PRESENTATION OF PARTY SUBMISSION TO THE NATIONAL TRANSPORTATION SAFETY BOARD

FIU UniversityCity Prosperity Pedestrian Bridge Construction Accident of March 15, 2018

Presentation to Honorable Robert L. Sumwalt, Chairman

October 7, 2019

A FOCUS ON SHARED VALUES

[redacted]

PARTY SUBMISSION

TO THE
NATIONAL TRANSPORTATION
SAFETY BOARD

FIU UniversityCity Prosperity Pedestrian Bridge
Construction Accident
Miami, Florida | March 15, 2018

Submitted by - Figg Bridge Engineers, Inc.

September 20, 2019

PARTY SUBMISSION BY FIGG BRIDGE ENGINEERS

NATIONAL TRANSPORTATION SAFETY BOARD

E PLURIBUS UNUM

INTEGRITY

TRANSPARENCY

INDEPENDENCE

EXCELLENCE

INTRODUCTION

40 YEARS in 2018

Exclusively Specializing in Bridges

FIGG

CREATING BRIDGES AS ART®

OVER 230 BRIDGES

42 States
6 Nations

Brazil
Columbia
Guyana
Canada
India
Saudi Arabia

Office Locations throughout United States

FIGG

CREATING BRIDGES AS ART®

Tallahassee	Florida (Worldwide Headquarters)
Dallas	Texas
Philadelphia	Pennsylvania
Denver	Colorado
Minneapolis	Minnesota
Mobile	Alabama
New Orleans	Louisiana

