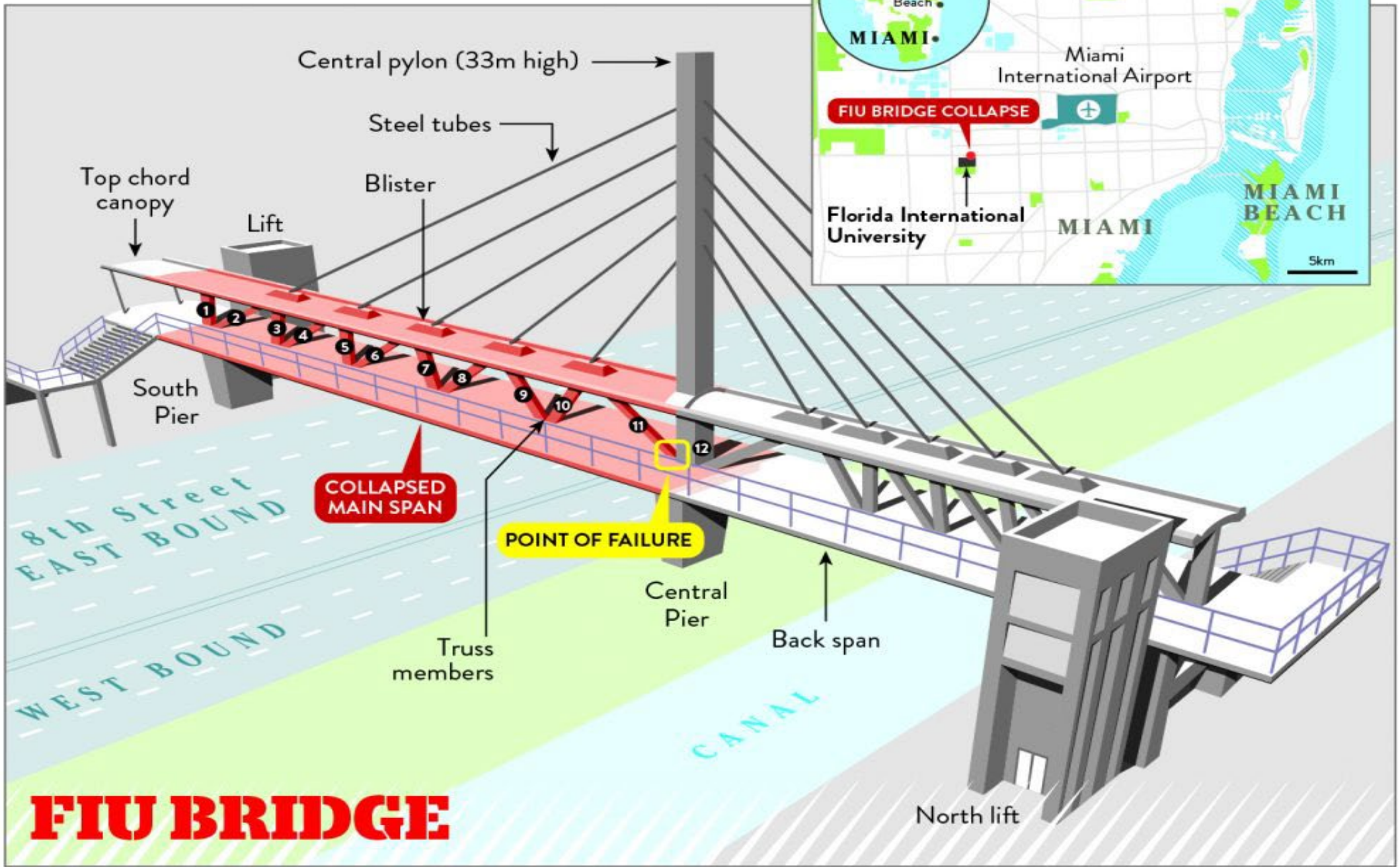

Central pylon (33m high)
Steel tubes
Top chord canopy
Blister
Lift
South Pier
COLLAPSED MAIN SPAN
POINT OF FAILURE
Truss members
Central Pier
Back span
North lift
8th Street
EAST BOUND
WEST BOUND
CANAL
FIU BRIDGE
Orlando
West Palm Beach
MIAMI
NORTH MIAMI BEACH
N
Miami International Airport
FIU BRIDGE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


FIU
SWEETWATER

FIU PEDESTRIAN BRIDGE FAILURE

- PROJECT: Florida International University (FIU) intended to build a concrete pedestrian bridge to cross an 8-lane major arterial highway, SW 8th Street (Route US41), and Tamiami canal connecting the Maidique campus in Miami and the Sweetwater residential community where many students live.

