FIU bridge collapse, Miami FL
Investigation of Failure (15/03/18)
~ Engineering aspects ~

(FESA presentation 22/08/19)

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FIU bridge, Miami

TUNNEL FAILURE – TUNNEL VISION

Forensic Engineering Society of Australia (FESA) *Melbourne, 22/03/18*

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TUNNEL FAILURE – TUNNEL VISION

Boston Big Dig

National Aeronautics and Space Administration

System Failure Case Studies

TUNNEL OF TERROR

In July 2006, massive suspended ceiling panels fell and crushed a passing car below.

Proximate Cause:
- Anchor bolts ripped loose from the ceiling as the epoxy adhesive failed

Underlying Issues:
- Design flaws and ineffective communication
- Bypassed verification and maintenance due to insufficient understanding of epoxy materials
- Lack of emphasis on system safety resulted in reduced safety margins and failure to identify epoxy as a key safety critical component
- Management ignored "warning signs" due to cost and schedule pressures

Underlying Issues:

- Design flaws and ineffective communication
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+ 2 years

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Investigation of March 15, 2018 Pedestrian Bridge Collapse at Florida International University, Miami, FL

U.S Department of Labor
Occupational Safety and Health Administration
Directorate of Construction

June 2019

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FIU-Sweetwater UniversityCity
Prosperity Project
Pedestrian Bridge

The FIU-Sweetwater UniversityCity Bridge, sidewalks and plaza will connect the Florida International University campus to the City of Sweetwater, offering a safer pedestrian route for students and visitors.

BRIDGE MOVE:
The bridge's main span has been built on temporary supports (temporary shoring) on the south side of Southwest 8th Street. Self-Propelled Modular Transporters (SMPTs) with pull-up gantries will be positioned under the main span, lift it from its temporary shoring, and then carry it along an arc-shaped path to the northeast roughly 90 degrees and lower it onto its permanent position. **It will be the largest pedestrian bridge move via a Self-Propelled Modular Transportation (SPMT) in U.S. history.**

174 feet
Length of section being moved

Dimensions
289' x 31.67'
including stairs and elevators on each end. The pylon is **109** feet tall.

Weight of section being moved:
950 tons

FIU FLORIDA INTERNATIONAL UNIVERSITY
fiu.edu

CITY OF SWEETWATER
cityofsweetwater.fl.gov

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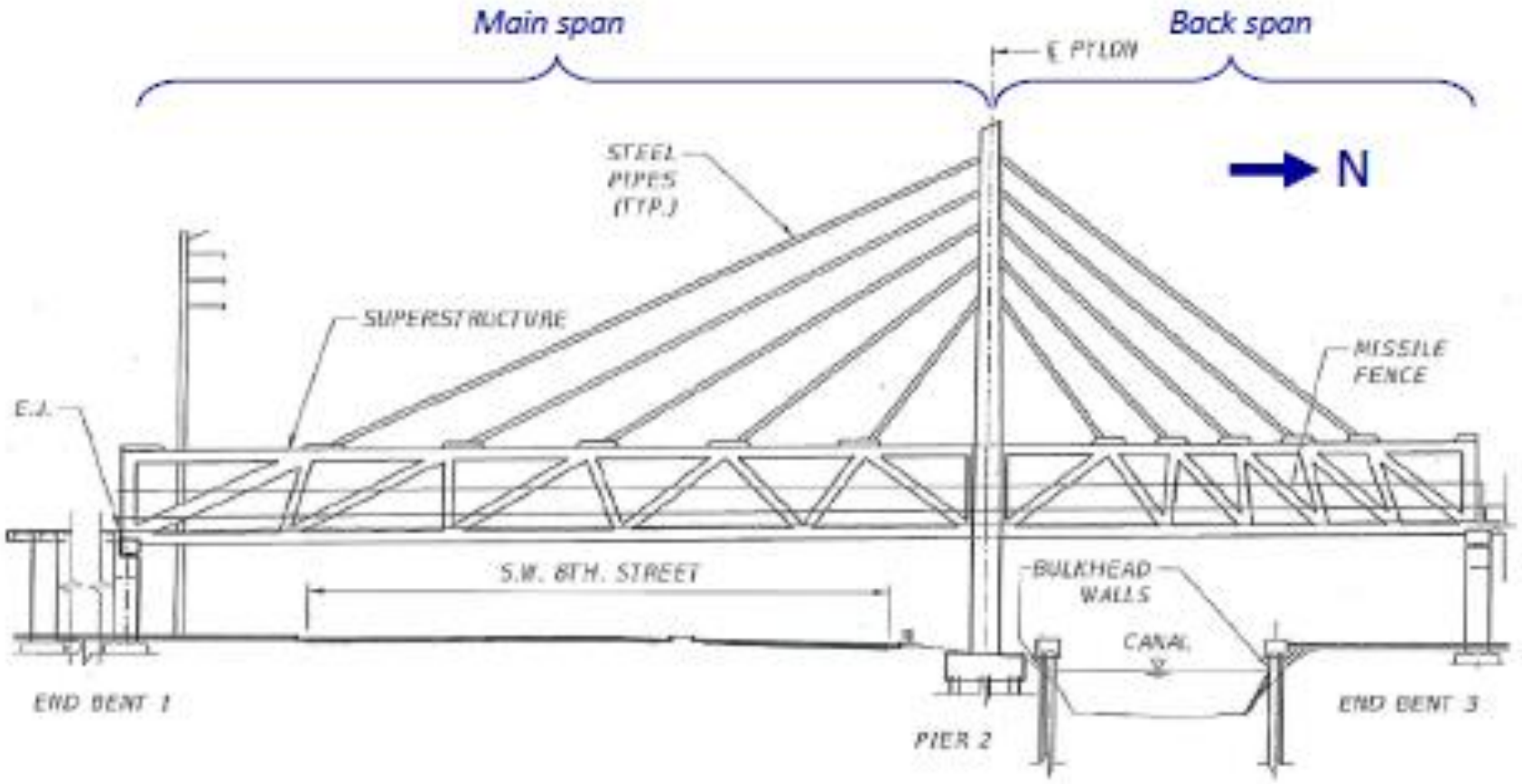

