ENGINEERING JUDGMENT

CE 4200

Professional Engineering Practice Issues

Spring 2022 Semester

William D. Lawson, P.E., Ph.D.

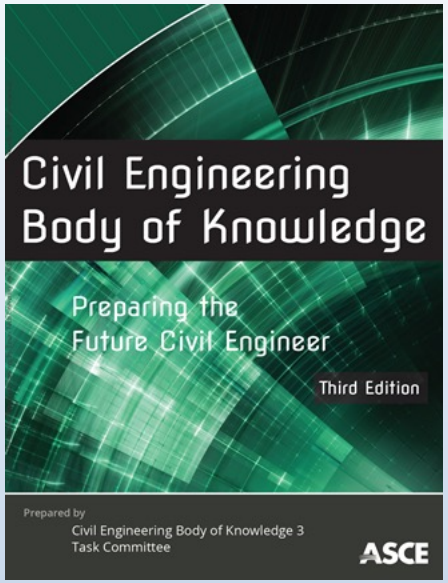
CRITICAL THINKING & ENGINEERING JUDGMENT

Professional Engineering Practice Issues

BASIS FOR INQUIRY

BOK3 Outcomes

1. Mathematics
2. Natural Sciences
3. **Social Sciences**
4. Humanities
5. Materials Science
6. Engineering Mechanics
7. Experimental Methods and Data Analysis
8. **Critical Thinking and Problem Solving**
9. **Project Management**
10. Engineering Economics
11. Risk and Uncertainty
12. Breadth in Civil Engr Areas
13. Design
14. Technical Depth
15. Sustainability
16. Communication
17. **Teamwork and Leadership**
18. Lifelong Learning
19. **Professional Attitudes**
20. **Professional Responsibilities**
21. Ethical Responsibilities



Recall **Assignment 1**, our review of BOK3E Outcomes?

CE 4200 Professional Engineering Practice Issues

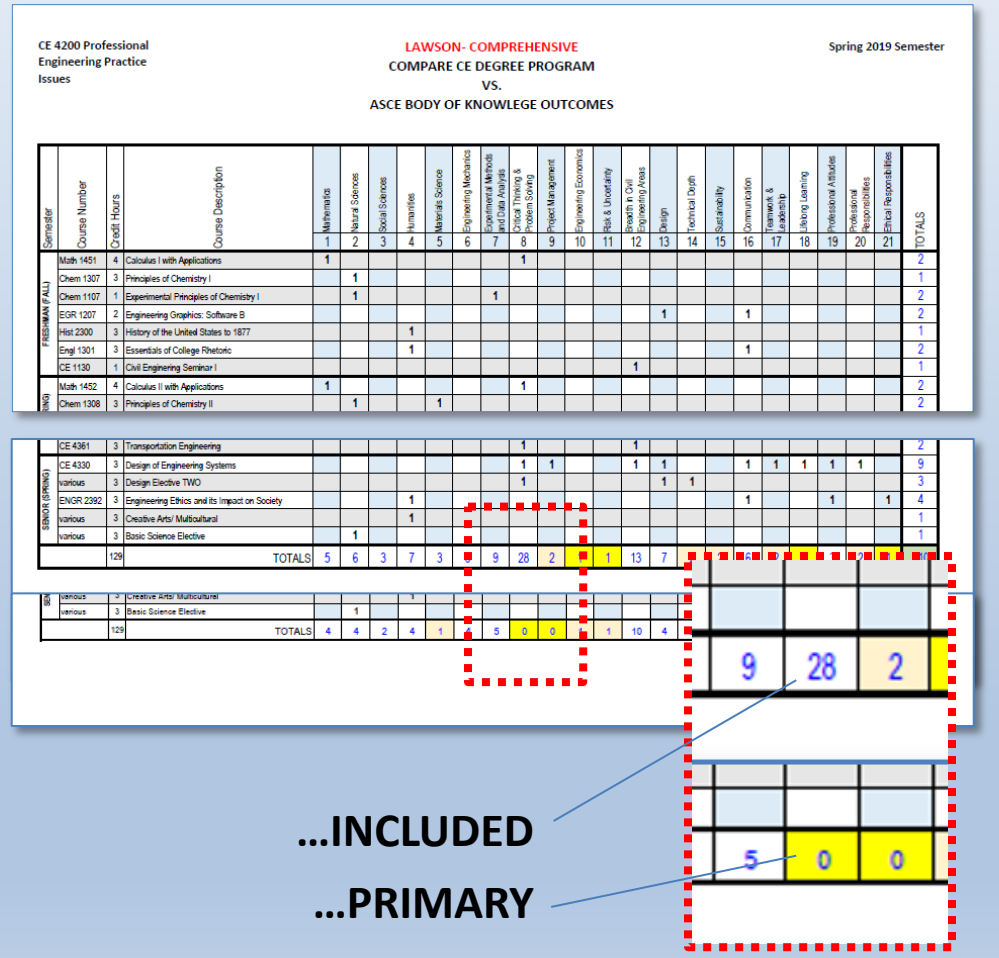
LAWSON- COMPREHENSIVE
COMPARE CE DEGREE PROGRAM
VS.
ASCE BODY OF KNOWLEGE OUTCOMES