  The bridge was built using a method called Accelerated Bridge Construction, built in an adjacent yard and then moved onto place. This technique was intended to minimize disruption of traffic.

FIU PEDESTRIAN BRIDGE FAILURE

- During construction the bridge failed on March 15, 2018 at about 1:46 PM.
- 7 occupied cars, stopped for a traffic light, were crushed by 930 tons of concrete and steel when the 174 ft main span dropped 18.5 ft.
  - 5 occupants died, 2 seriously injured, 3 minor injuries.
- Six persons were working on the bridge at the time,
  - 1 fatally injured, 4 seriously injured, 1 minor injury.
- The original project of $19.4M was running $2.6 over budget at failure and the completion date of July 2018 had slipped to Jan. 2019.
- Bridge related claims increased from $42M to $103M and forced the design/build contractor MCM into bankruptcy.

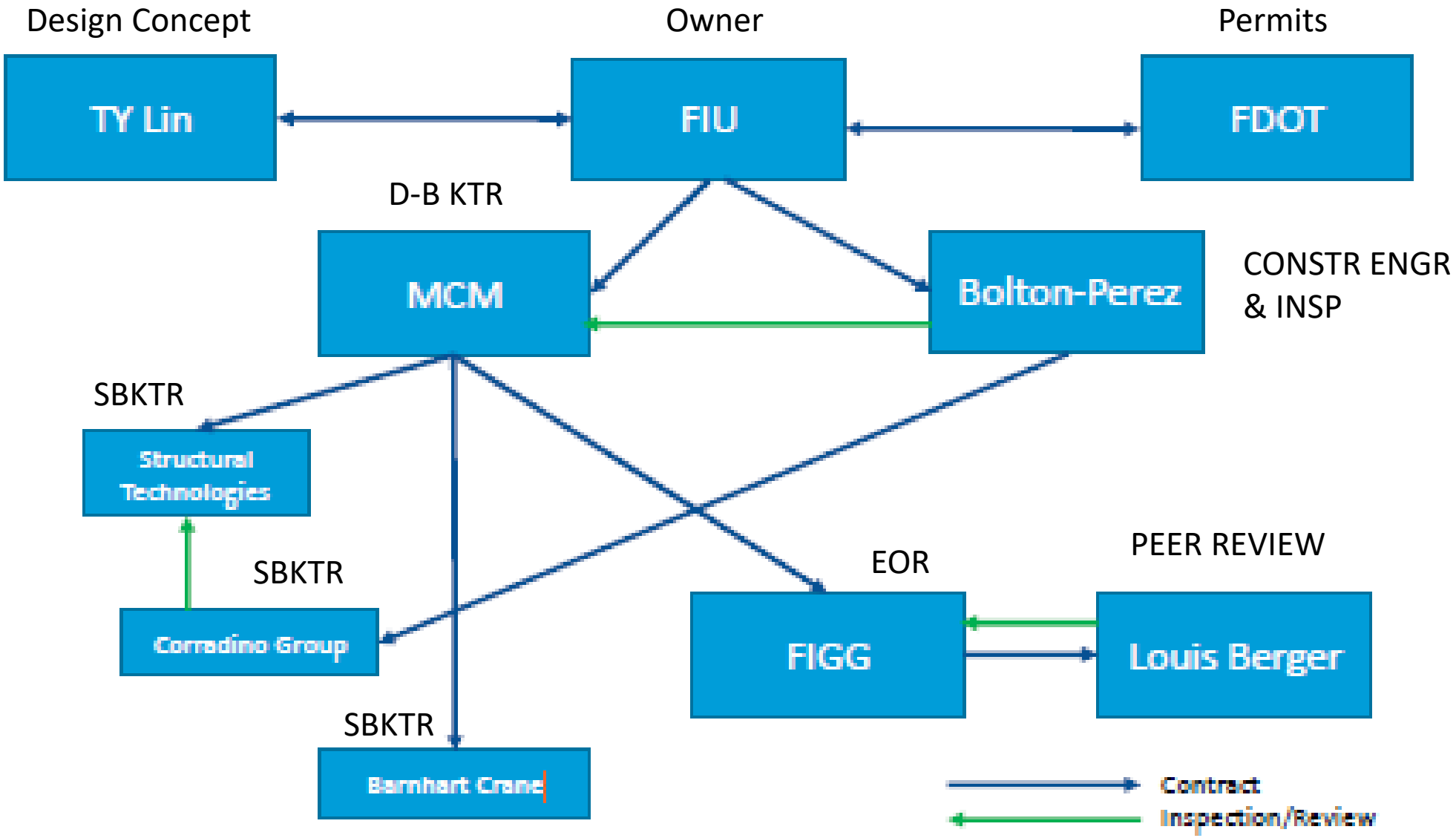
PROJECT TEAM/ Contractual Relationships

1. Permitting Agency; **Florida Department Of Transportation (FDOT)**
   a. Issued a permit for traffic control during installation of the structure,
   b. Acted as a pass-through for FHWA funding and providing state funding for this $19.4 million project,
   c. Conducted a routine preliminary review to ensure this project complied with the terms of the agreement (plans & specs) with the state,
   d. Authorized FIU to utilize the aerial space above the state road to build a structure.
2. Owner; **Florida International University (FIU)** intended to build a pedestrian bridge to cross an 8-lane highway and a canal.
3. Design Concept; **T.Y.LIN** provided FIU with the concept and criteria for design.
4. Contractor; **MCM** was hired by FIU as the design-build contractor.

PROJECT TEAM/ Contractual Relationships

5. Inspection; **Bolton Perez & Associates (BPA)** provided Construction Engineering and Inspection (CEI) under contract with FIU.
6. Engineer; **FIGG** was hired by MCM as the "Engineer of Record" to design the bridge.
7. Peer Review; **Louis Berger (LB)** was hired by FIGG to provide an "independent" peer design review of FIGG's bridge design
