LYCA.<sup>23</sup> While LYCA could not afford to abort negotiations on a new contract on

<sup>19</sup> Royal Commission, 80.

<sup>20</sup> Ibid.

<sup>21</sup> Royal Commission, 81.

<sup>22</sup> Ibid.

<sup>23</sup> Ibid.

the steelworks that were underway but still incomplete, JHC had no incentive whatsoever to assume responsibility beyond the immediate physical task of erecting this steelwork of the bridge. LYCA's General Manager, C. V. Wilson, admitted before the Royal Commission that "very little responsibility could be placed" on JHC and that he and his consultants "were all well aware of it while negotiations were taking place".<sup>24</sup>

As a consequence, LYCA accepted an organizational and contractual arrangement that inevitably increased risks at the expense of sound and safe completion of the works while at the same time reducing the capacity of risk management. "Contract E" signed 10 July 1970 purposefully limited the responsibility of JHC as the contractor assuming the most complex and ambitious task of the entire construction of the bridge. At the same time, it was acknowledged that JHC itself had neither expertise nor experience with the nature of construction it was tasked with and, yet, was contractually exempted from liability. This arrangement virtually eliminated what should have mattered most which was tight coordination and coherent control of a technically complex construction and erection process. The Royal Commission was plausibly conjecturing about the underlying incentives:

In the climate of urgency which prevailed, the willingness of JHC to undertake work immediately, without the inevitable interruption which would occur if any other contractor was appointed must have been an over-riding consideration for the Authority [= LYCA].<sup>25</sup>

The very fact that JHC had successfully rejected any responsibility for engineering decisions beyond the mere physical task of erecting the steelwork implied a crucial role of FF & P in assuming precisely that part of tasks and responsibilities. FF & P was represented in Melbourne and on the construction site by a Resident Engineer, Jack Hindshaw. It should have been clear from the very outset, however, that a related division of labor between JHC and FF & P in addition to that between JHC and WSC was virtually unacceptable. After all, every single step of erecting the steelwork could trigger erection stress in the bridge so that separating the responsibility for erecting the steelwork from the responsibility for the diagnosis and elimination of erection stress required constant

<sup>24</sup> Ibid.

<sup>25</sup> Royal Commission, 82.

communication and coordination between two independent firms. Not surprisingly, as the Royal Commission stated, the attempt “to define the roles of the FF & P staff and JHC engineers led to a confusion that was disastrous”.<sup>26</sup>

It turned out that London-based FF & P, represented in Melbourne in early 1970 temporarily by one of its most senior and influential partners, Sir G. Roberts, had not the slightest inclination to do justice to the highly unusual arrangement laid down in the agreement between LYCA and JHC. Roberts’ unwillingness was just the flipside of JHC’s attitude in the negotiations with LYCA: While JHC had every reason to reject responsibility for issues of structural engineering that were beyond its expertise and professional competence, Roberts and FF & P were not willing to accept responsibility for the solution of problems originating from the works of JHC without having any say about their execution. Again, this could have been anticipated since the very “confusion” deplored by the Royal Commission was implied in the arrangement between LYCA and JHC resulting in “Contract E” of 10 July 1970. It could not come as a surprise that neither JHC nor FF & P wanted to assume responsibility for decisions and consequences beyond their respective control.

### 2.2.3 *Predictable Rivalries and Quarrels*

It was not surprising either that the immediate consequences of the “confusion” referred to by the Royal Commission had to be borne by the representatives of FF & P and JHC on the construction site itself. Frictions and conflicts were unavoidable. While the Royal Commission was lenient as far as LYCA and the fundamental decision to split up the respective responsibility for the steelworks was concerned it was not reluctant at all to characterize the attitude of FF & P and its Resident Engineer, Jack Hindshaw (who had perished in the disaster of 15 October 1970) in critical and somewhat sarcastic terms:

Hindshaw’s communication to his superiors in London disclose his bewilderment and his attempts to rationalize the situation. His work-to-rule practice and somewhat pin-pricking attitude to the JHC staff created from them a natural reaction. This unhappy state of affairs had an inevitable effect on

<sup>26</sup> Ibid.

the work of construction and created a climate in which the probability of error in judgement was greatly increased.<sup>27</sup>

Yet, it was another euphemism when the Royal Commission stated that Hindshaw attempted “to rationalize the situation”.<sup>28</sup> Rather, he was facing an unsolvable dilemma. Hindshaw had to cope with a situation in which he, on the one hand, had to act just as a consultant and, on the other hand, was expected to take managerial decisions. Problem solving on the construction site would have required clear-cut competences and a seamless chain of command—which was exactly what the arrangement between LYCA and JHC failed to ensure. Hindshaw was thus tasked with the proverbial mission impossible.

The consequence was a constant quarrel between FF & P and JHC engineers. The entire construction crew was at times, it seems, more concerned with its internal affairs than with the construction itself. The Royal Commission, in its report, lamented about this state of affairs and stated, “all this confusion and difficulty could and should have been quite easily avoided, had the increased responsibility of FF& P been clearly defined in the first place”.<sup>29</sup> But, again, the Commission missed the point in ignoring that the lack of clarity was the inevitable consequence of appointing JHC as a substitute contractor for the steelworks of the West Gate Bridge despite the openly admitted lack of competence and expertise in this domain. What the Royal Commission characterized as “unhappy circumstances”<sup>30</sup> implied that “neither the FF & P site staff nor the JHC engineers knew where they stood, nor for that matter did the management of either body”.<sup>31</sup> And it continued that “this situation of doubt and misunderstanding had extremely serious consequences, as it created the circumstances in which the actions which were the immediate cause of the failure and collapse of span 10-11 were able to take place.”<sup>32</sup>

<sup>27</sup> Ibid.

<sup>28</sup> Ibid.

<sup>29</sup> Ibid.

<sup>30</sup> Ibid.

<sup>31</sup> Ibid.

<sup>32</sup> Ibid.

### 2.2.4 *Losing Control: The Struggle of the Lower Yarra Crossing Authority*

Still, the question remained, also in the perception of the Royal Commission, why The Lower Yarra Crossing Authority itself had not taken better care of the implementation of the new contractual arrangement with JHC in an effort to straighten out the emerging calamities of control and coordination.<sup>33</sup> As usual under similar circumstances, LYCA had no own engineering staff directly involved in the design and erection of the bridge. Its task was to select consulting engineers, participating in the decision about the design of the bridge and to exercise the general overview over the construction process, especially in terms of implementing and, if necessary, modifying or amending the existing contractual arrangements and coordinating the activity of the various consultants and contractors.

Although LYCA had been constituted by private enterprises it had experienced officials at its disposal. Especially LYCA's General Manager, C.A. Wilson, was not only a professional engineer himself "with considerable experience of bridge design"<sup>34</sup> but also a former senior design engineer in the Bridge Division of the Country Roads Board (CRB) of the state of Victoria. The fact, however, that Wilson was a trained engineer with considerable experience in bridge design had ambiguous consequences for the way control and oversight was exercised by LYCA. While Wilson kept a sharp eye on engineering details, issues of steel quality and potential brittle in particular, he, according to the assessment of the Royal Commission, neglected the requirements of coordination and conflict management, especially when related problems intensified due to the delay of the steelworks at the replacement of WSC by JHC.<sup>35</sup> To a large extent, however, the problems Wilson as the undisputed key-figure of LYCA was facing were enrooted in the very governance structure of planning, designing and constructing the West Gate Bridge. And, after all, LYCA itself and, necessarily, Wilson in person had been directly involved in creating that structure.

The logic of the arrangement was the delegation of supervision and control to FF & P in partnership with Maunsell as joint consultants. Only Maunsell was located in Melbourne while FF & P headquarters was

<sup>33</sup> Royal Commission, 83–85.

<sup>34</sup> Royal Commission, 84.

<sup>35</sup> Royal Commission, 84.

located in London. That FF & P in far-away London became part of the control and supervision structure at all was due to the fact that Maunsell itself had declared its lack of experience with bridge building projects of the envisaged and required scale and size while FF & P was a world-wide renowned consultancy firm for precisely this kind of construction. But FF & P had no permanent senior representative in Melbourne, much to the dismay of LYCA.<sup>36</sup> FF & P's key figure in Melbourne and on the construction site throughout the entire construction period remained Resident Engineer Jack Hindshaw. With him LYCA and, in reality, Wilson in person interacted directly and, according to the evidence, an intense conflict between the two emerged when the substantial delay of the steelworks to be performed by WSC became apparent.<sup>37</sup> The Royal Commission, in its report, hinted that Wilson was an unbridled person who easily lost temper so that he, according to all likelihood, also lacked the necessary patience and diplomatic skill required especially under the condition of a fragmented control and governance structure that made intensified coordination and conflict management even more indispensable.<sup>38</sup>

So what the Royal Commission suggested was that Wilson's selective expertise which was primarily focused on a narrow segment of the structural engineering together with his personal temperament rather aggravated than mitigated the undesirable consequences of an ill-structured system of control and supervision. At any rate, the Royal Commission left no doubt that the atmosphere between LYCA and Wilson in person on the one hand and FF & P and also JHC engineers on the other hand was poisoned: "Both the FF & P and JHC engineers on the site appear to have regarded Wilson as something as a 'bogey man', particularly Hindshaw, who claimed that Wilson had 'torn strips of him'".<sup>39</sup>

The Commission nonetheless conceded that "he [Wilson] was in a most unenviable position, with responsibility for a great and complex project which almost from the first encountered difficulties" and that with

<sup>36</sup> Royal Commission, 85.

<sup>37</sup> Ibid.

<sup>38</sup> In the words of the Royal Commission: "In one of Hindshaw's personal reports to London he described Wilson as being extremely antagonistic to FF & P claiming that the failure of WSC was due to lack of care and diligence by FF & P and threatening to sue them for \$1,000,000. A perusal of the early correspondence shows that from the beginning down to a week or so before the disaster there was a continuous complaint by Wilson and resentment by FF & P."—Royal Commission, 84.

<sup>39</sup> Ibid.

“regard to the lack of progress, as well as many other defaults and errors made by the engineers and contractors the attitude of the Authority [LYCA] was quite understandable”.<sup>40</sup> While the Commission one more time shed a mild light especially on the attitude of LYCA and its leadership it nonetheless pointed to one crucial aspect in stating that “fundamental to the whole sorry situation was the constant sense of urgency and pressure to complete the construction within specified times.”<sup>41</sup> The time pressure was, as we saw, created and aggravated by the substantial delay of the steelworks to be completed by WSC. But the Commission also pointed to the undesirable consequences of the particular institutional character of LYCA which was a legal entity composed of private businesses working with borrowed capital and therefore acting under the particular pressure of return of investment expectations.<sup>42</sup> “In a number of instances,” the Commission stated, “the burning desire for speed resulted in quick, ill-considered decisions which brought about trouble, difficulty and delay,” and underlined, “that this climate of urgency and pressure tended to lower morale, and in fact directly caused some of the more serious errors of judgment”.<sup>43</sup>

The most serious consequence of this “sorry situation”, as the Royal Commission put it,<sup>44</sup> was that LYCA and Wilson in person withheld crucial information about the overall safety of the bridge design that had been put forward by WSC and should have been brought to the attention of its successor as a substitute contractor for the completion of the steelworks. As a matter of fact, WSC’s Chief Engineer and Senior Representative in Melbourne, Gerit Hardenberg, back in the second half of 1969, had had a dispute with FF & P about appropriate measurement of stress impact on the steel construction, bending stress and buckling stress in particular.<sup>45</sup> This and the fact that FF & P was slow in responding to inquiries and correspondence in this matter was part of the protracted disputes and difficulties that contributed to the substantial delay of the completion of the steelworks initially assigned to WSC. Obviously, the subject of bending

<sup>40</sup> Ibid.

<sup>41</sup> Royal Commission, 85.

<sup>42</sup> “The financial consequences of any delay were serious to an organization working on borrowed capital—and a degree of pressure to reach completion on time is understandable and even praiseworthy.”—Royal Commission, 85.

<sup>43</sup> Ibid.

<sup>44</sup> Ibid.

<sup>45</sup> Royal Commission, 86–87.



stress and resulting buckling was of immediate and crucial importance for the overall stability and safety of the bridge, a fact that was tragically corroborated by the collapse of 15 October 1970.

Wilson as general director of LYCA whose prime concern should have been the ultimate safety of the bridge “was aware of the views of Hardenberg that the structure could have been unsafe” and was himself “still [i.e., in March 1970] concerned about the adequacy of the design, to the point where he had sought a complete re-checking by FF & P”.<sup>46</sup> However, Wilson withheld this information to JHC when the negotiations between LYCA and JHC were underway in the attempt to win over JHC as a substitute contractor replacing WSC.<sup>47</sup> Withholding essential information about doubts and disputes concerning the ultimate stability and safety of the bridge was a breach of trust committed by LYCA and its director general vis-à-vis the new contractor. JHC was left in the dark about already diagnosed risk zones affecting the stability of the steelworks and, thus, the overall safety of the bridge. This was even more serious an omission since JHC had no expertise nor experience with the steelwork part of bridge constructions of this scale, a fact that was perfectly known to LYCA and Wilson in person since JHC, when negotiating a new contract with LYCA, later on known as Contract E, successfully rejected any responsibility for steelwork design issues and the solution of resulting problems.

As a result, the Royal Commission concluded, “the new contractor [JHC] was about to enter upon the work without the necessary information enabling him to make calculations of safety factors” and it pointed to the fact that indeed “the form of the contract did not require him [JHC] to be responsible for such calculations”. In sum, the Commission stated “we feel that the Authority [LYCA] had at least a clear moral obligation to inform JHC fully of the doubts that were currently entertained”.<sup>48</sup>

### 2.2.5 *Improper Consultancy*

The lack of experience in steelworks of JHC as the substitute contractor replacing WSC and the fact that, consequently, the new contract (Contract E), ultimately signed after protracted negotiations on 10 July 1970,

<sup>46</sup> Royal Commission, 85.

<sup>47</sup> Ibid.

<sup>48</sup> Ibid.

exempted JHC from any responsibility for issues of structural engineering of the steelworks and necessary corrections implied, in turn, the sole responsibility and pivotal role of FF & P. FF & P was, however, ill-equipped to assume this crucial task on organizational grounds alone. Most of the necessary engineering calculations and, above all, key decisions concerning structural engineering were made in London. Much to the dismay of LYCA and its contractors WSC and JHC, no senior FF & P representative took residence in Melbourne.<sup>49</sup> The discrepancy between the degree and complexity of FF & P's responsibility and FF & P's lack of commitment and diligence was obvious. It was also perceived as such by LYCA—as we saw, Wilson in particular—and JHC. As the Royal Commission found out and stated in its report, “even the FF & P staff on the site had occasion to complain to the London office, chiefly on the ground that their urgent requests for instruction or information were answered only after long delays and repeated requests, or simply ignored.”<sup>50</sup>

Quite naturally, LYCA and Wilson in person were of the opinion that a more senior FF & P officer, maybe a Partner of the consultancy firm, with continuous residence in Melbourne could mitigate those problems through a better standing vis-à-vis the London office and extended discretionary leeway in assuming his responsibilities in Melbourne but related initiatives were to no avail.<sup>51</sup> FF & P “did not send out a senior man who could handle an unusual situation” but in April 1970 they did send out three more engineers, Jack Hindshaw, C. V. J. Simpson and David Ward.<sup>52</sup> Hindshaw became Resident Engineer replacing D. F. McIntosh who was made Resident Engineer for the fabrication and box-assembly work and returned to England in September 1970.

None of the four FF & P engineers, including the senior figure Hindshaw, had personal experience with the erection of any major steel bridge.<sup>53</sup> What is more, FF & P engineer's office was on the east bank of the Lower Yarra River while on-site inspections on the west bank were left to occasional visits by the junior and necessarily least experienced crew members. Hindshaw himself as, after all, Resident Engineer and most senior FF & P representative reportedly never truly inspected what was

<sup>49</sup> Royal Commission, 86.

<sup>50</sup> Ibid.

<sup>51</sup> Ibid.

<sup>52</sup> Ibid.

<sup>53</sup> Royal Commission, 87.

going on the west side. The Royal Commission noted that there was “evidence that on one occasion seven weeks elapsed without Hindshaw visiting the west side and, according to [JHC section engineer] Tracy’s diary, even then he ‘got no further than the office’”.<sup>54</sup> In sum, the Commission stated, “having failed to provide a senior engineer capable of fundamental professional decisions, the London partners left the relatively junior engineers on the site without sufficient communication.”<sup>55</sup> The negative consequences of this constellation materialized when serious problems of structural engineering did indeed occur on the west side of the bridge in September 1970.

### 2.2.6 *Evaporating Responsibility and a ‘Climate of Confusion’*

In general, both the organizational and the contractual arrangements between LYCA and FF & P were, in combination with the huge concessions LYCA had made to JHC as immediate contractor for the steelworks of the West Gate Bridge, a syndrome of risk zones undermining proper and diligent control and responsible action. It was therefore, a comprehensible but futile and even helpless conclusion when the Royal Commission, in its report, summarized the conditions with a battery of counterfactuals:

If the resident engineer had been properly and fully briefed as to his duties on site; if he had been required to submit regular full fortnightly reports to London, setting out the progress made, any delays and reasons for them, condition of steelwork, lines, levels &c., labour problems, any unexpected events; and if each report had been replied to at once by a senior engineer in London, charged with responsibility for the contract—all the errors that were committed might well have been avoided.<sup>56</sup>

However: If all the actors involved would have been this diligent and mindful, the whole complex and conflict-ridden arrangement between them would probably not have emerged in the first place. What contributed to the circumstances was that profound frictions and conflicts existed even between the joint consultants, Maunsell and FF & P. This is, at first glance, particularly counterintuitive since Maunsell had suggested to

<sup>54</sup> Ibid.

<sup>55</sup> Ibid.

<sup>56</sup> Royal Commission, 88.

involve FF & P due to its outstanding reputation especially with large bridge construction projects. Officially, Maunsell and FF & P were to act as “joint consultants” but the division of labor between them was yet another example of the complexity, overlapping competences and diluted responsibilities. While Maunsell was responsible for all contracts other than for steel spans, FF & P was responsible for the design of the steelwork and for supplying engineering staff for general supervision and control of the entire construction. As far as the steelwork itself was concerned, Maunsell acted as sole representative of the joint consultants in Melbourne and had also to control all administrative matters while FF & P controlled the technical side.<sup>57</sup> Accordingly, FF & P’s Resident Engineer for the steelwork reported to of a senior Maunsell partner, E. Miles Birkett, but only for administrative purposes while technical matters had to be handled in cooperation and communication with FF & P headquarters in London. FF & P London was tasked with the scrutiny and approval of the actual contractors’—WSC and JHC—working drawings and erection scheme drawings for which the necessary technical conferences were to be held with WSC in London or Utrecht.<sup>58</sup>

Not surprisingly, a similar pattern of distrust and rivalry emerged out of this as between the contractors, LYCA and FF & P. One reason was, again, FF & P’s “habit of not answering letters or telex messages and generally being the opposite to forthcoming with information quite legitimately sought”.<sup>59</sup> Moreover, there was blunt rivalry involved. As it turned out in the course of the Royal Commission’s investigations, Maunsell’s senior partner Birkett had actively discouraged FF & P headquarters in London to follow the request of LYCA to have a senior partner of FF & P permanently on site in Melbourne. For Birkett, a senior representative of Maunsell, this was apparently a question of prestige since it could be anticipated that his own role as sole representative of joint consultants would have been much more limited with a senior FF & P partner permanently present in Melbourne. Conversely, FF & P’s Resident Engineer, Hindshaw, when communicating with London, was not only constantly complaining about Maunsell and Birkett in person but also “deliberately by-passing Maunsell”.<sup>60</sup> The separation between administrative and technical matters,

<sup>57</sup> Ibid.

<sup>58</sup> Ibid.

<sup>59</sup> Ibid.

<sup>60</sup> Ibid.

one to be handled by Maunsell and one by FF & P, was artificial and almost unmanageable which was just another source of arguments and related inefficiencies.<sup>61</sup> The Royal Commission concluded:

There are many other incidents revealing an unhappy and uneasy relationship between the joint consultants which it would be merely tedious to record. Sufficient to say that this disagreement added to the climate of confusion which prevailed throughout the period of construction.<sup>62</sup>

As a consequence of Contract E ultimately signed on 10 July 1970, JHC took over the steelworks of the West Gate Bridge as a substitute contractor succeeding WSC. JHC's project manager in charge, T.R. Nixon, an experienced construction engineer and project manager, had been working with the Country Roads Board (CRB) of the state of Victoria after college graduation in the early 1950s before joining JHC in 1958 where he was primarily concerned with the management of roads and roadway bridges. The fact that JHC in general had by its own admission no experience or substantial expertise in steelworks should have implied efforts of compensation and an elevated level of diligence and compliance. According to the findings of the Royal Commission, this was by no means the case. Nixon as the project manager was required to attend "numbers of meetings in Sydney, Hobart and elsewhere and also engineering symposia and other meetings".<sup>63</sup> Already in formal terms, the Royal Commission stated, this was a breach of JHC's contract.<sup>64</sup> The technical problems of structural engineering that soon turned out to be particularly challenging were left to junior engineers of the JHC team. Services and expert knowledge of senior engineers of WSC as the firm initially in charge of the steelworks now in the hands of JHC were not requested.<sup>65</sup> In general, according to the judgment of the Royal Commission, "there was lamentably poor output by the labour force under JHC, particularly on the west side" of the bridge (where the disaster of 15 October 1970 occurred).<sup>66</sup> The Royal Commission left no doubt that "some part of the trouble was caused by

<sup>61</sup> Ibid.

<sup>62</sup> Ibid.

<sup>63</sup> Royal Commission, 89.

<sup>64</sup> Ibid.

<sup>65</sup> Ibid.

<sup>66</sup> Ibid.

the inadequacy of the JHC staff, who were lacking in steel erection experience sufficient for the work they had to do on the contract”.<sup>67</sup>

Not surprisingly, frictions and conflicts emerged between FF & P’s Resident Engineer, Jack Hindshaw, and JHC engineers.<sup>68</sup> What initially had been an abstract and objective conflict of interest between JHC and FF & P as far as jurisdiction and responsibility were concerned turned out to be a substantial problem on the construction site itself. Those disputes, just to remember, had their roots in the fact that JHC staff “were lacking in steel erection experience sufficient for the work they had to do on the contract”.<sup>69</sup> For that very reason, JHC, when negotiating with LYCA on a new contract (Contract E) through which JHC ultimately stepped in as a substitute contractor replacing WSC, had successfully insisted on limiting its own responsibilities to the mere physical part of the steel erection leaving aside the control of overall structural engineering, a task to be assumed by FF & P. FF & P, in turn, was all but enthusiastic about this division of labor since responsibility for structural engineering implied being liable for decisions and omissions in the process of the steel erection that, by definition of the contract, remained beyond the control of FF & P. As a consequence, the relationship between JHC and FF & P was tainted from the very outset. “There were constant arguments between the JHC management and the FF & P organization as well as between the consultants’ engineers and the contractors’ engineers on the site.”<sup>70</sup> The result was organized irresponsibility in a literal sense.<sup>71</sup> The Royal Commission came to the following conclusion:

The question of responsibility was still unresolved on 15<sup>th</sup> October, when the span 10-11 collapsed. Leaving this question unresolved considerably reduced the effectiveness of the resident engineer, Hindshaw, and endangered the whole project by tending to create an atmosphere in which co-operation between the engineers for the consultants and engineers for the

<sup>67</sup> Ibid.

<sup>68</sup> “From the time JHC began to work on steel spans, there were constant arguments between the JHC management and the FF & P organization as well as between the consultants’ [FF & P] engineers and the contractors’ [JHC] engineers on the site.”—Ibid.

<sup>69</sup> Ibid.

<sup>70</sup> Ibid.

<sup>71</sup> The report of the Royal Commission mentions several examples of non-decisions and responsibilities being shifted back and forth between JHC and FF & P, cf. Ibid., 89–90.

contractor was difficult. Several witnesses spoke of a state bordering on chaos prevailing on the west side.<sup>72</sup>

The west side of the bridge referred to in the remark of the Commission was where span 10-11 was located. The Royal Commission also stated unmistakably that it deemed the “chaos” on the west side the decisive factor for sloppiness and inaccuracy that occurred in the process of bolting up the steel boxes as the core-components of the girders of the bridge span:

There are reports of large groups of men wandering aimlessly around in the middle of the morning with nothing to do; of other men attempting to perform impossible operations when trying to bring parts into line for bolting up. Bolting up on that side appears to have been done without system, putting in bolts where they would go, with little regard for how later ones could be placed. Reaming of bolts was in consequence widespread. In some cases, the over-enlarging of the holes by reaming was so bad that special washer plates had to be provided under the bolt heads.<sup>73</sup>

In its own conclusion, the Royal Commission stated, “Error begat error, and the events which led to the disaster moved with the inevitability of a Greek tragedy.”<sup>74</sup> There is good reason to disagree with the last part of this conclusion. Of course, the acts and omissions of those involved were tragic but, according to the Commission’s own findings, they were not inevitable. The institutional arrangement of public oversight could and should have been different, the contracts between the Lower Yarra Crossing Authority could and should have secured the coherence of expertise, competence, jurisdiction and control of consultants and contractors. Remaining fault-lines and frictions within a necessarily division of labor-based system of construction and control could and should have been neutralized by capable and mindful senior managers.

The logic of inevitability referred to by the Royal Commission does apply, however, to the consequences of neglect and lack of mindfulness that remained unaddressed and uncorrected even when the first signs of a potentially fateful path dependency had already occurred. The Commission stated quite convincingly that avoiding the disaster would not have required any particularly high standard of perfection. Just sticking to a

<sup>72</sup>Royal Commission, 90.

<sup>73</sup>Ibid.

<sup>74</sup>Royal Commission, 97.

moderate “standard of reasonable competence to be expected from men holding themselves out as competent professionals” would have sufficed.<sup>75</sup> Which makes the failure of consultants and contractors with an outstanding professional reputation to meet those standards even more counterintuitive.

### 2.3 THE DISASTER IN THE MAKING

As a consequence of the chosen technique of assembling and lifting two separate halves of the box-girder based spans, two half-spans of every segment had to be joined together once lifted into position at a height of 170 feet above ground level. While lifting the entire half spans into position was certainly challenging since it had to be performed by using jacking straps and rolling beams, the accuracy of joining the two halves turned out to be the tricky part. The stability of the construction depended on the accuracy of the assembling procedure on the ground and that the core-parts, the boxes, had to have exactly identical size and shape since otherwise difficult and time-consuming corrections would be unavoidable.

The Royal Commission stressed that the chosen method of the erection of the bridge spans was entirely unique and that it had found “no evidence ... that this method of erection had ever been attempted before, anywhere in the world, under conditions similar to those prevailing at the West Gate Bridge.”<sup>76</sup> Still, the Commission underlined, the method could have been “successfully adopted, provided that very careful forethought had been given to dealing adequately with all the potential difficulties”.<sup>77</sup> Those difficulties, however, turned out to be dramatic but they remained unchecked due to absence of coherent control and mindful management.

Serious issues became apparent when a first girder of eight half boxes was to be lifted at the north half of the east Side of the bridge under construction designed to form span 14-15.<sup>78</sup> When the pre-assembled span was lifted to be put in position, significant instability of the projecting flange plates was observed. That instability caused a severe buckle at the

<sup>75</sup> Ibid.

<sup>76</sup> Royal Commission, 16.

<sup>77</sup> Ibid.

<sup>78</sup> The report of the Royal Commission does not mention the exact date of the incidence. Since the report, on page 21, does mention a note written by FF & P engineer McIntosh to JHC of April 1970 referring to the problems at span 14-15 the incidence itself probably occurred in early 1970.



splice between boxes 4 and 5 of a row of eight boxes forming span 14-15. The estimated depth of the buckle was 15 inches thus representing a sharp kink which was beyond the elastic limit of the construction, a fact that was nonetheless not recognized by the engineers on the site.<sup>79</sup> Buckles of minor dimensions affecting the upper cover flat were usually pressed out using specially long bolts between the cover flat and the robust substructure underneath. Once this work was completed the long bolts were removed and replaced with the final bolts with a particular friction grip. This procedure could be carried out for most part of the northern half of the 14-15 span thus straightening out most of the buckles on the plate edge of the north boxes.

However, precisely because the operation of straightening out the buckles had been successful for most part of the 14-15 span, for a remaining short section around box 5 there was no flexibility left. It was therefore decided to undo the transverse seam of the north inner panel in an attempt to regain flexibility of the construction allowing for small movements between plates in the hope that the movement itself would be enough to straighten also the remaining buckle. For that purpose, bolts were removed that had connected the north and the south half of boxes 4 and 5 and, simultaneously, from the joint between boxes 5 and 6.<sup>80</sup> Since the removal of the bolts connecting box 5 to neighboring boxes 4 and 6 resulted in new flexibility of box 5 the operation “had the desired effect of flattening out the remaining bulge”.<sup>81</sup> Subsequently, new bolts reconnecting box 5 to boxes 4 and 6 were re-entered.<sup>82</sup>

While the operation of flattening out the buckles on the covering plates—i.e., the surface of the construction—was apparently successful it was diagnosed by the Royal Commission as “a regrettable necessity”.<sup>83</sup> Moreover, it turned out to be the epitome of successful failure.<sup>84</sup> The successful coping with the buckle issue on the east side of the bridge gave the engineers in charge the false impression that the unbolting and re-bolting procedure was an appropriate and relatively easy technique to apply. So the very same procedure was repeated on the west side of the bridge in

<sup>79</sup> Royal Commission, 17.

<sup>80</sup> Royal Commission, 19.

<sup>81</sup> *Ibid.*

<sup>82</sup> *Ibid.*

<sup>83</sup> *Ibid.*

<sup>84</sup> Wolfgang Seibel: Successful Failure. An Alternative View on Organizational Coping. *American Behavioral Scientist* 39 (1996): 1011–1024.

October 1970 when buckles at span 10-11 had occurred. The Royal Commission commented:

Having successfully dealt with the buckle on the east side, the engineers were reasonably confident of their ability to handle the buckle on the west side; a confidence that was fatally misplaced.<sup>85</sup>

The consequences of misplaced confidence started to evolve when the two half girders (the substructure of the span) on the west side of the bridge concerning span 10-11 had been brought into position up in the air and were to be connected to each other. It turned out that a camber difference of about 4 ½ inches existed between the two halves of the span. Engineers of the contractor in charge, John Holland Constructions Proprietary Ltd. (JHC), proposed to use kentledge to push down the higher half span, the north part, to equalize its level relative to its south counterpart. For that purpose, ten blocks of concrete that happened to be onsite anyway, each with a weight of eight metric tons, were positioned as a concentrated lot in the middle of span 10-11.

The loading of the kentledge was completed on 5 September 1970. The next day, 6 September, a major downward buckle had developed more or less in the middle of the span at the splice between box 4 and box 5. At that time, there was still a one inch camber difference between the northern and the southern part of span 10-11. Accordingly, the diaphragms supposed to connect the two parts could not be bolted. That gap was eliminated by jacks pushing down on the north half and pushing upwards on the south half. As a result of that operation, almost all connections of the inner diaphragms could be made with the exception of those at box 4 where a transverse beam to which the diaphragm should have been bolted was too much displaced by the buckle. Since all other diaphragms were fully bolted and even the diaphragm at box 4 was bolted except for the one connection to the transverse beam the kentledge was removed since it had basically done its job.

With the removal of the kentledge the entire bending stress had necessarily to be borne by the core structure of the girders buttressing the two half spans that in the meanwhile had been bolted together. Since no sound calculation existed, the amount of stress and the consequences for the overall stability of the structural design was not subject to accurate

<sup>85</sup> Royal Commission, 19.

assessment.<sup>86</sup> The successful bolting procedure connecting the two half spans on the west side had no effect on the buckle at the splice between boxes 4 and 5 on the northern part of the span between pier 10 and pier 11 which itself was the consequence of the added kentledge. The buckle clearly indicated a structural damage and a reduced margin of safety of the entire bridge.<sup>87</sup>

The Resident Engineer of the main consultancy firm supervising and basically running the operation, Jack Hindshaw of Freeman, Fox and Partners (FF & P), was nonetheless confident that the buckle could be relatively easily eliminated according to the method used months before on the east side of the bridge. After all, that method was to increase local elasticity of the girder structure through unbolting and, thus, isolating an individual box which in fact had made it possible to flatten out the buckle that had developed there at span 14-15. Applying the same method on the west side to span 10-11 implied to take out the bolts at the splice between box 4 and box 5 of span 10-11. On the west side, however, the longitudinal splices between the half spans were not completed yet at this point. As the Royal Commission stated in its report, even

a most rudimentary assessment let alone familiar with stress analysis would ... have recognized that undoing the bolts before the longitudinal splices between the half spans were complete would create a dangerous ‘notch effect’ with its associated stress concentration at the head of the notch.<sup>88</sup> The possibility of its producing calamitous failure was not to be dismissed without serious consideration.<sup>89</sup>

“Serious consideration” did not take place, however. If FF & P’s Resident Engineer would have undertaken it, “he should have instantly vetoed any suggestion of taking out the bolts”.<sup>90</sup> For several weeks prior to 15 October 1970 the buckle issue remained unaddressed though since there was consensus among the engineers in charge to wait until the last box of span 10-11 (box 9) had been completed. However, on 13 October 1970 Hindshaw changed his mind and instructed the section engineer in

<sup>86</sup> Ibid.

<sup>87</sup> Ibid.

<sup>88</sup> Royal Commission, 24.

<sup>89</sup> Ibid.

<sup>90</sup> Ibid.

charge to have the buckle eliminated.<sup>91</sup> The bolts at the splice between box 4 and box 5 were removed on a step-by-step basis—no more than 6 or 8 bolts at a time—in order to allow for thorough examination that no undesirable reaction of the structure would occur.<sup>92</sup>

The work of unbolting the splice between box 4 and box 5 of span 10-11 on the west side of the West Gate Bridge started at about 8:30 a.m. on 15 October 1970. When 30 bolts had been removed from the box 5 side of the splice and seven bolts from the box 4 side of the splice “a dramatic change took place”<sup>93</sup> since the initial buckle spread into two outer flange plates. This and the fact that witnesses confirmed that they felt “a gentle settlement of the north half span of the bridge”, implied, according to the assessment of the Royal Commission, that “from that time onwards the north half span had inadequate strength to sustain its own weight and only survived because it was able to bear down on to the south half through the interconnected transverse diaphragms”.<sup>94</sup> According to the Commission, “the margin of safety in the south half span was not such that the entire dead load of the north half span could be borne in addition to its own self weight”.<sup>95</sup>

Still, it took 50 more minutes after the spreading of the buckle into the outer flange plates until the total collapse of span 10-11. In the meantime, a frenzy of hectic work had started in the attempt of getting the bolts back into place. The rebolting was even going quite well which might have created confidence that the situation was not really deteriorating.<sup>96</sup> That Hindshaw who together with FF & P’s site engineer P. J. F. Crossley had meanwhile rushed to the site of the incident was nonetheless gravely concerned is indicated by the fact that he telephoned chief engineer Hardenberg of the meanwhile marginalized WSC whose expertise in the steelwork part of the construction was much bigger than the one of JHC, the firm officially in charge. Hindshaw asked Hardenberg to come over to the location of the incident. However, “almost immediately after that telephone conversation at 11:50am span 10-11 collapsed”.<sup>97</sup> Hindshaw himself was among the 35 men who died in the disaster (Illustration 2.2).

<sup>91</sup> Ibid.

<sup>92</sup> Royal Commission, 25.

<sup>93</sup> Royal Commission, 26.

<sup>94</sup> Ibid.

<sup>95</sup> Ibid.

<sup>96</sup> Ibid.

<sup>97</sup> Ibid.