Spring 2019 Semester

Semester	Course Number	Credit Hours	Course Description	1 Mathematics	2 Natural Sciences	3 Social Sciences	4 Humanities	5 Materials Science	6 Engineering Mechanics	7 Experimental Methods and Data Analysis	8 Critical Thinking & Problem Solving	9 Project Management	10 Engineering Economics	11 Risk & Uncertainty	12 Breadth in Civil Engineering Areas	13 Design	14 Technical Depth	15 Sustainability	16 Communication	17 Teamwork & Leadership	18 Lifelong Learning	19 Professional Attitudes	20 Professional Responsibilities	21 Ethical Responsibilities	TOTALS
FRESHMAN (FALL)	Math 1451	4	Calculus I with Applications	1							1														2
	Chem 1307	3	Principles of Chemistry I		1																				1
	Chem 1107	1	Experimental Principles of Chemistry I		1					1															2
	EGR 1207	2	Engineering Graphics: Software B													1			1						2
	Hist 2300	3	History of the United States to 1877				1																		1
	Engl 1301	3	Essentials of College Rhetoric				1												1						2
	CE 1130	1	Civil Engineering Seminar I														1								1
FRESHMAN (SPRING)	Math 1452	4	Calculus II with Applications	1							1														2
	Chem 1308	3	Principles of Chemistry II		1			1																	2
	Chem 1108	1	Experimental Principles of Chemistry II		1			1		1															3
	Phys 1408	4	Principles of Physics I		1						1														2
	Engr 1315	3	Introduction to Engineering								1					1									2
	Engl 1302	3	Advanced College Rhetoric				1				1														3
SOPHOMORE (FALL)	Math 2450	4	Calculus III with Applications	1							1														2
	ECE 3301	3	General Electrical Engineering								1						1								2
	CE 2301	3	Statics						1		1														2
	CONE 2302	3	Surveying							1	1						1								3
	CE 2201	2	Construction Materials Laboratory					1			1									1					3
	Pols 1301	3	American Government			1																			1
SOPHOMORE (SPRING)	Math 3350	3	Higher Mathematics for Engineers and Scientists I	1							1														2
	CE 3303	3	Mechanics of Solids						1		1														2
	IE 2324	3	Engineering Economic Analysis								1			1											2
	CE 3305	3	Mechanics of Fluids						1		1														2
	IE 3341	3	Statistics	1						1	1				1										4
	various		International Experience				1										1								2
JUNIOR (FALL)	CE 3309	3	Environmental Engineering								1						1			1					3
	CE 3171	1	Environmental Engineering Laboratory I							1							1								2
	CE 3354	3	Engineering Hydrology								1						1								2
	CE 3440	4	Structural Analysis I								1						1								2
	CE 3103	1	Mechanics of Solids Laboratory						1	1															2
	Hist 2301	3	History of the United States since 1877				1																		1
	CE 3105	1	Mechanics of Fluids Laboratory						1	1															2
JUNIOR (SPRING)	CE 3372	3	Water Systems Design								1							1							2
	CE 3341	3	Principles of Structural Design								1							1							2
	CE 3302	3	Dynamics						1		1														2
	CE 3321	3	Introduction to Geotechnical Engineering								1						1								2
	CE 3121	1	Geotechnical Engineering Laboratory							1							1								2
	Pols 2306	3	Texas Politics and Topics			1																			1
SENIOR (FALL)	CE 4200	2	Professional Engineering Practice Issues			1					1	1										1		1	6
	CE 4343	3	Design of Concrete Structures								1							1							2
	various	3	Design Elective ONE								1							1	1						3
	various	3	Oral Communication								1										1				2
	CE 4361	3	Transportation Engineering								1						1								2
SENIOR (SPRING)	CE 4330	3	Design of Engineering Systems								1	1					1	1		1	1	1	1		9
	various	3	Design Elective TWO								1							1	1						3
	ENGR 2392	3	Engineering Ethics and its Impact on Society				1													1			1	1	4
	various	3	Creative Arts/ Multicultural				1																		1
	various	3	Basic Science Elective		1																				1
	129		TOTALS	5	6	3	7	3	6	9	28	2	1	1	13	7	2	2	6	2	1	3	2	1	110

REV: 01/10/2019

PAGE 1 OF 1



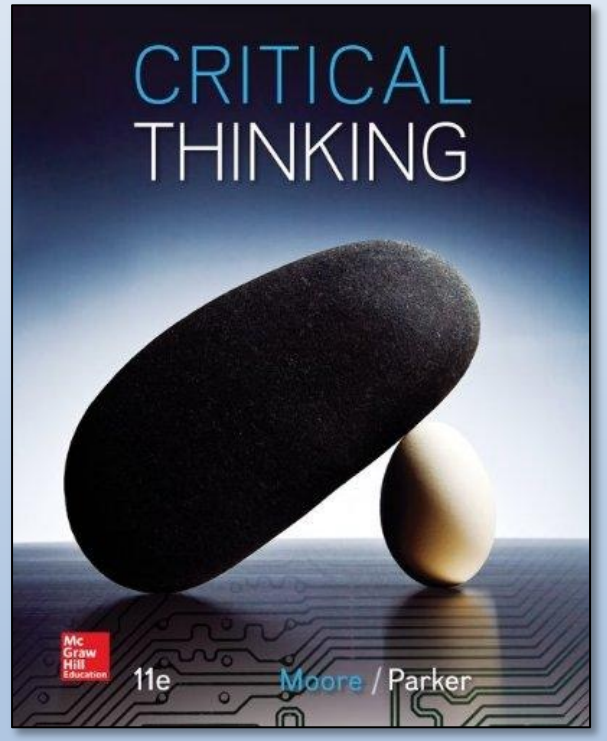
48 courses…
21 outcomes…

CRITICAL THINKING & PROBLEM SOLVING

Critical Thinking… *Definition*

- **Critical thinking** is the careful, deliberate determination of whether we should accept, reject, or suspend judgment about a claim – and of the degree of confidence with which we accept or reject it.