8. SBKTR; **Structural Technologies** was hired by MCM to perform the post tensioning of the bridge.
9. SBKTR; **Barnhart Crane** was hired by MCM to move the structure from the adjacent casting yard to the final position over the road.
10. SBKTR; **Corradino Group** was contracted by BPA to inspect the post tensioning work.

Contractual Relationships



PROJECT TEAM/ Contractual Relationships

11. Forensic Engineer; **Wiss, Janney, Elstner Associates (WJE)** performed testing of full scale replicas of critical connections to determine the fundamental cause of the collapse.

12. Federal Investigation; **National Transportation Safety Board (NTSB)** Conduct accident investigation, number HWY18MH009.

13. Federal Investigation; **Occupational Safety and Health Administration (OSHA) Office of Engineering Services (OES)**

DESIGN FLAWS/PROJECT FAILS
ETHICS ISSUES/CONFLICTS OF INTEREST

1. FDOT did not require road closure during construction but a temporary detour was permitted for the moving and erection of the main truss. Operations failure
2. Design did not meet the FDOT requirement to include components. details and construction techniques that have greater than 5 years of FL use.
3. LB was not pre-qualified by FDOT to perform an “independent” peer design review of FIGG’s bridge design. Peer review failure
    a. LB did not provide 90% design review comments as required.

DESIGN FLAWS/PROJECT FAILS
ETHICS ISSUES/CONFLICTS OF INTEREST

4. Cracking of the pre-cast/post-tensioned structure was not considered a safety issue of concern by FIGG (Engineer of Record), MCM (Design/Build Contractor),BPA (Construction Engineer & Inspector), for the span suspended over the open road. Safety failure

- Dynamic cracking is a sign of structural distress:

  i. Feb 24, cracks appear in Member 11/12 node after form work is removed.

  ii. Mar 10, Significant crack growth measured as main span is moved into position and PT rods are de-tensioned.

  iii. Mar 15, A.M. Team meeting held at 0900, no safety concerns noted from concrete cracks.

  iv. Mar 15, P.M. at 1346, bridge collapse.