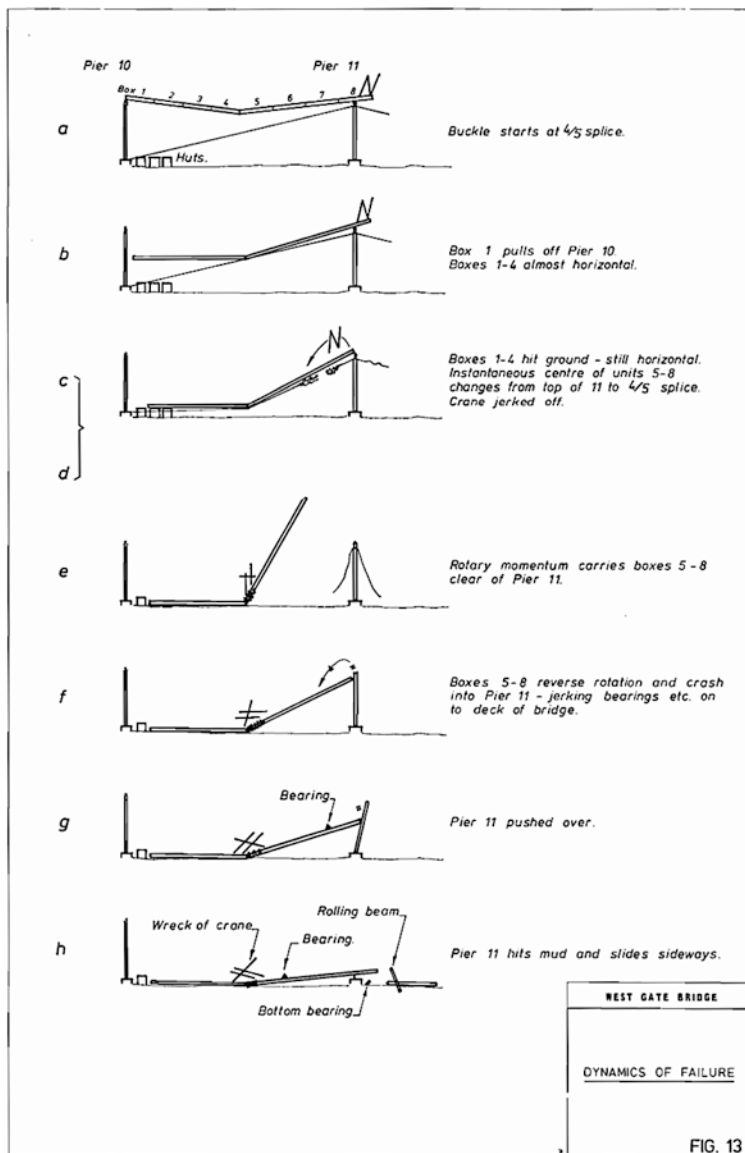


Illustration 2.2 “Dynamics of Failure”. (Source: Royal Commission, Appendix, p. 134)

## 2.4 CASE ANALYSIS

### 2.4.1 *Turning Points and Critical Junctures*

According to the Royal Commission, neither the unusual and sophisticated method of assembling and lifting the box girders nor the fragmented and conflict-ridden structure of management and control in the triangle of LYCA, the joint consultants Maunsell and FF & P and the main contractors WSC and JHC had made the disaster of 15 October 1970 unavoidable. Still, the Commission stated by way of conclusion, mindful officials, consultants and senior engineers would and should have been able to handle those complex technical and organizational conditions if only they would have been mindful and determined enough to do so.<sup>98</sup> While the assessment in the present study differs from the Commission's judgment to the extent that the latter implied the possibility of professional skill that, if existent, would probably have prevented the emergence of a risk-prone technical and organizational structure in the first place, there is good sense in acknowledging the proverbial forks in the road where alternative pathways presented themselves but were not taken. There were turning points at which the resulting path dependency was relatively weak and critical junctures whose determining force in shaping the remaining pathway was relatively strong.

The first turning point of major importance was, in 1966, the creation of a quasi-non-governmental organization (QUANGO) as supervising authority for the public works connected with the construction of the West Gate Bridge. This at least reduced the possibility to shield off interference of private interests, business interest in particular, since the authority itself, the Lower Yarra Crossing Authority (LYCA), was not only initiated and literally created by the private business community but also governed by private enterprises whose interests were vested in the construction of what became the West Gate Bridge. By the same token, LYCA was not financed through the state budget but through private loans whose repayment was guaranteed by the state of Victoria.

LYCA's solid embeddedness in the local business community did play a role when, in early 1970, the Authority had to decide whether or not to continue business with the Dutch contractor WSC. This was a critical juncture indeed. And LYCA's decision to discontinue the cooperation

<sup>98</sup> Royal Commission, 88.

with WSC as far as the main part of the steelworks of the bridge was concerned was, according the Royal Commission, at least indirectly influenced by the institutional choice of how to create and to govern LYCA itself. After all, LYCA was working with borrowed money which left it with no choice but to exert massive pressure on WSC when the Dutch contractor turned out to be way behind schedule with the completion of the assigned works. Moreover, when a local alternative presented itself in the form of John Holland Constructions Proprietary Ltd. (JHC) it seemed to be one more time a natural choice, especially since JHC was already present on the construction site as the contractor for all concrete related works. Despite all the plausibility of this choice, the Royal Commission maintained that LYCA should have invested more effort in keeping the initial contract with WSC (Contract S) but it also pointed to the incentives not to do so. What mattered in the perception of LYCA was not only the undeniable time pressure but also the alleged smooth relationship of JHC with labor and the plausible assumption that JHC's well-known lack of experience and professional competence concerning sophisticated steelworks could be offset by close cooperation with FF & P as main consultant for structural engineering. So the decision to discontinue Contract S with WSC was plausible but nonetheless irreversible and fateful in its consequences. A productive cooperation between JHC and FF & P never materialized. Necessary measures of risk-assessment and related calculations did not take place. Division of labor between JHC and FF & P/Maunsell as well as the remaining tasks of WSC as quasi-consultant in support of JHC remained more than blurry.

A turning point in the sense that the course of events was not decisively shaped but accentuated was the collapse of the Milford Haven Bridge in Wales on 2 June 1970. Although occurring in faraway Great Britain, the disaster impacted significantly on the situation in Melbourne because FF & P had been the chief designer of the Milford Haven Bridge. And the design itself was quite similar to the one of the West Gate Bridge now under construction. This prompted LYCA's general manager C. V. Wilson to express explicit safety concerns as far as the West Gate Bridge was concerned. A sharp confrontation between Wilson and FF & P's Resident Engineer, Jack Hindshaw, followed. As a tragic consequence, Hindshaw, according to the findings of the Royal Commission, developed the attitude to conceal existing engineering problems occurring in the course of the construction of the bridge, the erection of the steelworks in

particular.<sup>99</sup> The most consequential of these efforts was Hindshaw's decision to straighten the buckle occurring on span 10-11 of the bridge, an instruction executed the morning of 15 October 1970. This he did, according to the judgment of the Royal Commission, out of embarrassment, being "concerned that Wilson should not see the buckle".<sup>100</sup> The decision was the immediate trigger of the collapse of span 10-11 the same morning at 11:50AM.

While the consequences of the collapse of the Milford Haven Bridge of 2 June 1970 were quite indirect though counterintuitive in nature, two episodes preceding the critical works on the west side of the West Gate Bridge strengthened a fatal path dependency. One was, quite ironically, the successful dealing with a buckle on the plate edge of the north boxes of span 14-15 located on the east bank of the river Yarra, the other one was a meeting held on 16 September 1970 between representatives of WSC, Maunsell and FF & P at which the joint consultants gave unsubstantiated assurances on the general safety margins of the erected steelwork of the bridge.

What had happened during the erection phase of span 14-15 on the east side of the bridge established was, according to the Royal Commission, a dangerously misleading pattern of problem solving should bending stress affecting the box girders and the covering plates and related buckles occur. In the case of span 14-15 a remaining buckle had been straightened through the temporary removal of bolts that had connected three individual boxes in order to reach flexibility of the box in the middle which had indeed the desired effect of flattening out the buckle. The tragedy was that on 15 October 1970 under apparently similar conditions—i.e., when a buckle occurred on span 10-11 on the west side of the bridge—the same technique was applied. This was done, however, hastily and without diligent and accurate assessment of the actual conditions at span 10-11, especially as far as bending stress was concerned. When, according to the pattern applied at span 14-15, two boxes within span 10-11 were unbolted on 15 October 1970 the procedure triggered the collapse of the entire span 50 minutes later. Certainly, the pattern established at the east side of the bridge months before was not a strictly determining factor but the Royal Commission was convinced that the fatal decision to unbolt the relevant boxes of span 10-11 on the west side of the bridge was made in

<sup>99</sup> Royal Commission, 28.

<sup>100</sup> Royal Commission, 25.



full confidence that the buckle there could be handled the same way the previous buckle at the east side had been dealt with.<sup>101</sup>

The ultimate critical juncture that almost inevitably opened the gate to disaster was therefore an on-site meeting held 16 September 1970 at which JHC's chairman and managing director, C. V. Holland, was present and explicitly requested assurances on the overall safety margins of the bridge. This would have been *the* opportunity to give a sober account of all relevant safety assessments. After all, it was the chief executive of JHC himself who asked the most relevant of all questions, addressed to engineers of the joint consultants, FF & P in particular, whose expertise and responsibilities specifically pertained to all relevant calculations. The consultants gave the safety assurances Holland had asked for. Almost parallel to this on-site meeting, another JHC representative, project manager T.R. Nixon, wrote to WSC's senior representative G. Hardenberg who despite WSC's dismissal from the initial contract concerning the steelworks of the bridge still served as an advisor on erection method and technique. Nixon was seeking Hardenberg's opinion on "the adequacy of the structure in its present condition to properly withstand erection stresses".<sup>102</sup> He raised the same question to Maunsell and FF & P. Hardenberg replied to Nixon on 16 September 1970 that "the structure is quite adequate to allow erection of box 12".<sup>103</sup> Although this answer was more specific than the general assessment Nixon had asked for it came in a similar vein as the assurance of Maunsell and FF & P given to Nixon's boss, Hardenberg, at the on-site meeting the very same day.

The Royal Commission concluded that "the effect of Hardenberg's letter, combined with the assurance of the joint consultants, was to give JHC a false sense of security." After all, neither Hardenberg, representing WSC, nor Maunsell or FF & P had based their assurances on recent calculations. The Royal Commission clearly stated, "had Hardenberg refused the assurances sought from him JHC might well have declined to proceed further with the erection [of the steelwork of the bridge]" since he "had no justification for the reassuring opinion he expressed".<sup>104</sup> The path dependency emerging from here was that the absence of calculations to be provided either by WSC or FF & P or both was not compensated by

<sup>101</sup> Royal Commission, 19.

<sup>102</sup> Royal Commission, 99.

<sup>103</sup> *Ibid.*

<sup>104</sup> *Ibid.*

JHC's own staff. When JHC engineers suggested to use kentledge in order to reduce the camber between the north half and the south half of the bridge near span 10-11 to an acceptable level and thus committed in fact "the gravest of errors"<sup>105</sup> they had "no calculations available giving them any knowledge of the stresses likely to be created".<sup>106</sup> It was the kentledge, however, that caused the buckle to appear on span 10-11 whose removal was hastily initiated the morning of 15 October 1970.

The meeting of 16 September 1970 turned out to be the classic missed opportunity to do what was imperative namely "to put any question of safety beyond reasonable doubt".<sup>107</sup> Instead, appropriate steps to do so fell prey to an organizational and contractual arrangement that systematically generated the type of organized irresponsibility aptly characterized by the Royal Commission (Fig. 2.1):

A contractor more familiar with the erection of large steel bridges might have recognized the danger signs more readily. The consultant engineers on site do not appear to have taken the matter sufficiently seriously, while the consultants in London did not consider the matter at all, because they knew nothing of either kentledge or buckles until after the bridge had fallen.<sup>108</sup>

#### *2.4.2 Contributing Factors, Necessary and Sufficient Conditions*

In its report, the Royal Commission stated that none of the organizational and contractual arrangements, however insufficient and unsatisfying in detail, sufficiently explains the occurrence of the serious engineering problems on the construction site of the West Gate Bridge and the ultimately disastrous attempts to solve them. This remains an ambivalent statement since, on the one hand, it underlines the role of guidance and management especially under circumstances that are difficult and challenging in terms of coordination and risk-management while, on the other hand, the Commission's judgment missed one important point: What should justify the assumption that the very key-actors responsible for the awkward and risk-increasing organizational and contractual arrangement established for the construction of the West Gate Bridge could have been able to handle

<sup>105</sup> Royal Commission, 102.

<sup>106</sup> Ibid.

<sup>107</sup> Royal Commission, 66.

<sup>108</sup> Ibid.

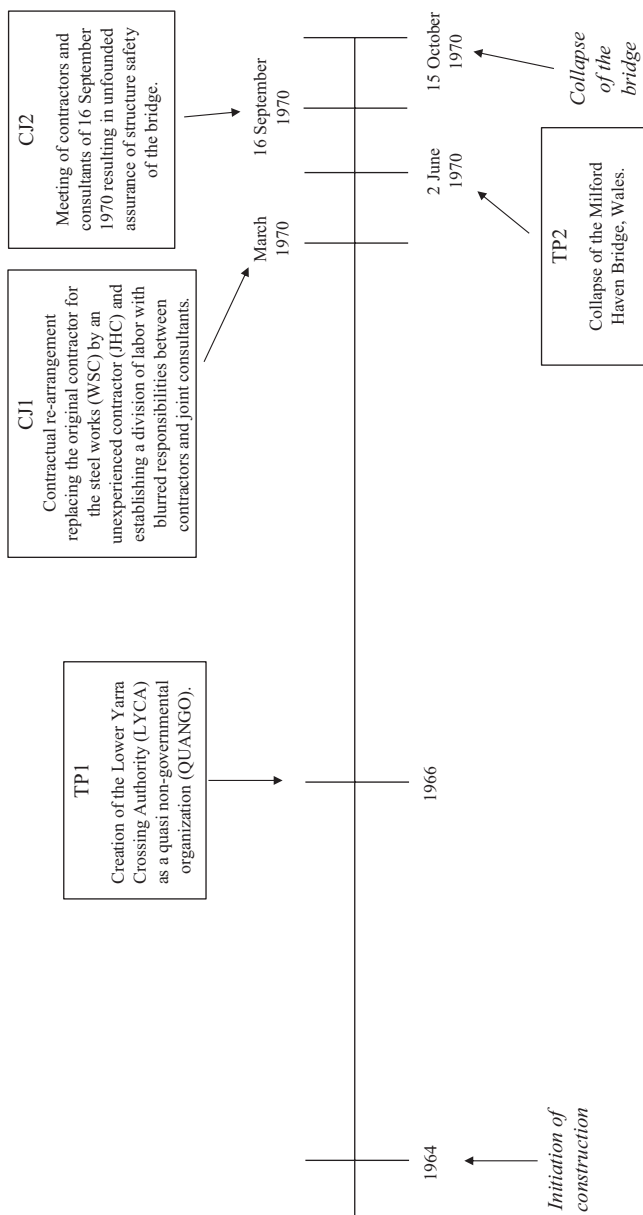


Fig. 2.1 Turning Points (TP) + Critical Junctures (CJ), Collapse of West Gate Bridge

these conditions with professional skill and the necessary sense of responsibility? To that extent the Commission's assessment is rather a normative plea with the benefit of hindsight than a neutral analysis of the interplay of structural conditions and human agency that paved the way to the disaster of 15 October 1970.

While it is true that the collapse of the West Gate Bridge was a man-made disaster in an almost classic sense, errors of design—technical and organizational in nature—and errors of situational judgment have to be distinguished. Some of the design errors can be characterized as necessary conditions of the disastrous outcome in the sense that without them the rest of the causal chain would have been unthinkable or at least highly unlikely to occur. Some of the judgment errors, however, can be characterized, actually quite in accordance with the conclusions of the Royal Commission, as sufficient conditions in the sense that, under the given circumstances, they made the disaster inevitable.

There were, however, antecedent conditions to which the Royal Commission's skeptical judgment can be applied as risk factors in their own right. This affects the nature of LYCA, the fragmented governance of the entire planning and construction process and the unique and unusually challenging method of erection of the steelworks chosen by WSC. LYCA as sole representative of the public interest was no public authority in the proper sense. Instead, it was a private organization both in legal terms and as far as its stakeholders and, above all, as far as its financial commitments were concerned. LYCA basically represented the business community and it was working with borrowed money. The only constitutive element of public interest was the fact that the state of Victoria guaranteed the status of LYCA as a first class debtor. This, however, did not make LYCA an independent authority robust enough to shield off collisions of interest. For instance, it was the fact that financial obligations were piling up already in 1969 due to the substantial delay of the works assigned to WSC which soon would pave the way to an entirely new contractual arrangement in the framework of which WSC was replaced by JHC as a contractor with no experience in erecting steelwork-based box girder bridges. Yet, the stakeholder background and the nature of LYCA as a private organization assuming tasks of a public authority cannot be classified as a necessary condition in the sense that a different type of institutional arrangement, typically a public agency in the proper sense, would have made the ensuing components of the causal chain unthinkable or highly unlikely. LYCA had all the necessary means and competences to

supervise and control the planning and construction of the West Gate Bridge in full accordance with the necessary safety requirements.

The same holds true even for the fragmented governance of the entire planning and construction process concerning the West Gate Bridge. To some extent, it was the epitome of unnecessary organizational complexity inviting the relevant actors to silo-thinking and blame-avoidance in the triangle of LYCA as a quasi-nongovernmental organization, the “joint consultants” Maunsell and Partners and London-based FF & P plus the actual contractors JHC and WSC. But, again, this kind of structure was, basically, not entirely unusual in the realm of public works and, specifically, in the field of bridge construction. So it was, in principle, manageable as well.

What made both of these anteceded factors critical in terms of risk-management was, however, a crucial technical aspect of the ultimate erection of the bridge that, according all likelihood, could not have been anticipated in all clarity by the joint consultants, let alone LYCA: WSC, the contractor in charge of the steelworks of the bridge, decided to construct and to erect the two parallels halves of the overall span of the box girder bridge separately. Instead of cantilevering in a piecemeal way the integral components of the box girders up in the air as usual, WSC’s method of choice was to assemble the steel boxes on the ground, to bolt them together to girder segments and to lift those up to top-of-pier level at a height of 170 feet. This method was risk-prone in at least two respects. Accuracy and diligence when assembling the boxes on the ground were of the essence. Moreover, since the two half spans, the north part and the south part, were prefabricated and lifted separately camber between the two halves was likely to occur.

Yet, these intricacies of structural engineering were certainly not beyond managerial control either. It was only in combination with the likewise complex governance of the entire planning and construction process of the West Gate Bridge that the technical particularities turned out to be the decisive risk factor as far as engineering as such was concerned. If the key-actors in the triangle of LYCA, joint consultants and contractors would have been aware of the combined technical and managerial risk zones and mindful enough to address them appropriately the risks themselves could have been kept under control. The problem was precisely the absence of that kind of awareness and mindfulness among the key-figures running the complex machinery of planning, controlling and construction. Which

leads us to the inner circle of necessary and sufficient conditions of the ultimate disaster to occur.

What one can define as the one necessary condition without which the rest of causal chain resulting in disaster according to all likelihood would not have evolved is the contractual rearrangement of tasks and responsibilities between the contractors WSC and JHC and the joint consultants Maunsell and FF & P that took place in March 1970. It was initiated by LYCA in response to the serious delays of the steelwork portion of the construction assigned to WSC. WSC engineers and managers were exhausted by protracted conflicts with organized labor and, consequently, more than ready to withdraw from their initial contractual obligations as soon as LYCA indicated its own readiness to relinquish WSC from substantial penalty fees accumulated through the considerable delay of the completion of the steelworks. As a result of the rearrangement, JHC stepped in as substitute contractor replacing WSC and thus assuming the task of completing the steelworks.

The fact that JHC lacked the special expertise necessary for the work involved was, as the Royal Commission wrote, “manifestly plain” to LYCA.<sup>109</sup> It was therefore agreed upon that WSC would continue to serve as an advisor in all questions of the practical erection of the steelwork itself while the general oversight and the specific tasks connected to issues of structural engineering were assigned to the joint consultants Maunsell and FF & P. Among them, in turn, the division of labor was such that Maunsell was in charge of administrative and managerial aspects while FF & P was in charge of overseeing engineering itself including the relevant calculations. FF & P thus had to coordinate the activity of its engineers on the construction site in Melbourne and the supporting advice and control of FF & P headquarters in London. JHC was now the sole contractor for the entire construction of the bridge and thus in a strong position as LYCA’s last hope as far as the successful completion of the entire bridge works was concerned. In protracted negotiations before the final signing of a new contract (Contract E) in July 1970, JHC insisted on limiting its responsibilities strictly to mere construction thus discarding any responsibility for issues of structural engineering and related calculations. Yet, JHC engineers, after assuming the new task of completing the steelworks without substantial experience in that field, became, according to the findings of the Royal Commission, “over-confident” which, according to the

<sup>109</sup>Royal Commission, 101.

Commission, implied a “course of conduct [that] resulted in the breakdown of the arrangement originally envisaged by the Authority [LYCA] and the joint consultants”.<sup>110</sup>

However, the “arrangement originally envisaged” was a syndrome of organized irresponsibility anyway. Not only made it an inexperienced contractor in charge of an unique and particularly complex method of erection of the steelwork but at the same time exempted the very contractor by the very same reasons—lack of experience—from the “sophisticated calculations and highly technical decisions necessary to ensure the safe and satisfactory completion of the contract”.<sup>111</sup> This was, according to all evidence, a high risk arrangement and therefore the opposite of what was required under the already difficult conditions of an unusually complex method of erection of the steelwork part of the bridge. Which leaves little doubt that without the replacement of WSC by JHC in March 1970 and the formal agreement laid down in Contract E signed on 10 July 1970 the ensuing wrongful decisions and omissions would not have evolved.

Still, even the arrangement of Contract E, however risk-increasing, did not trigger the disaster quasi-automatically. The Royal Commission was right in emphasizing that careful handling of what meanwhile was a high-risk governance structure still could have prevented the errors and omissions that resulted in the catastrophe. The sufficient condition for the disaster to occur was indeed the failure of a handful of chief engineers of the contractors and the joint consultants who should have acted as professional “linking pins” in what had emerged as a fragmented yet manageable network of firms and individuals. Their mutual relationship was characterized by rivalry instead of trustful cooperation, withheld information instead of transparency and pugnacious rather than conflict-mitigating attitudes. This culminated in a meeting of WSC, Maunsell and FF & P engineers on 16 September 1970 as a result of which unsubstantiated assurances confirming the overall stability and stress resistance of the steelwork of the bridge were given to JHC. No proper and specific calculations had been made on which such assurances could have been founded. Neither were any such assessments performed prior to the fatal decision to temporarily remove a major number of bolts at the slice of two boxes of

<sup>110</sup> Ibid.

<sup>111</sup> Ibid.

span 10-11 in an attempt to straighten a buckle—the immediate trigger of the disaster of 15 October 1970 (Table 2.1).

### 2.4.3 *Causal Mechanisms*

The distinction of necessary and sufficient conditions just like the distinction of turning points and critical junctures is case-specific and, accordingly, of limited value for generalization. Certainly, scholarly experts and, especially, seasoned practitioners will recognize typical patterns of both ill-conceived organizational and contractual arrangements and lack of professional skill. Yet, there is an inevitable epistemological gap between the uniqueness of causality in a given case of disaster and the quest for generalization in terms of predictability for the sake of prevention. That gap cannot be entirely closed but substantially reduced in a differentiated perspective on causal mechanisms.

The circumstances under which key-actors in Melbourne started to build what was deemed a necessary organizational and contractual arrangements for satisfying the quest for a bridge crossing the Lower Yarra River were rather conventional in nature. However, the question arises what the driving mechanisms were behind the choice of a particularly risk-prone arrangement and to what extent those mechanisms can be generalized. A subsequent question concerns the actual risk-taking and risk-increasing behavior of the key-actors involved. What were the characteristic behavioral patterns and to what extent did they contribute to the disastrous outcome of the causal process under scrutiny? Finally, what can be generalized when it comes to the question why points of intervention were not recognized in a timely manner and what lowered the threshold that

**Table 2.1** Contributing Factors (CF), Necessary Condition (NC) and Sufficient Condition (SC), Collapse of West Gate Bridge

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CF1	Nature of the Lower Yarra Crossing Authority (LYCA) as a Quasi Non-Governmental Organization (QUANGO).
CF2	Unusual and particularly sophisticated method of bridge erection.
NC	Contractual re-arrangement of tasks and responsibilities between contractors and joint consultants, March 1970 (made official 10 July 1970), and transfer of main part of works to contractor with no experience with complex steelworks.
SC	Meeting of contractors and consultants of 16 September 1970 resulting in unfounded assurance of structure safety of the bridge.

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separated risk-increasing behavior of key-actors from the actual occurrence of the disaster?

Following what Hedström and Ylikoski suggested in terms of discernable situational, action-formation and transformational mechanisms<sup>112</sup> as outlined in the introduction to this book, it is through the lenses of ontologically specific theories that we recognize relevant mechanisms and it is with the help of those theories that related diagnoses can be generalized for the sake of predictability and prevention.

As far as situational mechanisms are concerned, an initial institutional choice resulted in the creation of The Lower Yarra Crossing Authority (LYCA) as a private institution in charge of securing a vital public interest—the safety of a roadway bridge. LYCA was a quasi-non-governmental organization or QUANGO,<sup>113</sup> a type of organization that, almost by definition, weakens enforcement capability.<sup>114</sup> The flipside of blame-avoidance was the actual diffusion of responsibility. Fragmented jurisdiction for what was a technically complex and challenging project anyway implied information asymmetries at the expense of the control capacity of both LYCA and the joint consultants Maunsell and FF & P. These mechanisms were inherent to the initial institutional choices and contractual arrangements regardless of any individual behavioral attitude of the key-actors involved.

However, those key-actors did not withstand, let alone neutralize, the incentives of the situational mechanisms. Rather, they brought to bear the undesirable effects in the form of particular action-formation mechanisms. A typical pattern here was silo-thinking and related selective perception of what actually required an integral plan and comprehensive planning.<sup>115</sup> This applied to both LYCA, the contractors WSC and JHC and to the joint consultants Maunsell and FF & P. Basically, all of these institutional actors and their individual representatives followed their own agenda

<sup>112</sup> Peter Hedström and Petri Ylikoski: Causal mechanisms in the Social Sciences. *Annual Review of Sociology* 36 (2010): 49–67.

<sup>113</sup> Carsten Greve, Matthew Flinders, and Sandra Van Thiel: Quangos—What's in a Name? Defining Quangos from a Comparative Perspective. *Governance* 12 (1999): 129–146; Flinders, Matthew V., and Martin J. Smith: Quangos, Accountability and Reform. *The Politics of Quasi-Government*. London: Palgrave Macmillan 1999.

<sup>114</sup> For a classic description of softening institutional integrity through delegating authority to an independent public agency cf. Philip Selznick: *TVA and the Grassroots. A Study in the Sociology of Formal Organization*. Berkeley and Los Angeles: University of California Press 1949.

<sup>115</sup> DeWitt C. Dearborn and Herbert A. Simon: Selective Perception: A Note on the Department Identifications of Executives. *Sociometry* 21 (1958): 140–144.

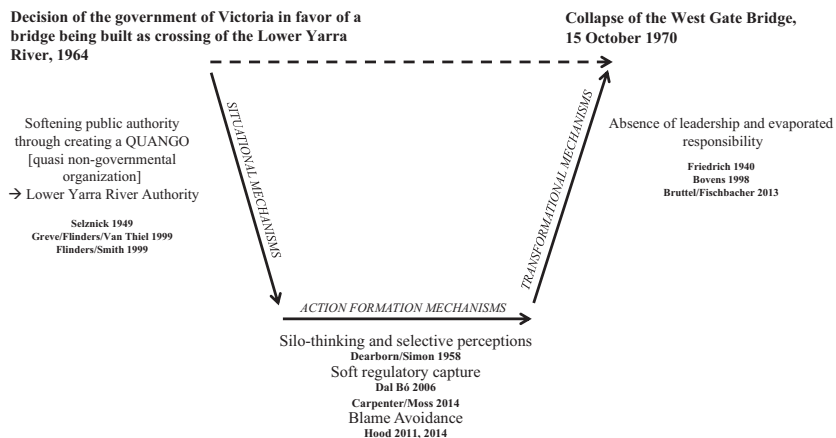
according to what the institutional and contractual arrangement suggested in the first place. From this resulted a culture of blame avoidance<sup>116</sup> combined with a mild type of regulatory capture.<sup>117</sup> Rather than controlling the contractors and the joint consultants, LYCA came under pressure from JHC when the Authority, in its own perception, had no choice but to accept JHC as supplement contractor for the steelworks of the bridge replacing WSC. Banking on its own indispensability, JHC achieved substantial concessions from LYCA as far as the limitation of responsibilities was concerned and, consequently, related liability risks. These concessions were virtually made at the expense of the public interest in safe and sound construction and related mechanisms of control and accountability.

Still, just as the Royal Commission concluded in its report, the risk-generating consequences of organizational and contractual choices and the risk-increasing impact of resulting behavioral attitudes of key-actors could have been neutralized by mindful and determined management. Accordingly, what can be classified as ultimate trigger factor or transformational mechanism was the absence of appropriate leadership, a sense of responsibility in particular.<sup>118</sup> Both the notion and the reality of responsibility had evaporated. This pertained to awareness in general as well as to conflict management and the managerial and social skills to reintegrate a highly fragmented governance structure. Basically, none of these managerial virtues and attitudes came to bear so that, in the essence, the failure of the West Gate Bridge was, according to the Royal Commission, the consequence of mismanagement and failed leadership (Fig. 2.2).

<sup>116</sup>Christopher Hood: *The Blame Game: Spin, Bureaucracy and Self-Preservation in Governments*. Princeton and Oxford: Princeton University Press 2011.

<sup>117</sup>Cf. again Selznick, *TVA and the Grassroots*. For more recent analyses cf. Ernesto Dal Bó: *Regulatory Capture: A Review*. *Oxford Review of Economic Policy* 22 (2006): 203–225; Daniel Carpenter and David A. Moss, eds.: *Preventing Regulatory Capture*. *Special Interest Influence and How to Limit It*. Cambridge: Cambridge University Press 2014.

<sup>118</sup>Herman Finer: *Administrative Responsibility in Democratic Government*. *Public Administration Review* 1 (1940): 335–350; Mark Bovens: *The quest for responsibility: Accountability and citizenship in complex organisations*. Cambridge: Cambridge University Press 1998; Paul ‘t Hart and Lars Tummers: *Understanding Public Leadership*. 2nd ed., London: Red Globe Press 2019.



**Fig. 2.2** Causal Mechanisms, Collapse of West Gate Bridge

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# Intended Ignorance: The Collapse of the I-35 W Mississippi River Bridge on 1 August 2007

## 3.1 CHARACTERISTICS OF THE CASE

At 6:05 PM on 1 August 2007, the I-35 W Highway Bridge crossing the Mississippi River in Minneapolis, Minnesota, collapsed due to the failure of crucial parts of the bridge's steel truss structure. A 1000 feet long part of the bridge disintegrated and 456 feet of the main span fell 108 feet into the river. At the time of the disaster, 111 vehicles were on the part of the bridge that collapsed of which 17 were recovered from the water. Thirteen people died in the disaster, 145 were injured. The origins of the collapse of the Mississippi River Bridge have been analyzed by the National Transportation Safety Board of the United States whose report was published on 14 November 2008.<sup>1</sup> Prior to the NTSB report, a law firm serving as consultant to the Minnesota Legislature had published its report.<sup>2</sup>

The bridge crossed the Mississippi in north-south direction. Its entire length was 1907 feet and the bridge carried eight lanes for traffic, four in each direction. The main structure of the bridge was based on concrete

<sup>1</sup>National Transportation Safety Board: Highway Accident Report. Collapse of I-35 W Highway Bridge Minneapolis, Minnesota, 1 August 2007. Washington D.C., 14 November 2008 (henceforth: NTSB, page number).

<sup>2</sup>Gray Plant Mooty [= law firm consultant by the Minnesota Legislature]: Investigative Report to Joint Committee to Investigate the I-35 W Bridge Collapse, May 2008 (henceforth: GPM, page number).

piers carrying fourteen spans. Three of those spans between pier five and pier eight formed the deck truss portion in the middle based on steelwork (Illustration 3.3).

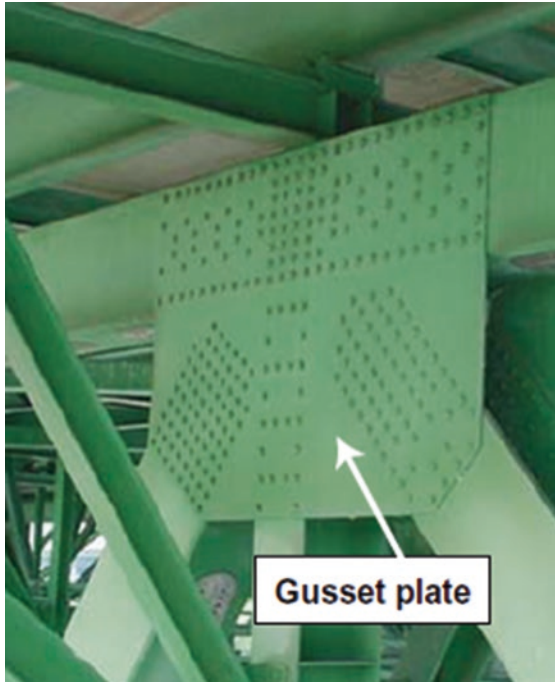
The middle part of the bridge where the failure of 1 August 2007 occurred consisted of welded built-up steel beams forming truss-structured girders whose individual components are referred to as “members”. The steel beams and truss members were riveted and bolted together. The nodes of supporting steel spans, steel beams and truss members were connected by riveted gusset plates. As the NTSB found out, the collapse of the Mississippi River Bridge was triggered by the concurrent failure of the gusset plates at the two nodes at position U10.<sup>3</sup> The failure, according to the NTSB, was due to “a combination of (1) substantial increases in the weight of the bridge, which resulted from previous bridge modifications, and (2) the traffic and concentrated construction loads on the bridge on the day of the collapse”.<sup>4</sup> The bridge’s load capacity was inadequate relative to an undetected design error pertaining to insufficient robustness of the gusset plates. The fact that the error had remained undetected was,



**Illustration 3.1** Collapsed I-35W Bridge center section. (Source: NTSB Report, p. 19)

<sup>3</sup>NTSB, 61.

<sup>4</sup>NTSB, xiii.



**Illustration 3.2** I-35W Bridge, main truss member with node and gusset plate. (Source: NTSB Report, p. ix)

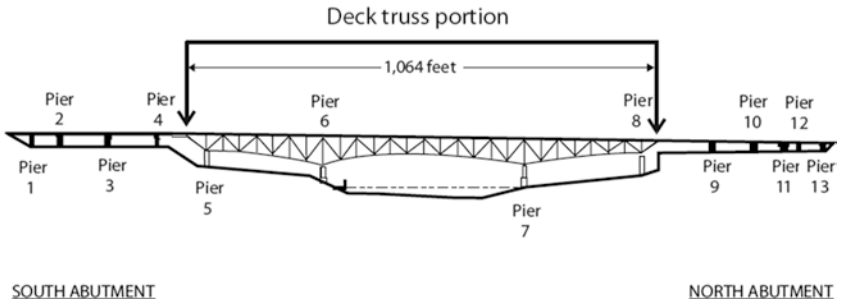
according to the findings of the NTSB, due to the fact that it had been a “generally accepted practice among Federal and State transportation officials of giving inadequate attention to gusset plates during inspections for conditions of distortion, such as bowing, and of excluding gusset plates in load rating analyses” (Illustration 3.2).<sup>5</sup>

## 3.2 FACTS OF THE MATTER

### 3.2.1 *Design Errors*

The immediate trigger of the disaster of 1 August 2007 were roadway works for which four of the eight travel lanes, two outside lanes northbound and two inside lanes southbound, were closed to traffic.

<sup>5</sup>NTSB, 152.



**Illustration 3.3** I-35W Bridge, deck truss portion. (Source: NTSB Report, p. 7)

Subsequently, construction equipment and aggregates such as sand and gravel were positioned in the closed inside southbound lanes. These works were completed by about 2:30 PM. At about 6:05 PM, the bridge center span separated from the rest of the bridge and fell into the river.

According to the NTSB report, the fact that moving heavy construction material onto the temporarily closed lanes of the bridge was able to trigger the collapse of the main span was due to a fundamental design error, under-designed gusset plates in particular. The bridge was designed by an engineering consultant firm Sverdrup & Parcel and Associates, Inc. located in St. Louis, Missouri. The design plan and its certification by the Department of Transportation of the state of Minnesota took place in 1965. The bridge was opened to traffic in 1967. When the construction of I-35 W was completed in 1971, the Mississippi River Bridge became part of that highway.

Relevant for the specification and certification of the bridge design were the Standard Specification for Highway Bridges of the American Association of State Highway Officials (AASHTO) plus Relating Interims Specifications of 1961 and 1962 as well as the Minnesota Highway Department's Standard Specification for Highway Construction of 1964. The contractor for building the bridge was Hurcon Inc. of Houston, Texas. The erection of the structure was engineered and staged by the Industrial Construction Division of Allied Structural Steel Company (ASSC). ASSC was also the steel fabricator for the project. Daily traffic crossing the bridge had risen from 60,600 vehicles in 1976 to 141,000 vehicles in 2004.<sup>6</sup>

<sup>6</sup> cf. for these facts and figures NTSB, 5-6.

The basic design was that of a truss bridge whose straight structural components formed triangles. In larger bridge structures, truss members are joined with gusset plates designed to enhance elasticity when it comes to alternating tension or compression.<sup>7</sup> The tarred surface of the bridge or “deck” was based on two reinforced concrete slabs each of which accommodating four 12-foot-wide traffic lanes. The deck slab had an initial thickness of 6.5 inches which in the course of bridge renovation projects was increased by about 2 inches.