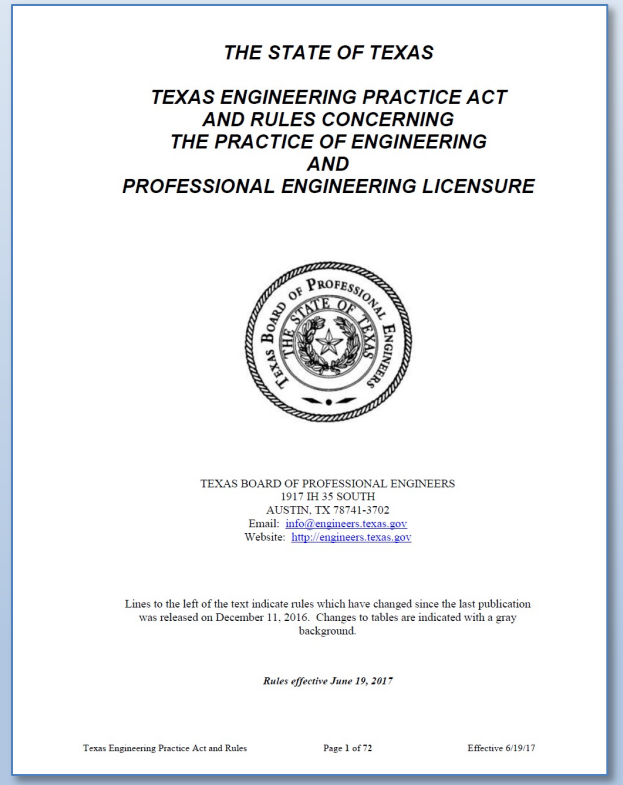
  ~ Moore & Parker




Critical
Thinking
Education
Knowledge
Attention
Outcomes
Defined
Deductive
Insight
Thought
Solving
Syllogism
Perspective
Evidence
Diagram
Creativity
Organization
Retrieval
Reasoning
Language
Logic
Challenge
Learning
Experiment
Anecdotes
Bias
Emotion
Encoding
Skeptical
Observation
Assessment
Fallacy
Skeptic
Random
Hypothesis
Argument
Inductive
Memory
Problem
Rational
Science
illusion
Decision-Making
Inquiry
Judgment

LEGAL
DEFINITION OF ENGINEERING

Engineering--The profession in which a knowledge of the mathematical, physical, engineering, and natural sciences gained by education, experience, and practice is applied **with judgment** to develop ways to utilize, economically, the materials and forces of nature for the benefit of mankind.



THE STATE OF TEXAS

TEXAS ENGINEERING PRACTICE ACT
AND RULES CONCERNING
THE PRACTICE OF ENGINEERING
AND
PROFESSIONAL ENGINEERING LICENSURE

TEXAS BOARD OF PROFESSIONAL ENGINEERS
1917 IH 35 SOUTH
AUSTIN, TX 78741-3702
Email: info@engineers.texas.gov
Website: http://engineers.texas.gov

Lines to the left of the text indicate rules which have changed since the last publication was released on December 11, 2016. Changes to tables are indicated with a gray background.

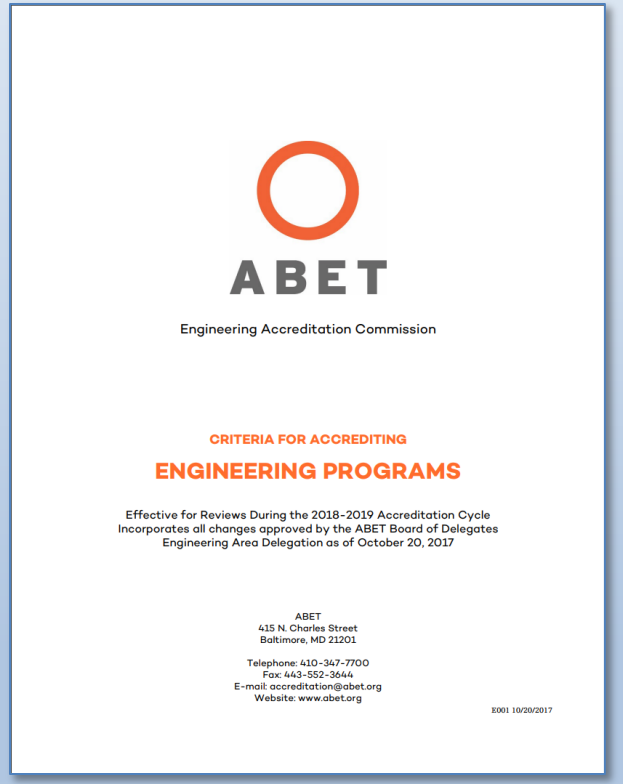
Rules effective June 19, 2017

Texas Engineering Practice Act and Rules Page 1 of 72 Effective 6/19/17

SUBCHAPTER F
§131.81 Definitions

EDUCATIONAL INSTRUCTION OF ENGINEERING

Student Outcomes –
Student outcomes describe what students are expected to know and be able to do by the time of graduation. These relate to the knowledge, skills, and behaviors that students acquire as they progress through the program.



ABET

Engineering Accreditation Commission

CRITERIA FOR ACCREDITING

ENGINEERING PROGRAMS

Effective for Reviews During the 2018-2019 Accreditation Cycle
Incorporates all changes approved by the ABET Board of Delegates
Engineering Area Delegation as of October 20, 2017

ABET
415 N. Charles Street
Baltimore, MD 21201

Telephone: 410-347-7700
Fax: 443-552-3644
E-mail: accreditation@abet.org
Website: www.abet.org