DESIGN FLAWS/PROJECT FAILS
ETHICS ISSUES/CONFLICTS OF INTEREST

5. The FIGG bridge engineer's analytical model underestimated design loads and overestimated design capacity resulting in factors of safety being significantly lower than originally assumed. Design Failure

   a. EOR design fails:

      i. Truss did not have a redundant load path, meaning if one element failed the entire structure failed.

      ii. There was an inadequate peer review/oversight by LB and a conflict of interest eliminating "independence" of action.

6. The Constructability assessment did not include assessments of forces and loads at connections during all stages of construction, omitting the lift and place and 90% design concrete placement.

DESIGN FLAWS/PROJECT FAILS
ETHICS ISSUES/CONFLICTS OF INTEREST

7. The post failure forensic engineer, WJE, determined the cause of failure was from not building the construction joints to FDOT standard construction specifications.

8. The design peer review by LB had inadequate knowledge and experience. They negotiated a contract with FIGG that had incomplete time and budgets to thoroughly focus on errors and omissions by FIGG throughout design development.

9. There was no Fail-Safe procedure or responsibility taken by the principal engineers to observe signs, detect and avoid a catastrophe.

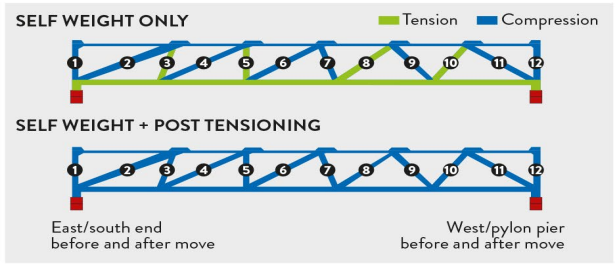
10. A Final ethics determination will be made by the appropriate licensing board.

FIU BRIDGE
LESSONS LEARNT

PRELUDE TO THE DISASTER

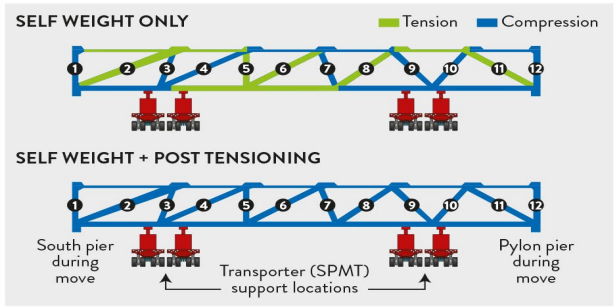
STAGE 1: IN POSITION IN THE YARD

Supported on its end diaphragms, truss members **2** and **11** are in compression. Post tensioning is correctly applied to put the bottom chord in compression also.



STAGE 2: PREPARING FOR TRANSPORT

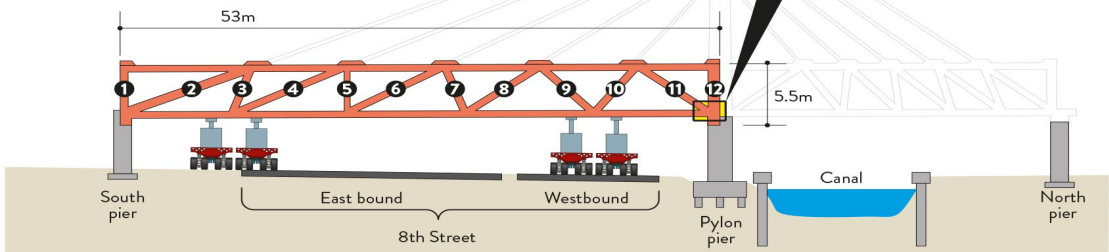
Without post tensioning, members **2** and **11** would now be tension (top image) – hence temporary post tensioning is applied (all structure is now in compression).