The truss structure of the bridge comprised two parallel main so-called Warren-type trusses, one at the East and one at the West side, with vertical and diagonal beams connecting the lower and the upper chords of the main trusses. The members of the truss boxes—the components of the chords plus the diagonals and verticals—were welded together, forming nodes covered by the gusset plates. The gusset plates themselves were riveted to the truss box members.

The NTSB report underlined that “the I-35W bridge was designed and built before metal fatigue cracking in bridges was a well-understood phenomenon”.<sup>8</sup> In the late 1970s, however, when the bridge was already in full use, deck truss bridges such as the I-35 W Bridge were “recognized as being ‘non-load-path-redundant’—that is if certain main truss members (termed ‘fracture-critical’) failed, the bridge would collapse”.<sup>9</sup> From which follows that, from then on, the risk should have been known to the relevant authorities.

When the gusset plates at the U10 position,<sup>10</sup> West and East, disintegrated at approximately 6:05 PM on 1 August 2007, it triggered a chain reaction in the course of which the three main parts of the I-35 W collapsed. The major part of the center span, between piers 6 and 7, separated from the rest of the truss structure and fell into the river while the section south of pier 6 fell onto land just as the north section.

<sup>7</sup>NTSB, 8, including footnote 6.

<sup>8</sup>NTSB, 12.

<sup>9</sup>Ibid.

<sup>10</sup>The “U” of “U10” stands for the upper chord of the main truss of the steel structure. By contrast, “L” stands for the lower chord.



### 3.2.2 *Blind-Folded Attention*

A counterintuitive part of the pre-history of the disaster of 1 August 2007 is that the Mississippi River Bridge had undergone several renovations throughout the 40 years of its existence none of which led to closer inspection of the gusset plates which undeniably were crucial to the stability and, thus, the safety of the bridge. On the contrary, two of those renovations increased the dead load on the structure, i.e., the weight of the bridge structure itself.<sup>11</sup> A renovation in 1977 increased the thickness of the deck from 1.5 inches to 8.7 inches accounting for an increase in dead load by more than 3 million pounds (or 1361 metric tons). A renovation in 1998 involved the replacement of the medium barrier, upgrading outside concrete traffic railings, improving drainage, repairing the concrete slab and piers, retrofitting cross-girders, replacing bolts, and, last but not least, installing an anti-icing system—quite an effort of modernizing the bridge structure and quite at odds with general accusations after the collapse that overall maintenance of the bridge was poor. However, this renovation too resulted in an increase of dead load by about 1.13 million pounds (or 512 metric tons). The disaster of 1 August 2007 occurred when the third renovation was underway which involved removing the upper part of the concrete wearing course to replace it by a new 2-inch-thick concrete overlay. Part of the renovation plan was also the removal of unsound concrete from the curbside of the eight-lane highway on the bridge and batching it with concrete, reconstructing expansion joints and replacing the anti-icing system spray disks and sensors in the deck. Those works began in June 2007 and were scheduled to be completed by the end of October the same year.

The removing and replacing of the concrete wearing course was performed by Progressive Contractors, Inc. (PCI), a firm from St. Michael, Minnesota. Part of the works involved staging construction materials, primarily aggregates, on the bridge deck. This was required in the framework of cementing jobs with a lower water and higher cement content than typical concrete and, accordingly, just a short timespan between mixing and final screeding. Taken that into account, specifications of the Minnesota Department of Transportation (MnDOT) required “that all concrete overlays be mixed at the job site, with a 1-hour window from

<sup>11</sup>NTSB, 22–24.

initial mixing to final concrete screeding”.<sup>12</sup> For that purpose, the necessary materials had to be staged on the bridge deck. This started on 6 July 2007, though not yet on the deck truss portion of the bridge. The staging of vehicles and aggregates on the deck truss of the bridge for a pour of cementing began on 23 July 2007. The area for staging the material was about 183 feet long stretching from node 4’ between pier 7 and pier 8 to the North end of the deck truss. On the blocked lanes in that area three 24-ton loads of gravel and three 24-ton loads of sand were staged.

As it turned out through the investigations of the NTSB, the staging procedure was performed in the presence of a MnDOT bridge construction inspector. This used to be a routine procedure to ensure that contractors fulfill their responsibilities and that the materials used met required standards.<sup>13</sup> However, unlike what their official designation suggests, bridge construction inspectors are not engineers. They were, at the time, not even trained in bridge inspections.<sup>14</sup> Indicative enough is what a PCI foreman told the NTSB in the course of the Board’s investigation, namely “that he had asked a MnDOT bridge construction inspector if materials could be staged in the bridge for the July 23 pour in the northbound lanes”. According to the foreman’s testimony,

the inspector evidenced no concern about the staging, which the job foreman interpreted as permission. The foreman said the reason he asked was because of the time and labor that would be required to move materials and clean the area after delivery. He did not indicate that he considered the weight of the materials to be an issue.<sup>15</sup>

On the afternoon of 1 August 2007, preparation started for a pour of a 430-foot overlay on the southbound inside lanes. This procedure included the calculation and procurement of the materials needed for the works. It also included one fully loaded cement tanker while two additional tankers were positioned off the deck. According to the findings of the NTSB, the combined aggregate piles of materials consisting of sand and gravel were “centered longitudinally over the deck truss U10 nodes”.<sup>16</sup> In addition, a water tanker truck with 3000 gallons of water, a cement tanker, a concrete

<sup>12</sup>NTSB, 24.

<sup>13</sup>NTSB, 25.

<sup>14</sup>Ibid.

<sup>15</sup>Ibid.

<sup>16</sup>NTSB, 26.

mixer and several buggies for moving smaller amounts of materials were placed in the same area. According to the assessment of the NTSB the total estimated weight of parked construction vehicles, aggregates and materials positioned over the inner west side of the bridge center span just north of peer 6 and thus node U10 amounted to 578.735 pounds (263 metric tons).<sup>17</sup>

The NTSB made the placing of construction material a crucial focus of its investigation.<sup>18</sup> Its report pointed to the fact that the construction inspector on site was not in the position to decide whether or what kind of additional weight could be allowed to be placed on the deck of the bridge. Rather, the MnDOT's Standard Specifications for Construction made basic distinctions between the task and jurisdiction of the Project Engineer on the construction site and the construction inspector.<sup>19</sup> However, regardless of the fact that DOT supervision on the construction site was not performed by a project engineer and that placing the additional materials and aggregates and vehicles on the bridge deck was undoubtedly the immediate trigger of the collapse, post-accident analyses left no doubt that the added construction loads "were within operating limit capacities".<sup>20</sup> Lack of DOT oversight on the construction site or the additional weight placed on the bridge deck on 1 August 2007 prior to the collapse were thus not themselves responsible for the disaster. Rather it was an initial design error that made the bridge collapse under what under usual circumstances would have been a weight "within operating limit capacities" just in accordance with existing specifications of the American Association of State Highway and Transportation Officials (AASHTO), even when taken into account full vehicle traffic load on the four remaining lanes open to traffic during the relevant construction phase.<sup>21</sup>

As the NTSB found out, however, it was not the design error pertaining to the gusset plates alone from where the ultimate disaster originated but the fact that gusset plates had not been included in the prescribed procedure of load rating for each member (component) of a bridge. A fundamental part of that procedure is that the component with the lowest

<sup>17</sup>NTSB, 28.

<sup>18</sup>NTSB, 28–33.

<sup>19</sup>NTSB, 28–29.

<sup>20</sup>NTSB, 32.

<sup>21</sup>NTSB, 32.

load rating—the weakest point—had to be used to classify the entire structure.<sup>22</sup> However, MnDOT documentation did not contain information regarding the capacity of the gusset plates. Actually, no documentation whatsoever existed “to show which member was classified as the critical or controlling member of the bridge until 1995”.<sup>23</sup> MnDOT documentation turned out to be sketchy.<sup>24</sup> A Bridge Rating and Load Posting Report of 1995 did not include an evaluation of gusset plate capacity. According to the assessment of NTSB investigators, the 1995 report filed by MnDOT demonstrated MnDOT’s inability to determine “which portion of the bridge controlled the rating”—in other words, what component had the lowest load rating as a yardstick for determining the load rating of the entire bridge.<sup>25</sup> An independent testimonial report solicited by the NTSB investigators corroborated the fact that “no information on load rating of the truss portion of the [bridge] structure was found in the documentation supplied for any of the load ratings conducted [by MnDOT]”.<sup>26</sup>

So, in a way, the entire MnDOT inspection system was blindfolded as far as the I-35 W Bridge was concerned. It is even more remarkable that, regardless of the in-existent gusset plate inspection, the inspections that did take place throughout the 40 years history of the bridge resulted in poor ratings from 1991 on. The relevant regulation to be applied were the National Bridge Inspection Standards pertaining to the deck, superstructure and substructure of a bridge. Inspections according to these standards result in a sufficiency rating and the definition of a “status”. The assigned status has a double function though. It is both an indicator for the general condition of a bridge and for the eligibility for Federal bridge replacement and rehabilitation funding. The sufficiency rating is conducted according to a scale ranging from 9, “excellent condition”, to 0, “failed condition”. A rating of 4 (poor condition) or less implies the status of “structurally deficient” and, at the same time, eligibility for Federal rehabilitation funding.

Since 1991, the I-35 W Bridge had been classified “structurally deficient”.<sup>27</sup> However, the NTSB report underlined that “according to

<sup>22</sup>NTSB, 34.

<sup>23</sup>Ibid.

<sup>24</sup>NTSB, 39–40.

<sup>25</sup>NTSB, 40.

<sup>26</sup>NTSB, 42. The testimonial assessment was delivered by the FHWA Turner-Fairbank Highway Research Center on 30 June 2008.

<sup>27</sup>NTSB, 48.

the FHWA [Federal Highway Administration] a status of *Structurally Deficient* does not indicate that a bridge is unsafe but only that the structure is in need of maintenance, repair, or eventual rehabilitation.”<sup>28</sup> In 2008, no less than 72,500 or 12% of the 600,000 bridges registered the US National Bridge Inventory were rated “structurally deficient”. The total number of roughly 600,000 bridges necessarily entailed and entails every type of bridge regardless of size and type of construction. Steel truss bridges such as the I-35 W Mississippi River Bridge were typically large bridges of which 465 existed in the United States back in 2008. Of those 465 steel truss bridges registered in the National Bridge Inventory, however, 145 or 31% were rated “structurally deficient” in 2008.<sup>29</sup>

Under the given conditions, a critical juncture was reached when a regularly scheduled inspection was conducted by the MnDOT in June 2006. Again, MnDOT inspectors assigned a rating of 4 (poor) to the bridge superstructure. The main findings pertained to “the ‘Fracture Critical’ configuration of the main river spans and the problematic ‘crossbeam’ details, and fatigue cracking in the approach spans,” and concluded that the “eventual replacement of the entire structure would be preferable”.<sup>30</sup> This inspection report also referred to the critical condition of a number of gusset plates, even adding a photograph of the inside of one gusset plate, the one at the L11E node—i.e., node 11 at the east side of the lower chord of the main trusses—and mentioned specifically “pitting”—i.e., localized corrosion creating holes in the metal—“inside gusset plate connection at L11 toward L10”.<sup>31</sup>

Unmistakable or even alarming as this inspection report should have been, it nonetheless remained below the radar of MnDOT. One reason was that the inspection reporting system was split into two different branches. There were annual inspection reports prepared for all bridges in

<sup>28</sup> Ibid.

<sup>29</sup> Ibid.—FHWA language is not always intuitively comprehensible when it comes to status definition. Beyond the status “structurally deficient” there is the status “functionally obsolete”, which, however, does not indicate that the structure of the respective bridge is not sound and safe. Rather, this classification applies to bridges with substandard geometric features such as narrow lanes, narrow shoulders or inadequate vertical under-clearance of bridges or tunnels. This, for instance, may also be the consequence of changing regulation. In this sense about 79,800 or 13% of the bridges registered in the National Bridge Inventory were classified “functionally obsolete” in 2008.

<sup>30</sup> MnDOT report of June 2006 as quoted in NTSB, 52.

<sup>31</sup> Ibid.

the state of Minnesota and fracture-critical inspection reports prepared only for bridges considered to be fracture-critical indeed. The inspection report of June 2006 was in fact a “Fracture-critical Bridge Inspection In-Depth Report” and therefore not part of the annual report. The annual reports were much shorter and less detailed than the fracture-critical inspection reports, usually four to six pages in length.<sup>32</sup> The fracture-critical inspection reports, by contrast, were required to contain detailed narrative reports, sketches and photographs.<sup>33</sup> While crucial information in the annual inspection reports was primarily based on numbers and indicators easy to glance over, information in the fracture-critical inspection report was necessarily narrative in style and complex in substance. As the investigative report of the GPM law firm, commissioned by the Minnesota Legislature, stated, “the flow of information regarding the condition and safety of the bridge was informal and incomplete” within the MnDOT.<sup>34</sup> According to GPM’s Investigative Report, MnDOT at the time operated “largely as an oral culture” and it was, not surprisingly, highly compartmentalized.<sup>35</sup> As a result, “important information did not always reach consultants or the appropriate parties within MnDOT”<sup>36</sup>

Still, the critical condition of the gusset plates could have been detected in the course of the regular inspections of the bridge but certainly in the course of the fracture-critical inspections.<sup>37</sup> The report commissioned by the Minnesota Legislature described the sloppiness with which, instead, MnDOT bridge inspections were carried out, “resulting in the same comments often appearing in reports from year to year”.<sup>38</sup> This kind of superficial routine also applied to the inspection of the gusset plates. MnDOT’s 1994 fractural critical report noted: “Section loss at gusset plate, bottom chord, truss #2.”<sup>39</sup> However, the GPM report continues, “the report [of the MnDOT fracture-critical inspection] does not quantify the amount of section loss observed as required by MnDOT’s policies. The same

<sup>32</sup> GPM, 18.

<sup>33</sup> GPM, 19.

<sup>34</sup> GPM, 31.

<sup>35</sup> Ibid.

<sup>36</sup> Ibid.

<sup>37</sup> Which was stated by the NTSB in its report. Cf. NTSB, 142.

<sup>38</sup> GPM, 35.

<sup>39</sup> GPM, 35, quoting 1994 Annual Fracture-critical Bridge Inspection Report for bridge No. 9340, p. 4, app. Vol. IV tab 161.

notation is found in fraction critical inspection reports in subsequent years.”<sup>40</sup> GPM investigators did not conceal their astonishment either that visual evidence in the form of pictures was not updated so that, for instance, the 2006 fracture-critical inspection report included pictures that were taken in 2004.<sup>41</sup> Put another way: MnDOT applied red tape technique where it was least appropriate, namely when it came to the inspection of components that were key to the stability and safety of the steel truss structure of the bridge.

Yet, it would be misleading to assume that MnDOT was over-bureaucratized. What characterized the attitude of MnDOT officials was rather red tape combined with sloppiness. So one core ingredient of true bureaucracy in the classic sense was missing which is professionalism. To some extent, the organizational culture within MnDOT was even distinctly un-bureaucratic. The GPM report repeatedly referred to the “oral culture that exists within MnDOT” so that, accordingly, “decisions regarding maintenance were often communicated verbally, with sparse documentation reflecting that decision-making”.<sup>42</sup> So, on the one hand, MnDOT was over-bureaucratized, on the other hand it was not bureaucratic enough. Standard operating procedures and protocol were applied where case by case inspections would have been indispensable while documentation did not take place where it should have been a matter of routine.

### 3.2.3 *Compromising at the Expense of Safety*

The Fracture-critical Inspection Report of June 2006 was the closest thing to a full scale in-depth inspection of the I-35 W Bridge that, under regular circumstances, should have raised focused attention on the gusset plates as a structural risk zone. As the investigations of both the NTSB and the GPM revealed, the condition of the gusset plates had not been addressed in previous inspection reports, neither in the annual reports nor in the fracture-critical inspection reports or in a special Fatigue Assessment of the I-35 W Bridge conducted by the Department of Civil Engineering of the University of Minnesota in 1999.<sup>43</sup> An additional fatigue evaluation conducted by a private contractor, the URS Corporation of Minneapolis

<sup>40</sup> Ibid., same original source.

<sup>41</sup> GPM, 39.

<sup>42</sup> GPM, 42. Similar remarks were made on pp. 31 and 82.

<sup>43</sup> NTSB, 57.

under contract to MnDOT in June 2003, did mention the gusset plates but only in stating that and why the corporation had not included them into its own calculations and assessments “because of the complexities and uncertainties in possible failure sections of the gusset plates and in [the] ultimate capacities of [their] rivets and bolts”.<sup>44</sup>

URS as a Minneapolis-based consultant firm was continuously employed by MnDOT throughout the years prior to the collapse of I-35 W.<sup>45</sup> Communication about the potential fragility of the connecting components of the truss members went actually back and forth. Moreover, the necessity of retrofit of the main truss members of the bridge was basically undisputed while the appropriate method was subject to further discussions. In January 2007, URS recommended to retrofit all 52 fracture-critical truss members through steel plates on both sides of the respective box members using high-strength bolts.<sup>46</sup> MnDOT had started the retrofit planning in July 2006. Still, the method to be applied was disputed among MnDOT staff members some of whom were concerned that installing all the steel plates on the critical box members of the steel truss according to the recommendations of URS could have counterproductive effects. The critics were quoted in the NTSB report as being concerned whether “drilling all those holes in the truss box members and terminating the plates at the gusset won’t somehow make things worse”.<sup>47</sup> As an alternative, a monitoring system was considered, based on sensors designed to detect cracks on the critical members of the steel truss.<sup>48</sup> Discussions with URS about the matter followed as a result of which URS, in January 2007, came up with a summary that entailed two basic alternatives, one referring to the initial recommendation to stabilize all existing 52 fracture-critical truss members through steel plates and an alternative one referring to a two-step procedure consisting of an initial non-destructive examination of the fracture-critical truss members and, subsequently, the removal of all measurable defects.<sup>49</sup> MnDOT decided to perform “ultrasonic nondestructive examination” of, however, only a limited number of truss members located in the south portion of the deck truss.<sup>50</sup> This was meant

<sup>44</sup> URS assessment as quoted in NTSB, 59.

<sup>45</sup> GPM, 50, 58–63; NTSB, 58–61.

<sup>46</sup> NTSB, 59.

<sup>47</sup> NTSB, 59–60.

<sup>48</sup> NTSB, 60.

<sup>49</sup> NTSB, 60.

<sup>50</sup> Ibid.



to be a test phase so that the decision whether or not to perform the actual plating retrofit was made dependent on whether or not “inspectors had confidence in the visual inspection and ultrasonic test results”.<sup>51</sup>

So, in sum, the intense interaction between MnDOT and URS resulted in a sort of compromise. URS knew or at least became aware after submission of the initial recommendation to entirely retrofit the fracture-critical truss members that MnDOT was reluctant to accept that idea and, subsequently, came up with a recommendation that combined the “radical” and the “moderate” method of improving the conditions of the elementary steel parts of the truss structure. MnDOT, in turn, did not entirely rule out the “radical” method of the plating retrofit but preferred to wait for the results of the “nondestructive examination” in the form of ultrasonic measurement. In March 2007, this was laid down in a contract between MnDOT and URS.<sup>52</sup> The contract itself did not only reflect the continuity of the cooperation between MnDOT and URS but also the mutual benefit of both parties. After all, the compromise kept URS in business while MnDOT was enabled to stretch the costs of renovation over several fiscal years.<sup>53</sup>

According to the contract of March 2007, the envisaged in-depth non-destructive inspections were performed by MnDOT teams on the basis of what URS had identified as critical structural members of the steel truss of the bridge. This was meant to be the first sequence of the inspection focusing on 26 members of interest on the west truss and a number of members on the south end of the east truss.<sup>54</sup> The NTSB report summarized:

In May 2007, Mn/DOT inspection teams performed in-depth and nondestructive inspections of half the critical structural members identified by URS. The inspections focused on all 26 members of interest on the west truss and several members on the south end of the east truss. Field notes and photographs from those inspections did not indicate the presence of any significant cracks in those members. A meeting was scheduled between URS and Mn/DOT for August 20, 2007, to discuss the results of the inspections

<sup>51</sup> Ibid.

<sup>52</sup> Ibid.

<sup>53</sup> GPM’s Investigative Report of May 2008, while emphasizing that the investigation did not explore MnDOT’s policy of selecting and retaining outside consultants and contractors and related conflicts of interest, did consider the extent to which financial considerations “may have adversely influenced decision-making”. Cf. GPM, 30. See also *infra*.

<sup>54</sup> NTSB, 61.

to date and determine whether to continue the inspections or to proceed with retrofit. This meeting was cancelled because of the collapse of the bridge on August 1.<sup>55</sup>

### 3.2.4 *Insufficient Reporting, Negligent Monitoring*

One cannot take for granted that the collapse of the I-35 W Bridge would not have occurred if only the Minnesota Department of Transportation had followed the initial recommendations of URS of January 2007 to retrofit through steel plating all 52 identified fracture-critical truss members. Certainly, such retrofit would have provided so-called member redundancy to each of the identified fracture-critical members via additional plates bolted to the existing webs. But URS itself had pointed to the fact that “the critical issue of this approach is to ensure that no new defects are introduced to the existing web plates through the drilled holes” as well as to the unfavorable ratio between “relatively high cost” of this procedure that “may not be justified by the actual levels of stresses the structure experiences” under such conditions.<sup>56</sup> Yet it is undeniable that accepting URS’ initial “radical” approach to the renovation would have increased the likelihood to discover damaged gusset plates and to replace them.

This assumption is supported by the fact that previous evidence of definitely damaged gusset plates had not been documented, let alone acknowledged by MnDOT. The evidence was available since 2003 in the form of photographs taken by URS experts from, according to the NTSB report, “almost every structural element of the I-35W bridge”.<sup>57</sup> Similar photographs had already been taken in 1999 by researchers of the University of Minnesota in the attempt “to document the placement of strain gauges on truss members near the U10 nodes”.<sup>58</sup> While, according to MnDOT statements, the photographs taken by the University of Minnesota were not transmitted to the agency, a set of no less than 225 photographs taken by URS experts was made available to MnDOT. In that set, however, the prints were reduced to 2 × 1.5 inches size, on average six to a page of the URS inspectional report.<sup>59</sup> Nonetheless, on individual photographs from both the University of Minnesota evaluation of 1999 and the URS study

<sup>55</sup> Ibid.

<sup>56</sup> URS executive summary of January 2007 as quoted in NTSB, 60.

<sup>57</sup> NTSB, 61.

<sup>58</sup> Ibid.

<sup>59</sup> Ibid.

of 2003 bowing in all four gusset plates at the two U10 nodes was visible when the pictures were reviewed by NTSB investigators after the collapse of the I35W Bridge. The same phenomenon was recognizable at the counterpart, the U10' node on the north half of the bridge.<sup>60</sup> The NTSB report stated that “the U10 and U10' gusset plates were the only plates on the bridge for which the photographs showed obvious evidence of bowing.”<sup>61</sup>

If the irregular condition of the U10 gusset plates would have been brought to the attention of MnDOT this would have at least been taken into account four years after the two evaluations by the University of Minnesota and URS when, in early 2007, the question came up in discussions between MnDOT and URS how to proceed with the renovation of the fracture-critical members of the steel truss of the I-35 W Bridge. However, “neither the University of Minnesota nor URS evaluations made note of the bowed condition of the gusset plates.”<sup>62</sup> The irregular condition of these fractured critical parts of the steel truss was just not taken seriously and, accordingly, not brought to the attention of MnDOT either. Without special notice, however, the probability that MnDOT officials would recognize the bowed gusset plates at nodes 10 and 10' on a couple of pictures out of a series of more than 200 photographs of little more than post stamp size was virtually zero. Which, however, only underlines how consequential it was to forego the steel plating of all 52 fracture-critical truss members earmarked to be retrofitted by URS in a draft report to MnDOT in July 2006.<sup>63</sup> Retrofitting the gusset plates at the nodes U10 and U10' would have been part of the renovation initially suggested by URS. It was at these nodes just north of pier 6 and just south of pier 7 that the center part of the bridge span started to disintegrate on 1 August 2007, 6:05 PM and broke away from the rest of the deck truss structure.<sup>64</sup>

### 3.2.5 *Corporate Prestige and Misplaced Trust*

The NTSB investigation revealed that a series of nodes of the steel truss at both the upper and the lower chord had gusset plates with inadequate

<sup>60</sup> Ibid.—The two U10 nodes were located at the upper chord (thus “U”) at the south part of the bridge at the east and the west side.

<sup>61</sup> Ibid.

<sup>62</sup> NTSB, 63.

<sup>63</sup> NTSB, 59–60.

<sup>64</sup> NTSB, 64.

capacity which “most significantly” affected the U4+U4’, U10+U10’ and L11+L11’ nodes.<sup>65</sup> That assessment was not based on documented calculations of the designers Sverdrup & Parcel since no such documentation could be located. Some parallels to the West Gate Bridge case of the previous chapter and the Bad Reichenhall case of the last chapter are striking. Sverdrup & Parcel was one of the most respected engineering companies of the United States specialized in bridge construction. Just like Freeman, Fox and Partners, the consultancy company responsible for the design of the West Gate Bridge in Melbourne, Sverdrup & Parcel had an impressive track record of spectacular bridge constructions including prestigious projects like the Amelia Earhart Bridge in Kansas and the “Bridge of the Americas” across the Panama Canal. The fact that the calculations of the steel truss bridge design was flawed and had remained partly undocumented was probably beyond the imagination of officials in charge at the MnDOT and, basically, everybody else—a situation similar to the one in Bad Reichenhall where no documented structural analysis of the roof of an ice skating rink could be found after the collapse of the roof in January 2006.

The post-collapse recalculation of the truss design conducted under the auspices of the NTSB revealed that due to insufficient thickness the gusset plates at the nodes U4, U10 and L11 had been “substantially underdesigned”.<sup>66</sup> The NTSB report maintained that such “basic and very serious design error” and the fact that “additional nodes had gusset plates with inappropriate thicknesses” indicated that the error must have been systematic in nature.<sup>67</sup> NTSB investigators also mobilized evidence that Sverdrup & Parcel engineers did know how to properly apply calculations for the type of steel truss designed for the I-35 W Bridge since the same type of bridge had been engineered by the firm in Venezuela whose construction was properly documented.<sup>68</sup> The NTSB therefore came to the conclusion that none of the main truss gusset plates had been designed correctly “because the appropriate calculations were simply not made for these design elements”.<sup>69</sup> It remained the plain fact, however, that none of MnDOT’s own engineers had realized that these basic calculations were missing. At the same time it would have been Sverdrup & Parcel’s prime

<sup>65</sup>NTSB, 130.

<sup>66</sup>Ibid.

<sup>67</sup>Ibid.

<sup>68</sup>Ibid.

<sup>69</sup>Ibid.

responsibility to conduct an appropriate design review process. Design quality control did take place but, according to NTSB findings, it “was inadequate in that it did not detect and correct the error in design of the gusset plates at the U4(?), U10(?), and L11(?) nodes before the plans [of the design] were made final”.<sup>70</sup> This, too, would have had to be supervised by MnDOT.

As a matter of fact, neither the Minnesota Department of Transportation nor the US Federal Highway Administration “detected the failure to perform the appropriate design calculations for the gusset plates in the main trusses” of the I-35 W Bridge. The NTSB, in its report, made no effort to conceal its own surprise about this omission since both authorities were not only “closely involved in some aspects of the design process for the I-35W bridge”<sup>71</sup> but also did intervene very specifically with regard to critical components of the steel truss design of the bridge. And Sverdrup & Parcel, according to all evidence, always reacted promptly and “changed the design to address these concerns”.<sup>72</sup> The problem was, according to NTSB findings, that neither MnDOT nor FHWA “evaluated the design of the gusset plates for the I-35W bridge in sufficient detail during the design and acceptance process to detect the design errors in the plates, nor was it standard practice for them to do so”.<sup>73</sup>

The absence of design calculations for the gusset plates implied that load ratings for the I-35 W Bridge could not be properly conducted either. The first load rating for the bridge was only performed in 1979 anyway, twelve years after the bridge was put into service. Which was, however, at that time in accordance with the relevant guidelines of the American Association of State Highway and Transportation Officials (AASHTO). The NTSB stated: “Had a load rating been performed before the bridge was opened, and had it included an evaluation of the connections (gusset plates), the design error might have been detected, and this accident [the one of 1 August 2007] would not have occurred.”<sup>74</sup> Moreover: “Had gusset plates been included in the 1979 and 1997 load rating analyses of the I-35W bridge, Mn/DOT might have determined that the gusset plates at U10 and L11 were in fact the weakest points of the bridge”.<sup>75</sup>

<sup>70</sup>NTSB, 131.

<sup>71</sup>NTSB, 132.

<sup>72</sup>Ibid.

<sup>73</sup>Ibid.

<sup>74</sup>NTSB, 133.

<sup>75</sup>NTSB, 134.

### 3.2.6 *Intended Ignorance*

What, in a nutshell, characterized MnDOT's attitude toward the I-35 W Bridge was intended ignorance.<sup>76</sup> If the authority would have known what it was supposed to know it would have been forced to initiate costly action. GPM's evaluation of MnDOT staff Meeting Minutes revealed that the I-35 W Bridge had been identified, at least from early 2004 on, as one of the "budget buster" bridges in need of substantial and therefore expensive "replacement or renovation in the next 10 years".<sup>77</sup> The fact that "as a major fracture critical bridge, the renovation or replacement of the I-35W Bridge presented a daunting financial challenge ... was fully acknowledged in a February 8, 2005, Report for Commissioner's Staff Meeting where it was noted that 'major fracture critical bridge projects continue to be postponed due to funding'."<sup>78</sup> Intensive discussions about the scale and scope of necessary renovations did take place in 2006 but they focused on the bridge deck rather than on the steel truss, let alone the gusset plates.<sup>79</sup> The replacement of the entire bridge as a long-term project was also under consideration but it was "immediately ruled out" since the estimated \$75 million or more were diagnosed as "cost prohibitive."<sup>80</sup> MnDOT staff engineers, however, were also clearly aware of the fact that in the absence of substantial renovation or replacement the bridge might have to be closed for safety reasons and that the high cost of a then indispensable replacement would "result in delaying many other projects" due to the existing budget constraints.<sup>81</sup>

Even within the narrow angle of attention meanwhile focusing solely on the condition of the bridge deck there were two alternative proceedings, the redecking option and the overlay option. The redecking option—replacing the weary old deck by an entirely new one—promised to yield more redundancy, thus stability, to the bridge<sup>82</sup> but it was also considerably more costly—\$13 million as opposed to \$3.5 million for just renovating the deck overlay of the bridge. Since the \$13 million were not available

<sup>76</sup> Cf. Wolfgang Seibel: Successful Failure. An Alternative View on Organizational Coping. *American Behavioral Scientist* 39 (1994): 1011–1024.

<sup>77</sup> GPM, 64, quoting a Report for Commissioner's Staff Meeting of 5 April 2004.

<sup>78</sup> GPM, 64, quoting a Report for Commissioner's Staff Meeting of MnDOT of 8 February 2005.

<sup>79</sup> GPM, 65–67.

<sup>80</sup> GPM, 69, quoting the Minutes of a MnDOT Meeting of 3 April 2006.

<sup>81</sup> *Ibid.*, quoting the Minutes of the MnDOT meeting of 3 April 2006.

<sup>82</sup> GPM, 69.

in the budget as opposed to the just \$3.5 million for the overlay option the recommendation by URS rather to replace the bridge deck than to repair it fell on deaf ears.<sup>83</sup> GPM, in its report, concluded: “Unfortunately, funding considerations deferred work on the Bridge that would have improved its structural integrity, not just maintain its drivability.”<sup>84</sup>

It was in the course of those overlay works devoted to the renovation of the bridge deck that the bridge collapsed on 1 August 2007. Not only was a “potential unbalancing of the Bridge ... not taken into account in the design of the 2007 Overlay Project” but the critical condition of the gusset plates at several sections of the steel truss of the bridge had remained entirely unknown to MnDOT staff engineers—despite photo documentation in the relevant MnDOT files. As a consequence, no particular precautions were taken when a great amount of additional weight in the form of cement, other construction material and equipment was placed on the deck of the bridge in preparation of the overlay project.<sup>85</sup> Where to place the construction material, let alone the nature and quality, was never discussed between MnDOT and the contractor in charge, Progressive Contractors Inc. (PCI).<sup>86</sup> What is more, those who did have indispensable knowledge about the steel truss of the bridge and its weak points, URS and MnDOT’s Office of Bridges and Structures (OBS or just “Central Bridge”), did not participate in the meetings with the contractors and others involved in the overlay project. Central Bridge staff were invited but did not attend while URS was not involved at all.<sup>87</sup>

### 3.3 CASE ANALYSIS

#### 3.3.1 *Turning Points and Critical Junctures*

Although the NTSB report continuously refers to the flawed structural engineering of the bridge’s steel truss simply as “design error” committed by the main contractor and consultant Sverdrup & Parcel, the report itself reveals that both the Minnesota Department of Transportation (MnDOT) and the Federal Highway Administration (FHWA) officials were

<sup>83</sup> GPM, 69.

<sup>84</sup> Ibid.

<sup>85</sup> GPM, 72.

<sup>86</sup> GPM, 72–73.

<sup>87</sup> GPM, 74.

constantly involved in the consecutive decisions concerning construction topics back in the 1960s. This pertained specifically to the type of steel to be used including direct instructions given by MnDOT and FHWA to Sverdrup & Parcel to replace specific types of steel in specific segments of the steel truss structure of the bridge.<sup>88</sup> So there was a close relationship between the authorities and the designers of the bridge. Yet, the fact that Sverdrup & Parcel did not perform the necessary calculations for the gusset plates of the steel truss structure and therefore had no basis for a sound assessment of the actual load capacity of the steel truss escaped the otherwise close scrutiny exerted by MnDOT and FHWA. This omission can be defined as the first critical juncture that strongly shaped the subsequent history of the bridge leading to its ultimate failure on 1 August 2007. Although the relevant decision making process stretched over almost two years, a marker is the day when the final design of the bridge was certified by Sverdrup & Parcel's registered professional engineer which happened on 4 March 1965.

With the certification of the design and the opening of the bridge in 1967 the faulty gusset plates became the proverbial unknown unknowns. Yet, no visible and undeniable opportunity to detect the hidden risk presented itself throughout decades despite continuous inspections of the bridge. This changed at the turn of the millennium when in the course of one of those inspections two series of pictures were taken in 1999 and 2003, the first by researchers from the University of Minnesota, the second by the contractor URS. They depicted virtually all the critical parts of the steel truss structure of the bridge including the connecting nodes kept together by the gusset plates. Although the URS pictures series was part of an entire report about an inspection conducted by the contractor they were not brought to the attention of MnDOT as the supervising authority in any particular way. Accordingly, MnDOT had no reason to pay attention to the details of more than 200 photographs printed in minuscule size, six on each page of the relevant folder. None of the photographs was inspected diligently enough to discover that they indeed depicted that several gusset plates were bowed in an irregular way. Neither the University of Minnesota nor URS, in their respective reports, mentioned the bowed condition of the gusset plates. So at least June 2003 when URS came up with its report can be marked as a turning point: The ignorance of both URS and MnDOT about the critical condition of the gusset plates was

<sup>88</sup>NTSB, 88–91.



accentuated since one of the rare opportunities to mobilize accurate knowledge about the conditions of the underdesigned gusset plates was missed.

Yet another window of opportunity opened, however, when regularly scheduled State inspection of the I-35 W Bridge was conducted in June 2006 that turned out to be the last inspection prior to the collapse on 1 August 2007. At this occasion, MnDOT inspectors assigned a general condition rating of 4 on a 0–9 scale which meant “poor”. What followed, was a protracted process of consultation between MnDOT and URS as the main contractor for renovation and repair. In an initial draft report submitted to MnDOT in July 2006, URS recommended to strengthen 20 out of the 52 so-called fracture-critical main truss members of the bridge and, after more thorough investigation, in January 2007 suggested to expand those retrofit measures to all 52 fracture-critical truss members. That would have included a “plating retrofit” pertaining to the gusset plates. MnDOT engineers were reluctant to accept URS’ recommendation based on a combination of engineering-related and financial considerations. Some MnDOT staff members were concerned that the repair which necessarily implied “drilling all those holes in the truss box members and terminating the plates at the gusset” could “somehow make things worse.”<sup>89</sup> It was also evident that a full retrofit according to URS’ recommendations would involve much higher costs than could be borne by MnDOT’s limited budget. The I-35 W Bridge had the reputation to be a “budget buster” anyway.<sup>90</sup>

In response to articulated or anticipated MnDOT objections, URS came up with a differentiated recommendation with several options one of which was the “non-destructive examination (NDE) and removal of all measurable defects at suspected weld details of all 52 fracture critical truss members.”<sup>91</sup> This was the method ultimately chosen. In addition, a renovation of the bridge deck was initiated which not only was less costly than a comprehensive retrofit pertaining to the truss members including gusset plates but also a more visible contribution to the improvement of the overall condition of the bridge. The tragedy was that the combination of delayed structural retrofit and the deck repair in the form of a new concrete overlay that involved the placement of much additional weight of

<sup>89</sup>NTSB, 59–60.

