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Editorial

Why Buildings Fail: Are We Learning From Our Mistakes?

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1. Introduction

Most building professionals have investigated or performed remedial designs for at least one architectural or engineering system failure during their careers. Other practitioners, especially those who work for forensic consultants or firms specializing in disaster response and repair, are more familiar with the variety and extent of building failures as they assist their clients in restoring damaged or deficient buildings. The advent of social medial and twenty-four-hour news channels along with the general ease of finding more examples of failures in the Internet have made us realize that building failures in the broad sense are much more common than we may have realized.

Relatively recent events leading to building failures such as the Christchurch, New Zealand earthquakes, the roof/parking deck of the Algo Centre mall in the northern Ontario, Canada city of Elliot Lake and the Indiana State Fairground stage collapse in the US are just a few reminders that much more work needs to be done on a variety of fronts to prevent building failures from a life safety standpoint. The need is compounded by economic concerns from what would be considered more mundane or common failures. Inspections by the author after Hurricane Katrina revealed a huge number of failures associated rain water alone as roofs, windows, flashing, mechanical penetrations etc. failed leading to interior water penetration often resulting in more damage from damp conditions and mold propagation than outright structural collapses.

2. What is a Building Failure?

Your viewpoint on the frequency of the occurrence of failures in our industry likely depends on your definition of a failure. Some would argue that the term *building failure* applies only to major collapses of an entire building or structure. Others—particularly many forensic engineers—are of the belief that a failure is any component or system that does not perform as intended. With that in mind, a building failure would include the EIFS façade failure from wind shown on the left as well as the structural collapse shown on the right in Figure 1.

Figure 1. EIFS Façade Failure Due To Wind and Anchorage Conditions (Left). Complete Collapse of Engineered Metal Building During Construction (Right); Photos by Author.

This broader definition in the context of the building industry would include myriad building performance problems associated with roofs, facades, mechanical, electrical, plumbing (MEP) system balancing and control, structural serviceability and so on. From that perspective, a non-inclusive list of structural and architectural/building system performance failures consists of the following [1]:

- Structural failures of all types, including those caused by natural disasters;
- Building envelope water and moisture performance problems (facades, roofing, waterproofing, flashing, sealants, and related issues);
- Durability, deterioration, maintenance, and repair of newer and historic buildings;
- Design and construction errors including those that occur during erection;
- Adjacent construction, infrastructure servicing and industrial mining operations;
- Inadequately conceived, designed or constructed temporary structures;
- Material defects;
- Failures related to confusion over design and construction responsibility;
- Comfort, performance and control of MEP systems; and
- Cost issues and failure to meet budgets.

Failures do not discriminate or target specific projects. Buildings, large or small and public works of all types can experience failures of a variety of types as outlined above. Even on a large project, the smallest of items can lead to an unanticipated and catastrophic event. Such was the case in July of 2006 when the failure of a grouted anchor caused the collapse of a concrete ceiling panel on the Interstate 90 connector tunnel (Boston's Big Dig) resulting in one fatality [2]. On the same project, a more recent failure resulted from something as simple as the anchorage for the light fixtures (repeated thousands of times) that resulted in a fixture crashing down onto a travel lane. Fortunately no drivers were injured in this more recent failure but it created the need to temporary stabilize huge numbers of light fixtures pending confirmation of the cause and determination of a more permanent fix or replacement program. Galvanic corrosion has been blamed for this failure, a design condition that many professionals would not think to consider as a typical part of their projects [3].

A number of recent events point to inadequate design, planning, construction and evacuation planning for temporary structures as being an area that needs attention by the AEC profession. Fatalities, injuries and to a lesser degree economic damages associated with the Indiana State Fairgrounds Stage collapse (August 13, 2011), Madonna's Concert Stage in the French city of Marseille (July 16, 2009), the Cheap Trick—Ottawa Bluesfest Stage collapse (July 17, 2011) and the Toronto Park Radiohead stage failure earlier this year (June 16, 2012) are stark reminders of a category of structures that need increased attention. Unfortunately, clear and conclusive standards for these types of structures do not exist in most jurisdictions. William Gorlin made the case for the need for industrywide standards for wind loads on temporary structures in an editorial in 2009 in the ASCE *Journal of Architectural Engineering* [4]. While some progress has been made, the industry is far from providing definitive direction or consensus standards on this building type. As a result, we can expect these types of failures to continue at least in the near term.

3. Are We Learning from the Mistakes of the Past?

Most practitioners learn from their past mistakes and tend not to repeat them. Why then do similar type failures continue to happen? A Google Feed set up by the author to monitor reported industry failures provides a constant stream of reports related to collapsed decks and balconies due to inadequate design, construction and maintenance; collapse during construction of inadequate temporary braced metal-plated wood trusses that fail in relatively light winds during construction; and façade failures of virtually all material types and sizes.