6 Field Offices

New York

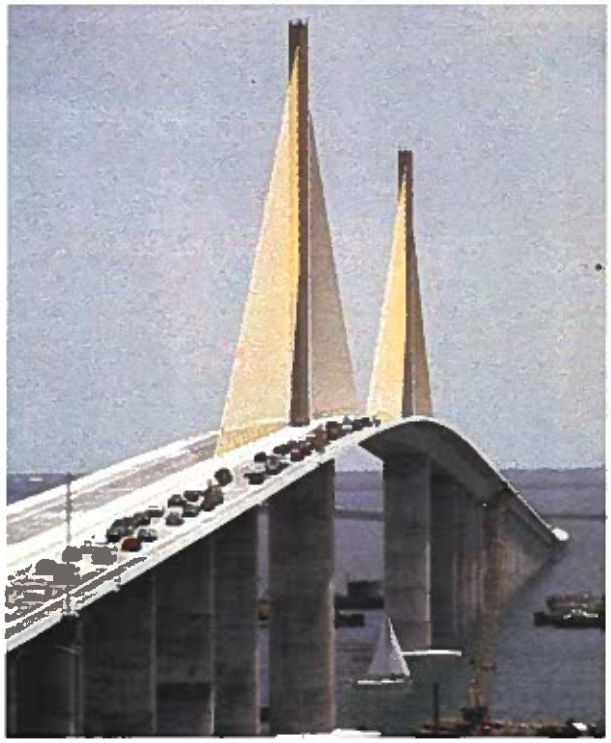
Pennsylvania

Tennessee

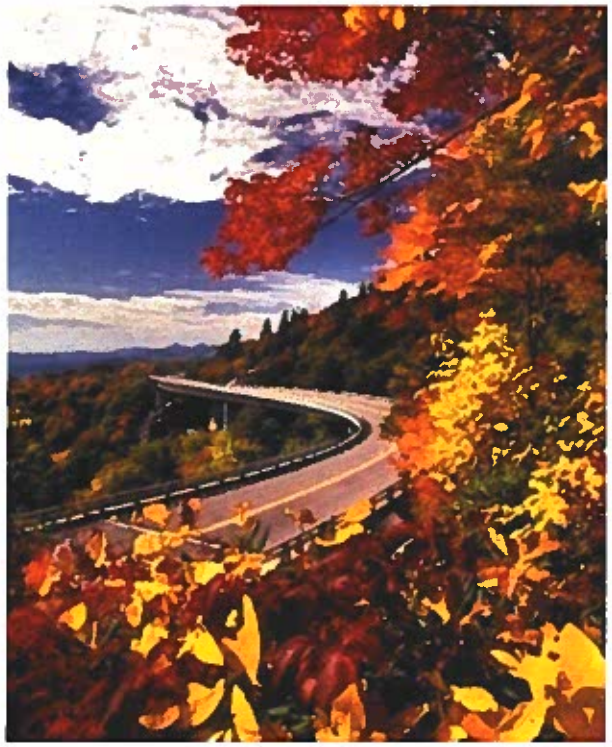
Vermont

Colorado

Texas



Sunshine Skyway Bridge, FL



Blue Ridge Parkway Viaduct, NC
National Park Service

Natchez Trace Parkway Arches, TN
National Park Service

3 Presidential Awards

through the National Endowment for the Arts
-US Presidents gave 5 of these awards for Bridges-

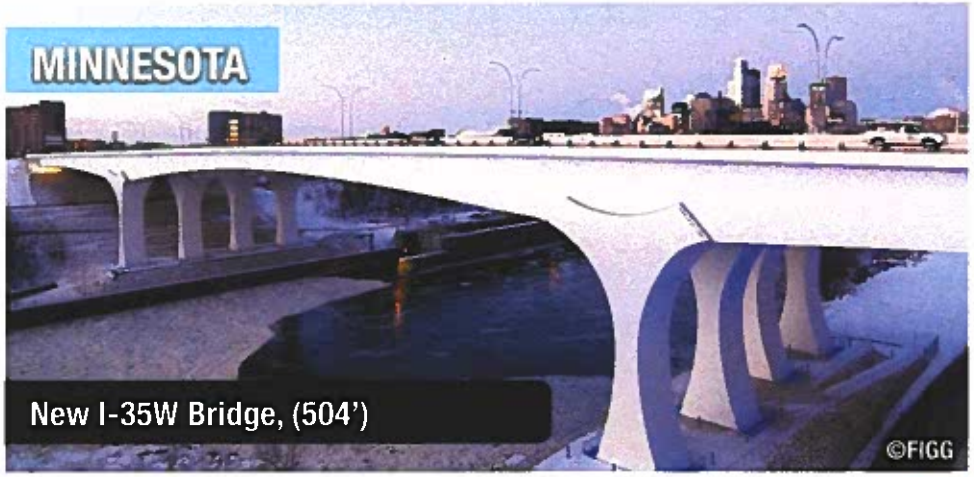
FIGG

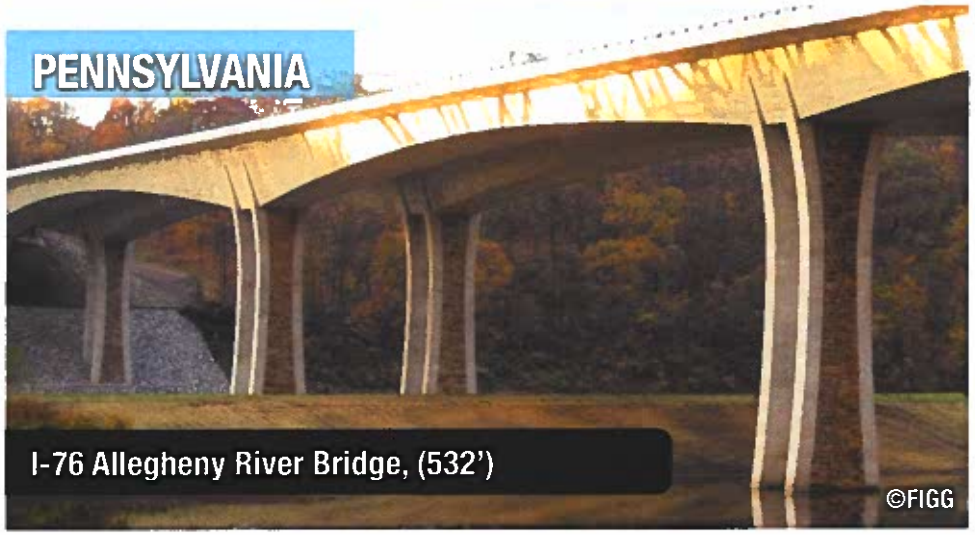
CREATING BRIDGES AS ART®

FIGG Has Delivered the Most Long Span Concrete Bridges than any Firm in America

54 built long-span concrete bridges from 300' to 1200' spans as Engineer of Record