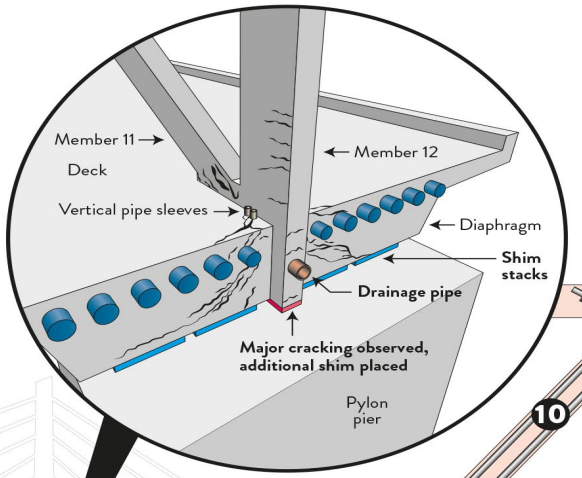


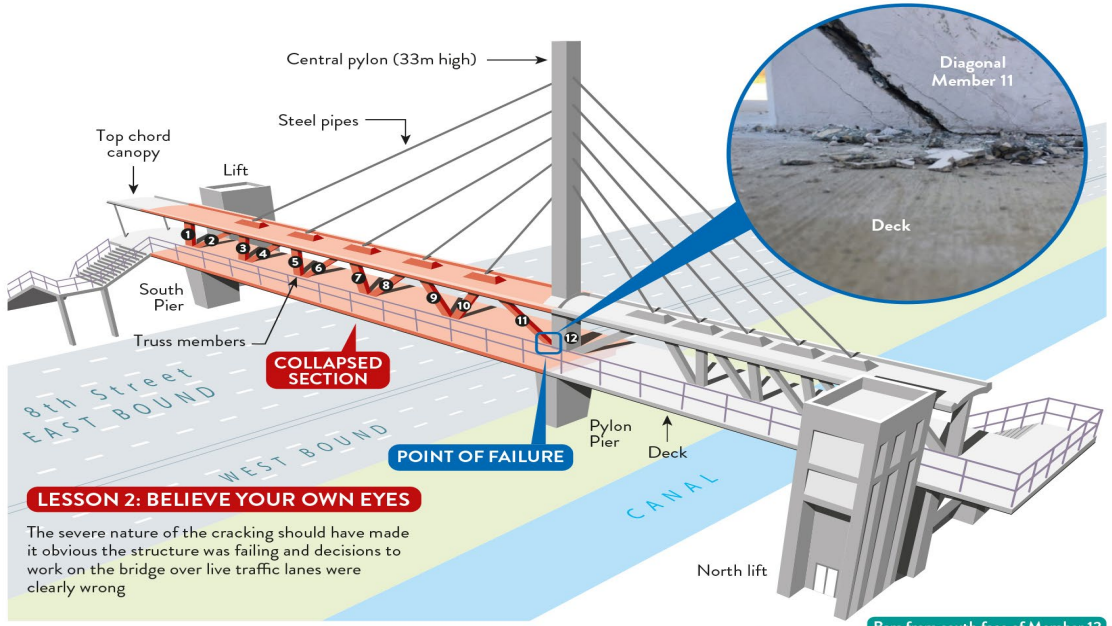
LESSON 1: CHECK DESIGN IN ALL STAGES OF CONSTRUCTION

STAGE 3: DECK PLACED ON TEMPORARY SHIMS IN FINAL POSITION

Post-tensioning of members **2** and **11** is removed as they are naturally in compression. However use of temporary shim stacks does not replicate the final resting position of the truss and induces stresses triggering cracking.