E001 10/20/2017

ABET Criterion 3. Student Outcomes

2018-2019 Criterion 3

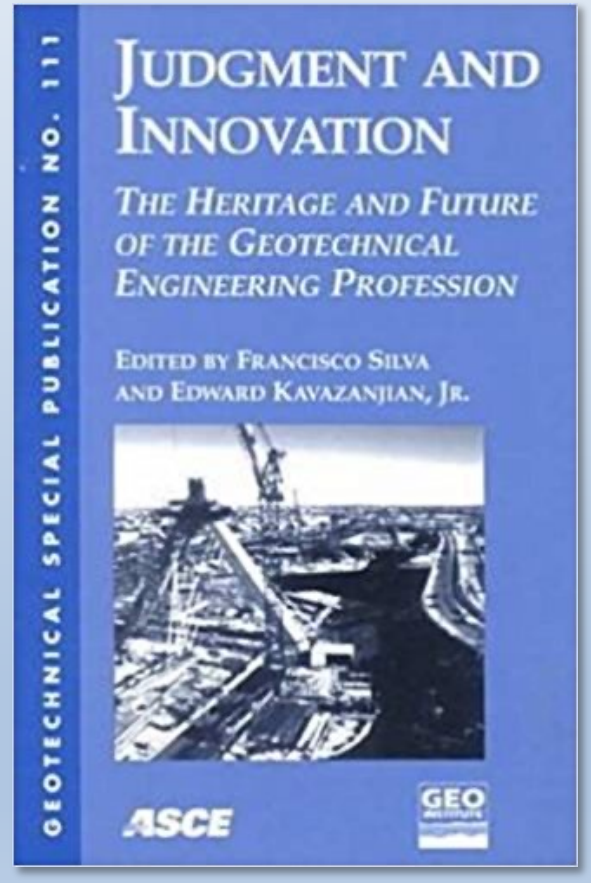
The program must have documented student outcomes that support the program educational objectives. Attainment of these outcomes prepares graduates to enter the professional practice of engineering. Student outcomes are outcomes (1) through (7), plus any additional outcomes that may be articulated by the program.

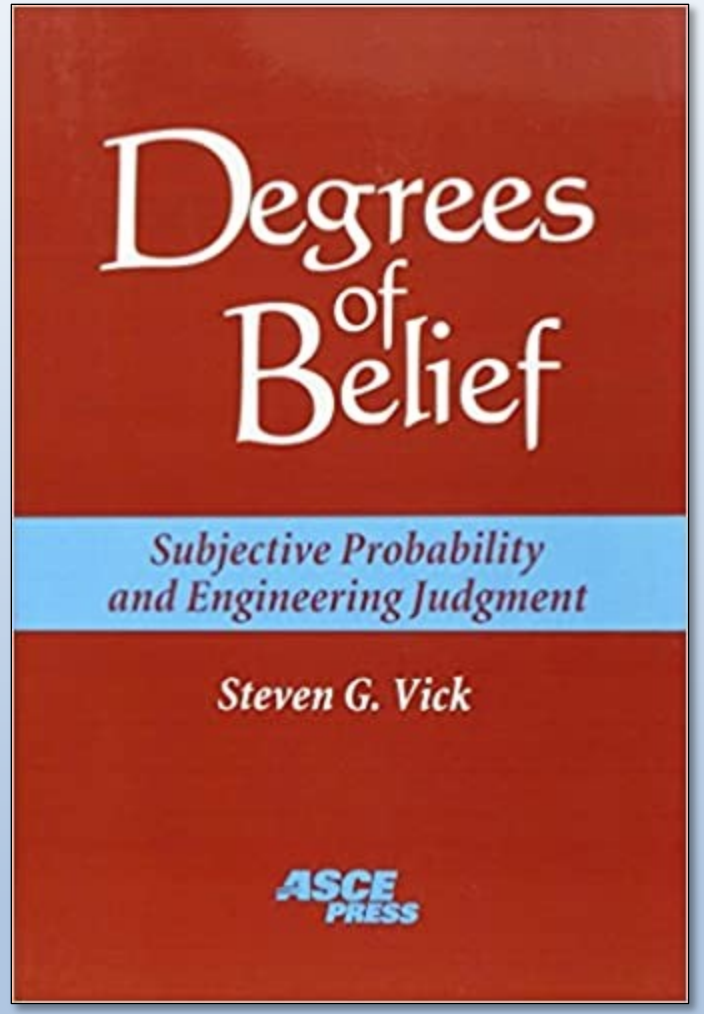
1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
3. an ability to communicate effectively with a range of audiences
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
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

PROFESSIONAL PRACTICE OF ENGINEERING

"The successful practice of engineering requires a high degree of engineering judgment."

-Ralph B. Peck
"A Man of Judgment"





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."

-Steven Vick

FLORIDA INTERNATIONAL UNIVERSITY PEDESTRIAN BRIDGE COLLAPSE

Professional Engineering Practice Issues

A CASE STUDY IN [LACK OF] ENGINEERING JUDGMENT

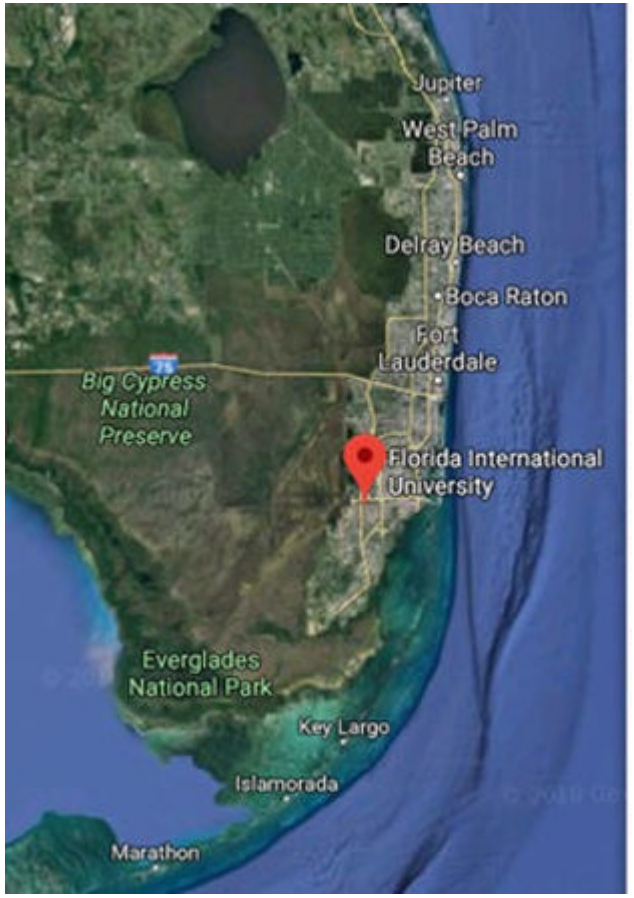
Signature Bridge for
FIU & Sweetwater (Rendering)