An unsurpassed record of success in long concrete spans





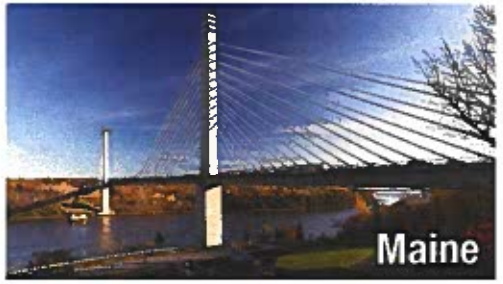
FIGG Has Delivered More Concrete Cable-Stayed Bridges than any Firm in America

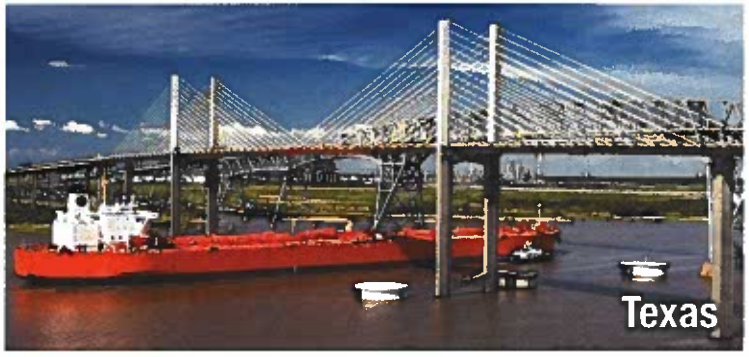
14 built concrete cable-stays in U.S.