Figure 3 Bridge as designed

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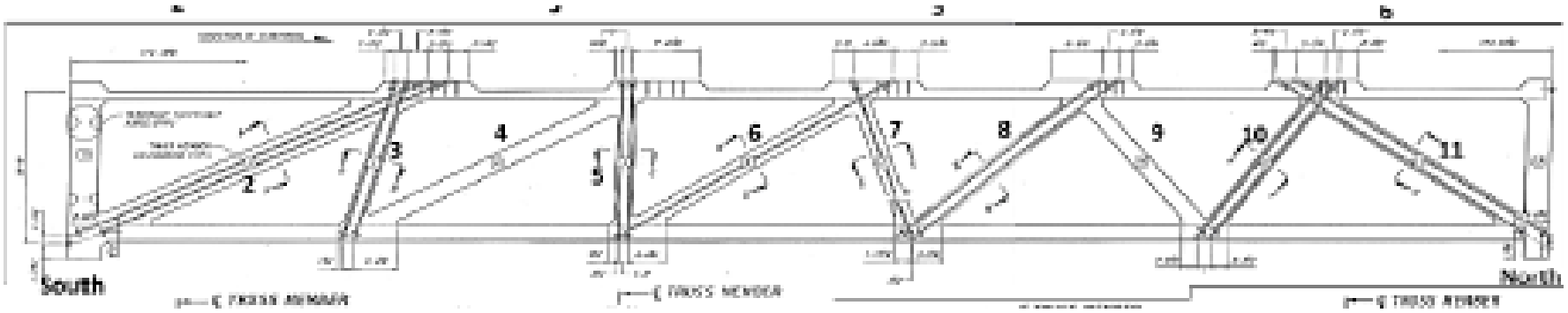