FIU
FLORIDA
INTERNATIONAL
UNIVERSITY
FIU

FLORIDA INTERNATIONAL UNIVERSITY

"A Top 50 Public Research University"

MIAMI, FLORIDA



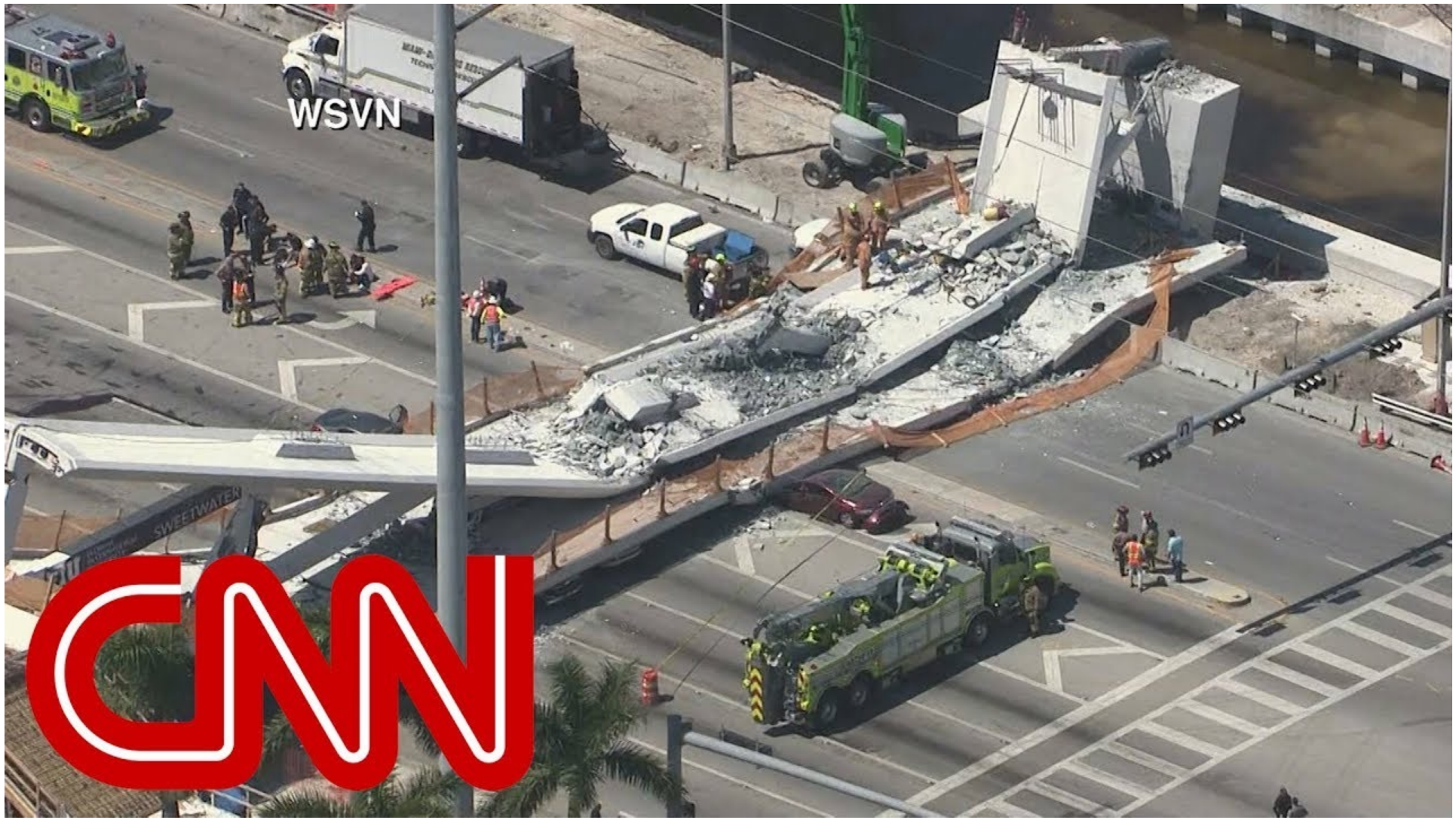
FIU | FLORIDA INTERNATIONAL UNIVERSITY

The pedestrian bridge was to serve as an elevated transit bridge for pedestrians and bicyclists crossing the travel lanes of SW 8th Street and the Tamiami Canal.

The main bridge section—spanning the south pier to the pylon pier—was 174 feet long, and the walking deck surface was elevated 18.5 feet.

“On Thursday, March 15, 2018, about 1:46 p.m., a partially constructed pedestrian bridge crossing an eight-lane roadway in Miami, Florida, experienced a catastrophic structural failure in the nodal connection between truss members 11 and 12 and the bridge deck.”

“The 174-foot-long bridge span fell about 18.5 feet onto SW 8th Street, which consists of four through travel lanes and one left-turn lane in the eastbound direction, and three through travel lanes in the westbound direction.”