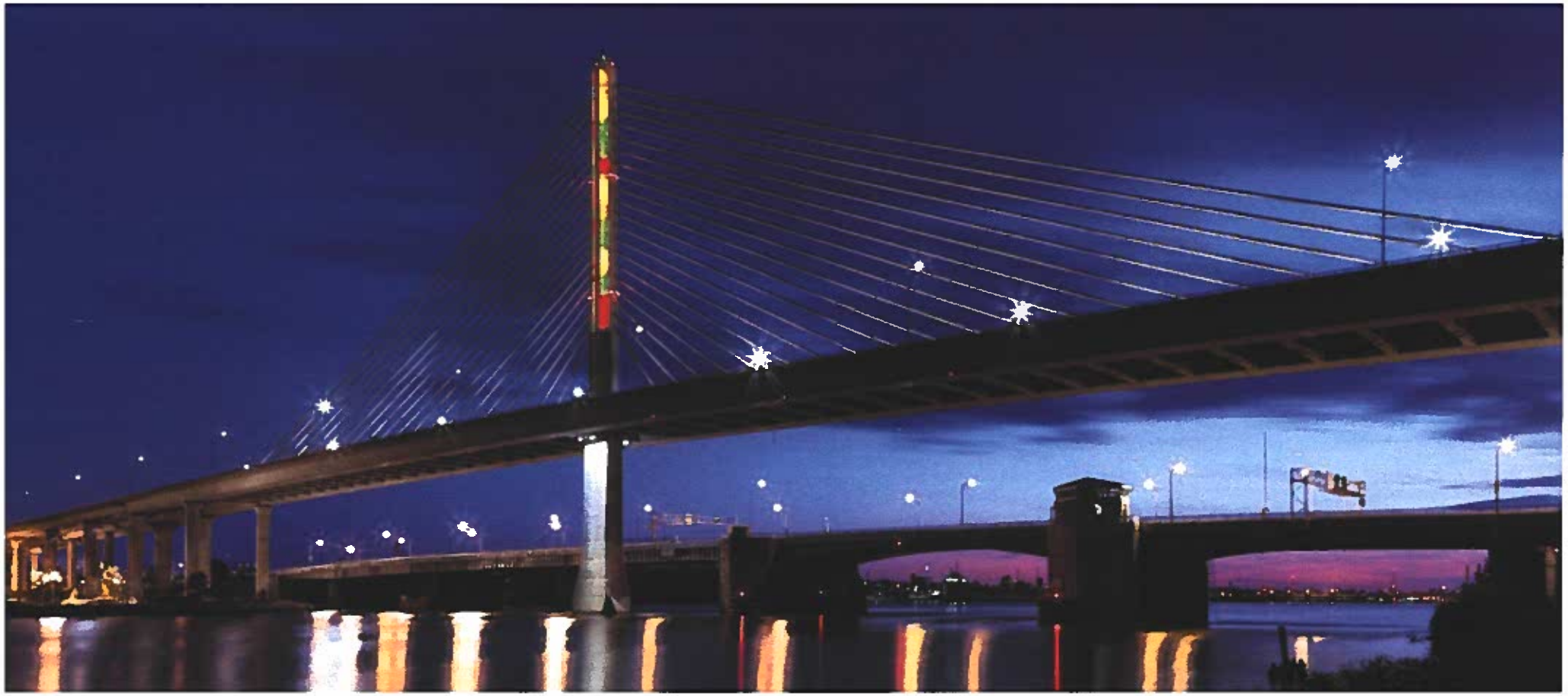
12 FIGG responsible charge

7 Engineer of Record -
A first for each state

5 Precast concrete -
