The Art of the Forensic Engineer

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ABSTRACT: The paper discusses the role of the forensic engineer in investigating and determining the causes of structural failures. It reviews the application of forensic engineering in the public reports of several structural failures and highlights some contractual and project execution lessons learnt.

1 THE ROLE AND ENGAGEMENT OF THE FORENSIC ENGINEER

1.1 *Introduction*

Forensic engineering typically involves the application of the art and science of engineering in the investigation of "failures", usually in connection with the legal system. Forensic engineering may involve investigation of the physical causes of the sources of claims and litigation, preparation of engineering reports, testimony at hearings and trials and provision of advisory opinions in connection with disputes.

1.2 *The forensic engineer's role in legal disputes"*

The two distinct roles that a forensic engineer may undertake in connection with a (potential) legal dispute are: expert consultant, or independent expert.

An expert consultant acts as part of a legal "team", providing forensic engineering advice at all stages of a legal dispute. As she/he may be privy to confidential details about the client's legal "case", such an expert is usually not perceived to exercise the independent judgment required of a credible expert witness in court or an arbitration.

An independent expert who is kept isolated from the confidential aspects of the client's legal case will be suitable to provide an expert opinion on forensic engineering issues, and able to give independent testimony in court or an arbitration. The legal team will need to carefully document the engagement of an independent expert to ensure that communications are transparent and the briefing material is clear.

1.3 *The forensic engineer's skills*

The forensic engineer must apply both the art and science and engineering. A fundamental skill is a deep knowledge of the relevant engineering. Equally important is the "art" of how a forensic engineer should apply engineering knowledge to prepare and conduct investigations to determine the facts, and apply the relevant engineering principles to determine the causes of failure and prepare clear persuasive reports.

Whereas the design engineer determines "how" to synthesise the required elements into a functional and operating whole, the forensic engineer determines "why" a failure occurred. The forensic engineer needs refined observation and recording skills to note all possibly relevant features of a "failed" structure, without any preconceptions. She/he needs good written and oral skills to communicate with lay persons who are not familiar with engineering "language".

A forensic engineer investigating another engineer's design should have recent design experience, and avoid opining on what the forensic engineer would have done if he/she was the designer. A forensic engineer must maintain the highest professional and ethical standards.

1.4 *Engagement of a forensic engineer*

A lawyer usually engages a forensic engineer to protect legal professional privilege to the extent possible.

Engaging a forensic engineer requires definition of the scope of his/her work, selecting a person with the appropriate skills and experience, and executing a consulting agreement with relevant terms that specify the required time, cost and quality of the forensic engineer's work. The forensic engineer may need to develop the scope as part of his/her brief, but the engaging lawyer must nevertheless identify what are the required "deliverables".

It is recommended that in determining the inevitable trade-off between the conflicting requirements of the time, cost and quality of the forensic engineer's work, the emphasis should be on quality, not an ad hoc determination of cost or timeframe. Suitably experienced forensic engineers inevitably have a high charge rate.

2 PUBLIC INQUIRIES INTO STRUCTURAL FAILURES

2.1 *Introduction*

Public inquiries into engineering failures draw heavily on the skills of forensic engineers to determine the technical and non-technical causes of failure. Public inquiry reports are valuable resources, as their focus is on determining the causes of failure, without regard to the legal liability of the participants. They frequently contain a summary of the relevant "state-of-the-art" of the engineering issues relevant to the failure.

In the common law world, public inquiries are conducted on similar lines to adversarial litigation, and forensic engineers may be called to give evidence on behalf of the inquiry itself or an interested party.

In each of the following cases, the public inquiry identified not only the direct "technical" causes of failure, but also the contractual and project execution deficiencies that did not detect or prevent the onset of failure before it was too late.

Revisiting these historical reports reinforces the importance of designing and constructing structures within contractual arrangements that encourage and support clear lines of authority and communication, with appropriate allocation of risks and an appropriate balance between the required time, cost and quality for project execution.

2.2 *Québec Bridge, Canada (1907)*

The Québec Bridge was procured by a design and construct contract. It collapsed during construction killing 74 men. The Royal Commission that investigated the collapse found the technical reason to be the failure of the lower chords in the anchor arm near the main pier, due to their defective design.

2.3 *Westgate Bridge, Melbourne (1970)*

This concrete and steel box girder bridge over the Yarra River was procured under the forerunner of modern Public-Private Partnership, in which the design was prepared by consulting engineers engaged directly by the Principal. A steel box girder span collapsed during construction after bolts were removed in a main transverse splice to correct difficulties encountered during construction. Thirty-five workers died. The Royal Commission made forthright comments about deficiencies in the design process.

2.4 *Milford Haven Bridge, Wales (1970)*

This steel box girder bridge collapsed during construction, caused by the inadequacy of the design of a vertical pier support diaphragm, which failed in compression over the column. The lessons from Milford Haven primarily concerned the inadequacy of the design methods used for the permanent design and checking of safety during erection. The "Merrison Rules" in the final report of the Committee of Inquiry, are still used today in the design and checking of steel box girder bridges.

2.5 *De La Concorde Overpass, Québec (2006)*

A span of this prestressed concrete bridge built in the 1970s collapsed under light traffic light, killing five people. The Commission of Inquiry concluded that the reason for the collapse was a shear failure in a reinforced concrete cantilever slab, the concrete of which had deteriorated over the years. Other contributing factors were unsatisfactory reinforcement details, errors of reinforcement placement and low quality concrete.

2.6 *Procedural and Contractual lessons*

The following are some of the contractual and project execution lessons relevant to major engineering projects extracted from the public inquiry reports discussed in the paper.

- Sufficient time should be allowed for preparation of initial studies, design, tender documentation and execution of the works.
- A project owner requires adequately qualified and experienced technical staff for both design and erection phases.
- The engineering design and erection method for a major project should be independently reviewed.
- The scope of the engineer's engagement should include both design and erection, with appropriate compensation for the scope of work required.
- The construction contractor needs appropriately qualified and experienced erection engineers on site, and the client should verify this.
- There should be a clear division of responsibilities between engineer and contractor, and the contracts should reflect their practical engineering relationship.
- Consulting engineers and contractors should be selected based on competency and past performance, with cost only considered for those meeting the competence criteria.
- Subcontracting requirements should be identified in bids, and contractors required to produce a work quality control plan.
- An engineer should certify that the structure was built in accordance with the contract documents on completion, and all documents should be kept for the life of the structure.

Charrett, D.E. 2008. Contractual lessons from construction failures: part one. *Construction Law International* V3 No 4: 15.

Charrett, D.E. 2009. Contractual lessons from construction failures: part two, *Construction Law International* V4 No 2: 19.

Charrett D.E. & Potts A.E. 2012. What corporate counsel need to know about engaging forensic engineers" *International In-house Counsel Journal* V5 No 19 : 1.