<sup>90</sup>GPM, 30–31, 63–69.

<sup>91</sup>NTSB, 60.

construction material and aggregates on the bridge deck was what triggered the disaster of 1 August 2007.

While the decision making process and related meetings stretched over several months starting with URS' first draft report it is safe to say that the critical juncture was reached in January 2007 when it was decided by MnDOT to perform "ultrasonic nondestructive examination of some of the members in the south portion of the deck truss"<sup>92</sup> instead of initiating as soon as possible a comprehensive retrofit of the 52 fracture-critical main truss members, including the gusset plates, as recommended by URS in the first place. That decision was the 'point of no return' beyond which the path to disaster became virtually irreversible (Fig. 3.1).

### 3.3.2 *Contributing Factors and Necessary Conditions*

Clearly, the necessary condition for the disaster to occur was the initial design error affecting the gusset plates and the fact that it remained undetected throughout the 40 years of the existence of the I-35 W Bridge. As we saw in the previous section, however, that error might have been detected if only MnDOT or its institutional predecessors would have been sufficiently attentive as far as the intricacies of the bridge design and the details of structural engineering were concerned. MnDOT's omission is especially undeniable since the authority was very diligent in taking care of minor details of the construction such as types of steel to be used and various consequences for the truss design. Nonetheless, the fact that the designers of Sverdrup & Parcel did not come up with specific calculations for the gusset plates stabilizing the nodes of the steel truss went unnoticed. There can be no reasonable doubt that sound calculations would have revealed that the gusset plates were, according to the wording in the NTSB report, "substantially underdesigned."<sup>93</sup>

There can be no reasonable doubt either that several opportunities to correct the initial error were missed. These omissions were, in turn, the cumulative effect of a series of contributing factors or permissive conditions and further necessary conditions that were ultimately jointly sufficient for the disastrous outcome to occur.

One set of contributing factors was a quite usual pattern of organizational fragmentation and, as a result, the loss of critical information. This

<sup>92</sup>NTSB, 60.

<sup>93</sup>NTSB, 130.

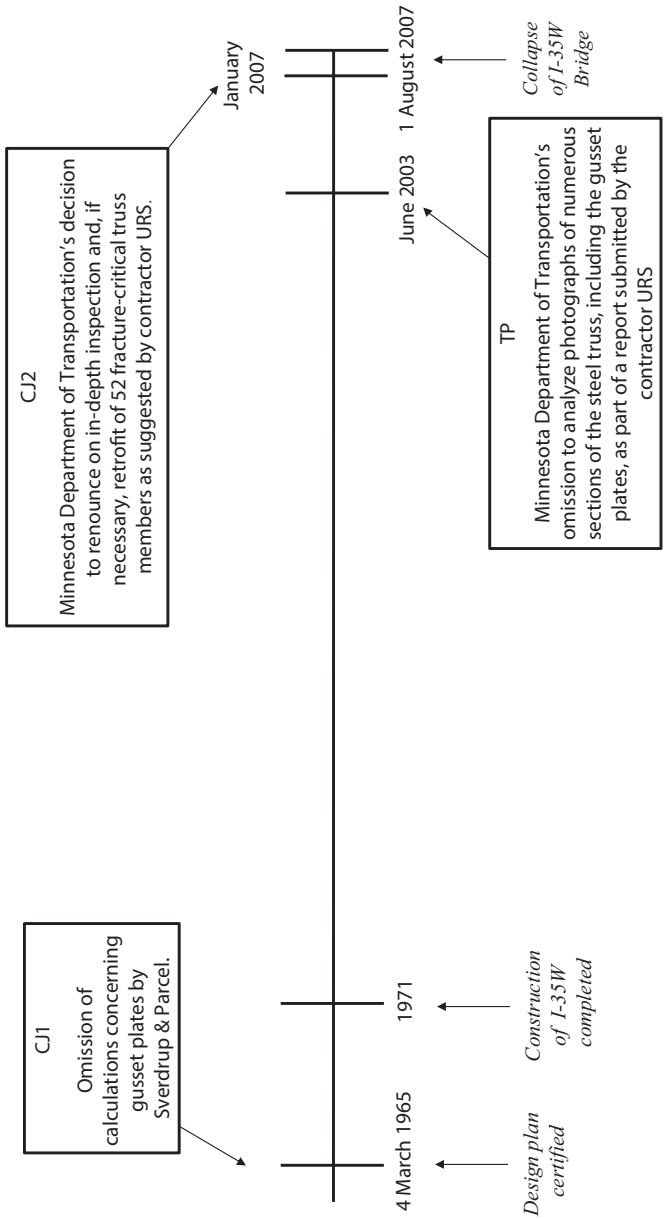


Fig. 3.1 Turning Points + Critical Junctures, collapse of I-35 Bridge

fragmentation was, on the one hand, not only usual but unavoidable due to the division of labor between private contractors and the public authorities in charge of supervision and control. What, on the other hand, aggravated the undesirable effects of that arrangement was that identifiable risk zones of insufficient information and a lack of cooperation remained unaddressed. Moreover, additional and unnecessary information asymmetries and coordination problems were created or tolerated. One was that inspections of the bridge, according to Federal Highway Administration standards, were conducted by “inspectors” who were not engineers nor trained in bridge inspections in any way. This not only implied that the “inspectors” had not the indispensable expertise for a sound assessment of the physical condition of the bridge but also that almost inevitably additional information gaps were created between the inspectors, project engineers in case of maintenance and repair and MnDOT officials ultimately responsible for safety issues. The undesirable effects of these conditions were intensified by an almost systematic lack of documentation to which the GPM report referred, somehow euphemistically, as “the oral culture” within MnDOT.<sup>94</sup>

These deficiencies were not mitigated by an implausible separation of two types of inspection, “fracture-critical inspection” as opposed to regular annual inspections. While the separation of two types of reports affecting the overall safety of the bridge was dubious in the first place, the two versions of reporting were different in nature and also part of different channels of communication. The annual inspection reports were relatively brief and focused primarily on numeric condition ratings with written comments. By contrast, the separate fracture-critical inspection reports focused in detail on fatigue prone areas, existing cracks in the steel truss and particular fracture-critical truss members, accompanied by a narrative report, sketches and photographs. The annual inspection reports were to be submitted to MnDOT Metro District Engineer and transmitted to the bridge management unit of MnDOT’s “Central Bridge” division. The fracture-critical inspection report was to be submitted to the same instances but to be reviewed by the Central Bridge Office Bridge Inspection Engineer. An integral perspective on the structural conditions of the bridge was thus contingent on the communication between two different segments of MnDOT.

These conditions inevitably weakened the influence of the more important type of reporting which was the fracture-critical inspection part. The consequences came to bear when the last fracture-critical inspection report

<sup>94</sup> GPM, 31, 42.

prior to the collapse had been submitted in June 2006 precisely at a time when MnDOT, in a series of consultations and meetings with the contractor URS, was preparing a decision about the scale and scope of the retrofit operations recommended by URS. A crucial statement in the fracture-critical inspection report about a section loss at a gusset plate of the lower chord of the steel truss and “pitting”—i.e., hole-generating corrosion—inside the gusset plate connection at node L11 remained therefore unaddressed in the deliberations about the dimension of the upcoming renovation.

Finally, a substantially constraining yet not decisive factor as far as MnDOT’s diligence and professionalism were concerned was the scarcity of financial resources. Significantly enough, the I-35 W Bridge was referred to in internal MnDOT jargon as a “budget buster”. Unfortunately, insufficient funds for renovation of Minnesota bridges impacted on the delay of a comprehensive structural retrofit of the fracture-critical members of the steel truss. This would have necessarily included the very gusset plates that in the post-collapse investigations turned out to be the decisively failing parts of the entire steel truss structure of the bridge.

Together with the initial necessary condition of an undetected design error these contributing factors constituted the permissive environment for two more necessary conditions to be fulfilled that turned out to be jointly sufficient for the disastrous outcome to occur. One was MnDOT’s decision of January 2007 not to perform the comprehensive retrofit of the fracture-critical truss members of the bridge, the other one the subsequent decision to renovate the bridge deck through applying a new concrete overlay. These two decisions were causally interactive in nature. Since the general need of redundant stability of the bridge was indeed undisputed a welcome side effect of the bridge deck renovation by way of a new concrete overlay was better protection against aggressive road chemicals in use, for instance for de-icing, that could react with the steel parts of the bridge.<sup>95</sup> This could, in turn, appear as a certain compensation for waving, for the time being, the retrofit of the fracture-critical truss members. The tragedy was that the very causal linkage had just the opposite effect. The under-designed gusset plates whose envisaged retrofit had been suspended cracked under the additional weight of construction vehicles, cementing equipment and further aggregates staged on the bridge deck in preparation of pouring the concrete overlay (Table 3.1).

<sup>95</sup>NTSB, 32.

**Table 3.1** Contributing Factors (CF) and Necessary Conditions (NC), collapse of I-35 W Bridge

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CF1	Insufficient information due to systematic lack of documentation and superficial performance of inspections.
CF2	Budget restraints of the Minnesota Department of Transportation.
NC1	Design error resulting in underdesigned gusset plates.
NC2	Minnesota Department of Transportation's decision to waive the in-depth inspection and, if necessary, retrofit of 52 fracture-critical truss members as suggested by contractor URS, January 2007.
NC3	Decision to renovate the bridge deck through applying a new concrete overlay.

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### 3.3.3 *Causal Mechanisms*

In terms of situational mechanisms that paved the way for risk increasing behavioral attitudes among key actors, the most influential factors were information asymmetries<sup>96</sup> and poor coordination as a consequence of uncompensated organizational fragmentation of supervisory bodies<sup>97</sup> and contractors in combination with serious budget constraints. Connected to this was what can be termed unbalanced bureaucracy<sup>98</sup>: Red tape routines prevailed where case-by-case scrutiny and in-depth diligence would have been appropriate while no routine existed for written documentation and ordinary file keeping.

Some of these deficiencies were the consequence of inevitable division of labor and separated responsibilities between public and private actors or the differentiation of jurisdiction within the realm of the Minnesota Department of Transportation, its Office of Bridges and Structures and the Federal Highway Administration. These organizational risk zones were unavoidable but both usual and manageable. Countervailing management did not take place though. So, unlike what conventional theory about information asymmetries and related principal-agent problems suggests, it was neither unwillingness nor exceeding costs of control that hampered or paralyzed appropriate managerial efforts. Rather, it was a lack of awareness and mindfulness that prevented MnDOT from achieving

<sup>96</sup>George A. Akerlof: The Market for "Lemons": Quality Uncertainty and the Market Mechanism. *Quarterly Journal of Economics* 84 (1970): 488–500.

<sup>97</sup>James D. Thompson: *Organizations in Action: Social Science Bases of Administrative Theory*. New York: McGraw-Hill 1967.

<sup>98</sup>Michael Crozier: *The Bureaucratic Phenomenon*. Chicago: University of Chicago Press 1964.

better coordination and an effective flow of information. The one thing MnDOT could not alter was the budget situation. Still, MnDOT leadership renounced on making the linkage of public spending and human safety an issue. It is here where situational mechanisms and transformational mechanisms overlap. Determination and resolve when it comes to defending the institutional mission is not likely to occur when risk prone conditions incentivize risk increasing behavioral attitudes in the first place.

Those attitudes did emerge in the form of action formation mechanisms. Three types can be identified. One was a phenomenon known as “normalization of deviance”<sup>99</sup> emerging out of intended ignorance<sup>100</sup>—individual or organizational behavior that deviates from rules and professional standards but, after a while, is taken for granted since people are getting used to it. This was clearly the case with the inspection regime under the auspices of MnDOT that, by its very nature with two separate and poorly coordinated types of inspection, created information gaps especially as far as the evaluation of the more sophisticated and detailed of the fracture-critical inspection reports were concerned. The most serious aspect of this counterproductive normalization was, however, that the lack of information about gusset plates as a critical component of the steel truss of the I-35 W Bridge remained unnoticed. The aggregate effect was an illusion of safety while the actual prerequisite of safety in the form of sound and reliable information about the structural condition of the bridge was missing.

The phenomenon of persisting illusions about the actual status of the bridge’s stability was reinforced by a standard pathology of bureaucratic organizations known as “goal displacement”<sup>101</sup>: Rules and routines initially designed to serve particular goals and purposes degenerate to an end in themselves. This is what characterized the inspection regime of MnDOT. It was dense, steady and, at first glance, rigid. As the reports of the NTSB and GPM revealed, however, inspection routines had replaced case-by-case scrutiny at the expense of the actual goal of thorough control and maintenance efforts so that even identified weaknesses of the steel

<sup>99</sup> Diane Vaughan: *The Dark Side of Organizations: Mistake, Misconduct, and Disaster*. *Annual Review of Sociology* 25 (1999): 271–305; Diane Vaughan: *The Challenger Launch Decision: Risky Technology, Culture and Deviance at NASA*. 2nd ed., Chicago and London: The University of Chicago Press 2016.

<sup>100</sup> Seibel: *Successful Failure*.

<sup>101</sup> Robert K. Merton: *Bureaucratic Structure and Personality*. *Social Forces* XVII (1940): 560–568.

truss of the I-35 W Bridge were just not taken seriously. Which decisively influenced MnDOT's decision of January 2007 to delay a comprehensive retrofit of steel truss members, including the very gusset plates whose under-designed dimension turned out to be the immediate cause of the ultimate collapse of the bridge.

A third action formation mechanism connected to the undesirable effects of bureaucratization was weak defense of institutional integrity.<sup>102</sup> Budget constraints to which MnDOT was exposed are a typical challenge to professional integrity anyway. In the case of the I-35 W Bridge this applied to both ends of the public-private partnership that necessarily is part and parcel of almost any type of public works. The critical period in the course of which this came to bear was when, as a result of the regular inspections in 2006, MnDOT started consultations with URS as the envisaged main contractor for unavoidable renovations. While URS engineers recommended a full-fledged retrofit of all 52 fracture-critical steel truss members of the bridge MnDOT was reluctant to accept that idea.

What emerged from this was a logic of negotiation and compromise in an area where compromises were least acceptable, namely the sound condition and safety of the bridge.<sup>103</sup> The characteristic problem was that both MnDOT and URS had specific incentives to make concessions at the expense of safety considerations. URS must have been keenly aware of MnDOT's limited discretionary leeway regarding cost intensive renovation and repair works. They came up with a more nuanced recommendation that entailed both the initially recommended comprehensive retrofit and, as an alternative, an initial phase of so-called non-destructive examination of the fracture-critical truss members as a kind of wait-and-see approach. Not surprisingly, this second and less costly option was preferred by MnDOT—*nota bene* in the absence of information about the actual condition of the most vulnerable fracture-critical truss members, i.e. the gusset plates. While it is a plausible assumption that in the presence of such knowledge MnDOT's preference would have been different, one might also argue that it should have been different under any circumstances. After all, this was about "safety first" in an almost classic sense.

<sup>102</sup> Philip Selznick: *Leadership in Administration. A Sociological Interpretation*. Berkeley and Los Angeles: University of California Press 1957: 119–133.

<sup>103</sup> cf. Paul R. Schulman: *The Negotiated Order of Organizational Reliability*. *Administration & Society* 25 (1993): 353–372, for a rather affirmative portrayal of negotiable reliability of organizations.



Discarding that principle in favor of making safety negotiable was thus *the* fundamental mistake committed by the MnDOT officials in charge.

Yet, there was no absolute path dependency. What came to bear on the final stretch of the way to disaster was MnDOT's incapability to re-integrate organizational segments and perspectives. In the essence, it was lack of coordination of an appropriate depth and sophistication.<sup>104</sup> And, to that extent, primarily a lack of mindful leadership.<sup>105</sup> The results of the 2006 inspections, the deliberation between MnDOT and URS during the subsequent months and the planning and preparation of the concrete overlay to be poured on the bridge deck were just not integrated into a comprehensive plan of control and oversight. As a consequence, neither the Office of Bridges and Structures (OBS or Central Bridge) nor URS as the contractor for the non-destructive examination of the steel truss components of the bridge were involved in the preparation and design of the overlay project whose execution finally triggered the collapse of the bridge on 1 August 2007.<sup>106</sup> It was them, however, who had the most intimate and extensive knowledge at their disposal necessary for keeping the load capacity of the bridge in balance. So much for the transformational mechanisms (Fig. 3.2).

From a normative point of view, it would have been desirable that the situational mechanisms of information asymmetry between poorly coordinated organizational segments would have been suspended or at least mitigated by a strong sense of institutional mission and related leadership as countervailing action formation mechanisms. However, if those countervailing forces could have been mobilized they probably would have been stopped or neutralized the emergence of poor coordination and information gaps in the first place. Likewise, efforts of reintegration of what otherwise was a fragmented structure of institutional jurisdiction and expertise would probably also have prevented goal displacement and normalization of deviance from emerging. Still, the interface between situational and action formation mechanisms and the threshold separating action formation mechanisms from transformational mechanisms as ultimate triggers of undesirable outcomes

<sup>104</sup> cf. James D. Thompson: *Organizations in Action: Social Science Bases of Administrative Theory*. New York: McGraw-Hill 1967, for a classic account.

<sup>105</sup> Carl J. Friedrich: *Public Policy and the Nature of Administrative Responsibility*. *Public Policy* 1(1) (1940): 1–20; Paul 't Hart and Lars Tummers: *Understanding Public Leadership*. 2nd ed., London: Red Globe Press 2019; Karl E. Weick and Kathleen M. Sutcliffe: *Managing the Unexpected: Resilient Performance in an Age of Uncertainty*. 2nd ed., Hoboken: John Wiley & Sons 2007.

<sup>106</sup> GPM, 74.

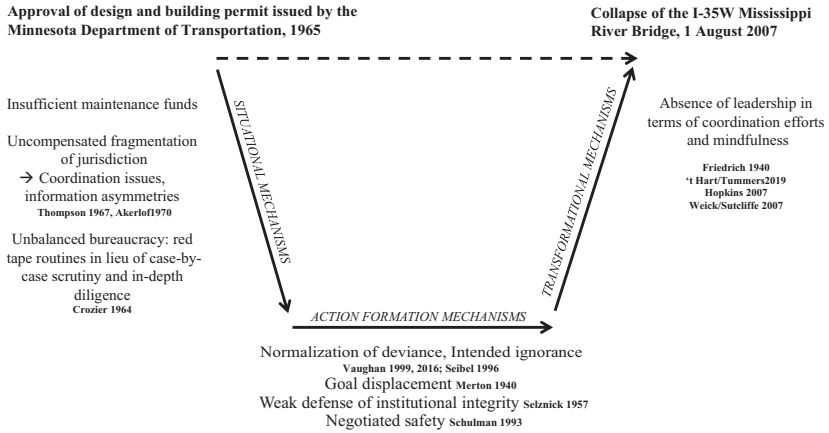


Fig. 3.2 Causal Mechanisms, collapse of I-35 W Bridge

mark the critical fault lines of potentially disastrous processes. To recognize those fault lines and to develop strategies and techniques to keep their undesirable effects under control is of pivotal importance when it comes to prevention. What the Mississippi River Bridge disaster reveals anew is how much depends on general risk awareness and a sense of responsibility when it comes to seemingly banal questions of public infrastructure. Just as Barry LePatner, author of “Too Big to Fall”,<sup>107</sup> noted:

It troubles me that the Federal government does not see this issue [of risk prone public infrastructure] the same as they see a crack in an engine on an airplane. It’s the same thing to me.<sup>108</sup>

It would be misleading though to attribute poor conditions of public infrastructure for which the failure of the Mississippi River bridge is exemplary to insufficient public funding alone. As this case analysis reveals, falsely focused attention and a misplaced logic of negotiation aggravated the impact of what certainly were unfavorable maintenance conditions in the first place. The fact that serious design errors had remained undetected

<sup>107</sup>Barry B. LePatner: Too Big to Fall. America’s Failing Infrastructure and the Way Forward. Libanon (New Hampshire): University Press of New England 2010.

<sup>108</sup>New York Times Retro Report, 3 August 2014, “When a bridge falls: Disaster in Minneapolis”.—<https://youtu.be/74JNl5n-YdI>, accessed 29 October 2020.

despite continuous inspections had nothing to do with scarcity of financial resources. In principle, the gusset plates were well known as critical and potentially vulnerable components of the bridge design. What is more, corrosion and irregular bowing of gusset plates had been documented even under the very eyes of the MnDOT.

It was, rather, the combination of unjustified trust and the illusion of safety combined with a logic of inappropriate compromises that created a toxic mixture of neglect at the expense of human safety. That the bridge design had been approved in 1965 on the basis of insufficient calculation and documentation was probably beyond the imagination of MnDOT officials and engineers. After all, the bridge had been designed by one of the most prestigious civil engineering consultants of the US, a firm of international reputation. Moreover, nobody within the MnDOT took care of prioritizing the different types of inspections and their results. Attention should have focused on the detailed reports of the fracture-critical inspections instead of on the brief and standardized reports of the annual inspections. Finally, a sound sense of professional integrity of both engineers and public officials should have restrained the logic of negotiation between MnDOT and its contractors, URS in particular, in the course of which improving the drivability of the bridge deck was prioritized over the in-depth inspection of the fracture-critical truss members, including the gusset plates whose failure triggered the disaster of 1 August 2007.

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## CHAPTER 4

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# Erosion of Professional Integrity: The Collapse of the Canterbury TV Building in Christchurch on 22 February 2011

### 4.1 CHARACTERISTICS OF THE CASE

Starting on 4 September 2010, a series of major earthquakes shattered New Zealand for more than one year. Four more significant earthquakes occurred on 25 December 2010, 22 February 2011, 13 June and 23 December 2011. The earthquake of 22 February 2011 was by far the most disastrous, claiming the lives of 185 people. Unlike the two previous earthquakes, the one of 22 February 2011 occurred in the middle of an urban agglomeration, Christchurch, the country's second largest city. Many buildings collapsed due to the earthquake with the magnitude of 6.2 on the Richter scale. The highest death tolls resulted from the collapse of two office buildings, the Canterbury Television (CTV) and the Pyne Gould Corporation (PGC) building. The collapse of the CTV building alone claimed the lives of 115 people or almost two-thirds of the total death toll. A Royal Commission was established on 11 April 2011 to inquire into building failure caused by the Canterbury earthquakes which submitted its reports in several portions starting on 29 June 2012. Volume 6 of the final report of the Royal Commission was devoted to the collapse of the Canterbury Television (CTV) building.<sup>1</sup> A separate investigation report was commissioned by the New Zealand Department of Building

<sup>1</sup> Canterbury Earthquake Royal Commission. Final Report. 7 Volumes. Wellington, 29 June 2012. Volume 6: Canterbury Television Building (CTV), henceforth quoted as Royal Commission Vol. 6, page number.

and Housing. That investigation was conducted by two engineering corporations, Hyland Fatigue and Earthquake Engineering (HCL) and Structure Smith Consulting Engineers (SSL).<sup>2</sup>

The results of both inquiries left no doubt that fundamental design errors due to incorrect calculations by the chief designer of the CTV building were the root cause of the collapse of 22 February 2011. Although, according to the relevant terms of reference, the Royal Commission did not inquire into any questions of liability it underlined that it did inquire into “errors or failings in design, permitting, construction, inspection or any other matter that might explain why the CTV building failed severely and why its failure caused such extensive injury and death”.<sup>3</sup> That included the failure of public authorities to supervise and to control properly the processes of designing, construction and inspection.

Accordingly, the report of the Royal Commission pertained to three main phases: The history of the CTV building before the first earthquake of 4 September 2010; the status and performance of the building in the September earthquake itself and in the subsequent earthquake of 25 December 2010; an assessment of the condition of the building after those two earthquakes and, finally, the collapse of 22 February 2011 and the immediate trigger factors.

In what follows, the emphasis is laid on the first two of those phases and on a part of the third phase as far as the assessment of the condition of the CTV building after the first earthquake of 4 September 2010 is concerned. It was primarily in the first two phases that public authorities failed to perform properly licensing, permitting and controlling the design, the construction and the overall safety of the CTV building. Unlike the report of the Royal Commission, the HCL & SSL report focused exclusively on structural engineering issues of the CTV building. It is nonetheless helpful for understanding particular intricacies of the relevant design errors and their consequences under the impact of the three earthquakes of 4 September and 25 December 2010 and the one of 22 February 2011 (Illustration 4.1).

<sup>2</sup>Clark Hyland and Ashley Smith: CTV building collapse investigation for Department of Building and Housing: 25 January 2012. Wellington, New Zealand: Department of Building and Housing, henceforth quoted as HCL & SSL Report, page number.

<sup>3</sup>Royal Commission Vol. 6, 38.



**Illustration 4.1** CTV Building Christchurch prior to its collapse on 22 February 2011. (Source: Royal Commission Vol. 6, p. 3)

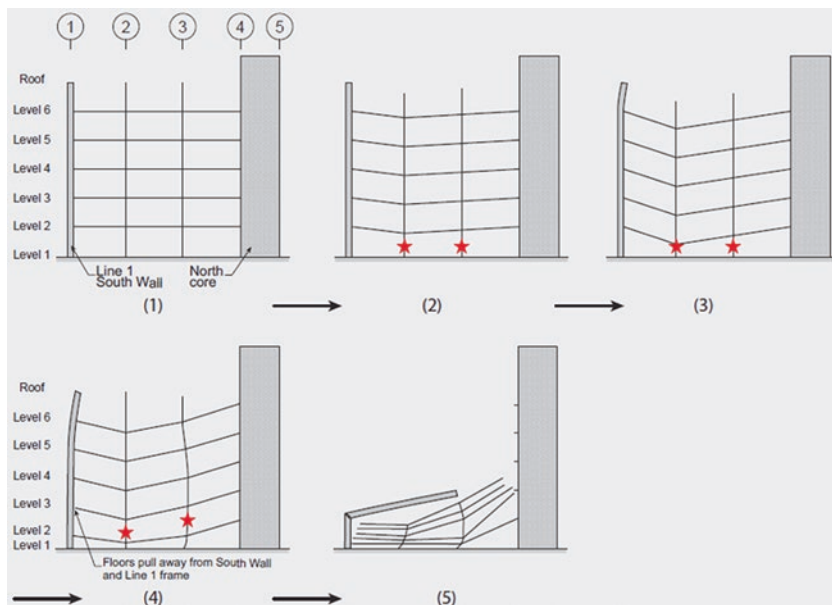
## 4.2 FACTS OF THE MATTER

The CTV building in downtown Christchurch was of modest height, comprising six stories. Part of the ground level or level 1 was an internal parking structure. The rest of level 1 and the entire level 2 was occupied by Canterbury Television (CTV), a community broadcasting station, hence the name of the building in colloquial language. Level 3 was left vacant. The tenant of level 4 was a private school named King's Education, mainly a language school for international students. On level 5 a medical center was accommodated after its previous domicile had been declared unsafe as a consequence of the earthquake of 25 December 2010. Part of level 6 was occupied by a family and relationship counseling institution named Relationship Services. Students of the language school on level 4 accounted for the majority of those killed on 22 February 2011.

The CTV building had to be designed in accordance with earthquake protection regulation and related professional standards. The building had two main seismic resisting elements, a particular complex or buffer zone at the north side of the building and a shear wall on the South of the building. Columns supported the floors while precast coupling beams connected the floors to the south shear wall and the north wall complex (Illustration 4.2).

Planning of what later became known as the CTV building started in 1986, initiated by the then owner of the premises, Prime West Corporation Ltd. On behalf of Prime West, William Construction Ltd. drafted a proposal to design and build a commercial building on the site in question. On behalf of William Construction Ltd., the architects Alun Wilkie Associates in corporation with Alan M. Reay Consulting Engineer (ARCE) assumed the task to carry out the architectural planning and the structural design of the building. Reay was characterized in the hearings of the Royal Commission as a "very prominent" and award-winning designer of impeccable reputation.<sup>4</sup> Immediately in charge of the structural design portion of these preparatory works though was David Harding who was employed by ARCE as an engineer. As the Royal Commission found out, Harding, in the process of calculating the structural design of the building, used a computer program at the University of Canterbury with which he was not familiar so that, according to the commission, "he was unaware of some of

<sup>4</sup>Royal Commission Vol. 6, 48.



**Illustration 4.2** Most likely collapse scenario of the CTV Building with disconnecting floors/diaphragms. (Source: Royal Commission Vol. 6, p. 236 (originally: C. Hyland C. A. Smith, CTV building collapse investigation for Department of Building and Housing: 25 January 2012. Wellington, New Zealand: Department of Building and Housing))

the program’s important limitations”.<sup>5</sup> Moreover, prior to assuming the task of developing the structural design of the future CTV building, Harding had never designed a multi-story building with characteristic design features relevant in the case of the CTV. He nonetheless “did not seek assistance with the design from Dr. Reay [the principal of ARCE] or anyone outside of ARCE”.<sup>6</sup> Alan Reay himself did not check or review any structural details for the building either. Based on the structural drawings of David Harding, the Christchurch City Council (CCC) granted the building permit on 30 September 1986.<sup>7</sup>

<sup>5</sup> Royal Commission Vol. 6, 302.

<sup>6</sup> Ibid.

<sup>7</sup> Royal Commission Vol. 6, 73.



As far as the phase of designing the building was concerned, the Royal Commission came to the following conclusion:

We have found that there were a number of noncompliant aspects of the CTV building design. We have concluded that a primary reason for this was that Mr Harding was working beyond his competence in designing this building. He should have recognized this himself, given that the requirements of the design took him well beyond his previous experience. We also consider that Dr Reay was aware of Mr Harding's lack of relevant experience and therefore should have realised that this design was pushing him beyond the limits of his competence. Dr Reay should not have left Mr Harding to work unsupervised on the design or without a system in place for reviewing the design, either by himself or someone else qualified to do so. The process led to a building design that was deficient in a number of important respects.<sup>8</sup>

#### 4.2.1 *Articulated Concerns and Misplaced Pragmatism*

At the Christchurch City Council, two engineers were concerned with the construction project and the processing the application for a building permit submitted by ARCE on 17 July 1986. One was Bryan Bluck, the responsible buildings engineer, the other one Graeme Tapper, his deputy.<sup>9</sup> Tapper who was in charge of reviewing the application for the building permit raised several concerns, both formal and substantive in nature, including missing calculations of the structural design. Although the Royal Commission could not entirely reanalyze whether or not ARCE responded to these demands, David Harding of ARCE did send further structural drawings and additional calculations to the CCC on 5 September 1986 and it was on 30 September 1986, after verification by Graeme Tapper, that the building permit was issued.<sup>10</sup>

As the Royal Commission found out, Mr. Tapper, through signing off on the structural design of the building on 10 September 1986, had approved the application for the building permit although his previous worries were not cleared. A crucial flaw of the structural design of the building indicated by himself in a letter to ARCE of 27 August 1986 had not been addressed in the additional drawings and calculations submitted by David Harding. Objections concerned the diaphragms at the ends of

<sup>8</sup> Royal Commission Vol. 6, 302.

<sup>9</sup> Royal Commission Vol. 6, 303.

<sup>10</sup> Royal Commission Vol. 6, 303.

the beams connecting of the floors to the north wall complex of the building which Tapper diagnosed as inadequate and non-compliant with the relevant regulation. The regulation was the CCC Building Bylaw 105 that adopted New Zealand Standards for the design of buildings to the local conditions.<sup>11</sup>

The fact of the matter was, however, that Graeme Tapper had been instructed to issue the permit for the building against his own professional judgment. That instruction came from Tapper's immediate superior, Bryan Bluck, the CCC's Chief Buildings Engineer. It also turned out that Bluck had been approached by Alan Reay, principal of ARCE, in person who, according to the findings of the Royal Commission, "convinced Mr Bluck that Mr Tapper's concerns were unfounded" whereupon "Mr Bluck instructed Mr Tapper to sign off on the design, despite his concerns".<sup>12</sup> The Royal Commission left no doubt that issuing the permit and the irregular behavior of Bryan Bluck made it possible to approve a design that was not in compliance with the relevant bylaw as it was valid and applicable at the time the permit was issued.<sup>13</sup>

It was most probably at the flawed diaphragms diagnosed correctly by Graeme Tapper that the structure of the CTV building started to disintegrate after the earthquake of 22 February 2011.<sup>14</sup> The Royal Commission found out that, unlike what was usual practice, the surface of the precast beam ends had remained unroughened so that the joints of the coupling beams were not tight enough.<sup>15</sup> One reason was that the roughening had not been envisaged in sufficient detail in the drawings of the design for which Harding was responsible. A second reason was that the roughening had not been performed on site as usual when the construction was under way.<sup>16</sup> It would have been the task of the construction manager to check on this which, however, did not happen.<sup>17</sup> At the time when the report of the Royal Commission was in the making, rumor spread that this manager had obtained a Bachelor of Engineering degree by fraud<sup>18</sup> which he

<sup>11</sup> Royal Commission Vol. 6, 73. The relevant standards were NZS 3101 of 1982 and NZS 4203 of 1984.

<sup>12</sup> Royal Commission Vol. 6, 73.

<sup>13</sup> Royal Commission Vol. 6, 73–74.

<sup>14</sup> HCL & SSL Report, 34–38.

<sup>15</sup> Royal Commission Vol. 6, 90; HCL & SSL Report, 182.

<sup>16</sup> Royal Commission Vol. 6, 90.

<sup>17</sup> Royal Commission Vol. 6, 91.

<sup>18</sup> Royal Commission Vol. 6, 96.

eventually admitted in the course of investigations by the Australian Federal Police.<sup>19</sup>

According to the findings of the Royal Commission, it was usual practice at the CCC, back in the 1980s, that applications for building permits were submitted and filed with architectural drawings only with structural drawings plus related calculations still to come. According to testimonial evidence before the Royal Commission this was typically the case when time was of the essence and contractors/consultants were eager to save time and to get the project moving through the CCC as quickly as possible.<sup>20</sup> This also was against the bylaw 105 according to which every application for a building to be permitted required the submission of complete information about “the exact nature and character of the proposed undertaking and the provision made for full compliance with the requirements of this bylaw”<sup>21</sup> to which necessarily belonged the essentials of the structural design of the building. The fact that filing and processing permit applications without complete sets of structural drawings was common practice at the CCC explains why Graeme Tapper as the CCC engineer in charge did not insist on the submission of the calculations he had asked for in the first place.

The Royal Commission stated in its report that, according to testimonial evidence, the mid-1980s was “a demanding period with a large volume of applications for building permits and a great deal of pressure”.<sup>22</sup> The general directive was “to get permits through and buildings up”.<sup>23</sup> One coping pattern developed under these conditions was that Bryan Bluck as CCC’s Chief Buildings Engineer sat down with the designer of a building and discussed issues of structural engineering in detail in meetings “sometimes lasting a whole day and usually ending with the designer completing a specifically worded design certificate”.<sup>24</sup> This was, on the one hand, a remarkable sign of flexibility and commitment on behalf of the CCC but, on the other hand, a temptation to make the enforcement of regulatory requirements negotiable at the expense of professional standards and, ultimately, CCC’s institutional integrity. Certainly, this practice was meant to be a sign of pragmatism and good will as far as the CCC was

<sup>19</sup> “Fake engineer found guilty,” *Engineers Australia*, 18 August 2014.

<sup>20</sup> Royal Commission Vol. 6, 75.

<sup>21</sup> *Ibid.*

<sup>22</sup> *Ibid.*

<sup>23</sup> A CCC official as quoted by the Royal Commission Vol. 6, 75.

<sup>24</sup> *Ibid.*

concerned and for the sake of efficient service delivery. It was obviously under these conditions and in accordance with a pragmatic attitude “to get things done” that CCC’s Chief Buildings Engineer Bryan Bluck instructed his second in command, Graeme Tapper, to issue the permit for the future CTV building after an extended conversation Bluck had held with Alan Reay of ARCE despite Tapper’s concerns about the floor diaphragms.

The Royal Commission, in its report, aptly characterized the chosen approach of the CCC and of Bryan Bluck as Chief Buildings Engineer as “pragmatic” but risk prone.<sup>25</sup> On the one hand, Bluck had authored internal guidelines for the structural checking process that encouraged CCC’s engineers to rely on the “recognized expertise” of a Professional Designer for the certification of the structural design of a building rather than to conduct the relevant checking in the form of complex and time-consuming calculations themselves. On the other hand, the same document made CCC engineers explicitly responsible for the verification of compliance with the building bylaw provisions and stated: “Do not amend the BPA [building permit applicant’s] drawings in any way (in order to expedite the permit process), as to do so could compromise the responsibility for the specific design which otherwise fully belongs to the Professional Designer.”<sup>26</sup> So, in the essence, these instructions were highly ambiguous. They reminded CCC engineers of their undeniable responsibility for the verification of an applicant’s strict compliance with the relevant legal provisions while at the same time encouraging them to delegate de facto that responsibility to a Professional Designer—in other words, a private firm—without specifying on whose behalf the designer would conduct his or her checking procedures. Regardless of their strict and explicit wording, Bluck’s guidelines rather distorted than clarified accountability. The consequences for the actual compliance with the provisions of the building bylaw were rather mildly circumscribed in the report of the Royal Commission in stating that this “approach [was] accompanied by some risks, including the risk that a non-complying would be approved” by the CCC.<sup>27</sup> The flipside of what the Commission appropriately denoted as a “pragmatic” arrangement was the convergence of counterproductive incentives on both ends, the CCC and a private Professional Designer, to expedite the structural checking process while implicitly maintaining the

<sup>25</sup> Royal Commission Vol. 6, 76.