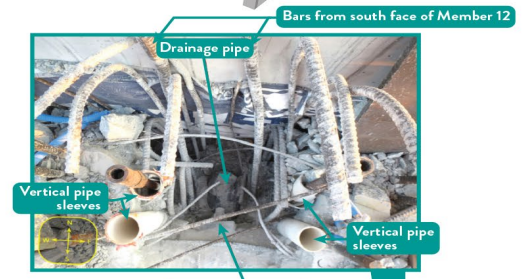


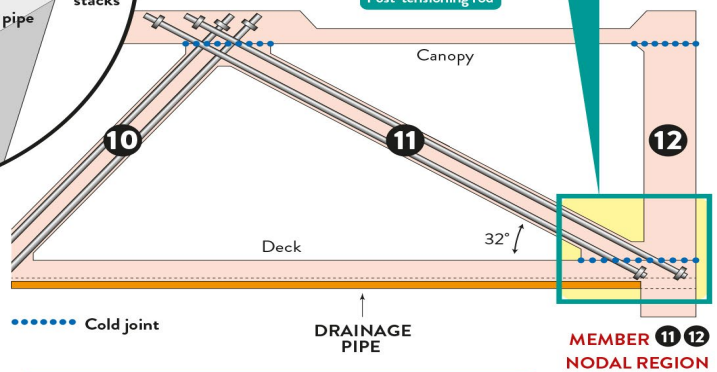




LESSON 2: BELIEVE YOUR OWN EYES

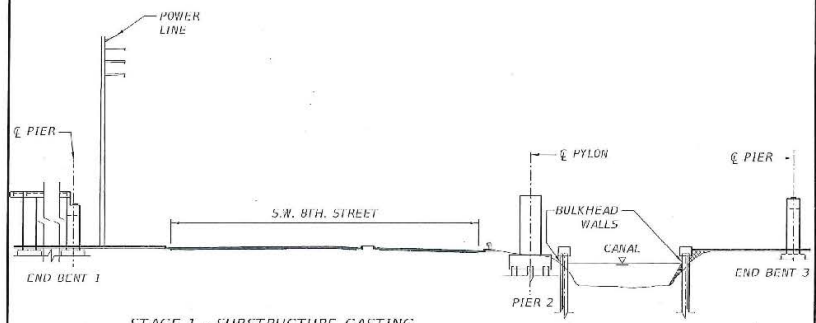
The severe nature of the cracking should have made it obvious the structure was failing and decisions to work on the bridge over live traffic lanes were clearly wrong





LESSON 3: PAY ATTENTION TO CRITICAL DETAILS

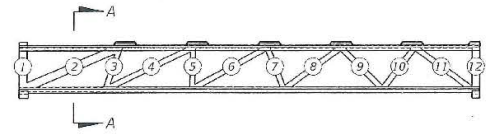
Decisions to locate a drainage pipe and run several cable ducts through the 11/12 nodal region, and construction decisions to cast the structure with cold joints at the base of the diagonals, all contributed to creating a weakness at a critical location



STAGE 1 - SUBSTRUCTURE CASTING

1. BUILD PIER 1 AND PIER 3 FOOTINGS AT THE SOUTH AND NORTH LANDINGS.
2. BUILD PYLON FOOTING AND BASE OF PYLON.
3. CAST THE END BENTS FOR BOTH LANDINGS.