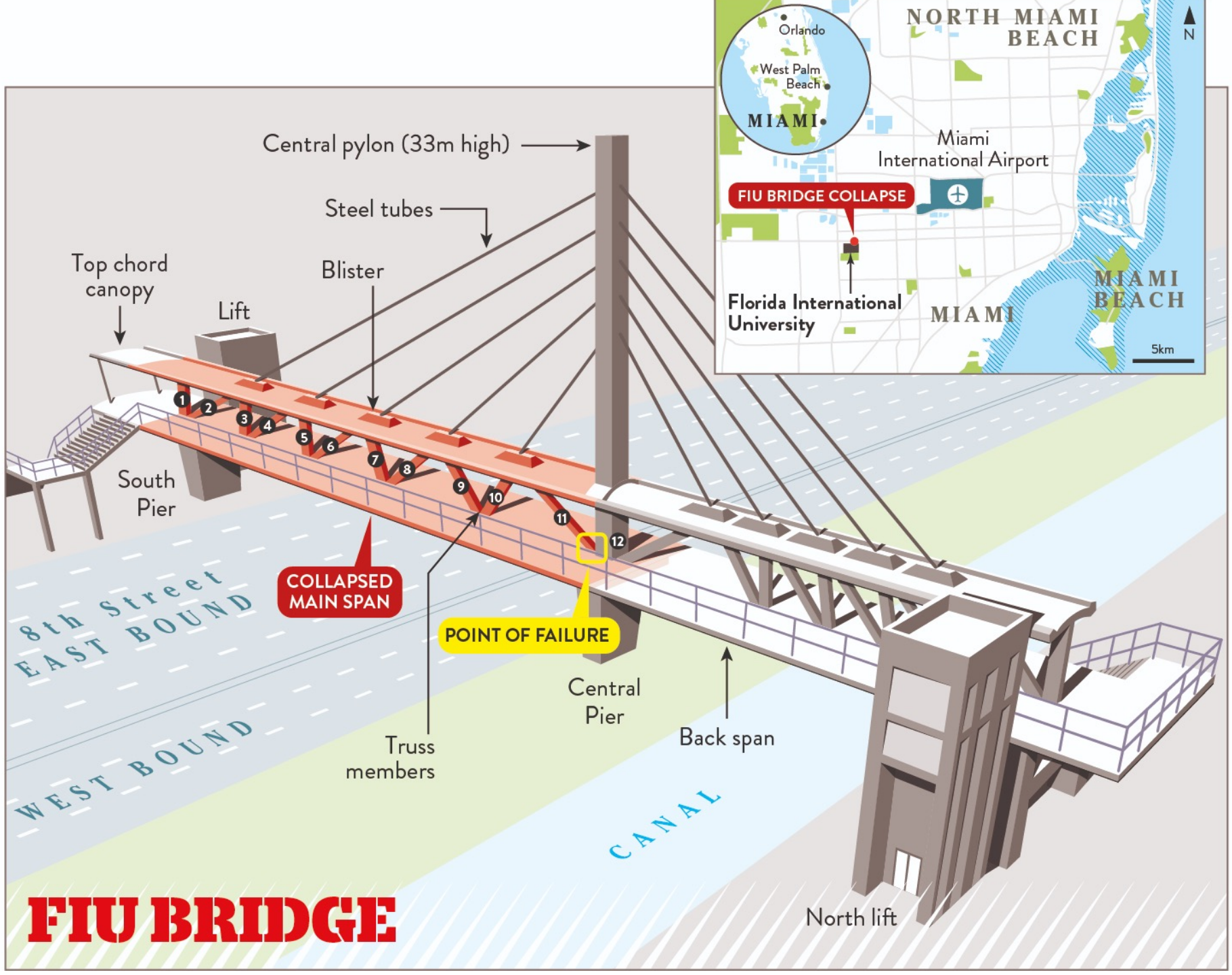


“Two of the westbound lanes below the north end of the bridge were closed to traffic at the time of the collapse; however, one westbound lane and all five eastbound lanes were open.”

“On the day of the collapse, a construction crew was working on retensioning the post-tensioning rods within member 11, connecting the bridge canopy and the deck at the north end.”

“Eight vehicles located below the bridge were fully or partially crushed. One bridge worker and five vehicle occupants died. Five bridge workers and five other people were injured.”


Alberto Arias
Alexa Duran
Navaro Brown
Rolando Fraga Hernandez
Brandon Brownfield
Osvaldo Gonzalez


Central pylon (33m high)
Steel tubes
Top chord canopy
Blister
Lift
South Pier
COLLAPSED MAIN SPAN
POINT OF FAILURE
Truss members
Central Pier
Back span
North lift
8th Street EAST BOUND
WEST BOUND
CANAL
FIU BRIDGE
Orlando
West Palm Beach
MIAMI
NORTH MIAMI BEACH
N
Miami International Airport
FIU BRIDGE COLLAPSE
Florida International University
MIAMI
MIAMI BEACH
5km

Highway Accident Report

Pedestrian Bridge Collapse Over SW 8th Street
Miami, Florida
March 15, 2018

National Transportation Safety Board

490 L'Enfant Plaza, S.W.
Washington, D.C. 20594

The investigation focused on the following safety issues: bridge design and construction plan errors, and unique bridge characteristics and mechanisms of failure; independent peer review of complex bridge design; shortcomings in oversight of evaluation of and response to significant observed bridge structure distress prior to collapse; and lack of redundancy guidelines in specifications for pedestrian and concrete truss bridges.