Engineer of Record For All of them







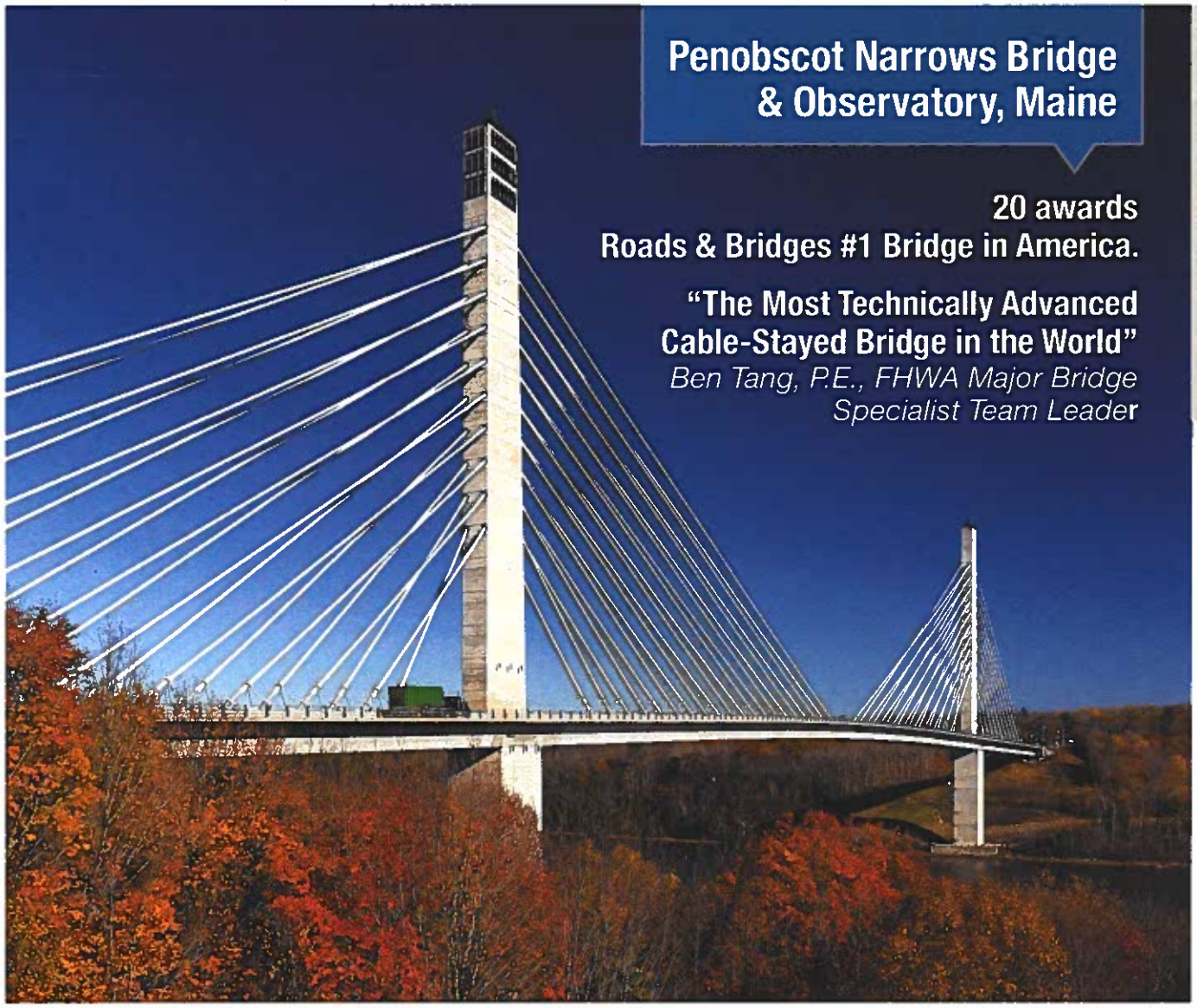
I-280 Veteran's Glass City Skyway Bridge, Toledo, Ohio