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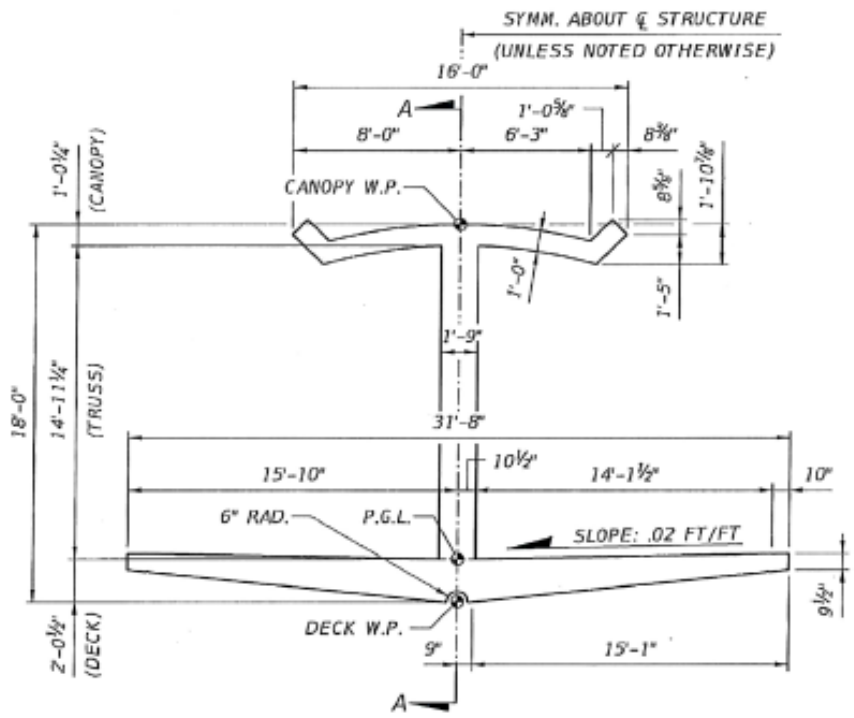

Figure 10 Cross section of the bridge main span deck

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Figure 48 Bridge immediately prior to the collapse, March 15, 2018 – camera #2

FIU bridge, Miami

Figure 49 Bridge immediately after the collapse, March 15, 2018 – camera #2
Employees engaged in re-tensioning the PT bars in diagonal 11