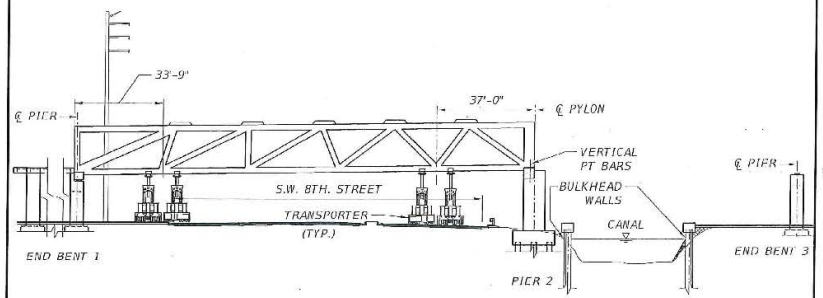
SECTION A-A



MAINSPAN

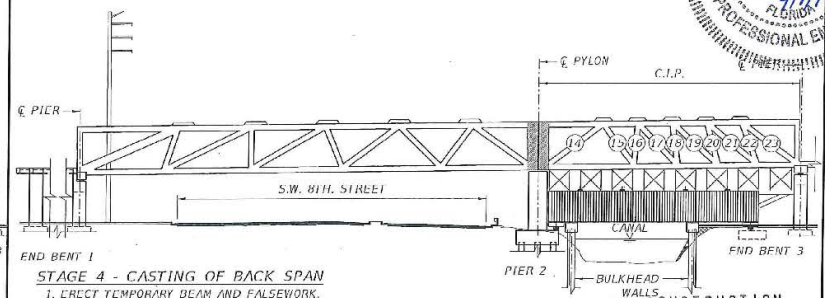
STAGE 2 - SUPERSTRUCTURE PRE-CASTING

1. CAST MAIN SPAN SUPERSTRUCTURE AS FOLLOWS:
   A) CAST DECK AND DIAPHRAGMS.
   B) CAST DIAGONAL AND VERTICAL MEMBERS. INSTALL PT BARS AS SHOWN IN SHEET B-38.
   C) CAST CANOPY AND TOP ANCHOR BLOCKS.
2. AFTER CONCRETE COMPRESSIVE STRENGTH HAS REACHED 6000 PSI, STRESS POST-TENSIONING OF THE MAIN SPAN IN THE FOLLOWING SEQUENCE:
   I. STRESS DECK LONGITUDINAL TENDONS D1.
   II. STRESS CANOPY LONGITUDINAL TENDONS C2.
   III. STRESS PT BARS IN DIAGONAL MEMBERS 2 AND 11.
   IV. STRESS DECK LONGITUDINAL TENDONS IN THE FOLLOWING SEQUENCE: D2, D3, D4, D5 & D6.
   V. STRESS BOTTOM SLAB TRANSVERSE POST-TENSIONING. ALTERNATED END STRESSING IS REQUIRED FOR THE TRANSVERSE TENDONS.
   VI. STRESS PT BARS IN DIAGONAL MEMBERS 3 AND 10.
   VII. STRESS PT BARS IN DIAGONAL MEMBERS 5 AND 8.
   VIII. STRESS PT BARS IN DIAGONAL MEMBERS 6 AND 7.
   IX. STRESS CANOPY LONGITUDINAL TENDONS C3.
3. TEMPORARY SUPPORTS OF MAIN SPAN SECTION SHALL STAY IN THE MIDDLE OF THE CROSS SECTION DURING SPMT TRANSPORT.



STAGE 3 - ERECTION OF MAINSPAN

1. INSTALL BEARING PADS AT PIER 1 AND SHIM PLATE AT THE PYLON BASE.
2. MOVE MAIN SPAN FROM THE STAGING AREA TO FINAL POSITION.
3. GROUT SPACE BETWEEN PRECAST SECTION DIAPHRAGM AND PYLON BASE.
4. STRESS PYLON VERTICAL PT BARS.



STAGE 4 - CASTING OF BACK SPAN

1. ERECT TEMPORARY BEAM AND FALSEWORK.
2. INSTALL BEARING PADS AT END BENT 3.
3. CAST INTERMEDIATE SECTION OF THE PYLON
4. CAST DECK, DIAGONAL MEMBER, VERTICAL MEMBERS, CANOPY AND TOP ANCHOR BLOCKS.
5. AFTER CONCRETE COMPRESSIVE STRENGTH HAS REACHED 6000 PSI, STRESS POST-TENSIONING OF THE BACK SPAN IN THE FOLLOWING SEQUENCE:
   I. STRESS DECK LONGITUDINAL TENDONS D7.
   II. STRESS CANOPY LONGITUDINAL TENDONS C5.
   III. STRESS PT BARS IN DIAGONAL MEMBERS 15 AND 23.
   IV. STRESS PT BARS IN DIAGONAL MEMBERS 16 AND 22.
   V. STRESS PT BARS IN DIAGONAL MEMBERS 17 AND 21.
   VI. STRESS PT BARS IN DIAGONAL MEMBERS 18 AND 20.
   VII. STRESS PT BARS IN DIAGONAL MEMBER 19.
   VIII. STRESS DECK LONGITUDINAL TENDONS D8 & D9.
   IX. STRESS BOTTOM SLAB TRANSVERSE POST-TENSIONING. ALTERNATED END STRESSING IS REQUIRED FOR THE TRANSVERSE TENDONS.

W. DENNEY PATE
LICENSE [redacted]
NO. 34332
[redacted]
4/7/17
FLORIDA
PROFESSIONAL ENGINEER

FOR CONSTRUCTION

REVISIONS

DATE	BY	DESCRIPTION	DATE	BY	DESCRIPTION

ENGINEER OF RECORD:
FIGG
424 North Calhoun Street
Tallahassee, Florida 32301
FLORIDA CERTIFICATE OF AUTHORIZATION NO. 5618
W. DENNEY PATE, P.E. - P.E. NO. 34332

DRAWN BY: LTC
CHECKED BY: MF
DESIGNED BY: MF
CHECKED BY: WDP

FIU FLORIDA INTERNATIONAL UNIVERSITY

ROAD NO.	COUNTY	PROJECT ID
	MIAMI-DADE	434888-1-58-01

SHEET TITLE: CONSTRUCTION SEQUENCE (1 OF 2)