Largest bridge in Ohio history, 2007
613' Cable Stay Main Span

I-93 Leonard P. Zakim Bunker Hill Bridge, Boston, Massachusetts

745' main span; widest cable-stayed bridge in the world (10 lanes wide - 183' bridge).

Completed 2002



FIGG Selected

#1 of 14

Design Proposals Internationally

Maine's first CM/GC

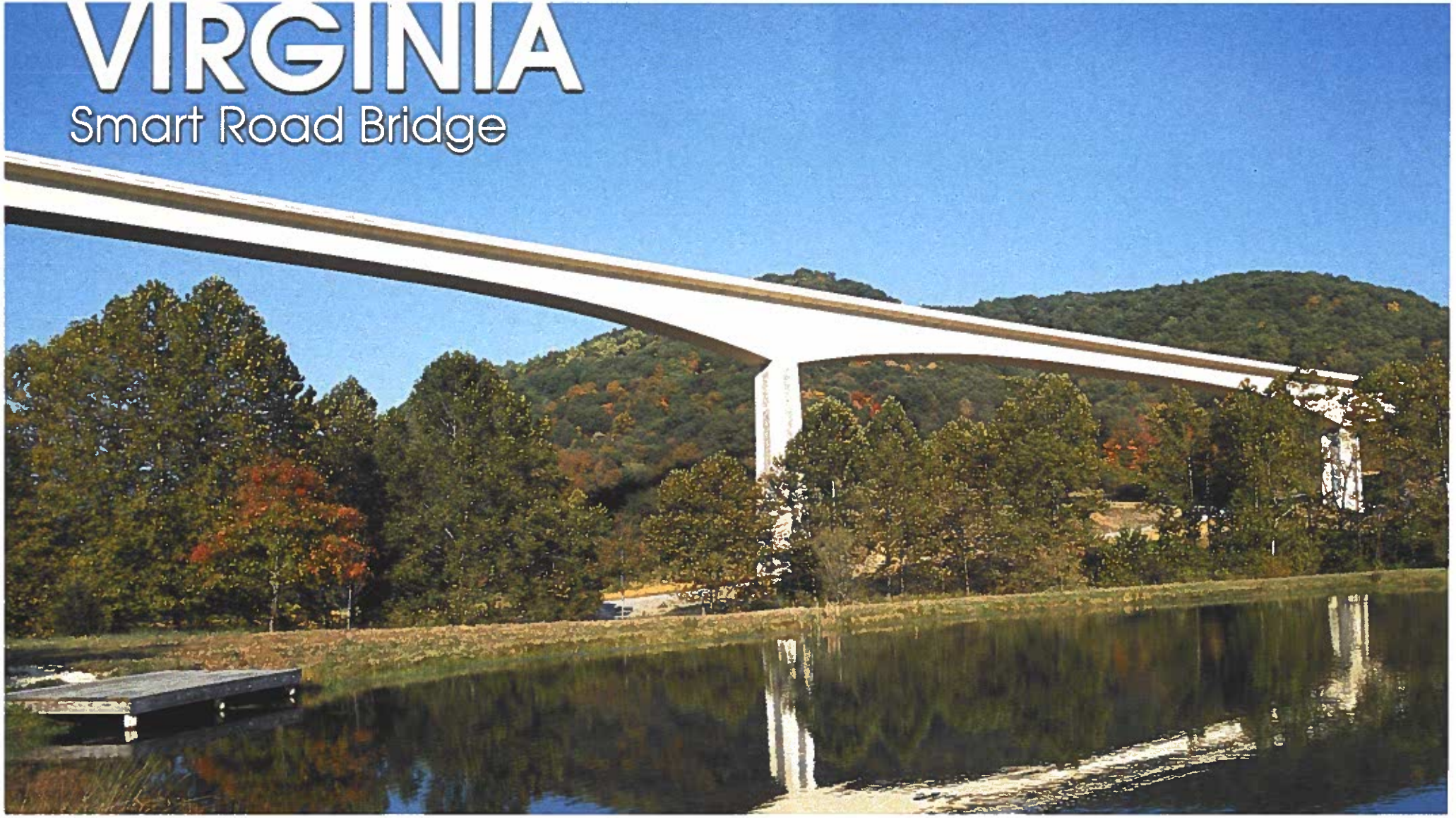
(Construction Manager/ General Contractor)