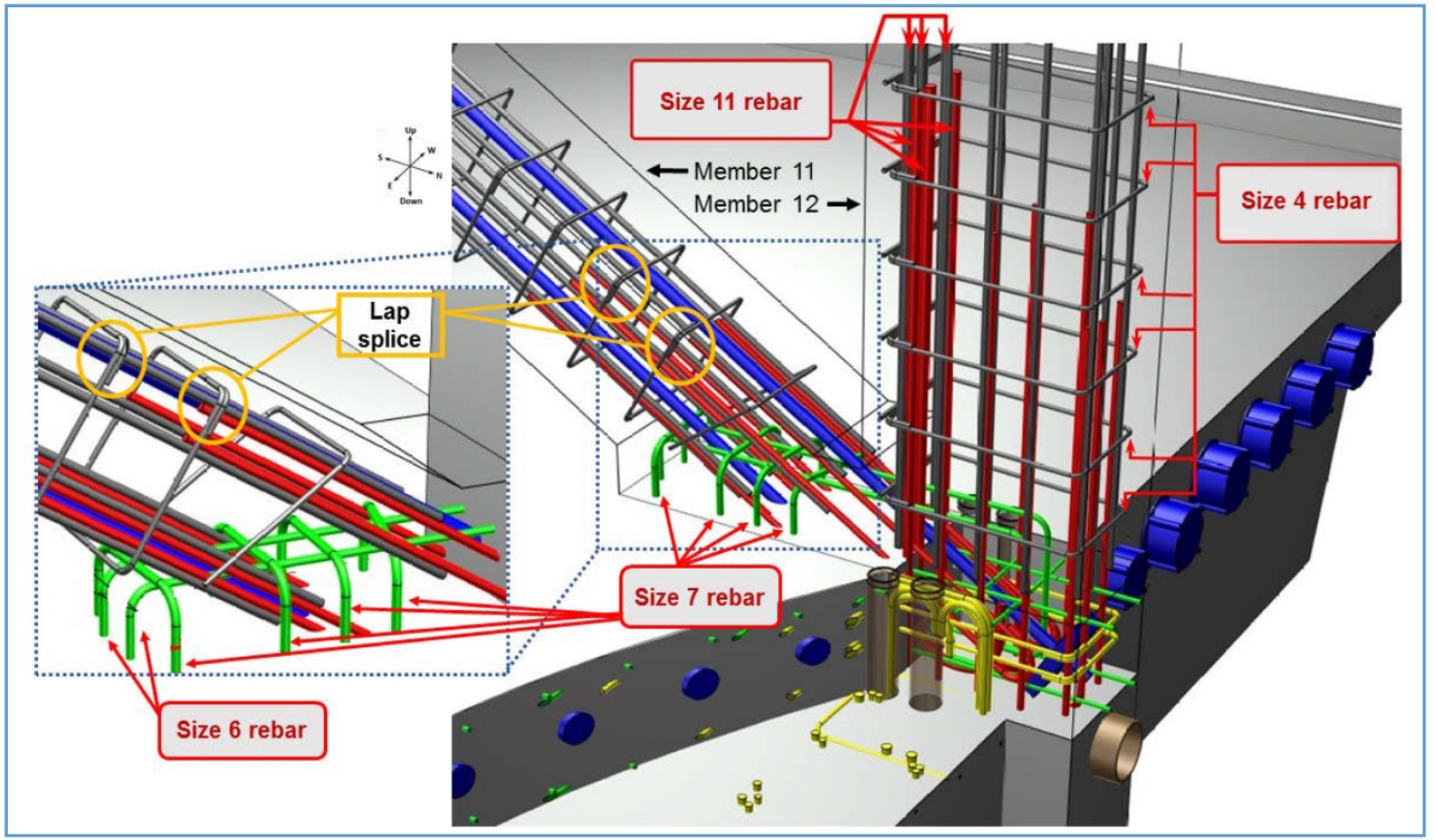


Figure 17. Main span, north end, showing rebar detailing in member 11, member 12, and node 11/12. Inset shows another view of rebar in node 11/12 and detail of lap splice from member 11. (Source: FHWA 2019)

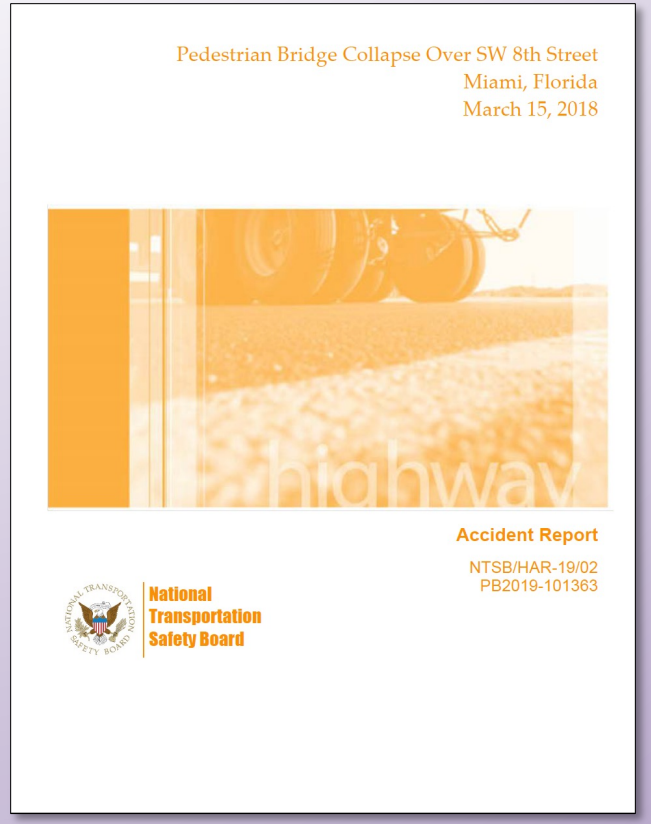
Highway Accident Report

Pedestrian Bridge Collapse Over SW 8th Street
Miami, Florida
March 15, 2018

Executive Summary

1. Factual Information
2. Analysis
3. Conclusions
4. Recommendations

Board Member Statement



Probable Cause…

"The National Transportation Safety Board (NTSB) determines that the probable cause of the Florida International University (FIU) pedestrian bridge collapse was the load and capacity calculation errors made by FIGG Bridge Engineers, Inc., (FIGG) in its design of the main span truss member 11/12 nodal region and connection to the bridge deck. Contributing to the collapse…"