<sup>26</sup> Ibid.

<sup>27</sup> Ibid.

option of blame shifting if need be. For instance, in case of ‘collateral damages’ of an accelerated checking process in the form of non-compliance with the existing legal provisions and resulting safety risks.

In the case of the CTV building these counterincentives were toxic. On both ends, the CCC and ARCE as the “Professional Designer”, professional competence and integrity was weakened. The critical assessment of the flawed diaphragms articulated by Graeme Tapper as CCC’s buildings engineer in charge was overruled by his superior Bryan Bluck. Bluck, according to his own guidelines, invested full trust in Dr. Alan Reay, the principal of ARCE, with whom he had an extended meeting prior to his decision passed down to Mr. Tapper to issue the construction permit. The true tragedy was that that trust was entirely unjustified. And although Alan Reay was necessarily unaware of the substantial deficiencies of ARCE’s expertise, Bryan Bluck was responsible for guidelines that implicitly encouraged CCC’s engineers to take the expertise of any Professional Designer for granted.

Yet the problem was not primarily the guidelines themselves but the fact that no provision had been made for their careful and case-by-case application. A mindful use of the guidelines should have made sure to conduct scrutiny of structural design issues to be performed solely by CCC engineers. The fact that Graeme Tapper as the CCC buildings engineer in charge had raised such doubts should have been reason enough to initiate a detailed review of the submitted application. Instead, Bryan Bluck as chief buildings engineer gave *carte blanche* to a private consultancy firm as Professional Designer despite the reluctance of CCC’s buildings engineer immediately responsible to issue the building permit.<sup>28</sup>

#### 4.2.2 *Delegation to Incompetent Personnel*

What was with necessity beyond the control of the CCC and thus of Buildings Engineer Tapper was the insufficient professional competence and experience of the immediately responsible ARCE engineer, David Harding. According to all evidence in hindsight, it was no coincidence that ARCE did not respond to Graeme Tapper’s request to furnish the city council with full documentation, especially calculations, about the critical

<sup>28</sup> Graeme Tapper’s request of 27 August 1986 for additional calculations and documentation addressed to ARCE to which ARCE never responded in detail is reproduced in the report of the Royal Commission Vol. 6, 77–78.

structural engineering components of the planned building. Harding was presumably just not capable to run those calculations. With ARCE not coming up with the requested documentation all alarm bells should have been ringing at the CCC. Instead, the building permit was issued without further ado.

The Royal Commission stated clearly that “Mr Harding was acting outside of his competence in designing the CTV building”.<sup>29</sup> Harding had no experience with multi-story building designs and no experience with the computer program which was the then current version of ETABS (Integrated Analysis, Design and Drafting of Building Systems). It turned out that Harding, instead of making his own calculations, whether by hand or computer-assisted, was just using the calculations made by his predecessor, John Henry, for a different building of the same type, known as Landsborough House.<sup>30</sup> Harding nonetheless remained unaware that Henry had revised the Landsborough House design and, as a consequence, had added additional reinforcements.

The Royal Commission did not only underline the lack of competence of Harding but especially his unwillingness to acknowledge these deficiencies and to ask for assistance.<sup>31</sup> The commission also emphasized, however, that it would have been Alan Reay’s obligation to verify if and to what extent David Harding was up to the job assigned to him.<sup>32</sup> In the hearings of the commission Reay, in turn, admitted that, back in 1986, he had trusted Mr. Harding’s self-assessment and that he took it for granted that otherwise David Harding would have approached him and asked for help. It was also evident that, on the one hand, Alan Reay had hired David Harding for a senior position because he trusted his ability while, on the other hand, Harding, assuming that position, presumably saw no easy way to admit that he was not entirely fit for the job.<sup>33</sup> One indicative argument of Alan Reay before the Royal Commission was that instead of closely supervising the work of Harding he “relied on the CCC to review the design during the permit process”.<sup>34</sup> Which only underlines the vicious circle of blame shifting in the relationship between ARCE and the CCC.

<sup>29</sup> Royal Commission Vol. 6, 65.

<sup>30</sup> Royal Commission Vol. 6, 67.

<sup>31</sup> Ibid.

<sup>32</sup> Royal Commission Vol. 6, 68.

<sup>33</sup> The Royal Commission alluded to this problem only implicitly. Cf. Vol. 6, 67, 71.

<sup>34</sup> Royal Commission Vol. 6, 70.

### 4.2.3 *Compromised Professional Integrity*

The application for the permit for the CTV building was formally filed by Alun Wilkie Associates, the actual contactor, on 17 July 1986.<sup>35</sup> It carried the handwritten note: “Structural Drawings to come”. The structural drawings themselves were received by CCC on 22 August 1986. A further set of structural drawings was submitted on 5 September 1986. As mentioned above, Graeme Tapper as the engineer in charge at the CCC signed off on the structural aspects of the design on 10 September 1986 despite his concerns about “a significant structural issue in the design, namely the connection of the floors (diaphragms) to the north wall complex”<sup>36</sup> which had not been amended by ARCE in the submitted design. The permit itself was issued on 30 September 1986 upon direct instruction by CCC’s chief buildings engineer Bryan Bluck.

According to the assessment of the Royal Commission, the calculations in support of the structural design of the building requested by Tapper on 27 August 1986 were never submitted by ARCE.<sup>37</sup> Testimonial evidence before the Royal Commission underlined that the personal relationship between David Tapper and his superior Bryan Bluck was difficult.<sup>38</sup> Tapper was described by staff members who had worked with him at the CCC as a “very thorough person” with “a good sense of the potential weak points” in a submitted structural design of a building and “little tolerance for consulting engineers who submitted poor details or incomplete work”.<sup>39</sup> Accordingly, the Royal Commission focused specifically on the very question why Tapper had signed off the plans submitted by ARCE in the form they were ultimately permitted by the CCC despite the deficiencies identified by himself.

It turned out in the hearings before the Royal Commission that it was, according to one testimony, “not uncommon for Alan Reay [the principal of ARCE] to go directly to Bryan Bluck [CCC’s chief buildings engineer] to obtain the release of a building consent when he could not get approval from Graeme Tapper”, a characterization that Alan Reay himself denied

<sup>35</sup> A facsimile of the form sheet used for the application is reproduced in the report of the Royal Commission, Vol. 6, 72.

<sup>36</sup> Royal Commission Vol. 6, 73.

<sup>37</sup> Royal Commission Vol. 6, 80.

<sup>38</sup> Royal Commission Vol. 6, 82.

<sup>39</sup> *Ibid.*

before the commission.<sup>40</sup> As a matter of fact, the Royal Commission had no doubt that arguments between Tapper and Bluck had occurred quite frequently and “sometimes resulted in Mr Bluck overruling Mr Tapper”.<sup>41</sup> It was confirmed through testimonial evidence that it was even heard through the “engineers’ grapevine” that “a new building in Christchurch had been the subject of some contention in relation to the issue of a building permit”<sup>42</sup> and that Graeme Tapper and Bryan Bluck were the key opponents. The Royal Commission had no doubt that “there was a difference of opinion between Mr Tapper and Mr Bluck about the structural integrity of the design” of the building.<sup>43</sup>

The Commission also accepted the evidence by Graeme Tapper’s widow that her husband had “told her he did not want to sign the building off but was under pressure from Mr Bluck to do so”.<sup>44</sup> The Commission concluded:

Mr Bluck then instructed Mr Tapper to sign off on the CTV building, which he did on 10 September 1986. This evidence, if we were to accept it, would explain how the building came to be permitted despite the floor connection being non-compliant [with the relevant Building Bylaw] and Mr Tapper having recognised this.<sup>45</sup>

The report of the Royal Commission also revealed the bizarre detail that Alan Reay did confirm that he had a meeting with Bryan Bluck that resulted in Bluck overruling the concerns of Graeme Tapper but that “Dr Reay himself ... knew very little about the structural detail of the building”. This illustrates how thin the ice was on which both Reay and Bluck based their conviction that Graeme Tapper’s concerns about the structural integrity of the building’s design were unfounded and how ethically questionable their determination was to overrule those concerns. The Royal Commission concluded:

<sup>40</sup> Ibid.

<sup>41</sup> Ibid.

<sup>42</sup> Royal Commission Vol. 6, 83.

<sup>43</sup> Royal Commission Vol. 6, 84.

<sup>44</sup> Ibid.

<sup>45</sup> Ibid.—The Royal Commission discussed thoroughly the validity of evidence from hearsay in this context but concluded that the relevant statements referring to the character of both Bluck and Tapper and of the situation in question were reliable.



It is therefore difficult to understand how he [Alan Reay] was in a position to give any proper assurance in relation to the design.<sup>46</sup>

The Royal Commission found sufficient evidence in support of the assessment that Dr. Reay's "assurances" did decisively influence Bryan Bluck's opinion about the design issue raised by Graeme Tapper. Bluck's former deputy, Peter Nichols, testified before the Commission that Bluck, whom he had met by mere chance right in front of the construction site, had confirmed that what was to be heard "through the grapevine" in the Christchurch engineering community about a quarrel between him, Bluck himself and Tapper, was true but that Alan Reay had convinced him that Tapper's reservations were unfounded. The Royal Commission concluded "that Dr Reay's involvement in the permitting process contributed, at least to some extent, to the wrongful permitting of the building".<sup>47</sup> The blunt truth was that Bluck, through conceding this kind of personal influence to an applicant seeking a building permit in the explicit attempt to overcome the reservations articulated within the CCC, compromised his own professional integrity as well as the integrity of the institution he was running.

#### 4.2.4 *Institutionalized Error*

There were opportunities to neutralize the path dependent errors evolving from the CCC's inability to perform proper licensing of the CTV building. In early 1990, the Canterbury Regional Council (CRC) considered to purchase the building and engaged a consulting firm, Holmes Consulting Group (HCG), to prepare a structural report that, when finished, was submitted to the CRC on 31 January 1990. The HCG report noted "a vital area of non-compliance [with the relevant design codes]"<sup>48</sup> in the connection of the floors to the north wall complex—in other words exactly what CCC's buildings engineer Graeme Tapper had detected when reviewing the application for the building permit before being overruled by his superior Bryan Bluck. In protracted discussions between HCG engineers and representatives of the actual designers of the CTV

<sup>46</sup>Royal Commission Vol. 6, 88.

<sup>47</sup>Ibid.

<sup>48</sup>Royal Commission Vol. 6, 101.

building—ARCE, meanwhile renamed ARCL—a plan for “remedial work” was drafted. It was shelved though until October 1991.<sup>49</sup>

The HCG engineer in charge in January 1990 was John Hare. Hare had architectural drawings at his disposal on the basis of which he carried out an “approximate seismic analysis”.<sup>50</sup> It was on this basis alone that Mr. Hare determined the existence of “an area of non-compliance with the code of the day with respect to the tying of the floors to the shear walls, specifically to the north core walls”.<sup>51</sup> In a draft report Hare referred to this observation as a “vital area of non-compliance with current design codes”.<sup>52</sup>

John Hare had several meetings with Alan Reay and with Geoffrey Banks who was a major shareholder of ARCL. The original design engineer, David Harding, was not available anymore since he had left the firm. Which necessarily impacted on the consistency of relevant information concerning the structural design of the CTV building. It turned out that Hare had a much more precise diagnosis of the structural flaws of the building’s design than Reay and the responsible buildings engineer of the CCC, Bryan Bluck, in their own deliberations of September 1986. According to Hare’s judgment, Harding’s design calculations did not address the critical tie force originating from an earthquake in the north south direction but only potential forces in the east west direction. Hare also pointed to the fact that the actual floor diaphragms connecting the building itself to the north wall complex was “punctured by the lift, stair and service risers”<sup>53</sup> so that the “relatively few direct connections from the floor diaphragm to the north wall complex and there appeared to be insufficient reinforcement tying the floors and north wall complex together”.<sup>54</sup>

It is indicative that a seasoned engineer like John Hare, on the basis of design drawings and personal inspection of the building, was able to make a concise and, basically, alarming judgment about the structural condition of the building’s architecture. So the episode one more illustrates what could have been achieved if only the responsible engineers in charge on both ends, ARCE/ARCL and the Christchurch City Council, would have been as diligent as Hare was as a single engineer occupied with the matter

<sup>49</sup> Royal Commission Vol. 6, 100–109.

<sup>50</sup> Royal Commission Vol. 6, 100.

<sup>51</sup> Ibid.

<sup>52</sup> Quoted in Royal Commission Vol. 6, 100.

<sup>53</sup> Quoted in Royal Commission Vol. 6, 100.

<sup>54</sup> Ibid.

just for a short period of time. In cross-examination before the Royal Commission both Reay and Banks accepted the assessment that the issue identified back in 1990 by John Hare “was a critical structural weakness” and in terms of “fundamental engineering”, according to Alan Reay himself, a “straight blunder”.<sup>55</sup>

Even more indicative and disturbing is, however, that the chief buildings engineer of the CCC, Bryan Bluck, in a meeting with John Hare of 29 January 1990, missed the opportunity to focus Hare’s attention to the concerns previously articulated by Bluck’s subordinate engineer Graeme Tapper. “Mr Hare’s purpose,” the Royal Commission reported, “was to ascertain whether the CCC had identified any issues during the building permit and construction process”.<sup>56</sup> The correct answer would have been a straight Yes. Instead, according to Hare’s statement before the commission, “Mr Bluck raised three issues unrelated to the structure of the building” while Hare did not see any of the relevant CCC files.<sup>57</sup>

On 31 January 1990, HCG submitted a preliminary report to the Canterbury Regional Council whose crucial parts could not have been more explicit:

A vital area of non-compliance with current design codes, seen in the documents, is in the tying of the floors to some of the shear walls. This item is under review with the original consultants [ARCE/ARCL], but if confirmed will require potentially expensive remedial work. However, this cost is a matter for discussion between the current owner and their consultants. (...) An area of concern however has been discovered in the connections of the structural floor diaphragm to the shear walls. While this is not a concern on the coupled shear wall to the south of the building, connections to the walls at the North face of the building are tenuous, due to penetrations for services, lift shafts and the stairs, as detailed on the drawings. The result of this would be that in the event of an earthquake, the building would effectively separate from the shear walls well before the shear walls themselves reach their full design strength. Discussion has continued on this matter with Mr Geoff Banks of Alan Reay Consulting Engineer, and it currently appears that there may have been some provision made for this during construction. However, no documentation apparently exists, so it would only be safe to assume that this aspect fails to comply with current design codes.<sup>58</sup>

<sup>55</sup> Reay’s statement quoted in the report of the Royal Commission, Vol. 6, 100.

<sup>56</sup> Ibid.

<sup>57</sup> Ibid.

<sup>58</sup> Quoted in Royal Commission Vol. 6, 101.

Hare's statement together with an assessment of the approximate costs of "remedial structural works" for fixing the defects identified in the floor connections resulted in the decision of the Canterbury Regional Council not to purchase the CTV building.

Triggered by Hare's report, ARCL as the original designer of the CTV building took issue with the identified defects of the structural design of the building was, from early February 1990 on, in constant contact with two HCG engineers, Grant Wilkinson and John Hare himself. The subject of these verbal and correspondence based exchanges was the nature of the structural defects identified by Hare and the potential costs of "remedial works".<sup>59</sup> There were, according to the evidence mobilized by the Royal Commission, divergent assessments of Banks of ARCL on the one hand and Hare of HCG on the other hand and in an "annual report" to the umbrella organization Consulting Engineers Advancement Society (CEAS) of 9 April 1990, Banks wrote that ARCL was "still investigating whether there is a deficiency [concerning the structure of the CTV building], and if so, details of remedial work".<sup>60</sup>

No further investigations took place though. According to the findings of the Royal Commission, in "a period of approximately one year until February 1991 ... it appears that nothing was done by Dr Reay or Mr Banks to address the issue".<sup>61</sup> This, however, was plausibly explained by Alan Reay in cross-examination before the Royal Commission by stating that neither ARCL had been informed that HCG was no longer involved in any further examination (because the engagement of HCG had been terminated by the Canterbury Regional Council in early February 1990) nor was there, in the perception of Reay himself or Geoffrey Banks, any reason to assume that a purchaser of the CTV building would refrain from further investigations.

When an article in the Christchurch newspaper *The Press* on 4 February 1991 reported that the CTV building had been sold indeed, Reay and Banks did take the initiative to inform the new owner, Madras Equities, about "the issue with the floor connections".<sup>62</sup> Due to consultation with their insurer regarding the consequences of potential liability in case design errors should be detected in course of another investigation, the

<sup>59</sup> Royal Commission Vol. 6, 103.

<sup>60</sup> Quoted in Royal Commission Vol. 6, 105.

<sup>61</sup> Ibid.

<sup>62</sup> Ibid.

insurer confirmed in 1991 the agreement that the new owner should be informed by ARCL. However, in a period of five more months nothing was done to notify the new owner of the CTV building. The report of the Royal Commission noted, “it is difficult to reconcile this delay with Dr Reay’s acceptance that once there was a new owner there was some urgency to notify”.<sup>63</sup>

Finally, on 11 September 1991, Geoffrey Banks wrote a letter to inform the new owner on behalf of ARCL. The owner was Madras Equities Ltd. represented by Mr. Russel Ibbotson. The existence of that letter the original of which remained undetectable for the Royal Commission became apparent through the response letter of Ibbotson of 30 September 1991. Ibbotson referred to the description of the “remedial work” by Geoffrey Banks which, according to Banks, “if required, will be relatively simple to carry out whilst the building is predominantly unoccupied and should not involve a major expense outlay”. Ibbotson’s description of the content of Banks’ letter went on in direct quotation: “It is also noted that [according to Banks] it is a possibility that the apparent problem may not, in fact, be a problem and that this can only be determined by further work involving some drilling to determine the extent to the reinforcing steel work in position.”<sup>64</sup>

It was a bitter irony that Banks’ counsel before the Royal Commission stated “that Mr Banks had been told by Dr Reay that the issue might have been addressed during construction and Mr Banks reasonably thought that may have been the case as the building had been given a building permit.”<sup>65</sup> Which not only underlines the negative impact of insufficient documentation of the original design procedure and related calculations but also a fateful vicious circle: Initially, in September 1986, the chief buildings engineer of the Christchurch City Council, Bryan Bluck, had overruled the objections of his subordinate fellow engineer Tapper in accordance with what Alan Reay as principal of the consultancy firm ARCL (then ARCE) had told him about the soundness of the structural design of the CTV building. Now, in September 1991, Geoffrey Banks accepted without further verification virtually the very same narrative of his superior Alan Reay on which he based his own statement vis-à-vis the new owner of the CTV building. He did that, however, in reference to the fact that,

<sup>63</sup> Ibid.

<sup>64</sup> Quoted in Royal Commission Vol. 6, 106.

<sup>65</sup> Ibid.

after all, the CCC had issued a permit for the building. So, the error became institutionalized.

To which contributed a conflict of interests. Although ARCL had obtained the agreement of its insurer to inform the new owner about the issues with the structural design of the CTV building the dimension of potential liability was incalculable. In the end, what remained of John Hare's (HCG) statement about "a vital area of non-compliance with current design codes, seen in the documents, is in the tying of the floors to some of the shear walls" of 31 January 1990 was Banks' (ARCL) reference to "a possibility that the apparent problem may not, in fact, be a problem".<sup>66</sup> The Royal Commission could not help stating, "We consider that while there appears to have been an element of minimisation in the actions of Dr Reay and Mr Banks, this was likely motivated by the perceived need to protect the insurance cover and does not, in our view, imply any ulterior motive."<sup>67</sup>

Now that the existence of "problems" with structural defects of the CTV building was finally brought to the attention of the new owner, Madras Equity, the responsibility for the appropriate calculations and design lay again with Reay and Banks of ARCL. The "remedial works" ultimately carried out consisted of drag bars as fortifying connection between the floors and the north wall complex at the upper levels of the CTV building (levels 4, 5 and 6).<sup>68</sup> These works were performed in October 1991. That happened without a building permit from the CCC. It would have been the obligation of ARCL though, i.e., of Alan Reay and Geoffrey Banks, to apply for such permit. This, however, was omitted as well. The Royal Commission stated that although the relevant legal stipulations "may have been widely framed, we think it clear that this structural work required a permit".<sup>69</sup>

Again, Alan Reay made a revealing statement before the commission in saying that, "based on his experience in dealing with Mr Bluck [the CCC's chief buildings engineer] over many years he believed Mr Bluck's view would have been that the retrofit works [= installation of the drag bars] were part of the original job and that no permit was required, although

<sup>66</sup> Indirect quote from Mr. Ibbotson's response letter of 30 September 1991 in Royal Commission Vol. 6, 106.

<sup>67</sup> Ibid.

<sup>68</sup> Royal Commission Vol. 6, 107.

<sup>69</sup> Royal Commission Vol. 6, 108.

Mr Bluck might have asked to receive details about what was undertaken”.<sup>70</sup> Which implies that Reay was not able or not willing to distinguish between the institutional role and duty of the CCC and his personal relationship with Bryan Bluck at the CCC’s chief buildings engineer. The Royal Commission stated “that the failure to apply for a permit was a clear omission, which meant that the inadequacy of the floor connections to the north wall complex in the original design was not drawn to the CCC’s attention in 1991”.<sup>71</sup>

The bottom line was indeed that, contrary to relevant legal prescriptions, the relevant public authority as the professional and neutral guardian of the public interest in the safety of buildings remained uninvolved. The Royal Commission highlighted with latent sarcasm that “so many people were aware of the issue with the connection of the floors to the north wall complex over some years, without the CCC ever being made aware of it”.<sup>72</sup> This observation does not alter the fact though that the CCC had issued a building permit back in September 1986, which, according to the Royal Commission’s own judgment, should never have been granted. The Commission came to the conclusion that it was indeed at the joints between floors and both the north wall complex and the south shear wall that the structure of the CTV building started to disintegrate on 22 February 2011:

All of the floors dropped, virtually straight down, due to major weaknesses in the beam-column joints and the columns. (...) The north wall complex was left standing, the floors having torn away and come to rest stacked up adjacent to its base. The south shear wall collapsed inwards on top of the floors in what we consider would have been the last part of the collapse sequence. The observed damage of both of these walls show that they had not been able to perform their intended role.<sup>73</sup>

#### 4.2.5 *The Legacy of Errors: The Aftermaths of the 4 September 2010 Earthquake*

The structural design errors committed by David Harding of ARCE/ARCL and not detected by the CCC which issued the building permit on

<sup>70</sup> Royal Commission Vol. 6, 109.

<sup>71</sup> Ibid.

<sup>72</sup> Ibid.

<sup>73</sup> Royal Commission Vol. 6, 262.

30 September 1986 nor in the course of the reinforcement of the floor diaphragms in 1991 constituted a necessary but not a sufficient condition for the failure of the CTV building on 22 February 2011. It took a series of earthquakes and aftershocks plus a series of additional errors and omissions of the Christchurch City Council to make the collapse of the CTV building the catastrophic event that claimed the lives of 115 people.

On 4 September 2010 at 4:35AM an earthquake of 7.1 magnitude shattered Christchurch whose epicenter was about 40 kilometers west of the city “on a previously unknown fault beneath the Canterbury Plains”.<sup>74</sup> On boxing day 2010 (26 December), several aftershocks followed with a minor magnitude of 4.6 to 4.7 whose epicenter was just 3.7 to 7 kilometers away from the Christchurch central business district (CBD) where the CTV building was located on 249 Madras Street.

After the earthquake of 4 September 2010 the CTV building still stood tall and without visible damages for laypeople’s eyes except for broken windows. Like dozens of other buildings in the CBD alone, the CTV building was subject to several inspections whose preliminary outcome was the classification of buildings according to damages and related safety statuses. The status assignment followed a traffic light pattern with “green” for buildings sound and safe, “yellow” for buildings with detected or presumed structural damages and “red” for seriously damaged buildings at risk of collapse. CCC inspectors used placards in the respective colors to mark the buildings visibly at the outside, usually at the main entrance. A green placard indicated that “no restriction on use or occupancy” was imposed (Illustration 4.3).<sup>75</sup>

The inspection and the marking of the buildings took place under the condition of a state of local emergency that had been declared in Christchurch immediately after the earthquake of 4 September 2010 and in the framework of a Civil Defense Emergency Management Response initiated by the CCC.<sup>76</sup> It was conducted at two levels of urgency called Level 1 Rapid Assessment and Level 2 Rapid Assessment. The Level 1 Rapid Assessment (LIRA) of the CTV building was conducted on the afternoon of 5 September by a CCC inspector, Peter Van der Zee, and Richard Sullivan, a chartered Professional Engineer, plus two Urban


<sup>74</sup>Royal Commission Vol. 6, 120.

<sup>75</sup>Royal Commission Vol. 6, 124.

<sup>76</sup>Ibid.



GREEN

**Christchurch City Council** 

# INSPECTED

## NO RESTRICTION ON USE OR OCCUPANCY

This building has received a brief inspection only. While no apparent structural or other safety hazards have been found, a more comprehensive inspection of the exterior and interior may reveal safety hazards.

Exterior Only  
 Exterior and Interior

Facility/ Tenancy Name and Address \_\_\_\_\_

Please ensure the owners are advised of this notification. Owners are encouraged to obtain a detailed structural engineering assessment of the building as soon as possible. Report any unsafe conditions to the Territorial Authority. Subsequent events causing damage may change this assessment. Re-inspection may be required. Secondary damage (partitions, windows, fittings and furnishings) may be hazardous. Electrical and mechanical equipment, gas connections, water supplies and sanitary facilities have not been inspected.

Do Not Remove this Placard. Placed on Behalf of the Civil Defence Emergency Management Controller Under the Authority of the Civil Defence Emergency Management Act 2002

This facility was inspected pursuant to the Civil Defence Emergency Management Act 2002

Inspector ID: \_\_\_\_\_

Acting under the authority of the Civil Defence Emergency Management Controller: \_\_\_\_\_

Date: \_\_\_\_\_  
 Time: \_\_\_\_\_

Contact for information: **ph(03) 941 8999**

Or

TXT: 021 02069179 with following details: Address, Placard colour, contact name, contact phone number

**Illustration 4.3** Green Placard used to mark buildings after the 4 September 2010 earthquake in Christchurch. (Source: Royal Commission Vol. 6, p. 131)

Search and Rescue (USAR) officers who remained unidentifiable for the Royal Commission.<sup>77</sup>

Van der Zee, according to the findings of the Royal Commission, had three years' experience on his job but no experience in building inspection. During cross-examination before the Commission, Van der Zee "said he had no training in post-earthquake building assessments before the September earthquake, nor had the majority of CCC building officers who carried out assessments at that time".<sup>78</sup> According to this first assessment conducted by Van der Zee on behalf of the CCC "the estimated overall building damage was 'None'".<sup>79</sup> The inspection team thus allocated a green placard to the CTV building. The green placard a facsimile of which, in original color, is reproduced in the report of the Royal Commission<sup>80</sup> carried the wording: "This building has received a brief

<sup>77</sup> Ibid.

<sup>78</sup> Royal Commission Vol. 6, 126.

<sup>79</sup> Royal Commission Vol. 6, 124.

<sup>80</sup> Royal Commission Vol. 6, 131.

inspection only. While no apparent structural or other safety hazards have been found, a more comprehensive inspection of the exterior and interior may reveal safety hazards.”<sup>81</sup> The header read in capital letters and partly in bold, “Inspected. No restriction on use or occupancy”. At the same time, the wording of the green placard entailed the following:

Please ensure the owners are advised of this notification. Owners are encouraged to obtain a detailed structural engineering assessment of the building as soon as possible.<sup>82</sup>

Quite obviously, this very first inspection was a routine operation and the CCC or USAR inspectors had based the grading of the building solely on a visual assessment with no reason or motivation whatsoever to suspect the structural damages, let alone inherent instability, of the building.

The compulsory Level 2 Rapid Assessment (L2RA) took place on 7 September 2010 initiated by a Building Evaluation Manager in the Christchurch City Emergency Operation Center, Stephen McCarthy.<sup>83</sup> McCarthy asked the CCC three buildings to be “urgently” inspected, including the CTV building. The task was assigned to three inspectors who happened to be extraordinarily experienced CCC staff members: David Flewellen, Russel Simson and Graham Calvert. However, none of them was an engineer. When cross-examined by the Royal Commission, McCarthy mentioned the tense situation after the earthquake with countless inspections to be performed so that “all available engineers had been dispatched elsewhere”.<sup>84</sup> McCarthy also maintained, however, he would have told the three CCC inspectors “that if there were any issues then they should request that an engineer inspect the building”.<sup>85</sup> In his own recollection, Flewellen, Simson and Calvert were also encouraged to advise “the owner [of the building] to engage an engineer”.<sup>86</sup> Which was just in accordance with the wording on the green placard assigned to the building two days earlier.<sup>87</sup> Nonetheless, the three inspectors received mixed messages from McCarthy. On the one hand, they were encouraged to

<sup>81</sup> Ibid.; the word “apparent” was underlined on the original placard.

<sup>82</sup> Ibid.

<sup>83</sup> Royal Commission Vol. 6, 126.

<sup>84</sup> Quoted by the Royal Commission. Cf. Vol. 6, 126.

<sup>85</sup> Ibid.

<sup>86</sup> Ibid.

<sup>87</sup> Ibid.

request a CCC engineer if necessary, on the other hand they were told to tell the owner of the building to engage (and to pay) an engineer himself. That must have raised the threshold to approach McCarthy with the request for dispatching an engineer for the inspection of the CTV building since it was common knowledge that the CCC engineers were extremely busy in the aftermath of the earthquake.

As the Royal Commission found out, Flewellen, Simson and Calvert were not even aware that a Level 1 Rapid Assessment had already taken place before their arrival at the CTV building where they found the green placard stuck to the main entrance of the building.<sup>88</sup> The three inspectors talked to someone who, they thought, was the building manager but the person remained unidentifiable for the Royal Commission.<sup>89</sup> Flewellen, Simson and Calvert did inspect the building but, as Flewellen admitted before the Royal Commission, only superficially. After all, they had noticed the green placard at the building's main entrance so that, in principle, they just looked around in various sections of the building but discovered "no structural abnormalities".<sup>90</sup> Finally, the three inspectors issued their own green placard on that day, 7 September 2010. The Royal Commission came to the conclusion that this second inspection was characterized by "a lack of understanding of the Rapid Assessment process" and that the three inspectors clearly acted without clear instructions from the CCC.<sup>91</sup> According to the findings of the commission, the inspectors "were confident that the person they spoke to had understood the importance of obtaining an independent engineering inspection".<sup>92</sup>

The immediate effect of the green placard classification was, however, the declaration of "no restriction on use or occupancy". This was, not surprisingly, instantly communicated to the various groups of occupants via circular mails. A message of the responsible CTV manager, Murray Wood, read: "We have just had an internal inspection of the building from 3 engineers and they have found that this building is in good condition and is deemed habitable."<sup>93</sup>

So, in the essence, what was certainly meant to be a solid and standardized framework for scrutinizing the structural status of buildings was

<sup>88</sup> Royal Commission Vol. 6, 127.

<sup>89</sup> Ibid.

<sup>90</sup> Ibid.

<sup>91</sup> Royal Commission Vol. 6, 128, 130.

<sup>92</sup> Royal Commission Vol. 6, 128.

<sup>93</sup> Quoted in Royal Commission Vol. 6, 131.

inappropriately handled. Part of the reason was the ambiguity of the inspection requirements themselves as far the engagement of trained engineers was concerned. It was left to the discretion of the inspectors—who, contrary to what CTV manager Wood wrote in his circular mail, were no engineers indeed—whether or not to ask CCC to send an engineer on site and their uncertainty what to do was not reduced by the wording of the green placard. In the end, the three CCC officers, when talking to the presumed building manager, just reiterated what the placard said which was to recommend the engagement of an engineer on behalf of the owner of the building.<sup>94</sup>

On the other hand, the official in charge at the CCC, McCarthy, in the middle of extreme workload after the earthquake of 4 September 2010, inevitably relied on Flewellen, Simson and Calvert as far as an in-depth inspection of the building was concerned. Yet, even if such an inspection would have been performed by a trained engineer no specific instructions existed about the nature of a more thorough scrutiny, for instance, whether it should pertain to structural analyses. Certainly, Flewellen, Simson and Calvert had only “limited training” for the job they were supposed to do<sup>95</sup> and Simson admitted before the Royal Commission, “we should have probably at least put a yellow sticker on the building”.<sup>96</sup> However, both the arrangement of oversight and control of the CCC officials on site and the ambiguous wording of the green placard created a diffusion of responsibility in the first place.

So, the Royal Commission itself remained uncertain if the presence of an engineer in the CCC inspection team would have made a difference.<sup>97</sup> Unless, one might add, an inspecting engineer would have been specifically instructed or determined to perform a structural analysis of the building on the basis of sound documentation of the structure’s architecture. Not only was there no plausible reason to conduct such a laborious, time consuming and, last but not least, expensive investigation nor was there any reason to assume that the structural design of the building had not been diligently inspected and certified in the first place. It is therefore only with a caveat that one can define the omitted in-depth inspection of the CTV building by an engineer as a missed opportunity—which it was from

<sup>94</sup> Royal Commission Vol. 6, 128.

<sup>95</sup> Royal Commission Vol. 6, 133.

<sup>96</sup> Royal Commission Vol. 6, 131.

<sup>97</sup> Royal Commission Vol. 6, 132.

an objective point of view. That omission would not have done any harm under regular circumstances, i.e. if only the structural design of the building would have been subject to proper scrutiny and approval back in 1986. And there was obviously every reason to take precisely this for granted. The tragedy was that, back then, a similar kind of diffused responsibilities between CCC's buildings engineer Tapper, his superior Bluck, and the principal of Alan Reay Consulting Engineer (ARCE), Mr. Reay himself, had created a situation in which such proper procedures were just not performed. Which in turn must have been beyond the imagination of CCC officials and any other person involved in the inspection procedures after the earthquake of 4 September 2010.

So it was not surprising that, when an inspection of the CTV building was indeed performed by an engineer in October 2010, it did not include a structural analysis of the building's design either.<sup>98</sup> The engineer, David Coatsworth, was a senior associate with CPG New Zealand Ltd. (CPG) with 40 years' experience in structural and civil engineering. He had been contacted on 7 September 2010 by the actual building manager, John Drew, immediately after what was supposed to be the Level 2 Rapid Assessment performed by Flewellen, Simson and Calvert earlier that day. Mr. Coatsworth inspected the building probably at the end of September 2010 (no exact date is mentioned in the report of the Royal Commission). The inspection remained visual-based but was nonetheless detailed and thorough. On a four hours tour throughout the entire building, accompanied by Mr. Drew and Mr. Lennart Pagan as an expert for necessary repairs, Mr. Coatsworth took 109 photographs, inspected every single column of the structure and spoke to occupants of the building who pointed him to assumed damages and described their observations since the earthquake of 4 September.

In an Email of 24 September 2010 sent by Coatsworth to Drew prior to the inspection Coatsworth had noted, "Structural and architectural drawings of the building would be very helpful. If these can be made available, they will help with the understanding of the structural systems within the building."<sup>99</sup> Mr. Drew forwarded Coatsworth's request to the CCC only to be told that, due to the "disarray" connected to the earthquake of 4 September, it might take eight weeks or so before the relevant file was

<sup>98</sup>Royal Commission Vol. 6, 134.

<sup>99</sup>Royal Commission Vol. 6, 134.

available.<sup>100</sup> It turned out that the drawings were available earlier than expected when Coatsworth had not yet submitted his inspection report. When this came to the attention of Mr. Drew he did not notify Coatsworth though and Coatsworth himself did not insist on receiving the drawings.<sup>101</sup> Quite ironically, this was criticized by Alan Reay’s counsel before the Royal Commission as a “critical omission”, a judgment which the Commission itself deemed “not justified”.<sup>102</sup> According to all likelihood, the statement of Alan Reay’s counsel was designed to relativize the co-responsibility of his client for the original omission not to seek a permit for the installation of the drag bars in 1991 which would have been the opportunity to correct the design errors committed in the first place. On the other hand, the Royal Commission stated that if Mr. Coatsworth had had the structural drawings “this may have prompted him to reconsider the type of inspection he was carrying out to conduct a more invasive damage-based inspection”.<sup>103</sup> So the judgment of the Commission was itself ambiguous to some extent which was, however, probably due to the effort not to blame unfairly Coatsworth whose way of inspection was, according to the commission, “consistent with the approach of most, if not all, engineers in the aftermath of the September earthquake”.<sup>104</sup> The Commission stated that the type of structural analysis on the basis of the original design drawings were “not common” and that “of all the inspections we considered in evidence over the course of the Inquiry, Mr Coatsworth’s was the most thorough”.<sup>105</sup>

#### 4.2.6 *Fatal Path Dependency: The Post-26 December 2010 Development*

When the aftershocks of Boxing Day 2010 (26 December) had happened a similar pattern of inspections evolved like the one after the earthquake of 4 September 2010. A Level 1 Rapid Assessment of the CTV building took place on 27 December again conducted by a team of CCC Building Inspectors to which belonged Marie Holland who held a bachelor’s degree

<sup>100</sup> Royal Commission Vol. 6, 139.