PROJECT NAME: UNIVERSITYCITY PROSPERITY PROJECT

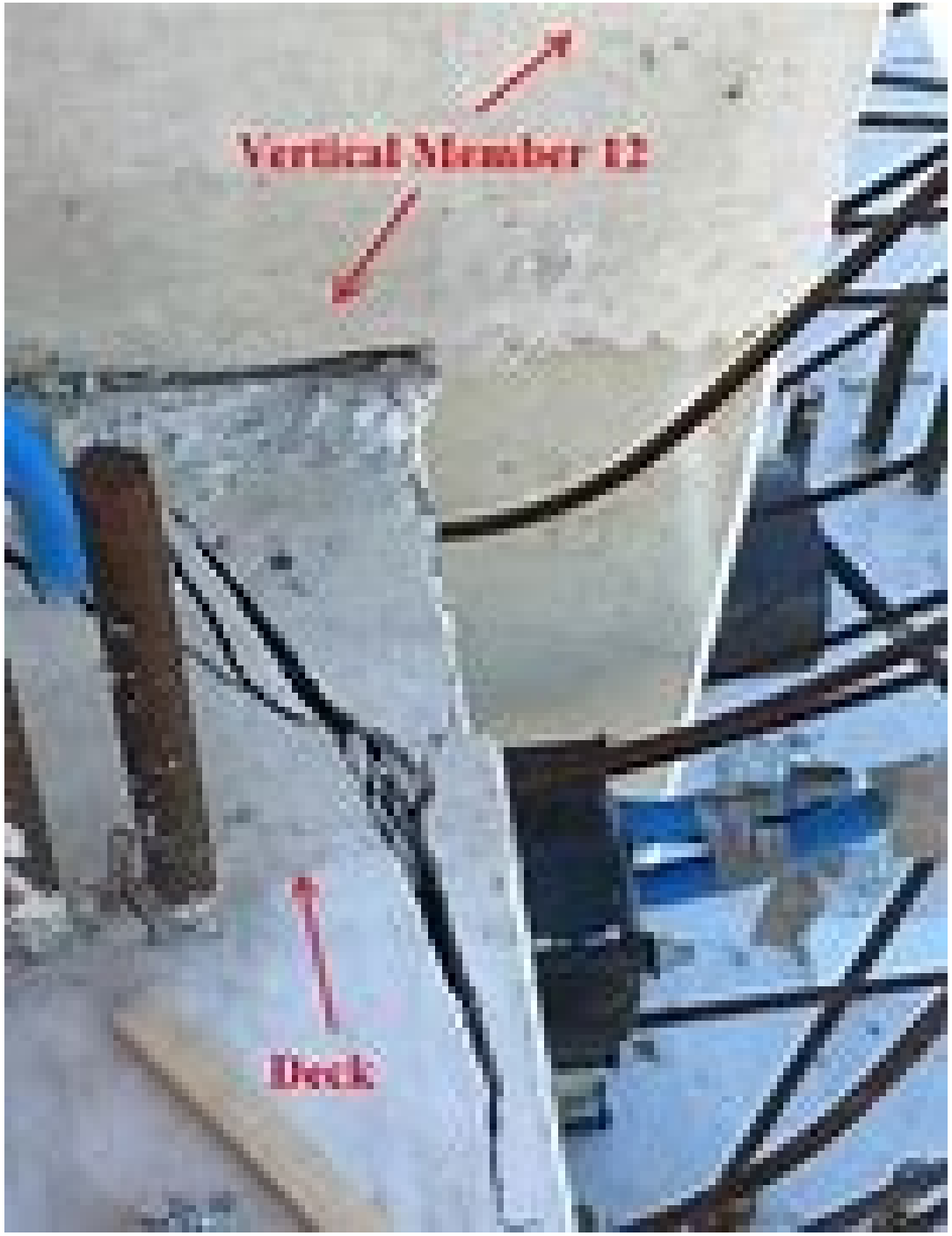
SHEET NO. B-109

Plotted By: tcavanaugh 4/7/2017 1:17:02 PM G:\434888\5801\Struc\B1_102 Constr_Seq_1.DGN


11
Deck
March 14, 2018
11
Deck


Diagonal Member 11
Deck
Diagonal


Vertical
Member 12


Vertical Member 12
Deck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SW 8 ST
TRIMA


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structural
TECHNOLOGIES
VSL


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Six Victims:
Navaro Brown, Bridge Worker
Alexa Duran, FIU student
Brandon Brownfield
Osvaldo (Ozzie) Gonzalez
Alberto Arias
Rolando Fraga