FIU bridge. Miami

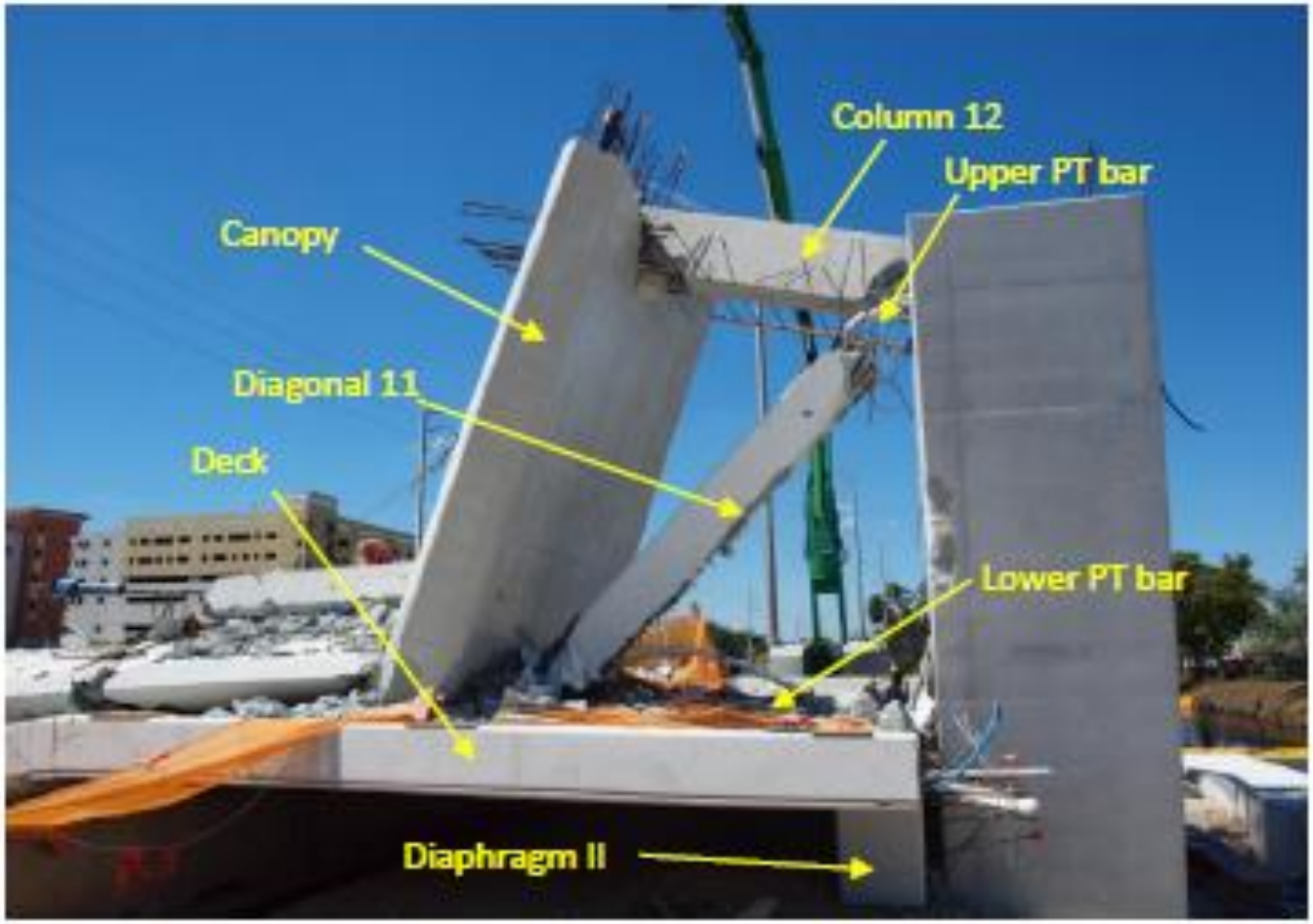

Figure 52 Column 12, diagonal 11 and part of the canopy after bridge deck and diaphragm fell to the ground, March 17, 2018, by OSHA

FIU bridge, Miami

3. Key Participants:

The following were the key participants in the project:

1. Florida International University Facilities Management	Owner
2. Florida Department of Transportation	LAP program
3. Munilla Construction Management, Inc.	General contractor (Design-Build)
4. FIGG Bridge Engineers, Inc.	Structural Engineer of Record
5. The Louis Berger Group, Inc.	Independent peer review
6. Bolton Perez and Associates, Inc.	CEI
7. The Structural Group of South Florida	Concrete subcontractor
8. Structural Technologies /VSL, LLC	Post-tensioning
9. RC Group, LLC	Formwork and scaffold
10. Barnhart Crane & Rigging Company	Precast bridge transporter (SPMT)
11. Georges Crane Service, Inc.,	Crane
12. Cemex	Concrete supplier
13. The Corradino Group	Post-tensioning inspection

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February 24-28, 2018 :

Removal of formwork completed, except for the mega shores under each diaphragm. It is important to note that the lateral bracings to the

When the shores under the bridge were removed and the truss was self-supported over the mega shores, a loud popping sound was heard by at least three employees - one from The Structural Group (TSG), and two from MCM. The employee from the TSG and one of the employees from the MCM walked over the bridge and noticed cracks at the bases of diagonal 2 and 11.

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March 10, 2018

It is estimated that the truss was placed over the supports around 11:30 am. Soon thereafter, MCM, BPA and FIGG employees walked over the bridge to look for anything unusual. Franklin Hines of FIGG walked over the bridge and reported no significant issues. However, on March 12, 2018, MCM sent an email to FIGG expressing its concern about the cracks MCM and BPA noticed in the afternoon of March 10, 2018.

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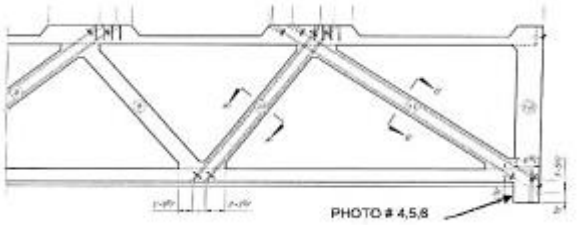

Figure 18 Photo #4 in 2/28/2018 E-mail from MCM to FIGG

Figure 20 Photo #6 in 2/28/2018 E-mail from MCM to FIGG

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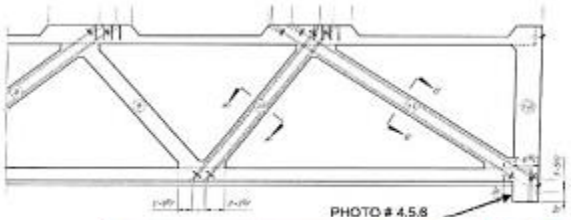