<sup>101</sup> Royal Commission Vol. 6, 140.

<sup>102</sup> Ibid.

<sup>103</sup> Ibid.

<sup>104</sup> Royal Commission Vol. 6, 138.

<sup>105</sup> Ibid.

in Architectural Design.<sup>106</sup> In cross-examination before the Royal Commission, Ms. Holland had no recollection of the actual assessment of the CTV building and it remained uncertain whether it was actually her who had filled out the specific form sheet since the designation of the CTV building and the street address had been inserted in a different handwriting than hers.<sup>107</sup> Ms. Holland had general knowledge about the nature of a Level 1 Rapid Assessment but had not conducted one so far. A team of the Urban Search and Rescue Service (USAR) also carried out an inspection. That team, however, completed only “a visual survey of the building from each direction”. The team did not discover any “obvious structural damage”.<sup>108</sup>

Building manager Drew, apparently on his own initiative during the post-Christmas holiday season, tried to reach Mr. Coatsworth by telephone but to no avail. He made no further attempt to contact Coatsworth.<sup>109</sup> However, now, for the first time, occupants of the CTV building were alarmed.<sup>110</sup> The report of the Royal Commission mentions more than ten witnesses and their testimonies before the commission about visible additional damages after the Boxing Day earthquake with the exact location of the building, level by level. The main concerns of the occupants were visible cracks although some of them must already have existed before the 26 December earthquake.

One of the occupants, Ms. Jo-Ann Vivian, a manager of the tenant Relationship Services, called the CCC on 5 January 2011 with the request to arrange an inspection of the CTV building. According to the CCC computer record of her call, she referred to “a round structural pillar ... (which) has significant cracks in it”.<sup>111</sup> However, Vivian withdrew her request after a telephone conversation with Mr. Drew on 7 January 2011. According to the findings of the Royal Commission, Drew as the building manager did notice additional damage to the CTV building as a result of the Boxing Day earthquake but perceived and interpreted it as “limited to some more broken windows and some cracks that had widened”. In cross-examination before the commission, he also referred to comments made by Mr. Coatsworth before the Boxing Day earthquake who, according to

<sup>106</sup> Royal Commission Vol. 6, 143.

<sup>107</sup> *Ibid.*

<sup>108</sup> Royal Commission Vol. 6, 145.

<sup>109</sup> *Ibid.*

<sup>110</sup> Royal Commission Vol. 6, 145–149.

<sup>111</sup> Royal Commission Vol. 6, 147.

Mr. Drew, had predicted that cracks could widen as “just a normal part of the flexing” but that Coatsworth had “indicated that there was no concern basically”.<sup>112</sup> In accordance with this assessment, Drew made arrangements for the repair of the identified damages and representatives of a firm specialized in concrete repairs did inspect the CTV building in the first half of February 2011.<sup>113</sup> Their preparations were still on their way when the earthquake of 22 February 2011 caused the CTV building to collapse. The Royal Commission maintained that it was Mr. Drew’s omission not to ask Mr. Coatsworth to re-inspect the building who, after all, had the most intimate knowledge about the pre-existing damages from the 4 September 2010 earthquake.<sup>114</sup> That Coatsworth, in the course of yet another inspection, would have conducted an analysis of the structural design of the building and potential damages to it is all but certain.

When the CTV building at 249 Madras Street in Christchurch collapsed during the earthquake on 22 February 2011, 115 people were killed and many others were injured. It goes to the credit of the Royal Commission that it devoted an entire chapter of the relevant volume of its report to those who had lost their lives.

### 4.3 CASE ANALYSIS

#### 4.3.1 *Turning Points and Critical Junctures*

The findings of the Royal Commission left no reasonable doubt that there was one single core episode from which the causal chain originated that resulted in the collapse of the CTV building on 22 February 2011. It comprises the timespan between 26 August and 30 September 1986 when Graeme Tapper, the buildings engineer of the Christchurch City Council realized flaws in the submitted design of the building but ultimately issued the building permit anyway. The Royal Commission stated: “We conclude that the building permit should not have been issued”.<sup>115</sup> So the issuance of the permit can be identified as the critical juncture at which a causal process started that was not unstoppable but shaped by a very strong path dependency. As the Royal Commission confirmed, the structural design of

<sup>112</sup> Royal Commission Vol. 6, 149.

<sup>113</sup> Ibid.

<sup>114</sup> Royal Commission Vol. 6, 150.

<sup>115</sup> Royal Commission Vol. 6, 88.



the CTV building did not comply with the relevant legal requirements, especially not with those devoted to the protection against seismic forces. This applied specifically to the connections between the floors of the six-story building and the north wall complex.<sup>116</sup>

According to the findings of the Royal Commission, the Christchurch City Council on 20 September 1986 issued a permit for the future CTV building that should never have been granted. The buildings engineer in charge at the time, Graeme Tapper, had asked the actual designer, David Harding of Alan M Reay Consulting Engineer (ARCE, later on Alan Reay Consultants Ltd. or ARCL), to submit detailed structural drawings calculations in support of the application for the building permit filed with the CCC on 17 July 1986. Tapper identified, according to the Royal Commission, “a significant structural issue in the design” of the building’s architecture, specifically pertaining to the diaphragms connecting the floors of the six-story building to an extension with the stairwells, denoted in the drawings as the “north wall complex”. Despite the fact that Tapper raised the issue with ARCE in a letter the design of these connections was not amended and despite this omission the building permit was issued on 30 September 1986. Prior to that, Alan Reay, the principal of ARCE, according to the findings of the Royal Commission “personally convinced” Tapper’s superior, Bryan Bluck, that Tapper’s concerns were unfounded whereupon Bluck instructed Tapper to sign off the design and to issue the permit. That moment marks the first and fundamental critical juncture. The alternative path was not fictitious but clearly available and it was the path Graeme Tapper as the buildings engineer of the CCC in charge would certainly have embarked on if not instructed otherwise.

Once taken, the wrong path turned out to be particularly strong in shaping the remaining sequences of decisions and omissions. Yet, it was not irreversible. What characterizes the tragedy of the ultimate collapse of the CTV building and the death of 115 people was, instead, that the path to disaster could have been suspended at at least three occasions. One was the retrofit of the diaphragms between the floors of the CTV building and the north wall complex and the long lasting phase of preparation that preceded it stretching from late January 1990 through October 1991. It culminated in the installation of three drag bars designed to strengthen the diaphragms, a measure taken without the required permit of the Christchurch City Council. Two more opportunities for intervention

<sup>116</sup>Royal Commission Vol. 6, 272.

presented themselves after the earthquake of 4 September and the aftershocks of Boxing Day (26 December) 2010.

In January 1990, the Canterbury Regional Council (CRC) articulated its interest in purchasing the CTV building. The council engaged an engineering consultant, Holmes Consulting Group (HCG). Their engineer, John Hare, explicitly asked Bryan Bluck of the Christchurch City Council if the CCC had identified any “issues” during the building permit and construction process. Bluck did mention three issues none of which was related to the structure of the building and Hare had no drawings or calculations at his disposal. He nonetheless identified “a vital area of non-compliance with current design codes” when inspecting the CTV building. This and the implied repair costs caused the CRC to abandon the plan to purchase the CTV building which was subsequently acquired by the investment firm Madras Equities.

Significantly enough, the original designers, Alan Reay Consultants Ltd. (ARCL), were clearly aware of the very structural issues that made the Canterbury Regional Council refrain from acquiring the CTV building. After all, those problems had been discussed between ARCE/ARCL principal Alan Reay and CCC’s chief buildings engineer Bryan Bluck when the review of the structural design was still underway in September 1986. It is also indicative that ARCL did not approach the new owner directly. Instead, ARCL’s principal Alan Reay asked the firm’s insurer whether informing the new owner of the CTV building was advisable given potential liability risks. In an extremely protracted process of deliberations and consultancy, Alan Reay and Geoffrey Banks of ARCL downplayed the issue and, in September 1991, came up with a plan to retrofit the diaphragms connecting the floors of the CTV building at the three upper levels in the form of steel drag bars to the north wall complex. These works were performed in October 1991 without the required CCC permit which was diagnosed by the Royal Commission as an act of non-compliance with the relevant legal stipulations. At any rate, no in-depth investigation into the nature of the design issues took place. Again, an opportunity to verify and to recalculate the soundness of the structural design of the building was missed. The responsibility clearly lay with those who were in possession of the original drawings and calculations, ARCL and Alan Reay in person. Reay, however, had an incentive to reduce liability risks while the Christchurch City Council as the neutral institution not exposed to such conflict of interest remained entirely uninvolved in this

crucial episode precisely because ARCL failed to apply for a permit for the drag bar related retrofit works.

While it is difficult to define a critical juncture in the conventional sense when it comes to a protracted process of half-hearted inspections, deliberations and sometimes deliberately delayed decision making it is quite obvious that the decisive threshold was surpassed when, in September 1991, Alan Reay and Geoffrey Banks of ARCL decided to go ahead with retrofit works of limited scale and scope without seeking the statutory building permit.

The final sequence of tragic errors and fateful omissions started with the earthquake of 4 September 2010. This episode stretched over a relatively long period of time, until the last and disastrous earthquake of 22 February 2011. It started with the misguided so-called Level 2 Rapid Assessment performed on 7 September 2010 by three CCC inspectors none of whom was a trained engineer nor were they experienced with building inspections. The inspectors were acting under ambivalent written and oral instructions since, on the one hand, they were told by the responsible CCC official to request additional inspection by an engineer in case they deemed that necessary given the conditions of the CTV building. On the other hand, they found a green placard already in place that had been stuck to the building since the afternoon of 5 September when a so-called Level 1 Rapid Assessment had been performed. Unaware of the exact proceedings of the rapid assessments and their requirements, the inspectors were neither aware of the superficial character of a Level 1 Assessment nor of the exact implications of the wording of the green placard that recommended the engagement of an engineer by the owner of the building. After visual inspection of various parts of the building the inspectors just re-issued the green placard, a measure they were not entitled to take in the absence of an engineer. The building manager did nonetheless engage an engineer who inspected the building three times between 29 September and 19 October 2010. He confirmed that the building remained “structurally sound” but, at the same time, recommended further assessment. No such assessment was carried out, however.

So one may define 7 September 1990 the actual critical juncture since it was at that point that an inappropriate handling of the Level 2 Rapid Assessment paved the way to further neglect which with necessity remained connected to the plausible assumption that no fundamental structural design issue could have aggravated the impact of the earthquake. Under this very assumption, the psychological threshold to insist on a thorough

structural analysis based on the original drawings and calculation of 1986 was high. Which applied also to David Coatsworth, a seasoned engineer, who carried out three additional inspections of the CTV building on behalf of the owner, Madras Equity.

Coatsworth remained the key figure, most likely without being aware of it, in the final part in the tragic series of cumulative errors and omissions that characterize the time span between the earthquakes of 26 December 2010 and 22 February 2011. It could have made a decisive difference if the building manager in charge, John Drew, would have been more insisting in his attempts to reach Coatsworth after the Boxing Day (26 December) earthquake. Coatsworth was at the time according to all evidence the best informed engineer around with intimate knowledge of the conditions of the CTV building except for an in-depth investigation into the structural design and potential issues. However, Drew made no further attempt to contact Coatsworth when a telephone call was to no avail. Drew's own trust in the stability of the CTV building was underlined by the fact that he moved into it with his family in early 2011. He reacted accordingly when occupants approached him, being alarmed by cracks and gaps in walls and columns. One occupant had contacted the CCC directly with a request for an inspection of the building but withdrew it after a telephone conversation with Drew on 7 January 2011.

In sum, Drew's omission to consult Coatsworth, although committed in good faith, one more time followed the pattern of neglect and insufficient risk awareness. Yet, it can be classified a turning point at which an existing path dependency was accentuated rather than generating a new one. Drew initiated repairs whose preparation were still on their way when the CTV building collapsed on 22 February 2011 (Fig. 4.1).

### 4.3.2 *Contributing Factors and Necessary Conditions*

While there were clearly identifiable errors and omissions which, in principle, could have been easily avoided by the relevant key actors there were also persisting organizational and legal permissive conditions whose existence was of a more objective nature. Those conditions could and should have been taken into account by the relevant decision makers. Still, a considerable amount of blurred responsibilities could have been avoided in the first place.

One 'contributing factor' in this sense was the practice at the Christchurch City Council to start the review of applications for a building

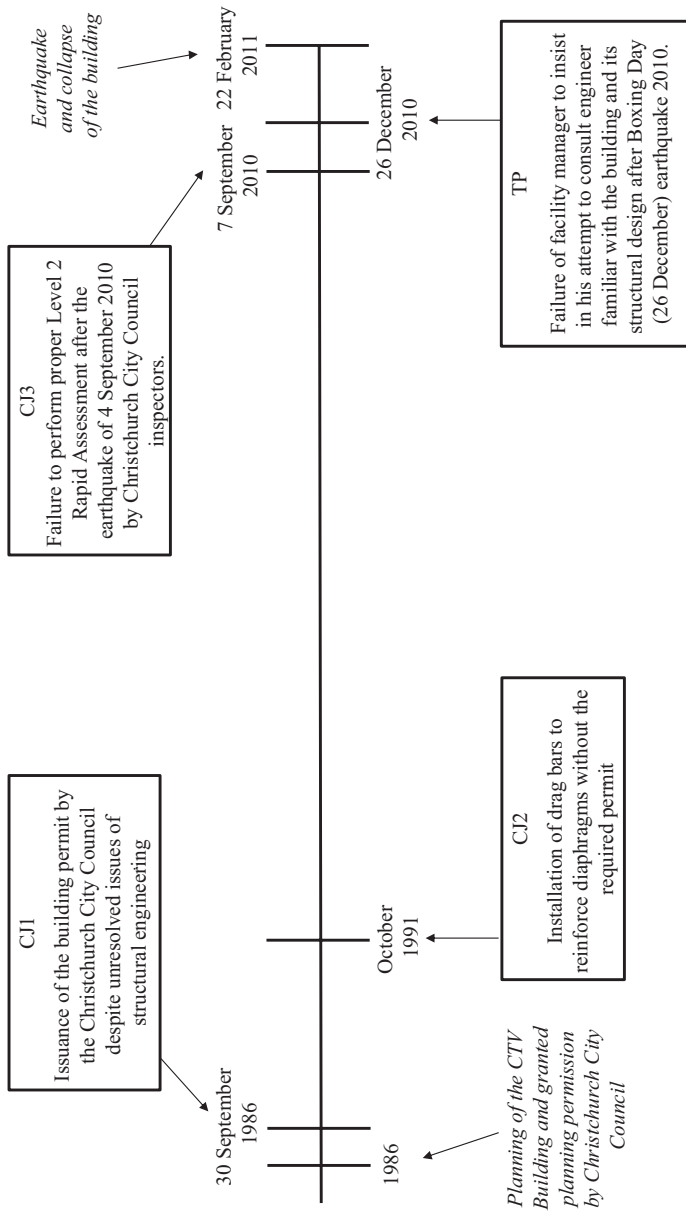


Fig. 4.1 Turning Point (TP) + Critical Junctures (CJ), collapse of CTV building

permit without complete documentation of the planned structural design of the envisaged structure. On the one hand, this was a plausible concession to applicants, typically design engineers working under pressure to get a project started. On the other hand, that pressure was likely to create counterincentives to diligent review. By their very nature, checking procedures and related calculations are particularly demanding while contractors and consultants typically act under time pressure. To start the review of applications for a building permit without complete documentation meant to compress the available time span for checking procedures even more once documentation was finally submitted. According to all evidence, this was exactly the situation the CCC's buildings engineer Graeme Tapper was facing when the structural drawings for the future CTV building were handed in to the CCC with a delay of 40 days after submission of the original application for the building permit. When Tapper, on the basis of additional documentation which still were incomplete due to missing calculations, articulated concerns about structural design issues his reluctance to sign off the design inevitably implied the risk of substantial delay of the entire project. Which in turn explains why Tapper's immediate superior, CCC's Chief Buildings Engineer Bryan Bluck, in a personal conversation with Alan Reay as the principal of ARCE as the applicant for the building permit, made the concession to have the permit issued without further scrutiny of the very design details that had raised the concerns of Graeme Tapper.

An implicit consequence of the established practice within the CCC was a creeping erosion of institutional integrity. This became apparent when in 1991 ARCL—previously ARCE—designed the retrofit of the diaphragms connecting the floors of the CTV building to the north wall complex without seeking a related building permit. Significantly enough, this omission was justified in cross-examination before the Royal Commission by the principal of the firm, Alan Reay, with the remark that according to his experience Bryan Bluck as the Chief Buildings Engineer of the CCC would certainly have approved the envisaged procedure anyway. The arrogance aside, this clearly indicated the extent to which personal linkages of decision makers had replaced compliance with due diligence standards.

Another avoidable contributing factor that facilitated misunderstandings and outright errors committed after the first earthquake of 4 September 2010 were the guidelines for post-earthquake “rapid assessments”. According to the traffic light system with green, yellow and red

placards, a green placard entailed the explicit assurance that the building was sound and safe and no restrictions on use or occupancy were pronounced. At the same time, however, the wording on the very same placard “encouraged” the owners of the respective building “to obtain a detailed structural engineering assessment of the building as soon as possible”. So neither was a detailed structural engineering assessment performed by the CCC itself on a standardized basis nor was it made a compulsory duty of the owner of a building. Specifications of a “detailed structural engineering assessment” did not exist either. The absence of such binding prescriptions made it possible that a seasoned engineer, Geoffrey Coatsworth, engaged by the owner after the 4 September earthquake, did indeed perform a structural engineering assessment but confined himself to do that without the relevant documentation which, in turn, was in possession of the CCC.

Yet, however insufficient and risk increasing these contributing factors were, their undesirable effect could have been neutralized with minor efforts. This is particularly striking with respect to the root cause of the entire tragedy, the building permit that according to the judgment of the Royal Commission should never have been issued.

It is beyond reasonable doubt that without the intervention of Bryan Bluck in his capacity as chief buildings engineer of the Christchurch City Council in favor of a prompt issuance of the permit a thorough and diligent review of the structural design of the building and a verification of the related calculations would have been performed. It is also extremely likely that in the course of such scrutiny the crucial design errors would have been detected. To renounce on a structural analysis and related calculations of the building’s design can therefore be defined as the basic necessary condition of the ultimate disaster to occur.

Another barely disputable necessary condition is the failure to perform a proper Level 2 Rapid Assessment after the earthquake of 4 September 2010. This assessment would have required the compulsory engagement of a trained engineer but it was performed on 7 September 2010 without one. The definition of this omission as a necessary condition depends admittedly on the assumption that a “detailed structure engineering assessment of the building” as recommended in the wording of the green placard would have included a re-analysis of the structural design of the CTV building based on CCC documentation and independent calculations. The validity of this assumption is underlined by the fact that the experienced engineer, David Coatsworth, who was indeed engaged by the

owner of the CTV building initially requested the relevant CCC documentation but did not insist on his request when CCC declared that handing over the documents, including the structural drawings and calculations, would take several weeks under the given circumstances. On the other hand, the building manager John Drew did not notify Coatsworth when the CCC documentation including the structural drawings turned out to be available earlier than expected. So, as far as the recommendations of the wording on the green placard were concerned, both Drew and Coatsworth had the right impulse to initiate and to conduct “a detailed structural engineering assessment of the building” but in the end they did not act accordingly. The same applies to the failure of building manager Drew to follow with sufficient resolve his own impulse to have Mr. Coatsworth return to the damaged CTV building for a structural engineering assessment after the Boxing Day earthquake of 26 December 2010.

There was ultimately no single sufficient condition for the collapse of the CTV building to occur. What emerged was a quite typical pattern of jointly sufficient necessary conditions that themselves were embedded in permissive conditions whose common denominator was diffused responsibility and diluted professional standards. Which brings us to a more detailed analysis of the identifiable causal mechanisms and their more or less exemplary nature (Table 4.1).

**Table 4.1** Contributing Factors (CF) and Necessary Conditions (NC), collapse of CTV building

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CF1	Tolerated practice to submit applications for building permits to the Christchurch City Council without supporting documentation at the date of submission.
NC1	Issuance of the building permit by the Christchurch City Council despite unresolved issues of structural engineering, 30 September 1986.
CF2	Imprecise Christchurch City Council guidelines for post-earthquake Rapid Assessments.
NC2	Installation of drag bars to reinforce diaphragms without the required permit of the Christchurch City Council, October 1991.
NC3	Failure to perform proper Level 2 Rapid Assessment after the earthquake of 4 September 2010 by Christchurch City Council inspectors.
CF3	Failure of facility manager to insist in his attempts to consult engineer familiar with the building and its structural design after the Boxing Day (26 December) earthquake 2010.

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### 4.3.3 *Causal Mechanisms*

The three main episodes resulting in the collapse of the CTV building on 22 February 2011 had a common substantive core. Each time, a thorough and diligent structural engineering assessment was at stake and each time it did not take place. This applies to the structural checking of the application for the building permit in 1986, the retrofit works of 1991 and the inspection of the damages to the building after the earthquake of 4 September 2010. What is more, the omission of a sound structural engineering assessment at three different occasions reveals a common pathological core in the form of almost identical causal mechanisms of an exemplary nature. “Exemplary” means that the mechanisms are typical for the institutional and professional environment in which they occurred. Therefore, their existence and risk increasing potential is known in principle. Moreover, because that is so the undesirable effects of those mechanisms are usually kept under control unless additional mechanisms suspend precisely that control. Accordingly, there is a high level of observable regularity when it comes to system-specific causal mechanisms, antidotes and the forces that might neutralize those antidotes. Hence, here again, the prospects of generalization for the sake of learning and prevention.

When it comes to the relevant permissive conditions in the form of situational mechanisms, it was a characteristic arrangement that blurred accountability and paved the way to the acceptance of diluted professional standards.<sup>117</sup> This affects the relationship between the relevant public authority with jurisdiction over building and issuing building permits on the one hand and applicants for building permits on the other hand. In the case of larger buildings or complex construction projects the applicant is typically a consultancy firm or major contractor. What matters are clear-cut jurisdictional boundaries that guarantee that both parts do justice to their professional obligations and to the institutional logic those obligations belong to. These boundaries were systematically blurred in the relationship between the Christchurch City Council (CCC) and the consultancy firm Alan Reay Consultancy Engineers/Consultancy Ltd. (ARCE/ARCL) as “Professional Designer” and key-consultant. While it was plausible policy of the CCC to process requests for building permits expeditiously given the economic importance of construction and the

<sup>117</sup> Johan P. Olsen: Accountability and Ambiguity. In Mark Bovens, Robert E. Goodin, and Thomas Schillemans, eds.: *The Oxford Handbook of Public Accountability*. Oxford: Oxford University Press 2014, 106–123.

overall requirements of service orientation one consequence was tolerance and concessions toward incomplete applications and late submission of documentation, especially structural drawings and related calculations. This gave contractors and consultants leverage over the CCC since late submission of sophisticated structural drawings and related calculations meant that the envisaged date of construction works to begin was approaching and, accordingly, the CCC was under pressure not to delay their start.

What emerged was a latent hybridity of public and private functions and ambiguous role patterns.<sup>118</sup> In the essence, the relationship between the CCC and larger consultants or constructors as applicants for a building permit were structurally asymmetric. Instead of the CCC being literally the authority enforcing the relevant legal stipulations even against reluctance of the applicants for a building permit—after all, the conventional model of serving the public interest—it was the applicants who were enabled to exert mild pressure on the CCC, even at the expense of due diligence in the process of structural engineering assessment as a typically tedious and time consuming task relevant authorities have to assume. Those were more or less the situational mechanisms to which the CCC was exposed in any larger process of structural checking and preparation of a building permit.

These conditions created a particular incentive structure at the level of the action formation mechanisms. In the essence, those incentives undermined the professional integrity of the civil engineers who worked with the Christchurch City Council as the building authority<sup>119</sup> a creeping erosion of professional integrity<sup>120</sup> that has been denoted as “normalization of deviance”.<sup>121</sup> The pre-history of the collapse of the CTV building may indeed be categorized as the classic example of misguided

<sup>118</sup>For latent hybridity, its functions and dysfunctions, cf. Wolfgang Seibel: *Studying Hybrids. Sectors and Mechanisms*. *Organization Studies* 36 (2015): 697–712.

<sup>119</sup>cf. Philip Selznick: *Leadership in Administration. A Sociological Interpretation*. Berkeley and Los Angeles: University of California Press 1957, 118–133, as a classic description of the necessity to defend professional and institutional integrity.

<sup>120</sup>For slow institutional decay see the classic study by Samuel P. Huntington: *The Marasmus of the ICC: The Commission, the Railroads, and the Public Interest*. *The Yale Law Journal* 61 (1952): 467–509.

<sup>121</sup>Diane Vaughan: *The Dark Side of Organizations: Mistake, Misconduct, and Disaster*. *Annual Review of Sociology* 25 (1999): 271–305; Diane Vaughan: *The Challenger Launch Decision: Risky Technology, Culture and Deviance at NASA*. 2nd ed., Chicago and London: The University of Chicago Press 2016.

taken-for-grantedness and its fatal consequences. Once the negligent handling of structural engineering issues was accepted inside the Christchurch City Council it became common practice. That practice, in turn, undermined the sense for case-specific uniqueness and the necessity to inspect the peculiarities of a particular structural design of a building and potential non-compliance with the relevant regulatory framework.

The strength of those detrimental psychological forces is underlined by the fact that they made even seasoned professionals ignore existing regulation. Moreover, the resulting institutional softness of the CCC was apparently anticipated by consultants and contractors. They knew that they could afford not to comply with formal requirements even when issues of structural engineering were at stake. This is demonstrated, *inter alia*, by the fact that ARCL did not seek the compulsory building permit when planning and designing the retrofit of diaphragms of the CTV building in 1991 and that that omission was justified by the company's principal with the remark that he took it for granted that the CCC's chief buildings engineer would have granted the permit anyway.

By the same token, the stabilized culture of neglect was complemented by essentially misplaced trust. Not surprisingly, the illusion of institutional integrity persisted so that both laypeople and professional engineers with only occasional contact with the CCC took it for granted that the indispensable and, basically, standardized procedures of structural checking of a building's design had been performed. The discrepancy between the latent erosion of professional standards and integrity on the one hand and persisting public trust on the other hand is comforting and disturbing at the same time. It obviously did not occur to David Coatsworth, the civil engineer engaged by the owner of the CTV building after the September earthquake of 2010, that a sound structural engineering assessment of the building had never been performed. And it probably never occurred to the building manager John Drew that the trust he and Coatsworth invested in the professional skill and integrity of the Christchurch City Council was unfounded.

It is, accordingly, a reasonable question if the distinction between situational and transformational mechanisms makes sense at all when applied to the CTV building case. It is, indeed, hard to imagine that the distinctly strong path dependency of the overall neglect of structural engineering issues and misguided trust could have been suspended at any moment in time. Yet, the answer is a principle Yes. The transformational mechanism

was the absence of leadership and resolve.<sup>122</sup> Not that at a particular point of a disastrous causal chain a single actor could have intervened and did not do so. It was, rather, a creeping crisis<sup>123</sup> of leadership especially at the helm of the responsible division of the Christchurch City Council that decisively contributed to both the “normalization of deviance” from regular professional standards of structural engineering assessment and the CCC’s inability to address properly the post-earthquake situation of September 2010. Judgment and resolve would have been necessary after the earthquake of 4 September 2010 for the adequate management of building inspections. Instead, it was left to the discretion of private owners whether or not to engage an engineer for a sound structural engineering assessment. Sloppiness in handling structural engineering checking procedures and their documentation could and should have been recognized by the relevant CCC officials in the first place. What is more, however, a sound sense of responsibility beyond formal accountability standards<sup>124</sup> should have ensured that standard operating procedures and routinized attitudes of staff had no detrimental effect on handling sensitive cases of structural engineering assessment in an earthquake prone environment. It was this particular quality of leadership that was tragically missing (Fig. 4.2).

<sup>122</sup>Cf. Paul ‘t Hart and Lars Tummings: *Understanding Public Leadership*. 2nd ed., London: Red Globe Press 2019, 50–51.

<sup>123</sup>Arjen Boin, Magnus Ekengren, and Mark Rhinard: *Hiding in Plain Sight: Conceptualizing the Creeping Crisis*. *Risk, Hazards & Crisis in Public Policy* 11 (2020): 116–138. The literature on “creeping crises”, mainly stimulated by the research of Arjen Boin et al., focuses on unresolved societal, economic or political problems. The phenomenon described in this chapter, however, refers to a “creeping” institutional crisis, “hidden in plain sight” as being addressed in Diana Vaughan’s work on phenomena of “normalization of deviance” and analyzed in a classic version as institutional “marasmus” by Samuel P. Huntington back in 1952 (“The Marasmus of the ICC: The Commission, the Railroads, and the Public Interest”, as quoted above).

<sup>124</sup>Carl J. Friedrich: *Public Policy and the Nature of Administrative Responsibility*. *Public Policy* 1(1) (1940): 1–20; Mark Bovens: *The quest for responsibility: Accountability and citizenship in complex organizations*. Cambridge: Cambridge University Press 1998.

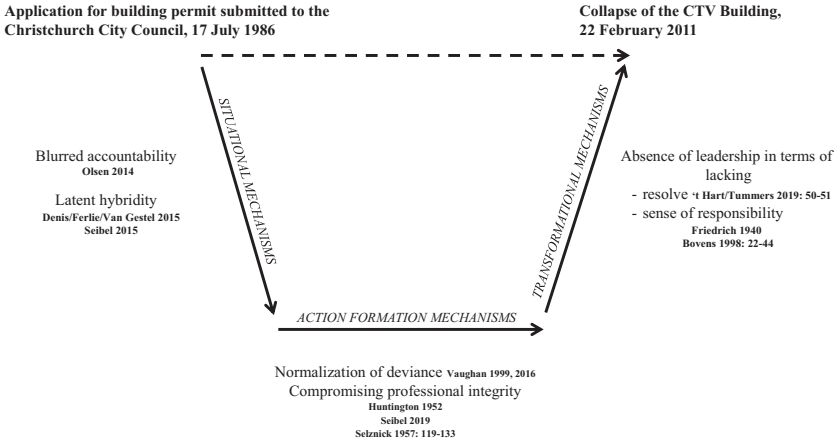


Fig. 4.2 Causal Mechanisms, collapse of CTV building

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# Politicization of the Non-politicizable: The Collapse of the Ice Skating Rink in Bad Reichenhall on 2 January 2006

## 5.1 CHARACTERISTICS OF THE CASE

After heavy snowfall, the ice skating rink of the city of Bad Reichenhall collapsed on 2 January 2006, five minutes before its scheduled closure at 4:00 PM.<sup>1</sup> The roof of the 33-year-old hall had not withstood the snow load.<sup>2</sup> Fifteen people, twelve children between the age of 7 and 15 and three mothers, were killed by the falling debris of the roof. Thirty-four people were injured, six of them seriously.<sup>3</sup>

The actual ice rink was connected to a public indoor swimming pool by a central wing in which the changing room, a restaurant, baths and company apartments were located. The ice rink and indoor swimming pool formed a hall complex. The roof constructions had been executed separately for the ice rink and the swimming pool, on the day of the disaster

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<sup>1</sup>Landgericht Traunstein, 2. Strafkammer, Verdict of 18 November 2008, 2Kls 200 JS 865/06, paragraphs 95 and 233. Henceforth cited as LG 2008 RN plus number of *Randnummer* (RN = paragraph no.).

<sup>2</sup>LG 2008 RN 96, 277.

<sup>3</sup>LG 2008 RN 66–90.

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This chapter is the revised and translated version of the related case study in Wolfgang Seibel, Kevin Klamann and Hannah Treis: *Verwaltungsdesaster. Von der Loveparade zu den NSU-Ermittlungen*. Frankfurt/New York: Campus Publ. 2017, 113–158. The German original was authored by Kevin Klamann and Wolfgang Seibel.

only the roof construction of the ice rink collapsed.<sup>4</sup> The relevant criminal investigations<sup>5</sup> revealed considerable errors in the planning and construction of the ice rink which remained largely undetected and had to be regarded as the actual cause of the collapse.<sup>6</sup> The maintenance of the building by the Bad Reichenhall city administration had also been neglected. Water ingress and condensation on the wooden support beams of the roof structure during operation of the hall did not cause the city, as the operator of the hall, to check the stability of the roof structure or take any other steps<sup>7</sup> despite complaints from users.<sup>8</sup> The City ignored also safety-relevant indications of defects in the hall complex which, however, were not connected to the collapse of the roof itself.<sup>9</sup> The presiding judge at the Traunstein Regional (Repeal) Court characterized the behavior of the Bad Reichenhall city administration as being shaped by “sloppiness, ignorance, irresponsibility and scrupulousness”.<sup>10</sup>

What the case has in common with other man-made disasters involving German governmental agencies is the absence of any investigation beyond criminal trial. No expert commission, no parliamentary investigation committee nor any otherwise independent investigation was undertaken. Among the four cases of collapsed bridges and buildings caused by public

<sup>4</sup>LG 2008 RN 32–33.

<sup>5</sup>The judicial processing of the catastrophe of 2 January 2006 began with a criminal trial before the Traunstein Regional Court or *Landgericht*. This ended on 18 November 2008 with the conviction of an engineer involved in the construction. A project manager involved in the construction and an expert who had issued a positive certificate for the hall roof in 2003 were acquitted of negligent manslaughter charges. An appeal trial filed by the Public Prosecutor with the Traunstein Regional Court and the joint plaintiffs regarding the expert’s acquittal ended on 12 January 2010 with the revocation of the acquittal and referral to the Traunstein Regional Court (Federal Supreme Court, Verdict of 12 January 2010, 1 StR 272/09). A different chamber of the Regional Court confirmed the first instance acquittal of the expert by Verdict of 27 October 2011 (Landgericht Traunstein, 6. Strafkammer, Urteil vom 27.10.2011, 6KLs 200 JS 865/06 (3)).

<sup>6</sup>LG 2008 RN 102–135.

<sup>7</sup>LG 2008 RN 139, 229, 452.

<sup>8</sup>LG 2008 RN 190, 391–2, 462; Landgericht Traunstein, 6th Strafkammer, Verdict of 27.10.2011, 6KLs 200 JS 865/06 (3), paragraph 271. Cited below as LG 2011 + *Randnummer* (number of paragraph).

<sup>9</sup>LG 2011 RN 272–277.

<sup>10</sup>“Schlamperei, Ignoranz und Skrupellosigkeit”, Welt Online, 27.10.2011, <http://www.welt.de/vermishtes/weltgeschehen/article13684199/Schlamperei-Ignoranz-und-Skrupellosigkeit.html>, last accessed 23 March 2017. In this chapter, all quotes from German originals are author’s translations.

administration mismanagement that are analyzed in the present volume, the German case with a death toll of twelve children and three mothers accompanying them to a pastime entertainment is the only one without official acknowledgment of responsibility.

## 5.2 FACTS OF THE MATTER

The construction of the hall complex on behalf of the city of Bad Reichenhall began in 1971. The part of the hall that collapsed in 2006 was used as an ice skating rink in winter, otherwise as a tennis hall.<sup>11</sup> The hall went into operation in the Fall of 1973.<sup>12</sup> A subcontractor working on behalf of the general contractor was responsible for the planning, manufacture and erection of the roof construction.<sup>13</sup> The subcontractor had delegated these works to a civil engineer for whom, according to his



**Illustration 5.1** Bad Reichenhall Ice Skating Rink after the collapse of 2 January 2006 (Deutsche Presseagentur / Picture Alliance, media no. 38145505, license 212103591)

<sup>11</sup> LG 2008 RN 56, 292.

<sup>12</sup> LG 2008 RN 277.

<sup>13</sup> LG 2008 RN 44.



statement before the Traunstein Regional Court, the intended construction method was “new territory”, so that he had to rely on the assistance of yet another engineer involved in the construction. On 18 November 2008, the civil engineer who was mainly responsible for the construction errors was sentenced to 18 months imprisonment on probation for negligent manslaughter and negligent bodily injury. A project manager was acquitted.<sup>14</sup> A civil servant of the Bad Reichenhall city administration who, according to the public prosecutor, had been responsible for supervising the construction of the hall complex, was indicted but fell seriously ill during the trial so that the criminal proceedings against him had to be suspended. The trial against a master carpenter involved in the production of faulty roof racks was also discontinued after his death.<sup>15</sup>

The negligent attitude of the city administration was partly driven by an exemplary conflict of interests. The city was both the owner of the hall and the supervisory authority of building safety. The quest for saving taxpayer’s money and the necessity to ensure the safety of infrastructure began to collide when maintenance costs increased and urban planning ideas of the Lord Mayor envisaged abandoning the hall complex altogether. So the building authority was exposed to the Lord Mayor’s expectation not to invest too much efforts and money into the maintenance, let alone renovation, of the hall complex which comprised both the ice rink and an indoor swimming pool. According to the Lord Mayor’s own admission before the Traunstein Regional Court, this culminated in the downright obstruction of a municipal parliament decision to substantially renovate the hall at estimated costs of 5.5 million Euros.

