Engineering Judgment and the Florida International University Pedestrian Bridge Collapse

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This article offers observations about *engineering judgment* relative to the Florida International University (FIU) pedestrian bridge collapse of March 2018. Information about the FIU pedestrian bridge collapse comes mostly from my review of several publications about this incident—in particular, the National Transportation Safety Board (NTSB) Highway Accident Report[1] issued in October 2019. I relied on the NTSB report as the basis for many of my observations, but I am aware that there are other detailed reports, studies, and project data that I have not reviewed.

About Engineering Judgment

Judgment is central to engineering and many other professional activities.[2] For example, engineering licensure laws identify sound judgment as a requirement for the professional practice of engineering.[3] Judgment is the means by which "evidence is recognized, supporting evidence compiled, conflicting evidence reconciled, and evidence of all kinds weighed according to its perceived significance."[4]

Engineers in certain disciplines intentionally consider how judgment influences their work, and here I think geotechnical engineering holds some prominence. The book *Judgment in Geotechnical Engineering*[5] presents lectures, papers, and other writings by eminent geotechnical engineer Ralph B. Peck. Building on his legacy, judgment remains an active and vital aspect of geotechnical engineering today. National Academy of Engineering member Allen Marr recently noted, "We must grapple with uncertainty in all aspects of our work: the project environment, the site data, limitations of our models, unknowns about construction, and others."[6] That is the nature of engineering judgment, or how geotechnical engineers see it, anyway.

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Engineering Judgment in the NTSB Report

The term "judgment" appears in the NTSB report 12 times: twice in the Executive Summary; three times in Chapter 1, "Factual Information"; six times in Chapter 2, "Analysis"; and once in the Conclusions. A closer look reveals the report's sharpest comments about judgment apply to design errors and misinterpretation of precollapse distress:

- "…used poor judgment when it determined that the bridge was a redundant structure" (p. 72).
- "…used poor engineering judgment and … chose not to use the higher demand model results…and did not provide a rationale for the engineering judgment it used when selecting modeling results" (p. 78).
- "…displayed poor engineering judgment by failing to recognize the extensive, large cracks observed in the member 11/12 nodal region as being abnormal for a reinforced concrete structure" (p. 92).
- "…this decision was based on judgment that returning the main span to its preexisting condition… as the right thing to do.…The NTSB does not agree" (pp. 94–95).

In addition to these specific instances, the NTSB report indicates poor engineering judgment and response to precollapse cracking by all parties—the design-builder, the designer, the construction project administrator/inspector, the owner/construction manager, and the state transportation agency—contributed to the severity of the collapse outcome.

Different Perspectives for Different Disciplines

I find it significant that the term "engineering judgment" appears so prominently in NTSB's analyses pertaining to causation of a structural engineering failure. NTSB vice chairman Bruce Landsberg states, "A bridge-building disaster should be incomprehensible in today's technical world," and "the science should be well sorted out by now."[7] The implication is that structural engineering risk has been handled probabilistically through research that underlies published code provisions. The (unwritten) corollary to such a view is critical: When an engineer "follows the code," engineering judgment is already handled and thus does not come conspicuously into play. This is strikingly different from branches of civil engineering where—because of limited knowledge or information (for example, geotechnical) or because of the randomness and variability of nature (for example, water resources)—these engineers are *often* thinking in terms of engineering judgment.[8]

How do *structural* engineers see the matter? Senior principal structural engineer and Fellow of the Structural Engineering Institute of the American Society of Civil Engineers (ASCE) J.G. Soules has commented:

> There is a growing number of regulators who believe the codes have solved all of the problems and if you follow the codes without question, you will not have problems or failures on your projects. As

> the vice chair of ASCE 7 [Committee on Minimum Design Loads for Buildings and Other Structures], I can tell you the codes are minimum requirements and that engineering judgment is very necessary in the design of safe structures. We who write the codes understand we cannot possibly cover every situation with rules. We also do not want to stifle innovation with draconian rules. I also know a growing number of younger engineers who believe they can analyze any problem (correctly) with today's software. While today's software makes many unique structures possible, a computer model is simply a simplified representation of reality based on a lot of assumptions. Many younger engineers accept the software defaults for modeling as gospel—they basically substitute a programmer's judgment for their own when they do this. Engineering judgment is still sorely needed in our profession (personal email communication, April 19, 2020).

Soules persuasively advocates that, notwithstanding the necessity and importance of codes, practicing structural engineers value engineering judgment and give it priority. But barriers exist for both the cultivation and the practice of judgment. What do we do about that?

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Lessons We Must Learn

As a civil engineer educator, I routinely assign senior undergraduate students to read articles and write an essay defining engineering judgment and explaining how it is obtained. My personal experience indicates that prior to the assignment, students "rarely" have encountered a definition of engineering judgment and most are "not sure" how to obtain judgment. A survey of engineering faculty shows they "strongly agree" that engineering judgment is important for problem-solving, but most struggle to "name specific things students can do to obtain judgment," and more are "not sure" how to assess judgment.

My point is this: If engineering judgment is important for engineering practice but faculty do not know how to teach or assess engineering judgment, and if students neither know what judgment is nor understand how to obtain it, we should not be surprised when "poor judgment" is prominently cited as the cause of a tragic bridge failure. I know there is more to it, but Landsberg asks, "Why?" My response is that if complacency existed in this failure, it was related to the lack of a proper understanding and use of engineering judgment. Such disasters point to a need for engineers to intentionally and continuously cultivate engineering judgment, not only during college but also through the internship period, and throughout their careers.

There is some good news on this point. The Accreditation Board for Engineering and Technology (ABET) has required that, effective fall 2019, "engineering judgment" is to appear in student learning outcomes. In the "Criteria for Accrediting Engineering Programs," Criterion 3: Student Outcomes,[9] now lists:

- Outcome 4: An ability to recognize ethical and professional responsibilities in engineering situations and make informed *judgments*, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts (emphasis added)
- Outcome 6: An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use *engineering judgment* to draw conclusions (emphasis added)

This is an important start, a beginning to be celebrated. Moving forward, if redemption from tragedy is possible, perhaps no better path exists to honor the people lost in the FIU pedestrian bridge collapse than for engineering leaders, including those directly involved in this incident, to invest in our profession—especially the next generations of engineers—by teaching the important lessons judgment requires we must all learn.

References

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