Excerpts from the report…

- **Section 2.3.1**, Design of Bridge Nodal Regions: “FIGG used poor judgment when it determined that the bridge was a redundant structure…” (p. 72).
- **Section 2.3.3**, FIGG Analytical Models: “FIGG 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).
- **Section 2.6**, Shortcomings in Oversight of Evaluation of and Response to Significant Observed Bridge Structure Distress Prior to Collapse: “The EOR 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).
- **Section 2.6.2**, Precollapse Decision to Retension Member 11: “the NTSB does not agree” that FIGG’s “judgment that returning the main span to its preexisting condition” was appropriate (pp. 94-95).

Excerpts from the report…

In addition to these specific instances, the NTSB report indicates that poor engineering judgment and response to precollapse cracking by the design-builder (Magnum Construction Management -MCM), the design consultant (FIGG), the construction project administrator/inspector (Bolton, Perez and Associates Consulting Engineers), the owner/construction project manager (Florida International University), and the Florida Department of Transportation (FDOT) contributed to the severity of the collapse outcome.

NTSB

Highway Accident Re

Board Member Statement

Vice Chairman Landsberg filed the following concurring statement on October 28, 2019.

Concurring Statement of Vice Chairman Bruce Landsberg re Miami Pedestrian Bridge C

A bridge-building disaster should be incomprehensible in today's technical world. We
building bridges in this country for over two hundred years, and long before that in oth
the world. The science should be well sorted out by now – and for the most part,
investigation clearly highlighted basic design flaws and a *complete lack of oversight by every single party* that had responsibility to either identify the design errors or stop work and call for a safety stand-down, once it was clear that there was a massive internal failure.

The "what" is very clear but the "why" is more elusive. Despite the public's anger, distress, and disappointment, none of the responsible organizations had any intent for this tragic event to occur or to cause any injury or loss of life. Sadly, good intentions do not suffice for competence and diligence.

Engineering schools will use this as a landmark case study for years – and they should. The Engineer of Record (EOR) employed by FIGG Bridge Engineers, Inc., was experienced, but his calculations were erroneous. Reflection on this event should go far beyond merely a technical review. The checks and balances that were required by the Florida Department of Transportation (FDOT) and American Association of State Highway and Transportation Officials guidance and incumbent upon Louis Berger (LB), the peer-reviewing organization, were completely lacking. ered their bid to review the project by 43 percent in order to get the business, but also f the review. The reason given was there wasn't enough money in the project h disingenuous and unconscionable. It also was in violation of nt second set of eyes to review everything – not for which they

PERSPECTIVE

Engineering Judgment and the Florida International University Pedestrian Bridge Collapse

by Dr. William D. Lawson, Murdough Center for Engineering Professionalism, Texas Tech University

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 has some prominence. The book *Judgment in Geotechnical Engineering*, lectures, papers, and other

- "…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," the science should be well sorted out by now."[7] The structural engineering risk has been handled that underlies published code

ENGINEERING JUDGMENT

Professional Engineering Practice Issues

HOW WELL DO YOU UNDERSTAND THIS CONCEPT?

Exercise 2.1

Meaning of “engineering judgment”

Please refer to “survey” handout. Provide responses to questions 1 through 10 (multiple choice).

Exercise 2.2

Meaning of “engineering judgment”

I think “engineering judgment” means:

Exercise 2.3

Meaning of “engineering judgment”

- Discuss your definition of engineering judgment with 2 or 3 persons near you
- Try to come up with an improved definition

ENGINEERING JUDGMENT

Professional Engineering Practice Issues

SOME MISCONCEPTIONS

Judgment for the engineering **STUDENT**

"[Engineering judgment] often appears to be an ingredient necessary for the solution of engineering problems, but one which s/he cannot acquire until later in her/his career by some process of absorption from his experience and his colleagues."

-Ralph B. Peck

"A Man of Judgment"

Judgment for the engineering **SCIENTIST**

"[Engineering judgment] may appear to be a crutch used by practicing engineers as a poor substitute for sophisticated analytical procedures."

-Ralph B. Peck

"A Man of Judgment"

Judgment for the **PRACTICING** engineer

"[Engineering judgment] may too often be an impressive name for guessing rather than for the collection of hard facts and for rational thinking."

-Ralph B. Peck

"A Man of Judgment"

“These are all **misconceptions**. There actually is such a thing as engineering judgment and it is indispensable to the successful practice of engineering.”

-Ralph B. Peck

“A Man of Judgment”

ENGINEERING JUDGMENT

Professional Engineering Practice Issues

SOME DEFINITIONS

“Engineering judgment could be defined as the ability to recognize and/or predict, through a combination of intuition, insight and experience, the probable outcome of an analysis, design or process.”

-Bruhl, JC, JL Klosky, T Mainwaring, JP Hanus (2017)

US Military Academy at West Point

“When I hear the words ‘engineering judgement’, I know they are just going to make up numbers.”

-Richard Feynman (1988)

Acclaimed Physicist

“Engineering judgment is a creative act generated under constraints, and it proceeds not from abstract or general formulae, but from practical engagement.”

-Michael Davis (2012)

Illinois Institute of Technology

THANK YOU.