An expert who had examined the roof construction of the ice skating rink without in-depth structural analyses in 2003 and nonetheless certified it to be in good condition was acquitted by the Traunstein Regional Court in 2008. The acquittal was annulled by the Federal Supreme Court in 2010, *inter alia* on the grounds that it was necessary to examine whether the expert opinion was a “carte blanche” for the City of Bad Reichenhall in the form of an inappropriate finding.<sup>16</sup> After referral of the case, the Traunstein Regional Court confirmed the acquittal. The Court could not clarify whether the expert had been explicitly commissioned to examine

<sup>14</sup>LG 2008 RN 1–10.

<sup>15</sup>LG 2011 RN 7, 30.

<sup>16</sup>Bundesgerichtshof, Verdict of 12.01.2010, 1 StR 272/09, paragraph 1 and paragraphs 81 to 86. Cited below as BGH 2010.

the roof construction and, in view of these doubts, did not see this defendant in a guarantor position with regard to the actual safety of the roof construction.<sup>17</sup> It was a telling detail when the Regional Court stated that even if a related contractual arrangement had existed, “the responsible city administration would not have taken any measures that could have prevented the accident of 02.01.2006”<sup>18</sup> in light of the sloppy and negligent attitude of the municipality in general.

The death of twelve children and three mothers who lost their lives under the collapsing roof of the Bad Reichenhall ice rink on 2 January 2006 was not the result of a tragic chain of unfortunate circumstances but of the failure of the Bad Reichenhall city administration to meet elementary professional and ethical requirements. The Lord Mayor of the city and leading officials in the building authority pursued their own urban planning ambitions at the expense of the safety of the hall users and the operational staff. This happened despite warnings of water ingress that had been noticed for years but were ignored by the city administration. While these water infiltrations did not cause the collapse, a risk-conscious reaction on the part of the city administration would have commissioned a thorough investigation into their origin which in turn, according to all likelihood, would have uncovered the basic construction and design errors of the roof that caused the collapse of the hall on 2 January 2006.

### 5.2.1 *Design and Construction Errors*

The civil engineer of the subcontractor commissioned with the planning, manufacture and erection of the roof construction made several serious mistakes in the structural calculations, so that the actual load capacity of the roof construction was considerably lower than shown in the calculations.<sup>19</sup> In Court, the relevant engineer stated that he had submitted his calculations for review to a consultancy firm also working for the general contractor where no objections were raised. Subsequently, the relevant calculations were forwarded to a structural engineering expert appointed by the general contractor.<sup>20</sup>

<sup>17</sup> LG 2011 RN 251.

<sup>18</sup> LG 2011 RN 3.

<sup>19</sup> LG 2008 RN 98, 266–267.

<sup>20</sup> LG 2008 RN 45, 176, 242.

According to the findings of the Traunstein Regional Court, the roof construction was under designed. Its basic elements were ten 48-meter-long wooden girders. In contrast to the indoor swimming pool, where these girders were supported by intermediate posts, they had to span a distance of 40.5 meters in the ice rink without such support.<sup>21</sup> According to the Court, girders of this length represented an unusual construction.<sup>22</sup> In order to ensure sufficient load-bearing capacity of the 48-meter-long girders, they had to be manufactured with a width of 2.87 meters. This was not in compliance with existing regulation stipulating a maximum width of 1.20 meters. In addition, the girders were designed in a hollow box cross-section which deviated from the building permit.<sup>23</sup> This would have required a special permit which the civil engineer failed to apply for.<sup>24</sup> In Court, he stated that he had not been aware of the permit requirement.<sup>25</sup> During the manufacture of the girders by two more subcontractors, more errors occurred the most serious of which was the use of urea resin glue with insufficient water resistance when assembling the wooden boxes of the girders.<sup>26</sup>

### 5.2.2 *Unbureaucratic Stoppiness*

A particularly serious aspect of mismanagement that directly impacted on the ultimate collapse of the ice rink roof was the absence of proper documentation of the relevant structural engineering and related calculations.<sup>27</sup> After the disaster of 2 January 2006, investigators did find a folder with a sticker “Statik Eishalle” (Statics, Ice Rink) but it was empty.<sup>28</sup> The absence of proper documentation turned out to be crucial when, in 1977, the city administration of Bad Reichenhall decided to vitrify the upper part of the ice rink. The reason was the noise pollution of the neighborhood caused by the initial open construction. The vitrification had already been included as an option in the original construction planning and had also been taken into account by the architect. However, in the course of the vitrification,

<sup>21</sup> LG 2008 RN 37–41.

<sup>22</sup> LG 2008 RN 428.

<sup>23</sup> LG 2008 RN 37, 108–109, 253.

<sup>24</sup> LG 2008 RN 109.

<sup>25</sup> LG 2008 RN 242.

<sup>26</sup> LG 2008 RN 125, 242, 433–439.

<sup>27</sup> LG 2011 RN 277.

<sup>28</sup> LG 2008 RN 273.

four exhaust air systems were installed on the roof of the ice rink in anticipation of the increased humidity in the now enclosed hall. The exhaust air systems increased the weight of the roof load by 2300 kilograms. The city administration failed to initiate a building permit procedure to have the statics of the construction checked under the conditions of the increased roof load.<sup>29</sup>

During the operating time of the ice rink there were repeated water ingresses and condensation on the girders. Rain water pipes were underdimensioned so that water also penetrated the box girders during overflow. In addition, an insufficient roof pitch led to more water ingress. These deficiencies had already been identified in 1975 but work to remedy them in 1975 and 1976 did not eliminate the issue. On the wooden girders, water run-off tracks were already noticeable in the late 1970s.<sup>30</sup> Both the operating staff of the ice rink and the local ice hockey club drew the city administration's attention to the water infiltrations.<sup>31</sup> Witnesses testified before the Traunstein Regional Court that the official in charge at the City Council had just replied laconically "that structure survives us all".<sup>32</sup> The board of the local ice hockey club stated that it had informed the Lord Mayor, but that he had merely pointed to other priorities at the time.<sup>33</sup> Buckets had to be put in the hall on a regular basis to collect water dripping from the roof.<sup>34</sup> In April 2005, the organizer of a flea market held in the hall contacted the hall manager pointing to water intakes—estimated at more than 750 liters—during the flea market alone.<sup>35</sup>

The Traunstein Regional Court, already in its first ruling of 2008, confirmed that the city Bad Reichenhall in dealing with the humidity problem displayed a "persistent breach of duty".<sup>36</sup> Since the late 1970s, the City had not carried out or initiated any special refit or renovation or in-depth

<sup>29</sup> LG 2008 RN 57–58, 436, 462.

<sup>30</sup> LG 2008 RN 60–63.

<sup>31</sup> LG 2008 RN 380–392.

<sup>32</sup> LG 2008 RN 389.

<sup>33</sup> LG 2008 RN 391.

<sup>34</sup> LG 2008 RN 62, 385, 390.

<sup>35</sup> "E wie Eishalle", in: DER SPIEGEL 14/2006, p. 58.

<sup>36</sup> LG 2008 RN 462: In the first proceedings, the Traunstein Regional Court discussed breaches of duty by third parties and their possible influence on the responsibility of the three defendants. The Court did not make a final assessment of the actions or omissions of the Bad Reichenhall municipal administration as criminal charges against municipal officials were ultimately dropped.

inspection of the hall.<sup>37</sup> No protective coating or special inspection of the roof structure was commissioned either although, according to the Traunstein Regional Court, “there would have been reason to do so due to the frequent water infiltrations and the visible water drainage traces on the girders [...]”.<sup>38</sup>

### 5.2.3 *Acknowledged Yet Unaddressed Safety Issues*

The general attitude of the City administration regarding the hall complex changed around the turn of the millennium. The driver was an EU Directive which necessitated costly renovation measures for the indoor swimming pool technology, in particular the replacement of the water treatment facility. An annual operational deficit of 600,000 to 700,000 Euros was also taken into consideration.<sup>39</sup> This prompted the Bad Reichenhall municipal authorities to commission a series of expert reports to estimate the costs of modernizing the indoor swimming pool and renovating the entire hall complex.<sup>40</sup> As early as 2001, an expert report was commissioned on the roof structure of the swimming pool hall.<sup>41</sup> In February 2002, estimates of refit costs, including sanitary facilities and bathing equipment, were obtained. In October 2002, a study was carried out on electrical installations with findings also on fire protection. In May and July 2003, expert opinions followed on the indoor swimming pool. Finally, a summary study was carried out in March 2004.<sup>42</sup>

The short report from 2001 found serious defects in the structure of the roof of the indoor swimming pool that did apparently not affect the roof of the ice rink in the same hall complex. The expert warned that “the secondary construction of the indoor swimming pool roof was at risk of collapsing, as was the canopy roof of the entrance area to the ice rink and indoor swimming pool”<sup>43</sup> where glued laminated timber beams were massively weakened.<sup>44</sup> Both assessments were confirmed by the 2003 study of a civil engineer who had already authored the short expert report of

<sup>37</sup> Ibid.

<sup>38</sup> LG 2008 RN 139.

<sup>39</sup> LG 2008 RN 177, LG 2011 RN 163.

<sup>40</sup> LG 2008 RN 177.

<sup>41</sup> LG 2008 RN 179.

<sup>42</sup> LG 2011 RN 166–176.

<sup>43</sup> LG 2008, RN 378.

<sup>44</sup> LG 2008, RN 184–185.

2001.<sup>45</sup> The experts consulted by the Traunstein Regional Court in 2008 repeated the obvious: That the defects in the roof construction of the indoor swimming pool and the canopy, which had been determined by the expert at the time, posed a “danger to life and limb” to the users of the indoor pool due to falling parts.<sup>46</sup>

Despite the disturbing reports, the City authorities did not initiate any countermeasures. The canopy of the hall complex was demolished in 2005. However, this only happened after parts had fallen from it and thus endangered the life and limb of the hall users indeed.<sup>47</sup> While the City administration stated in the trial before the Traunstein Regional Court that it had requested the operating staff of the hall complex to monitor the defects, staff members declared—“credibly”, in the opinion of the Regional Court—that they had never been informed of the results of the expert reports commissioned by the City. Rather, the poor condition of the canopy had been discovered by chance and only makeshift metal supports had been attached.<sup>48</sup>

The very expert who had determined the serious defects in the secondary structure of swimming hall roof and the canopy of the hall complex pointed out in his short report of 2002 that the pipe systems of the swimming hall were so badly corroded that soaking of the wooden construction could occur. The expert recommended a refit which, however, the City did not commission.<sup>49</sup> That same year, the city of Bad Reichenhall responded to warnings regarding fire protection in the indoor swimming pool only by renewing the fire alarm system. Other serious deficiencies in concerning fire protection were not taken into account.<sup>50</sup>

#### 5.2.4 *Mobilizing Recognizably Insufficient Expert Opinions*

Also in 2002, the building authority of the City of Bad Reichenhall contacted an architect asking for an expert opinion on the renovation costs of

<sup>45</sup> Ibid., LG 2011 RN 207–209.

<sup>46</sup> LG 2008 RN 378.

<sup>47</sup> LG 2008 RN 185, 378.

<sup>48</sup> LG 2011 RN 275.

<sup>49</sup> LG 2008 RN 187–8, LG 2011 RN 176.

<sup>50</sup> LG 2011 RN 276. Also with regard to a “highlighted in bold” (LG 2008 RN 401) danger of a hanging wooden ceiling crashing in the indoor swimming pool in the expert report of February 2002, the City only reacted with remedial work after a piece of wood had actually fallen down.

the hall complex. During an initial inspection, the architect determined that an expert opinion only made sense on the basis of an in-depth inspection of the hall complex by an experienced civil engineer. The architect also based his judgment on concrete damage visible to the naked eye and traces of water on the beams of the roof structure of the ice rink. He informed the building authorities of this in writing on 9 July 2002.<sup>51</sup> “Credibly”, according to the assessment of the Traunstein Regional Court, the architect recommended “a deeper investigation of the primary structure of the ice hall roof as well”.<sup>52</sup> The architect, who testified as a witness before the Traunstein Regional Court, stated that once he had submitted his report the City Council had not contacted him any further.<sup>53</sup> He said he had been under the impression that the City found the scope of the investigations he had proposed “too large”.<sup>54</sup>

Experts consulted by the Traunstein Regional Court stated that the cost of comprehensive inspection of the roof structure would have amounted to approximately 30,000 Euros but certainly not less than 20,000 Euros.<sup>55</sup> The expert opinion contract was finally awarded on 27 January 2003 to a civil engineer on the basis of a mere 3000 Euros fee.<sup>56</sup> In his report, he stated:

The supporting structures—both wooden and reinforced concrete—of the entire ice rink are in a generally good condition. Only water stains can be found in the wooden structure due to irregularities/water ingress from the roof drainage system. However, these have no influence on the quality or the load-bearing capacity of the supporting structure.<sup>57</sup>

As a defendant before the Traunstein Regional Court, this expert stated that the relevant official of the City’s building authority had reported to him during a joint inspection of the hall “that there had only been one water ingress”.<sup>58</sup> He had just been asked for a “rough cost estimate” and

<sup>51</sup> LG 2008 RN 190.

<sup>52</sup> LG 2011 RN 271.

<sup>53</sup> LG 2008 RN 190.

<sup>54</sup> LG 2008 RN 375.

<sup>55</sup> LG 2008 RN 411; LG 2011 RN 271.

<sup>56</sup> LG 2008, RN 169, 206.

<sup>57</sup> LG 2011 RN 129.

<sup>58</sup> LG 2008 RN 336.

was not supposed to investigate the roof structure of the ice rink in depth.<sup>59</sup> In the appeal verdict of 2011, the Traunstein Regional Court noted that the relevant City officials should have realized that an expert report for just 3000 Euros could not result in an in-depth inspection of the roof structure anyway.<sup>60</sup>

The consulted expert examined only one of the wooden girders at close range and only inspected the other girders through the telephoto lens of his camera. The Traunstein Regional Court stated that signs of weaknesses in the glued joints of the roof structure could have been detected in close examination at the time, i.e. in 2003, and, according to all likelihood, would have prompted the consulted expert to recommend an in-depth inspection.<sup>61</sup> Such an inspection, in turn, would have necessarily included a review of the construction documents. As it turned out after the disaster of 2 January 2006, however, those documents were undetectable.<sup>62</sup> It remained undetermined whether documentation of the structural design of the hall and related calculations analysis could no longer be found or had never existed in the files of the building authority.<sup>63</sup>

In the opinion of the Traunstein Regional Court in its final decision of 2011 the Bad Reichenhall City administration had not deliberately intended to extend the service life of the hall without costly remedying of defects.<sup>64</sup> On the other hand, the verdict of the Regional Court on the attitude of the Bad Reichenhall building authority was all the more devastating: In the opinion of the Court, even more thorough investigations, including an appraisal of the structural design of the ice skating rink roof which could have resulted in further recommendations, “with a probability bordering on certainty” would not have prompted the responsible officials of the City administration to take any measures that ultimately would have prevented the accident.<sup>65</sup> And, quite ironically, for this reason the

<sup>59</sup> LG 2011, RN 231.

<sup>60</sup> LG 2011 RN 244, see also LG 2008 RN 353.

<sup>61</sup> LG 2008 RN 208, 358–359.

<sup>62</sup> While the Traunstein Regional Court assumed in 2008 that the review of the original construction documents would only have become necessary in the course of an in-depth inspection that did not take place, a different Chamber of the same Court in 2011 assumed that the defendant had had the obligation to review the original documentation anyway. Cf. LG 2008 RN 361, LG 2011 RN 264.

<sup>63</sup> LG 2011 RN 262.

<sup>64</sup> LG 2011 RN 254–6.

<sup>65</sup> LG 2011 RN 160.



consulted expert, according to the Court, could not be held accountable for the consequences of his obviously misleading report on the structural conditions of the hall roof.

In March 2004, the city of Bad Reichenhall commissioned a summary report to be drawn up which estimated the costs of restoration of the hall complex at 5.5 million Euros and at the same time doubted the sense of such a measure.<sup>66</sup> This report also contained a reference to the fact that there was no separate estimate of the renovation costs for just the roof construction of the ice rink.<sup>67</sup>

### *5.2.5 An Obstructed Municipal Parliament Decision and the Path to Disaster*

The Bad Reichenhall *Stadtrat*—the municipal parliament—finally decided on 14 June 2005 to preserve and renovate the hall complex with the ice skating rink and indoor swimming pool. This decision was deliberately ignored by the City administration, as the Lord Mayor had to admit in Court. The Mayor, instead, preferred the closure of the hall complex and to envisage a new facility with a sports pool to a spa and wellness center that was in the making anyway elsewhere in the city.<sup>68</sup> In fact, that plan was realized later on.<sup>69</sup> This did not alter the fact that the immediate implementation of the City Council's decision or, alternatively, the shut-down of the ice skating rink would have saved the lives of twelve children and three mothers killed when the roof of the hall collapsed on 2 January 2006. The Traunstein Regional Court stated in this regard:

On 14.06.2005, the city council decided that the entire complex should be renovated. It commissioned the administration to create a renovation concept on the basis that both the ice skating rink and the indoor swimming pool would be preserved, but the indoor swimming pool would no longer be used as a public swimming pool, but as a pure sports pool. Contrary to this decision of the city council, the administration did not make any effort to implement this decision. Until the collapse of the hall on 02.01.2006 nothing was done in this respect. Rather, the Lord Mayor continued to

<sup>66</sup> LG 2011 RN 173.

<sup>67</sup> LG 2011 RN 271.

<sup>68</sup> LG 2011 RN 270.

<sup>69</sup> *Ibid.*

favour another solution, namely the incorporation of a sports pool into the new spa and the demolition of the entire hall complex.<sup>70</sup>

After heavy snow fall, the building manager of the ice rink took samples of the snow cover on the roof on the morning of 2 January 2006 and determined a snow load of 166 kilograms per square meter.<sup>71</sup> He had at his disposal only a handwritten note according to which the load-bearing capacity limit was 175 kilograms per square meter. The manager therefore saw no reason for an immediate evacuation and shut-down of the ice rink. Court experts later assessed that at the time of the measurement the roof load had presumably not exceeded 146 kilograms per square meter and that the correct load-bearing capacity limit was 150 kilograms per square meter—under the condition of a flawless roof construction.<sup>72</sup> The handwritten note routinely used was a copy made by the operating personnel which, according to Court experts, came from “an outdated design assessment for a completely different roof construction”.<sup>73</sup>

At 2:44 PM a weather warning of the German Weather Service announcing more heavy snowfall to be expected in the region from 3:00 PM on reached the manager of the hall. This prompted him to consult with the building authority of the city administration the result of which was the decision to close the ice skating rink prematurely at 4:00 PM. It was understood that the snow load on the roof should be reduced the next day according to common practice under such conditions.<sup>74</sup> Around 3:30 PM, according to witnesses, a cracking bang was to be heard in the ice skating rink, coming from the roof, which did not trigger any consequences.

At 3:55 PM the roof of the skating rink suddenly collapsed. The sequence of the collapse remained unclear in detail. Two scenarios were considered. In both, the failure of the wooden roof girder beams was assumed as the trigger factor. Both scenarios assumed that the failure was caused by the yielding of adhesive joints due to the constant moisture and the swelling and shrinking of the wood of the roof structure. In one of the scenarios, the urea resin glue used was particularly highlighted. It was

<sup>70</sup> LG 2011 RN 214–215.

<sup>71</sup> LG 2008 RN 94.

<sup>72</sup> LG 2008 RN 236–238; LG 2011 RN 279.

<sup>73</sup> LG 2011 RN 279.

<sup>74</sup> LG 2008 RN 95, General Prosecutor’s Office Munich, refusal of 21.08.2007, p. 6. The document was temporarily available at: [http://reichenhaller-pranger.de/resources/generals\\_taatSanwalt+m%C3%BCnchen+29.08.07.pdf](http://reichenhaller-pranger.de/resources/generals_taatSanwalt+m%C3%BCnchen+29.08.07.pdf), last accessed on 27 February 2013.

assumed that the urea resin glue, which is not sufficiently water-resistant, triggered the failure of one of the girders. In both scenarios, after the failure of one girder beam, the rigid connections between the remaining beams, which were also defective and weakened due to age, triggered a kind of chain reaction that led to the collapse of the entire roof.<sup>75</sup>

## 5.3 CASE ANALYSIS

### 5.3.1 *Turning Points and Critical Junctures*

If there was one critical juncture on the pathway to the catastrophe of 2 January 2006 then it was the decision of the Bad Reichenhall building authority of 27 January 2003 to forego a special inspection of the roof structure of the ice rink. An architect consulted by the city had suggested such an inspection in 2002. According to the Traunstein Regional Court, the inspection alone would have cost no less than 20,000 Euros.<sup>76</sup> The building authority decided, however, to seek the considerably cheaper expert opinion of a local civil engineer instead. According to the findings of the Traunstein Regional Court in verdicts of 2008 and 2011, this expert opinion could not provide reliable information about the actual condition of the roof construction of the ice rink.<sup>77</sup> If, on the other hand, the City administration had followed the recommendation of the previously consulted architect and had had a special examination of the roof construction carried out accordingly, the fundamental construction faults of the roof would have been determined “with a probability bordering on certainty”, according to the Regional Court.<sup>78</sup> Knowing the deficiencies of the ice rink, it seems very likely that the catastrophe of 2 January 2006 would have been averted by timely renovation measures or at least an earlier shut-down on the day of the disaster. The reason why the recommendation of

<sup>75</sup>With regard to the errors committed by the civil engineer convicted in 2008, the Regional Court 2008 declared: “All three established breaches of duty of the defendant G, construction contrary to the building authority approval, inadequate static calculation and careless monitoring of the manufacturing process were causal for the collapse. The existence of only one of the assumed breaches of duty in each case would possibly not have led to the collapse on 02.01.2006, but the simultaneous existence of these errors did have.” LG 2008 RN 450.

<sup>76</sup>LG 2011 RN 266, 271.

<sup>77</sup>LG 2008 RN 190; LG 2011 RN 265–272.

<sup>78</sup>LG 2011 RN 266.

the architect consulted in 2002 should have been taken seriously was the well-known signs of construction defects in the form of water ingress, the Regional Court stated.<sup>79</sup>

The extent of responsibility of the relevant officials of the Bad Reichenhall municipal administration is underlined by two further circumstances. Not only was an in-depth inspection of the roof construction omitted, but the City administration, the Lord Mayor in particular, also ignored the decision of the Bad Reichenhall municipal parliament of 14 June 2005 to have the hall complex completely renovated.<sup>80</sup> After the City administration had already two years earlier renounced on an in-depth inspection of the roof structure, which had been recommended to it by an expert, the attitude of not investing any major funds in further inspections became entrenched. This attitude did not change at all when the municipal parliament decided, in June 2005, to have the hall structure entirely renovated which was contrary to the interests of the administration in closing down and dismantling the hall complex instead.

An antecedent turning point that changed the disposition of the City administration was the turn of the millennium<sup>81</sup> when a new EU Directive for infrastructure standards caused doubts as to whether the hall complex as such could have an economically viable future at all. This provided an incentive for cost reduction in case of any renovation measures. Still, however, it was a serious omission that the Reichenhall City administration did not pay thorough attention to the water ingress and to the advice of the architect consulted in 2002 to conduct an in-depth inspection of the roof construction of the ice rink (Fig. 5.1).

<sup>79</sup> LG 2008 RN 139.

<sup>80</sup> The recommendation to take measures to estimate the renovation costs for the roof of the ice rink, which was found in the summary report of March 2004 (LG 2011 RN 248, 271), suggests that a more detailed inspection of the roof could have been expected for the renovation planning if the administration had actually wanted to carry out the renovation itself (LG 2011 RN 248, 271). The city did not react to this recommendation either, as the Traunstein Regional Court stated: “Even when Witness L. in his 2004 study—as he credibly described it—pointed out urgently to the obviously unexamined and unevaluated roof construction, there was still no reaction on the part of the city administration, neither the commissioning of an additional study nor a possible consultation with the defendant.” LG 2011 RN 248.

<sup>81</sup> LG 2011 RN 163.

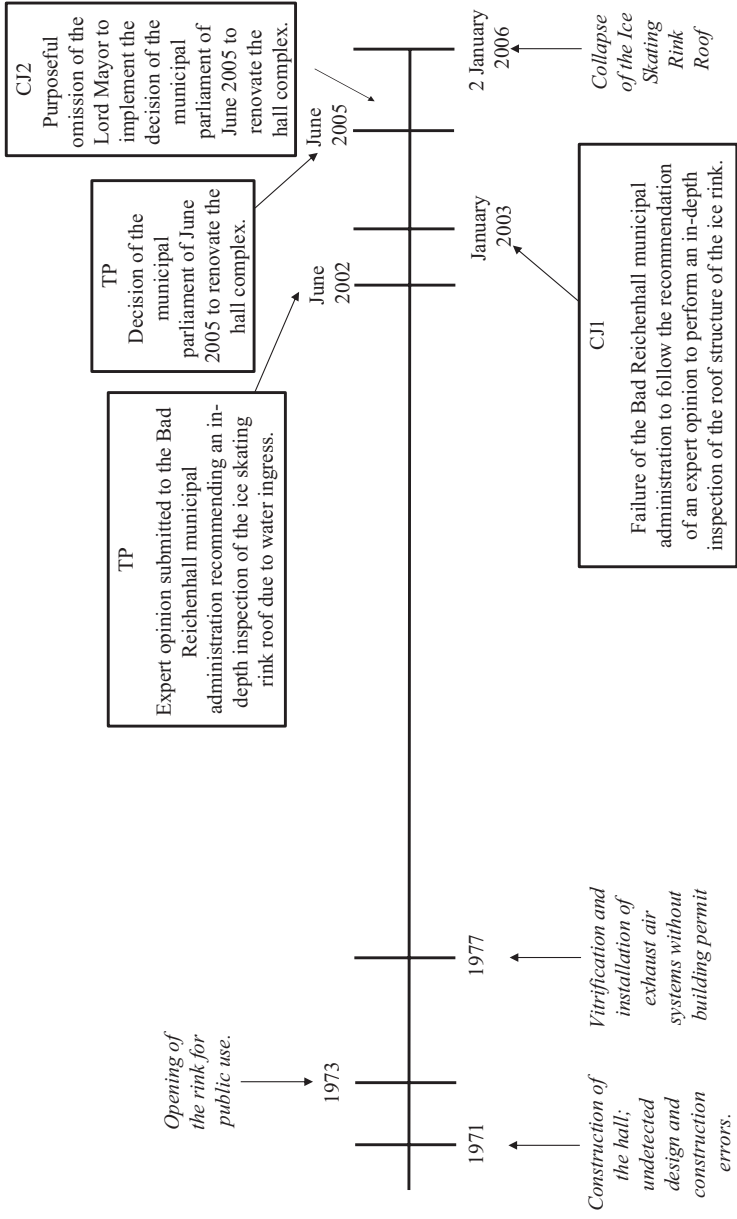


Fig. 5.1 Turning Points (TP) + Critical Junctures (CJ), Collapse of Bad Reichenhall Ice Skating Rink

### 5.3.2 *Contributing Factors and Necessary Conditions*

The collapse of the skating rink in Bad Reichenhall was the cumulative effect of several independent causal factors, yet it did not result from the proverbial chain of unfortunate circumstances. It was not the circumstances that triggered the catastrophe of 2 January 2006 but decisions taken by officials of the Bad Reichenhall City administration who themselves could not fully anticipate the consequences of their decisions or omissions but nevertheless failed to act mindfully and with the necessary sense of responsibility. This pertains to the original design and construction errors of 1973, the faulty initial inspection and approval of the roof structure, the way in which the vitrification of the ice rink was carried out including the installation of exhaust air systems in 1977, the disregard of an expert's recommendation of 2002 as well as the continued indications by users and operating personnel that water was entering the ice skating rink, the non-compliance with the municipal parliament's decision of June 2005 to renovate the hall complex and the decision making concerning the closure of the ice skating rink on the day of the accident itself.

The Bad Reichenhall ice rink would not have collapsed if it had not been for the construction faults, but these faults could have been recognized in due time and they could have been rectified.<sup>82</sup> Carelessness of supervision and maintenance was another necessary condition for the later collapse of the hall, but it alone would not have triggered the collapse given the original construction defects which were diagnosed by the experts consulted by the Traunstein Regional Court as the ultimate cause.<sup>83</sup> In addition, there was insufficient monitoring of the manufacturing process of the girder beams, so that their faulty construction and incorrect gluing with its detrimental effect given the high moisture load of the ice rink were not prevented. The civil engineer in charge did not seek the special permit required for girder constructions of the chosen type. The special permit, if granted, would have been based on a review of the structural design and on conditions whose fulfillment would have prevented, according to all likelihood, the construction faults of the roof. In their mutually reinforcing interaction, these errors were a necessary condition for the collapse of the hall on 2 January 2006.<sup>84</sup>

<sup>82</sup> See the assessment of the Landgericht Traunstein: LG 2008 RN. 98, 452.

<sup>83</sup> LG 2008 RN 98.

<sup>84</sup> This was also the evaluation of the Landgericht (Regional Court) Traunstein, cf. LG 2008 RN 109, 450.

After completion of the construction works in 1973, the city of Bad Reichenhall building authority had to decide on the final approval of the hall in terms of compliance with existing regulation. After the disaster of January 2006, it turned out that proper documentation of the relevant structural engineering and related calculations were missing. The relevant folder in the building authority did exist but it was empty. It remained unknown whether calculations of the structural design of the ice skating rink roof had been performed at all, which was highly probably though.<sup>85</sup> Therefore, the mere fact of the building permit issued in 1971 could only count as a relevant causal factor if it had actually taken place in the absence of the required review of the structural design and related calculations. In cross-examination before the Traunstein Regional Court, witnesses and experts stated that this kind of omission would be practically inconceivable.<sup>86</sup>

An additional risk factor was the vitrification of the ice rink carried out in 1977 which inevitably increased the level of humidity in the hall, so that in the same year an exhaust air system was installed with the necessary equipment placed on the roof of the hall. This double measure—vitrification and installation of the exhaust air system—was problematic on the one hand because an insufficiently moisture-resistant urea resin glue had been used to erect the wooden structure of the roof and, on the other hand, because the additionally installed exhaust system increased the roof load by a total of 2300 kilograms. With regard to the vitrification itself, the city of Bad Reichenhall acted flawlessly. This measure was already envisaged in the building contract of 1971, so the city could assume that the subsequent vitrification had been taken into account in the construction of the roof itself.

The situation was different for the decision to install the exhaust air system. According to the Traunstein Regional Court, the resulting increase in the roof load was not the cause of the collapse of the hall roof because the snow load that occurred on 2 January 2006 would have had to be carried in the absence of construction faults regardless of the dead weight of the exhaust air systems.<sup>87</sup> Irrespective of these construction-physical aspects, however, a breach of duty on the part of those responsible in the Bad Reichenhall city administration lay in the fact that no building permit

<sup>85</sup> LG 2008 RN 274, 290, 441.

<sup>86</sup> LG 2008 RN 275.

<sup>87</sup> LG 2008 RN 100.

procedure had been initiated for the installation of the exhaust air system and that, despite the increase in the roof load, no special inspection and, if necessary, reinforcement of the roof structure had been carried out.<sup>88</sup> If such an adjustment had taken place, the absence of documentation on the structural design and related calculations would have been noticed, the Traunstein Regional Court stated.<sup>89</sup> In this case, it is highly probable that the absence of a load-carrying test certificate for the stability of the entire roof construction would have been detected as well. Or, if at that time, i.e. 1977, complete documentation had still been available in the files the City administration it would at least have had precise information about the load-carrying capacity itself. Either way, a proper installation and approval of the exhaust air system would have led to a review of the relevant documentation.

A stronger counterfactual scenario can be assumed under the premise that no documentation was available and that this very fact would have been detected in a certification process in accordance with due diligence standards when the vitrification of the hall in 1977 was in the making. Continued operation of the hall in the knowledge that there was no verifiable documentation of the building's structural design would have been inconceivable. To that extent, the absence of a verification of the design can be defined a further necessary condition for the collapse of 2 January 2006.

Similar to the vitrification of the ice skating rink and the resulting installation of the exhaust air system, the Bad Reichenhall city administration's failure to react to the water ingress registered during almost the entire time the rink was in operation was also significant. As an isolated factor, the apparent leaks in the hall roof were "not the cause" of the collapse of the hall roof according to the Traunstein Regional Court.<sup>90</sup> However, the fact that those responsible in the Bad Reichenhall municipality simply ignored the water ingresses repeatedly admonished by hall users was, in the opinion of the Court, a breach of duty anyway.<sup>91</sup> The monitoring of the roof by the city was limited to a rough inspection of the girders of the roof construction on the occasion of the regular change of use of the hall from ice sports to tennis hall operation and vice versa. This—still

<sup>88</sup> LG 2008 RN 138, 452, 460–462.

<sup>89</sup> LG 2008 RN 452.

<sup>90</sup> LG 2008 RN 99.

<sup>91</sup> LG 2008 RN 462.



superficial—inspection, however, was not carried out by skilled experts but by the municipal operating personnel.<sup>92</sup>

Nevertheless, the head of the relevant department of the Bad Reichenhall building authority rated the necessarily superficial inspections as sufficient.<sup>93</sup> In cross-examination before the Court, the Lord Mayor himself stated that in view of the initially open roof construction it had been assumed that water would not harm the wooden roof structure and its stability. He stated that he and the relevant municipal officials were also convinced that the hall could be considered stable as long as no significant changes were made to the original design.<sup>94</sup> Court experts stated that this was a common assumption made by authorities when dealing with comparable halls. It was only after the collapse of the ice rink in Bad Reichenhall that regular inspections of the stability of similar constructions were legally prescribed.

With regard to water ingress, however, the Traunstein Regional Court made it clear that the decision not to carry out a review of the load-bearing capacity of the roof was indicative of a “careless handling of the building by those responsible in the city of B[ad] R[eichenhall]”.<sup>95</sup> In view of the water ingress, there would at least have been “reason” to commission an inspection of the glued laminated wooden beams.<sup>96</sup> After all, “every expert knows that wood constructions, especially glued laminated timber, in connection with frequent water contact, can cause damage to the wood and the construction”.<sup>97</sup> The experts called upon by the Traunstein Regional Court explained that, at least from 2003 onward, a “hands-on” examination of the girder beams would have already revealed the necessity of a stability test which would then have revealed the very defects that ultimately caused the collapse of the hall roof.<sup>98</sup>

In this respect, the non-observance of the repeated complaints about water ingress by those responsible in the Bad Reichenhall City administration can also be defined as a necessary, albeit insufficient, condition for the later collapse of the hall roof. According to the Traunstein Regional Court, obvious water ingress would have been assessed differently by a risk-sensitive administration. Even if the administration, unaware of the

<sup>92</sup> LG 2008 RN 229, 373.

<sup>93</sup> LG 2008 RN 373.

<sup>94</sup> LG 2011 RN 241.

<sup>95</sup> LG 2008 RN 380.

<sup>96</sup> LG 2008 RN 139.

<sup>97</sup> LG 2008 RN 380.

<sup>98</sup> LG 2008 RN 362; LG 2011 RN 266.

original construction errors which caused the collapse, could not have been fully aware of the consequences of its omission, a risk-sensitive attitude could have prevented the catastrophe of 2 January 2006.

An indirect warning which the city itself had triggered but then ignored arose in the course of the negotiations between the responsible officials of the Bad Reichenhall City administration and a consulted architect in 2002. At that point, the municipality was already considering the closure of the complex and presumably wanted to avoid greater financial expenditure for an expert review of the hall construction.<sup>99</sup> The architect consulted at the time suggested a comprehensive inspection of the roof structure of the ice rink in order to estimate renovation costs.<sup>100</sup> Such an investigation would very probably have revealed the existing design and construction errors. The city administration's decision to dispense with this investigation is therefore a further necessary condition for the occurrence of the catastrophe of 2 January 2006.

In its first ruling, the one of 2008, the Traunstein Regional Court emphasized the serious consequences of the risk-blind decisions of those responsible in the city of Bad Reichenhall. They pertained to the indifference to the complaints about the continued water ingress and the decision not to carry out a thorough in-depth inspection of the roof construction. The Court stated in remarkable clarity that even if experts would have performed a thorough inspection according to due diligence standards this would not have changed the negligent attitude of the Bad Reichenhall municipal administration which was driven by the desire to save retrofit costs to be spent for a building whose closure and demolition was envisaged anyway<sup>101</sup>—a diagnosis that was confirmed by a municipal official in cross-examination before the Court.<sup>102</sup>

A mentality of municipal officials of accepting risks to the life and limb of the hall users was reflected in the lack of response to the warnings in the 2001 and 2002 reports and, to a lesser extent, in the indifference regarding the water ingress and the recommendation of an architect consulted in 2002 who suggested an in-depth inspection of the roof structure. That mentality came to bear even on the day of the disaster itself.