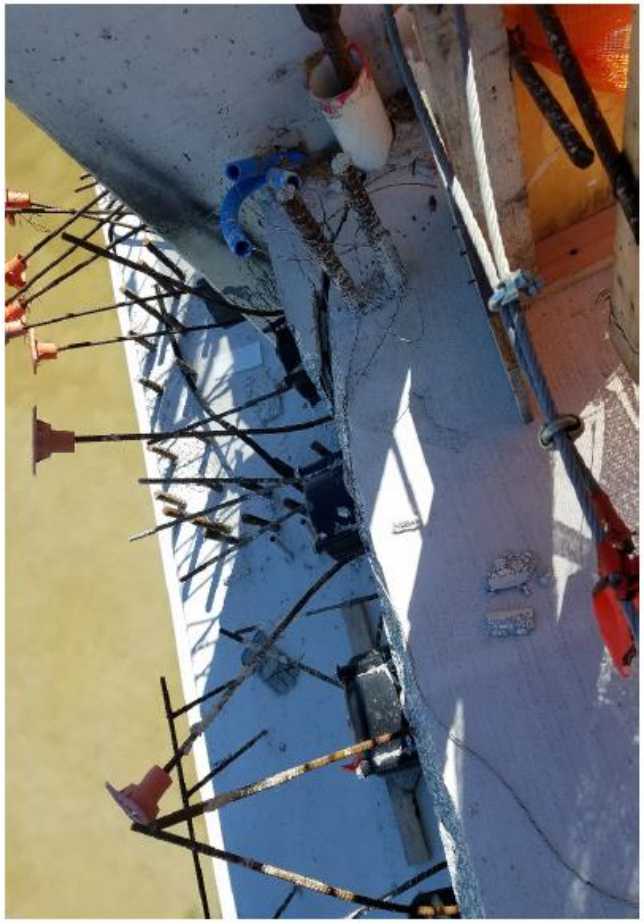

Figure 28 Diagonal cracks on the west side of diaphragm II on 3/13/2018, by BPA – top face

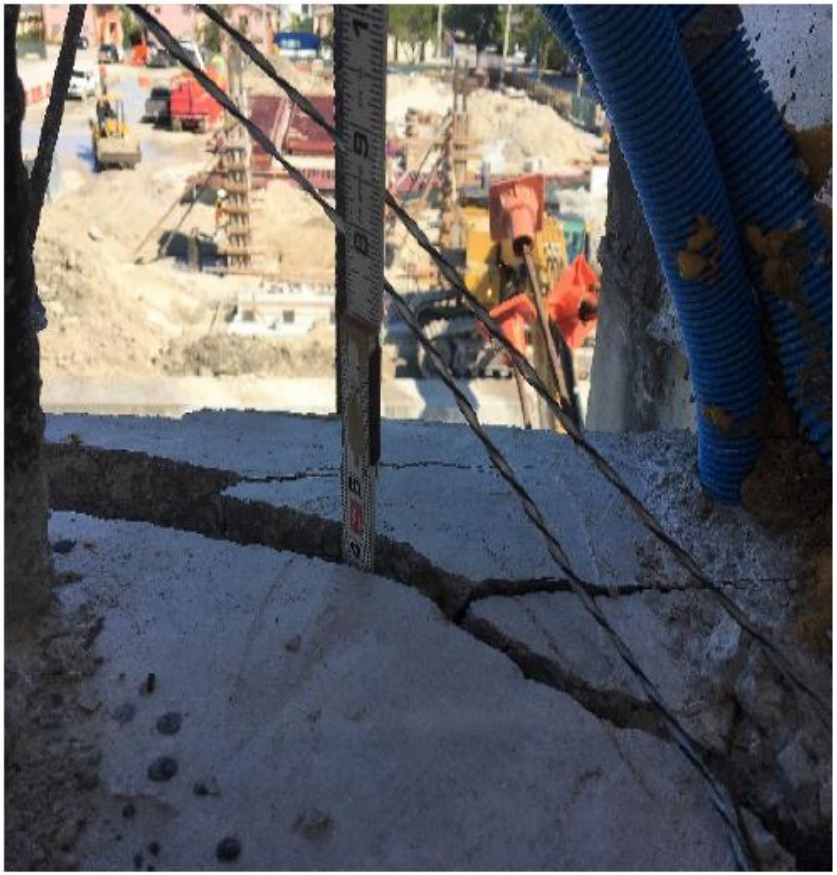

Figure 30 Notice the depth and width of diagonal cracks at the west side of diaphragm II on 3/14/2018 by BPA

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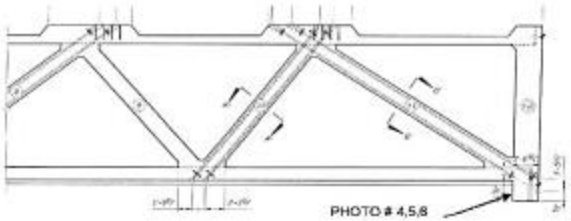