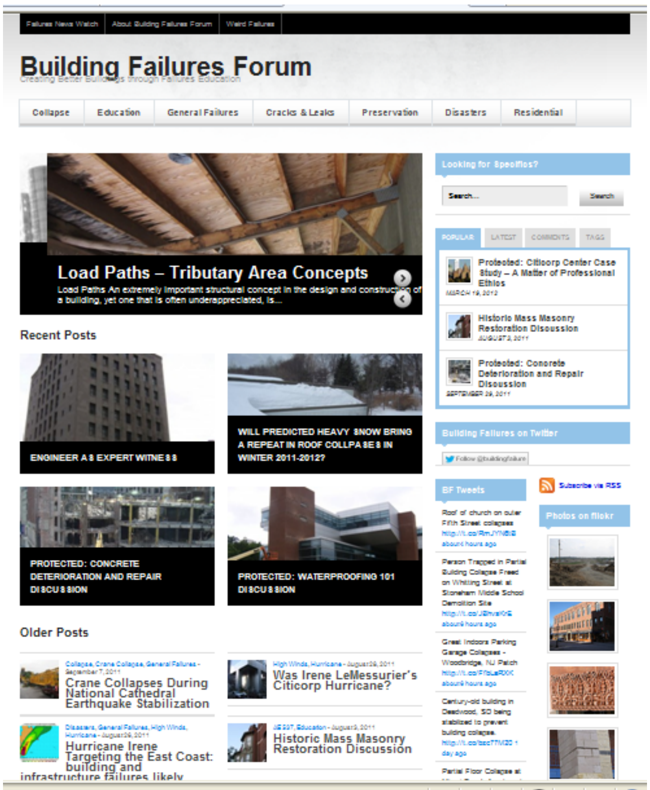
A large factor is education. Not continuing education, but the process of "continuous education". As an industry we have limited "Institutional Memory". What one person learns is seldom passed on to others. Continuing education addresses one individual at a time while the next new hire or generation of building designers has to start all over learning from their own mistakes. Institutionally, some of the lessons learned from major failures and collapses have been incorporated into our codes and standards over the years but even then, the origin of the lesson and context of the problems are often lost making it difficult to apply the lesson to future situations.

One of the problems is that the full details of many failure examples and lessons learned are not made public. Fear of blame, lawsuits, damaged business opportunities and ruined reputations are all often cited as reasons for keeping failure cases and actual examples under legal non-disclosure agreements and in insurance company files. But we need to find a way to at least generically share the lessons through more comprehensive failure dissemination methods and educational repositories such as *Failures Wiki* [5], the companion educational site *Building Failures Forum* [6] and *MatDL Failures Case Studies* [7]. Refer to Figures 2 and 3 for homepage screen captures from *Failures Wiki* and *Building Failures Forum* respectively.

In the US, NIST has launched the Disaster and Failure Events Data Repository which is aimed at making public extensive data on a number of the large scale failure events and disasters investigated by the agency such as the WTC collapses and the planned release of data on the 2010 Chile earthquake. [8] Likely the most organized self reporting system in place is the UK's SCOSS [9] and CROSS [10] reporting and dissemination system which allows confidential reporting of failures and related concerns combined with a view toward preemptive dissemination of information on perceived failure trends [11].

Figure 2. Screen Capture of Homepage of *Failures Wiki*.

Figure 3. Screen Capture of Homepage of *Building Failures Forum.*



As an industry we seem to be making progress on some fronts but regressing or stagnating on others. Every practitioner needs to make the effort to educate themselves on failure causes and the things that can go wrong on a project when we are not diligent. At the same time, we all need to mentor students and young practitioners entering the industry so that they can learn from our experience, and yes, even our mistakes. The industry and the public in general will be better for it if we take up the challenge.

References and Notes

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7. *Failure Case Studies: Civil Engineering and Engineering Mechanics*; MatDL: Kent, OH, USA, 2012; Available online: http://matdl.org/failurecases/Main_Page (accessed on 29 August 2012).
8. NIST disaster and failure events data repository. Available online: http://www.nist.gov/el/disasterstudies/repository_home.cfm (accessed on 22 August 2012).
9. The Standing Committee on Structural Safety (SCOSS) is the independent body established in 1976 to maintain a continuing review of building and civil engineering matters affecting the safety of structures. SCOSS aims to identify in advance those trends and developments which might contribute to an increasing risk to structural safety.
10. Confidential Reporting on Structural Safety (CROSS) is the scheme established by SCOSS in 2005 to improve structural safety and reduce failures by using confidential reports to highlight lessons that have been learnt, to generate feedback and to influence change. Reports sent to CROSS are completely confidential and neither personal details nor information that could be used to identify a project or product are seen by anyone other than the CROSS director.

11. Structural Safety. Available online: http://www.structural-safety.org/ (accessed on 22 August 2012).