<sup>99</sup> LG 2011, RN 163–165, 270–271.

<sup>100</sup> LG 2011 RN 181, 271.

<sup>101</sup> Cf. LG 2008 RN 373–406, 462, 482.

<sup>102</sup> LG 2008 RN 396, 411.

**Table 5.1** Contributing Factors (CF) and Necessary Conditions (NC), collapse of Bad Reichenhall Ice Skating Rink

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NC1	Design error and faulty construction of the ice skating rink roof, 1971–1973.
NC2	Omission of the engineer in charge to apply for a special permit for the installation of wooden girders with an extended length; omission to check on the type of glue used in the erection of the roof, 1973.
CF1	Improper documentation of structural engineering details and calculations.
NC3	Installation of exhaust air systems of the hall roof without building permit and without checking on relevant calculations of the roof statics, 1977.
NC4	Failure to follow the recommendation of an expert opinion of July 2002 to conduct an in-depth inspection of the whole roof, January 2003.
NC5	Purposeful omission of the Lord Mayor to implement the decision of the municipal parliament of June 2005 to renovate the hall complex.
CF2	Continuous carelessness and neglect of maintenance despite visible signs of water ingress.

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On 2 January 2006, the relevant official of the Bad Reichenhall building authority was in telephone contact with the facility manager of the ice skating rink and indoor swimming pool who called him because of the heavy snowfall and a possible shut-down of the hall. While the decision was made to close the ice skating rink at 4:00 PM, the official did not order any special measures. The Court emphasized that the official of the building authority “obviously had no idea how much snow load the considerably damaged structure of the swimming pool roof could withstand”.<sup>103</sup> Hence a vicious circle of general neglect: The expert opinion obtained in 2003 at conspicuously low costs had determined that the entire hall was in “generally good” condition. The Court stated that the city should not have interpreted this as a reliable statement about the condition of the roof structure of the ice rink because of the low expert fee of just 3000 Euros and the resulting limitation of the scope of the inspection. Accordingly, the building authority’s knowledge about true condition of the ice skating rink roof was limited too. Consequently, the building authority official, when called by the facility manager on site at 3:15 PM on 2 January 2006, saw no reason to evacuate the ice skating rink immediately (Table 5.1).

<sup>103</sup> LG 2011 RN 279.

### 5.3.3 *Causal Mechanisms*

Constitutive for the political and institutional environment of the decisions that led to the collapse of the roof of the ice skating rink and the death of fifteen people, among them twelve children, was a conflict of interest within the city administration of Bad Reichenhall, which in itself was not unusual.<sup>104</sup> As the owner of the hall, the city of Bad Reichenhall was interested in low maintenance costs; as the building authority, the city was supposed to be interested in the safety of infrastructure and its users. Prioritizing human safety over saving maintenance costs was the natural duty of the officials in charge. So it was decisive that the Lord Mayor set the wrong priorities.

From the basic conflict of interest within the City administration resulted further situational mechanisms. One pertained to information asymmetries and the control or principal agent problems that arose both in the relationship between the City administration and the expert consulted in 2003 and between the municipal parliament and the administration, especially the Lord Mayor himself. For its part, the city administration had to rely on the expert's assessment while the municipal parliament had to rely on the Lord Mayor as far as the comprehensive renovation of the hall complex was concerned which the parliament had agreed-upon on 14 June 2005. It was probably beyond the imagination of municipal parliament key-figures that the Lord Mayor not only had deliberately restrained the scope and precision of the expert inspection in 2003 and thus was acting on the basis of inadequate information but that he also was determined to obstruct the parliamentary decision anyway.

The Lord Mayor of Bad Reichenhall as the administrative key-figure was not only formally responsible but also a particularly committed decision-maker. According to the standards of due process and diligence in a matter of human safety he should have recognized and neutralized the detrimental effects of conflicting perspectives and interests within the municipality. Instead, his absolute priority was an urban planning intention of shutting down and dismantling the complex of the ice rink and indoor swimming pool altogether. So he used his power to politicize what should never have politicized which was the factual assessment of physical

<sup>104</sup> Cf. James D. Thompson: *Organizations in Action: Social Science Bases of Administrative Theory*. With a new preface by Meyer N. Zald and a new introduction by W. Richard Scott, London and New York: Routledge 2017 [1967], 132–143.

condition of the hall roof.<sup>105</sup> The city's building authority did not only not mitigate the Lord Mayor's course of action but rather implemented its detrimental consequences at the expense of the safety of the users of the ice skating rink.

The mechanisms promoting the one-sided determination to save costs at the expense of safety drove the city administration's action. This was reflected in the indolence vis-à-vis regular reports from users and operating personnel on water ingress. What is more, expert opinions submitted in 2001 and 2002 and the warning notices contained therein were not taken seriously. They pertained to the condition of the canopy of the hall, to fire protection deficiencies and presumed insufficient load-bearing capacity of the indoor swimming pool roof. The question is to what extent these omissions were intentional or the result of incompetence.

What the investigations of the Traunstein Regional Court revealed was that concerns about actual safety risks were never raised within the Bad Reichenhall city administration. A risk-sensitive administration would have taken seriously the recommendation of the expert consulted by the city in 2002 to carry out an in-depth inspection of the ice skating rink roof. Permanently risk-increasing behavior despite warning signs is not uncommon though. It has been classified in the literature "normalization of deviance": Deviations from due diligence or just risk mitigation standards can become entrenched as long as there are no catastrophic consequences.<sup>106</sup>

The capping of the expenses for the expert opinion at 3000 Euros in 2003 indicates that the building authority had not at all been aiming at an in-depth inspection of the roof of the ice rink as had been recommended a year earlier. The city administration might nevertheless have expected a statement on the roof that somehow responded to the expert recommendation of 2002 without, however, substantially doing justice to it.<sup>107</sup> In this scenario, which points to controlled and intentional inaction,

<sup>105</sup>For the phenomenon of power in organizations and its use to exert pressure on the supposedly a-political "operative core" cf. Henry Mintzberg: *The Power Game and the Players*. In Steven J. Ott, Jay M. Shafritz and YongSuk Jang, eds., *Classic Readings in Organization Theory*. Belmont: Wadsworth 1983, 330–337.

<sup>106</sup>Diane Vaughan: *The Dark Side of Organizations: Mistake, Misconduct, and Disaster*. *Annual Review of Sociology* 25 (1999): 271–305.

<sup>107</sup>This was one of the suppositions of the Federal Supreme Court in its ruling of 2010 (BGH 2010 RN 85). On symbolic problem solving and the interest in ignorance about it cf. Wolfgang Seibel: *Successful Failure. An Alternative View on Organizational Coping*.

the relationship between the city administration and the expert could not be interpreted as a conventional principal-agent-relationship. The relevant literature assumes that the “principal”, i.e. the client, has an interest in reducing information deficiencies.<sup>108</sup> However, the capping of the funds for the expert opinion commissioned in 2003 shows that the Bad Reichenhall city administration was not interested in complete information at all.

Finally, it is also characteristic of the irresponsible behavior of the Bad Reichenhall municipal leadership that it, as the Lord Mayor had to admit before the Traunstein Regional Court,<sup>109</sup> deliberately ignored the decision of the municipal parliament which had decided on 14 June 2005 to fundamentally renovate the ice rink and indoor swimming pool. This purposeful omission was due to the Mayor’s urban planning ambitions part of which was to demolish the hall complex altogether. The administration therefore made policy on its own initiative not only at the expense of the municipal parliament but above all at the expense of hall user safety. In the municipal parliament itself, however, no one has apparently insisted on the implementation of the decision of 14 June 2005. Local policy makers were unaware of the expert opinions solicited by the building authority since the reports of the experts had not been submitted to the municipal parliament.<sup>110</sup>

The mechanisms which created an incentive structure for the actions and omissions of the Bad Reichenhall city administration to downplay safety issues and, in contrast, upgrade aspects of urban planning and cost savings, can be defined as ‘situational’ in nature. One contribution to this constellation was the information deficits of the city administration with regard to the original construction defects. These situational mechanisms formed opportunity structures or permissive conditions but they obviously did not result in imminent risks for the safety of the hall complex. Rather, these mechanisms represented standard risks that could have been

American Behavioral Scientist 39 (1996): 1011–1024. On delegation and diffusion of responsibility see Björn Bartling and Urs Fischbacher: Shifting the Blame: On Delegation and Responsibility. *The Review of Economic Studies* 79 (2012): 67–87.

<sup>108</sup> Cf. George A. Akerlof: The Market for ‘Lemons’: Quality Uncertainty and the Market Mechanism. *Quarterly Journal of Economics* 84 (1970): 488–500; Michael C. Jensen and William H. Meckling: Theory of the Firm: Managerial Behavior, Agency Costs, and Ownership Structure. *Journal of Financial Economics* 3 (1979): 305–360.

<sup>109</sup> LG 2011 RN 270.

<sup>110</sup> LG 2011 RN 278.

brought under control by appropriate countermeasures. Which, however, did not happen. Instead, the Bad Reichenhall city administration was distinctly negligent in handling risks to life and limb of hall users despite continued indications of possible construction defects. This concerned water ingress, the canopy roof of the hall complex, flawed fire protection and defects of the secondary (non-structural) parts of the swimming pool hall roof. In addition, an expert had recommended to the city in 2002 to conduct an in-depth inspection of the roof structure of the ice rink. However, the city did not commission such an inspection.

At the action-formation level, therefore, no classic *principal agent* relationship existed: Contrary to the relevant theory, the municipal leadership was not interested in detailed information about the condition of the hall complex including its roof construction. On the one hand, organizational myopia<sup>111</sup> occurred due to the long-term negligent handling of the hall complex by the city administration. On the other hand, some sort of expert opinion was sought by the building authority but the comparatively low remuneration of 3000 Euros left doubt if this was just a placebo measure in order to avoid a costly renovation of a building whose demolition was envisaged anyway. Which would have been a case of deliberate ignorance.<sup>112</sup> One way or another, the behavioral pattern of negligence was accentuated by the targeted obstruction of the decision of the municipal parliament of June 2005 to fundamentally renovate the hall complex which contradicted the urban planning ambitions of the Lord Mayor.

Nevertheless, the question remains if the collapse of the roof of the ice rink on 2 January 2006 could have been averted at the very last moment. However, it became apparent even on that very day that the lack of risk awareness was deeply engrained so that a timely shut-down and evacuation of the ice rink was not initiated. The facility manager of the ice skating rink, worried about the heavy snow fall, was told by the relevant official of the building authority to wait until 4:00 PM to close the hall. This instruction was issued although the official, according to the Traunstein Regional Court, had not the “slightest idea” of the actual load-carrying capacity of the hall roof (Fig. 5.2).<sup>113</sup>

<sup>111</sup> Maurizio Catino: *Organizational Myopia. Problems of Rationality and Foresight in Organizations*. Cambridge: Cambridge University Press 2014.

<sup>112</sup> Wolfgang Seibel: *Successful Failure*.

<sup>113</sup> LG 2011 RN 279.

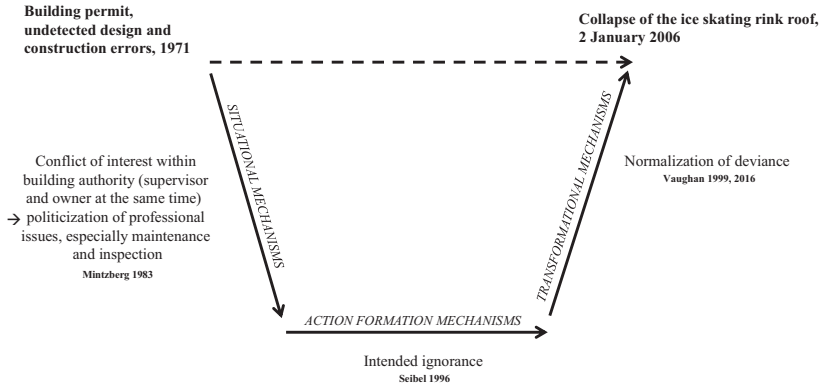


Fig. 5.2 Causal Mechanisms, Collapse of Bad Reichenhall Ice Skating Rink

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## CHAPTER 6

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# Conclusion: Strategic Learning and Situational High Reliability

Serious disasters in the form of collapsing bridges and buildings that claim the lives of people are rare for a reason. The standard risks are known, they are being addressed by regulation and the regulation is being enforced by public authorities. While any such tragedy has a single specific technical root cause, typically a serious structural design error, the non-technical origins of the disasters seem to be complex at first glance. Accordingly, related findings seem to defy generalization. Which, if true, would imply serious limitations for learning and prevention. The cases analyzed in this book, however, tell otherwise. They do reveal patterns of generalizable causal mechanisms that highlight exemplary risk zones and, thus, prospects for mindful prevention.

### 6.1 A SUMMARY

Melbourne's West Gate Bridge suffered a whole syndrome of anomalies. One affected public control and oversight, a second one the contractual arrangements between the authority in charge and contractors plus consultants, a third one the method of erection itself. In a way, it was too much of complexity. Yet, complexity as such was not the problem. Control of complexity would have been possible but control structures and intentions were weak or weakened in several dimensions.

There was no true public authority in charge. The Lower Yarra Crossing Authority was a QUANGO—a quasi-non-governmental organization—

established on the initiative of the local business community to which the state of Victoria had delegated regulatory powers and enforcement competence. This arrangement not only diluted the representation of the public interest in a formal sense but also in practical terms. As a private institution, the Lower Yarra Crossing Authority was not part of the state budget but, instead, working with borrowed money to be refinanced through a toll fee once the bridge would be in use. What could have been anticipated was that timing and adherence to schedule was the weak flank of this arrangement. When quarrels with the labor unions entangled in rivalry and turf wars escalated, causing a serious delay of the basic steel-works of the bridge, the Lower Yarra Crossing Authority found itself between the proverbial rock and a hard place. The question was whether to stick to the arrangement that included a penalty fee to be paid by the relevant contractor in case of delay without accelerating the construction process in any way or to relinquish the contractor and reducing his role to occasional consultancy. In March 1970, the Authority took the second option. As a consequence, a local contractor with no experience with the construction and erection of steel box girder bridges assumed responsibility for the completion of the works that were particularly complex and demanding anyway. The initial contractor, a Dutch-based international corporation, had decided to assemble the steel boxes of the girders on the ground which necessitated to lift them up and to bolt the various parts of the box girders together up in the air. It was in this complicated and vulnerable process that inaccuracies occurred whose ill-fated repair triggered the disaster of 15 October 1970.

So the critical juncture at which the disaster became almost inevitable was passed relatively early, seven months before the bridge, still under construction, actually collapsed. The semi-private status of the Lower Yarra Crossing Authority and a fragile contractual arrangements weakened control where control should have been of the essence. In the case analysis of Chap. 2 this is characterized as a risk increasing ‘situational mechanism’. By the same token, however, the risk increasing effects could have been neutralized at the level of the ‘action formation mechanisms’ where mindful intervention was both required and possible. However, ‘action formation’ was shaped by selective perceptions and silo-thinking. What emerged was rivalry, withheld information and a mood of general annoyance if not frustration. The Lower Yarra Crossing Authority turned out to be incapable of regaining a minimum of coordination capacity. As a consequence, the threshold between ‘action formation mechanisms’ and

‘transformational mechanisms’ was perforated as well. The real point of no return was passed on 16 September 1970 when, in an on-site meeting of contractors and consultants, a discussion of the overall safety margins of the bridge did emerge but remained inconclusive since nobody insisted on renewed structural analyses and calculations.

What the case analysis reveals is, accordingly, that structural risk zones in the form of fragmented and poorly coordinated governance had not only been deliberately created but also remained untouched even when the risk increasing effects materialized. The characteristic syndrome remained the absence of true leadership and organized irresponsibility. The Lower Yarra Crossing Authority did not live up to that requirement which was virtually the consequence of its own nature as a hybrid institution being half private and half public and, thus, without real authority and enforcement capacity when smooth cooperation and diligence was indispensable.

Unlike the Lower Yarra Crossing Authority, the Minnesota Department of Transportation was in full control of all relevant aspects as far as safety issues and the maintenance of the I-35W Bridge were concerned. The bridge was 40 years in use when it collapsed on 1 August 2006. The technical core of the matter was the failure of gusset plates that kept the steel truss structure of the bridge together. The root cause of the disaster, however, was again non-technical in nature. The bottom line was information asymmetry among relevant actors and institutions and, as a consequence, the loss of information that otherwise could and should have been available or mobilized in the course of inspections that, ironically enough, did take place on a regular basis throughout the lifespan of the bridge. The ‘situational mechanisms’ creating risk increasing behavioral patterns within the Minnesota Department of Transportation (MnDOT) were characterized by uncompensated fragmentation of jurisdiction and red tape routines in lieu of case-by-case scrutiny and in-depth diligence of inspections. Moreover, the regular inspections were carried out by repair staff instead of engineers and by inspectors not even systematically trained in bridge inspections.

What emerged at the level of ‘action formation mechanisms’ is known as “normalization of deviance”<sup>1</sup> and goal displacement in the sense that standard operating procedures designed for particular purposes—proper maintenance—became hollow and an end in themselves. In the essence,

<sup>1</sup> Diane Vaughan: *The Dark Side of Organizations: Mistake, Misconduct, and Disaster*. *Annual Review of Sociology* 25 (1999): 271–305.

inspection routines turned into the fiction of inspection. Inspections were carried out on both an annual basis and in the form of so-called fracture critical inspections as supposedly in-depth assessments focusing on the especially vulnerable parts of the steel truss structure of the bridge. Several of these fracture critical inspection reports had even stated from the early 1990s on that the I-35W bridge was “structurally deficient”. The epitome of neglect was an almost systematic lack of documentation within the Minnesota Department of Transportation whose “oral culture” was notorious. Another vicious circle established in the interaction between ‘situational mechanisms’ and ‘action formation mechanisms’ was connected to insufficient maintenance funds. Contractors were thus tempted to adapt their offer for necessary inspections and repairs accordingly. As a consequence, and in addition to an already diluted inspection practice, the diligence of inspections became subject to implicit or explicit negotiations between contractors and the Minnesota Department of Transportation. Which almost inevitably came at the expense of accuracy and thoroughness of the inspections.

As a result, the roles of private and public actors were inverted. The productive impulse of a Minneapolis based consultancy firm to conduct a revision of all fracture critical truss members of the bridge was stifled by the MnDOT which itself should have been the first advocate of sound inspections and safety measures. Again, it was ultimately the absence of leadership in terms of coordination efforts and mindfulness that created a situation in which the fundamental design error affecting the gusset plates remained undetected. Which was only to a limited degree the consequence of the financial restrictions to which the Minnesota Department of Transportation was exposed. It was primarily due to a culture of neglect and sloppiness that MnDOT officials remained unaware of the fact that damaged gusset plates had been depicted in series of photographs taken in the course of two subsequent inspections performed in 1999 and 2003. It was at exactly the same nodes of the steel truss that the bridge span started to disintegrate on 1 August 2007, when, nine days earlier, a great amount of additional weight in the form of cement and construction material had been placed on the deck of the bridge in preparation of repair works.

Regardless of the fact that the weakness of the gusset plates had been the proverbial unknown unknowns since the opening of the bridge in 1967 there was clearly one missed opportunity at which those structural flaws could have been detected. That moment came when, in January 2007, the Minnesota Department of Transportation decided to perform a

cheaper “ultrasonic non-destructive examination” of only a couple of members of the steel truss of the bridge instead of a comprehensive retrofit of the 52 fracture critical truss members already specified by the relevant contractor. It was, basically, intended ignorance. The fact that the designers of the bridge, back in the 1960s, had failed to submit specific calculations for the gusset plates of the steel truss remained unrecognized throughout the life span of the bridge.

The characteristics of the non-technical root causes of the collapse of the CTV building in Christchurch in 2011 are stunningly similar to those of the I-35W bridge disaster. It was about a self-inflicted ‘unknown unknown’ in the form of a design error whose persistence had a parallel in a persistent culture of sub-standard performance of the building authority, the Christchurch City Council (CCC). Another parallel was the soft institutional backbone of both the Minneapolis Department of Transportation and the Christchurch City Council in their relationship with contractors and consultants. Neither institution had insisted when documentation submitted by consultants and contractors was incomplete. Relevant calculations were missing so that the authorities had virtually no basis for their review and the subsequent issuance of building permits.

So, just like in the case of the I-35W bridge, a first critical juncture decisively shaping the subsequent pathway of what resulted in the collapse of the CTV building was reached at an early stage. The crucial omission occurred when the CCC’s responsible buildings engineer was persuaded by the owner of the relevant consultancy firm that previously stated concerns of the CCC’s civil engineer in charge about potential structural design errors and missing calculations were unfounded. This episode was indicative of blurred responsibilities not only within the CCC but also between the authority and its own client, the consultancy firm responsible for the structural design of the building. Similar to the relationship between the Minnesota Department of Transportation and its main contractor for repair works, the public versus private role patterns were virtually inverted. In reality, it was not the Christchurch City Council who defined what was required for a proper building permit application but the consultancy firm whose drawings and calculations should have been subject to objective scrutiny. How deeply enrooted this pattern was became apparent when, in 1991, the very same consultancy firm was involved in retrofit works concerning the CTV building. The owner did not even think of seeking the indispensable permit of the CCC. This he justified before the Royal Commission with the telling statement that based on his

personal experience in dealing with the CCC's chief buildings engineer over many years he was convinced that the CCC official would not have asked for such an application anyway. What could appear as arrogance as far as the consultant in his role as a client of the CCC was concerned essentially reflected the erosion of the CCC's institutional integrity.

Accordingly, no intervention took place at the interface between 'situational mechanisms' and 'action formation mechanisms'. Instead, what should have been neutralized as the impact of blurred responsibilities and a weak standing of the CCC was transformed, at the level of 'action formation mechanisms', into the erosion of professional integrity within the CCC's building authority. Moreover, no intervention took place at the threshold between 'action formation mechanisms' and 'transformational mechanisms' either. Potential "near miss" scenarios did occur throughout the 25 years of the CTV building's lifespan. Thorough and diligent "rapid assessments" at the two essential levels (Level 1, Level 2) could have been performed after the initial earthquake of 4 September 2010. Instead, the CCC did neither ensure nor control if the second "rapid assessment" was performed by an engineer which was required by the authority's own rules. As a consequence, the CTV building was declared "structurally sound" after two subsequent inspections which, one more time, was entirely unfounded. What the case of the collapse of the CTV building in Christchurch demonstrates is therefore a key factor that makes that deviance persistent which is lack of leadership in terms of resolve and a strong sense of institutional integrity.

Lack of resolve was certainly not what characterized the attitude of Bad Reichenhall's Lord Mayor. On the contrary, he used his authority to obstruct the renovation of the ice skating rink as decided by the municipal parliament. Similar to the characteristics of the I-35W bridge case but substantially more accentuated was the intra-administrative conflict of interest. The ice skating rink was not a private facility but part of public infrastructure so that the municipality was owner and supervisor of the facility at the same time. This alone made issues of civil engineering and safety vulnerable to politicization. Part of that politicization was, just like in the I-35W bridge case, the constant need of prioritization, especially as far as public spending and investment was concerned. What made the situation peculiar and especially critical as far as safety issues were concerned was that the entire hall complex and its expensive maintenance stood in the way of the urban planning ambitions of the Lord Mayor. The mayor was determined to have the hall dismantled anyway and, consequently, he

had no intention to ‘waste taxpayers’ money’ for the expensive retrofit in accordance with the decision of the municipal parliament of June 2005.

An intervention at the interface between ‘situational mechanisms’ and ‘action formation mechanisms’ could have neutralized the detrimental impact of urban planning ambitions on handling the safety issues connected to the ice skating rink. The Lord Mayor, however, did the opposite when he used his dominant position to purposefully obstruct the decision of the municipal parliament. What should have been subject solely to professional scrutiny in accordance with the expert opinion consulted by the municipality itself—to inspect thoroughly and in detail the roof of the hall where water ingress was notorious—became a bone of contention in local politics.

What makes the collapse of the Bad Reichenhall ice rink specifically tragic is the extremely thin line that separated the disaster of 2 January 2006 from a “near miss” scenario. It was just a matter of minutes. Even though it was in no way connected to the actual fragility of the roof structure—which remained unknown until the post-disaster investigation—the hall manager, after heavy snowfall on that winter’s day at the outskirts of the Alps, had the right impulse to evacuate the ice skating rink. So the quasi-instinctive impulse of a last moment intervention was there and, accordingly, the threshold between the ‘action formation mechanism’ of intended ignorance and the transformational mechanism paving the way to the actual disaster—the last slice of the Swiss cheese, metaphorically speaking—was real. However, the power of ‘normalization of deviance’ was strong enough to penetrate that threshold: Asked for advice by the hall manager at 3:15PM, an official of the building authority who, according to the findings of the post-disaster criminal trial, had not the slightest idea about the actual conditions on site, told the hall manager to evacuate the ice skating rink at 4:00 PM. It was at 3:55PM that the roof collapsed, killing 12 children and 3 mothers accompanying them (Table 6.1).

While the distinct mechanisms can be identified with the help of theoretical reasoning about organizational pathologies, they are usually known to seasoned practitioners as well. Just like risk zones of particular structural designs in the realm of construction, risk zones of particular organizational arrangements are known to the practitioners of public administration. Situational mechanisms such as organizational fragmentation at the risk of blurred responsibilities and jurisdiction are ubiquitous and inevitable in the relationship between licensing and supervising public authorities and contractors and their subcontractors. It does not come as a surprise

**Table 6.1** Causal Mechanisms, Cross-Case Synopsis

	<i>West Gate Bridge Melbourne 1970</i>	<i>I-35W Mississippi River Bridge 2007</i>	<i>CTV-Building Christchurch 2011</i>	<i>Bad Reichenhall Ice Skating Rink 2006</i>
Situational mechanisms	Softening public authority through creating a QUANGO [quasi non-governmental organization] <i>Selznick 1949 Greve/Flinders/Van Thiel 1999 Flinders/Smith 1999</i>	Insufficient maintenance funds, Uncompensated fragmentation of jurisdiction → Coordination issues, information asymmetries <i>Thompson 1967, Akerlof 1970</i> Unbalanced bureaucracy: Red tape routines in lieu of case-by-case scrutiny and in-depth diligence <i>Crozier 1964</i>	Blurred accountability <i>Olsen 2014</i> Latent hybridity <i>Denis/Ferlic/Van Gestel 2015 Seibel 2015</i>	Conflict of interest within building authority (supervisor and owner at the same time) → politicization of professional issues, especially maintenance and inspection <i>Mintzberg 1983</i>
Action formation mechanisms	Silo-thinking and selective perceptions <i>Dearborn/Simon 1958</i> Soft regulatory capture <i>Dal Bó 2006 Carpenter/Moss 2014</i> Blame Avoidance <i>Hood 2011, 2014</i>	Normalization of deviance; Intended ignorance <i>Vaughan 1999, 2016; Seibel 1996</i> Goal displacement <i>Merton 1940</i> Weak defense of institutional integrity <i>Selznick 1957:119–133</i> Negotiated safety <i>Schulman 1993</i>	Normalization of deviance <i>Vaughan 1999, 2016</i> Compromising professional integrity <i>Huntington 1952 Seibel 2019 Selznick 1957:119–133</i>	Intended ignorance <i>Seibel 1996</i>

*(continued)*



**Table 6.1** (continued)

	<i>West Gate Bridge Melbourne 1970</i>	<i>I-35W Mississippi River Bridge 2007</i>	<i>CTV-Building Christchurch 2011</i>	<i>Bad Reichenhall Ice Skating Rink 2006</i>
Transformational mechanisms	Absence of leadership and evaporated responsibility <i>Friedrich 1940</i> <i>Bovens 1998:22–44</i> <i>Bruttel/Fischbacher 2013</i>	Absence of leadership in terms of insufficient coordination and lack of mindfulness <i>Friedrich 1940</i> <i>‘t Hart/Tummers 2019</i> <i>Hopkins 2007</i> <i>Weick/Sutcliffe 2007</i>	Absence of leadership in terms of – lacking resolve <i>‘t Hart/Tummers 2019:50–51</i> – lacking sense of responsibility <i>Friedrich 1940</i> <i>Bovens 1998:22–44</i>	Normalization of deviance <i>Vaughan 1999, 2016</i>

In italics: Theoretical references

either that, when it comes to action formation, those structural weaknesses have a mind shaping effect on decision makers in charge in the form of silo thinking and selective perceptions, lack of coordination at the expense of professionalism and, ultimately, human safety. Again, however, those are well-known phenomena so that related risk increasing effects are usually kept under control. Put another way, the risk zones at the interface between situational mechanisms and action formation mechanisms are natural zones of intervention. It is here where, under usual circumstances, the undesirable effects of organizational pathologies are being neutralized through regulation, mindful governance and responsible leadership. And even when, by some reason, risk neutralizing intervention was omitted it does take place in most instances at the threshold between detrimental action and a potentially disastrous outcome. Which results in near miss scenarios when disasters are averted at the very last moment.

What the disasters analyzed in this book have in common is that the zones of intervention—the one between situational mechanisms and action formation mechanisms and the one between the latter and transformational mechanisms—were not activated. Not because key actors were

unable to recognize the risks or because they lacked the skill to draw the necessary consequences. Rather, they did not offer resistance when plausible and attractive excuses presented themselves to ignore the risk zones in the first place. What paved the way to disaster was, in the essence, absence of responsible leadership in various forms. Nobody took the initiative to reintegrate the fragmented organizational structure of construction, consultancy and public oversight and the resulting turf wars when the West Gate Bridge in Melbourne was under construction. No one took care of a comprehensive review of the numerous inspections conducted throughout the lifespan of the I-35W Bridge in Minneapolis. No one was willing to acknowledge, let alone to face the consequences of, the erosion of independence and integrity of the Christchurch City Council vis-à-vis consultants or contractors. And nobody intervened when the Lord Mayor of Bad Reichenhall purposefully ignored the decision of the city's municipal parliament to entirely refurbish the ice skating hall whose roof was obviously in poor shape.

## 6.2 LACK OF MINDFULNESS?

So the key question remains what accounts for those omissions. In response to that question, the 'usual suspects' in the realm of theory yield unsatisfying results. Certainly, the essentials of the case analyses of this book are in line with Normal Accident Theory (NAT) in the sense that structural risk zones of public control and oversight do exist and need to be addressed when it comes to the construction and maintenance of bridges and buildings. Moreover, in accordance with High Reliability Theory (HRT) the cases also demonstrate the importance of mindfulness. The project management of construction as well as the checking and control procedures of building authorities are necessarily characterized by division of labor that typically involves public administration, contractors and consultants. Certainly, there are structural fault lines within a relatively complex organizational setting so that mindful coordination and interface management is essential. But, again, that is what mindful project managers and public officials usually do without major difficulties.

As a matter of fact, lack of mindfulness is just too vague a notion. It leaves us with little more than the truism that being mindful matters. After all, the question is what exactly may make capable and professional actors neglect what they usually would acknowledge as a challenging but manageable duty of control and coordination in a field where human safety is

inevitably at stake. What the case studies of this volume reveal is that an appropriate understanding of ‘what is at stake’ cannot be taken for granted. Key actors were not able or not willing to acknowledge the importance of compliance with existing regulation or, conversely, the potential consequences of poorly coordinated action or just negligence and sloppiness at the expense of proper checking procedures or simple documentation. Hence the question: What were the origins of inability and unwillingness? Rather than assume incompetence—which is rare and, in terms of generalization, lacks any predictive power—it is helpful to think in terms of most likely rationalities and related incentive structures. Which, at the same time, may indicate pathways of strategic learning for the sake of prevention.

An essential part of what the cases studies illustrate is that public bureaucracies are not high reliability organizations by definition and yet need to act like ones under particular circumstances. By its very nature, public administration is exposed to ambiguous requirements of accountability and, thus, legitimacy.<sup>2</sup> Public agencies need to respond to what citizens like them to do, especially when, at the local level, the action or inaction of authorities impacts directly on the conditions of everyday life. Hence the notion of the “listening bureaucrat”<sup>3</sup> or “street level bureaucracy”<sup>4</sup>: Public agencies need to be responsive. By the same token, however, public agencies and their representatives cannot be held accountable by individuals or social groups in their immediate societal or political environment alone. They are bound by legislation and to be held accountable in accordance with legal and professional standards. Just as the rigidity of rule-boundedness and protocol entails the risk of inadequate reaction to individual and local requirements, unrestrained responsiveness entails the risk of arbitrariness, clientelism and corruption. The tension between responsiveness and responsibility is part and parcel of public bureaucracy and therefore a risk factor in its own right.<sup>5</sup>

<sup>2</sup>B. Guy Peters: Accountability in Public Administration. In Mark Bovens, Robert E. Goodin and Thomas Schillemans (eds.): *The Oxford Handbook of Accountability*. Oxford: Oxford University Press 2014, 211–225.

<sup>3</sup>Camilla Stivers: The Listening Bureaucrat: Responsiveness in Public Administration. *Public Administration Review* 54 (1994): 364–369.

<sup>4</sup>Michael Lipsky: *Street-level Bureaucracy: Dilemmas of the Individual in Public Services*. New York, NY: Russell Sage Foundation 1980.

<sup>5</sup>Wolfgang Seibel: Are Public Bureaucracies Supposed to be High Reliability Organizations? *Global Perspectives* 1(1) (2020).

### 6.3 THE RESPONSIVENESS VERSUS RESPONSIBILITY CHALLENGE

The elementary challenge when it comes to proper conduct of public officials concerned with safety issues is to strike the right balance between the requirements of responsiveness and the requirements of responsibility. In the four cases analyzed in this book that tightrope walking failed. The officials of the Lower Yarra Crossing Authority had every reason to be concerned about the delay of the erection of the West Gate Bridge because the main stakeholders of the authority—representatives of the local and regional business community—expected the expeditious completion of the infrastructure project which was ultimately the result of private initiative and, after all, financed through private loans. The officials of the Christchurch City Council made honest efforts to expedite the checking procedures pertaining to applications for building permits and to cultivate a cooperative relationship with their counterparts among contractors and consultants. A similar kind of partnership and cooperation characterized the conduct of the Minnesota Department of Transportation vis-à-vis contractors for maintenance and repair as well as the department's efforts to improve at least the drivability of the I-35W bridge and to invest taxpayers' money in a new concrete overlay rather than in invisible in-depth inspections of the steel truss structure. And, finally, the Lord Mayor of the city of Bad Reichenhall wanted to respond to the legitimate expectations of citizens concerning the modernization of past time infrastructure instead of spending taxpayers' money for the renovation of an Ice Skating Rink earmarked for demolition. What prevailed in all those cases was the logic of responsiveness that undermined the sense of responsibility of the relevant key actors and made them neglect professional and ethical standards at the expense of human safety.

Which refers to two relevant levels of learning for the sake of prevention. One type of learning is related to what Chris Argyris has denoted as "single loop learning".<sup>6</sup> It is practical in nature and designed to adapt rules and routines in use, often in the wake of crises and disasters.<sup>7</sup> Eliminating loop holes in existing regulation, strengthening coordination capacities or

<sup>6</sup> Chris Argyris: *On Organizational Learning*. 2nd ed., Cambridge: Blackwell 1999.

<sup>7</sup> Cf. for similar assessments Arjen Boin, Allan McConnell, Paul 't Hart: *Conclusions: The Politics of Crisis Exploitation*. In Boin, McConnell, 't Hart (eds.): *Governing after Crisis. The Politics of Investigation, Accountability and Learning*. Cambridge: Cambridge University Press 2008, 285–316; D. Christopher Kayes: *Organizational Resilience. How*

defining minimal standards for the recruitment of skilled staff are typical examples. Striking an appropriate balance between the requirements of responsiveness and the requirements of responsibility, however, cannot be achieved on a routine basis. This refers to “double loop learning”<sup>8</sup> in the sense of reflecting and, if necessary, adapting the overall premises of the organizational rationale and related civil servant attitudes. When it comes to the responsiveness versus responsibility trade-off, it is about making human safety nonnegotiable even when requirements of responsiveness might recommend otherwise. In the essence, it is about acknowledging the situational logic of high reliability in defense of professional and institutional integrity.<sup>9</sup> Strategic learning requires to realize the responsiveness versus responsibility trade-off in the first place and to acknowledge the consequences for personal conduct. While the former should be easy to understand and easy to generalize since it comes with the very nature of public bureaucracy the latter remains a challenge to individual judgment and resolve on a daily basis.

Learning Sustains Organizations in Crisis Disaster, and Breakdown. Oxford and New York: Oxford University Press 2015.

<sup>8</sup> Argyris: On Organizational Learning, 67–91.

<sup>9</sup> Philip Selznick: Leadership in Administration. A Sociological Interpretation. Berkeley and Los Angeles: University of California Press 1957, 119–133.

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