Figure 39 Close-up of longitudinal cracks in diagonal 11 on 3/14/2018 by BPA

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As a result of the investigation, OES concludes that:

1. FIGG Bridge Engineers (FIGG), the Engineer of Record (EOR), failed to recognize that the bridge was in danger of collapsing when it inspected it hours before the collapse. The concrete truss had developed numerous wide and deep structural cracks jeopardizing the integrity of the bridge. The EOR should have immediately instructed that the bridge be shored at appropriate locations and SW 8th Street be closed. At the time of collapse, the post-tensioning bars were being re-tensioned at the specific instructions of the EOR.
2. The bridge had structural design deficiencies that contributed to the collapse during construction stage III. The cracks on the bridge occurred due to deficient structural design.
3. The morning of the incident, EOR held a meeting with project participants after evaluating the cracks over the course of the previous two days. At that meeting, the EOR acknowledged that his computations could not replicate the cracks and therefore, he did not know why the cracks were occurring. The Construction Engineer and Inspector (CEI) of the project advised the EOR at this meeting that the cracks were lengthening daily. Despite these admissions and the knowledge that the cracks were growing in size, EOR stated more than once that the cracks did not present any safety concerns.

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4. The magnitude of the cracks warranted that SW 8th Street be immediately closed, and the concrete truss be shored and supported at multiple intermediate locations to reduce the loads in the north diagonal and the node until final evaluations were done and remedial measures implemented.
5. Networking Engineering Services, Inc. dba Bolton Perez and Associates, Inc. (BPA) was retained by FIU to be the CEI of the project. BPA failed to classify the cracks, which were structural in nature, in accordance with the Florida Department of Transportation (FDOT) requirements. BPA, as a CEI, was expected to exercise its own independent professional judgement in accordance with their contract with FIU and FDOT requirements. With intimate knowledge of extensive cracking on the bridge, BPA failed to recognize that the bridge was in danger of collapsing, and did not recommend to FIU, MCM or others to close the street and shore the bridge, regardless of the opinion held by the EOR.

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6. Munilla Construction Management, Inc. (MCM), the design-build contractor, was aware that the cracks were "getting larger" as reported by MCM superintendent and quality control personnel on March 12 and 14, 2018. On March 13, 2018, EOR stated in an email to MCM, among the list of facts, that "since Saturday (March 10, 2018), MCM has been monitoring the cracks and they have not grown in size." MCM should have immediately informed EOR on March 14, 2018, that this assumption was not valid. Despite this oversight on the part of MCM, EOR was provided with photographs and measurements of the cracks in the days leading up to the collapse and was specifically informed by BPA during the morning meeting on March 15, 2018, that the cracks were lengthening.
7. MCM, the design-build contractor, deferred to the decision of EOR and failed to exercise its own independent professional judgement, as a constructor of the bridge, to close the traffic on SW 8th Street until the cause of the cracks were conclusively determined by EOR and peer reviewed. MCM had extensive construction experience in concrete structures and had intimate knowledge of the magnitude of cracks, which were growing in size daily. MCM's deference to EOR in light of the conclusion No. 6 above, and failure to exercise their own independent judgment with regard to implementing necessary safety measures were unreasonable.

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8. The evaluations of the cracks by EOR, and his recommendation to re-tension the post-tensioning bars of diagonal 11, were not included in the original design and therefore should have been subject to peer review.
9. The consultant retained by EOR to conduct independent peer review of the EOR's design, as per FDOT requirements, did not check the structural integrity of the bridge under different construction stages, a violation of the FDOT requirements. The independent check was performed only under the final design stage when all segments of the bridge were constructed and completed.
10. EOR failed to provide construction documents to Louis Berger at 30%, 60% and 90% of completion of construction documents, in accordance with the FDOT requirements.
11. EOR should have known that the consultant who conducted the peer review did not check the structural design of the truss design at stage III, as required by FDOT, meriting extra safety precautions by EOR.
12. EOR should have known that the truss was a non-redundant structure and if one diagonal member failed, the entire bridge could collapse. Given the nature and extent of the cracking and the non-redundancy of the bridge design, necessary safety precautions should have included closing the roadway below the bridge and immediately providing shoring to the bridge at suitable locations until a complete evaluation was done.


WHAT YOU ALLOW IS WHAT WILL CONTINUE.

Thank You