2,120' long
1,161' cable-stayed main span

$85M owner-facilitated design-build project.

AirTrain JFK, New York

9 miles of bridge built in 21 months


VIRGINIA
Smart Road Bridge

South Norfolk Jordan Bridge,
Chesapeake, Virginia

27 AWARDS OF EXCELLENCE 2018-2019


VIRGINIA
Lesner Bridge

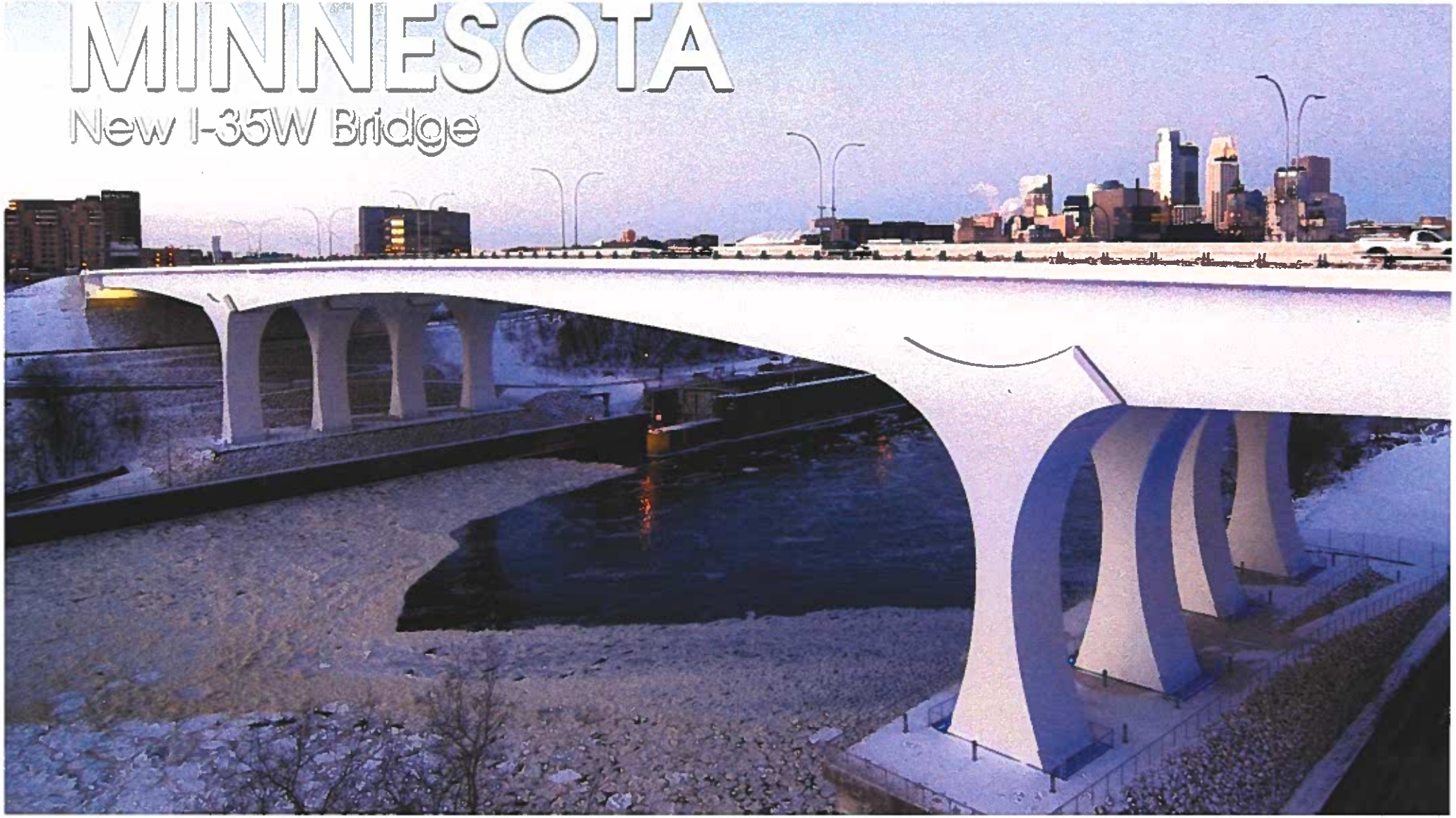

MAINE
Sarah Mildred Long Bridge


VERMONT
Brattleboro Bridge

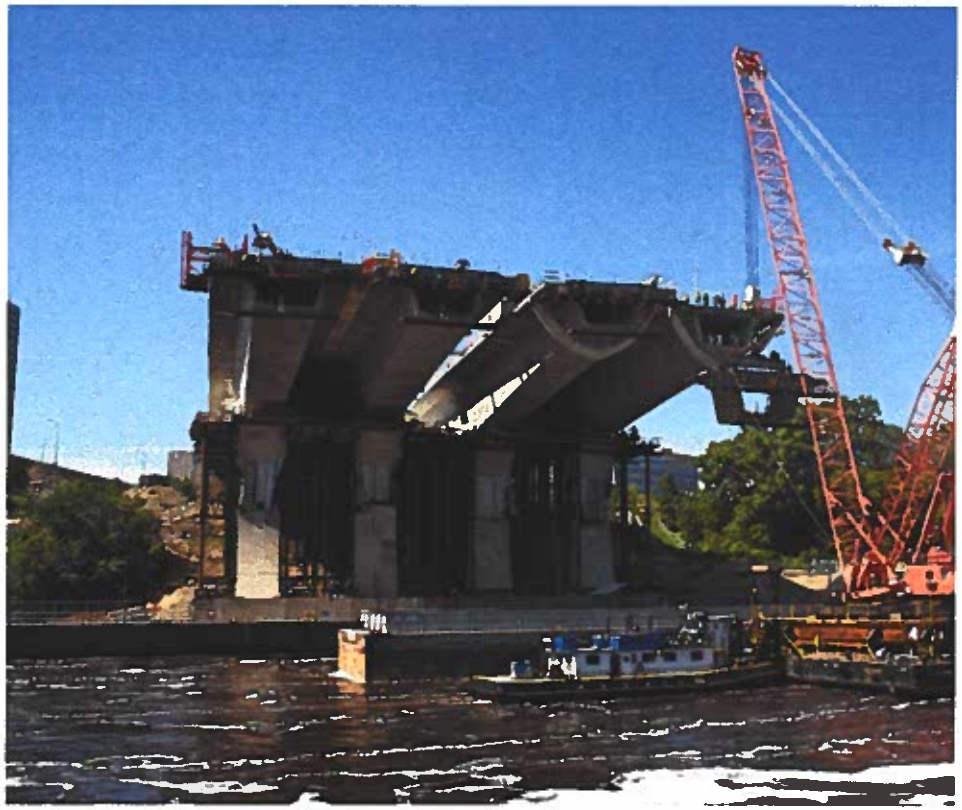

FLORIDA
Cascades Connector Bridge

MINNESOTA

New I-35W Bridge



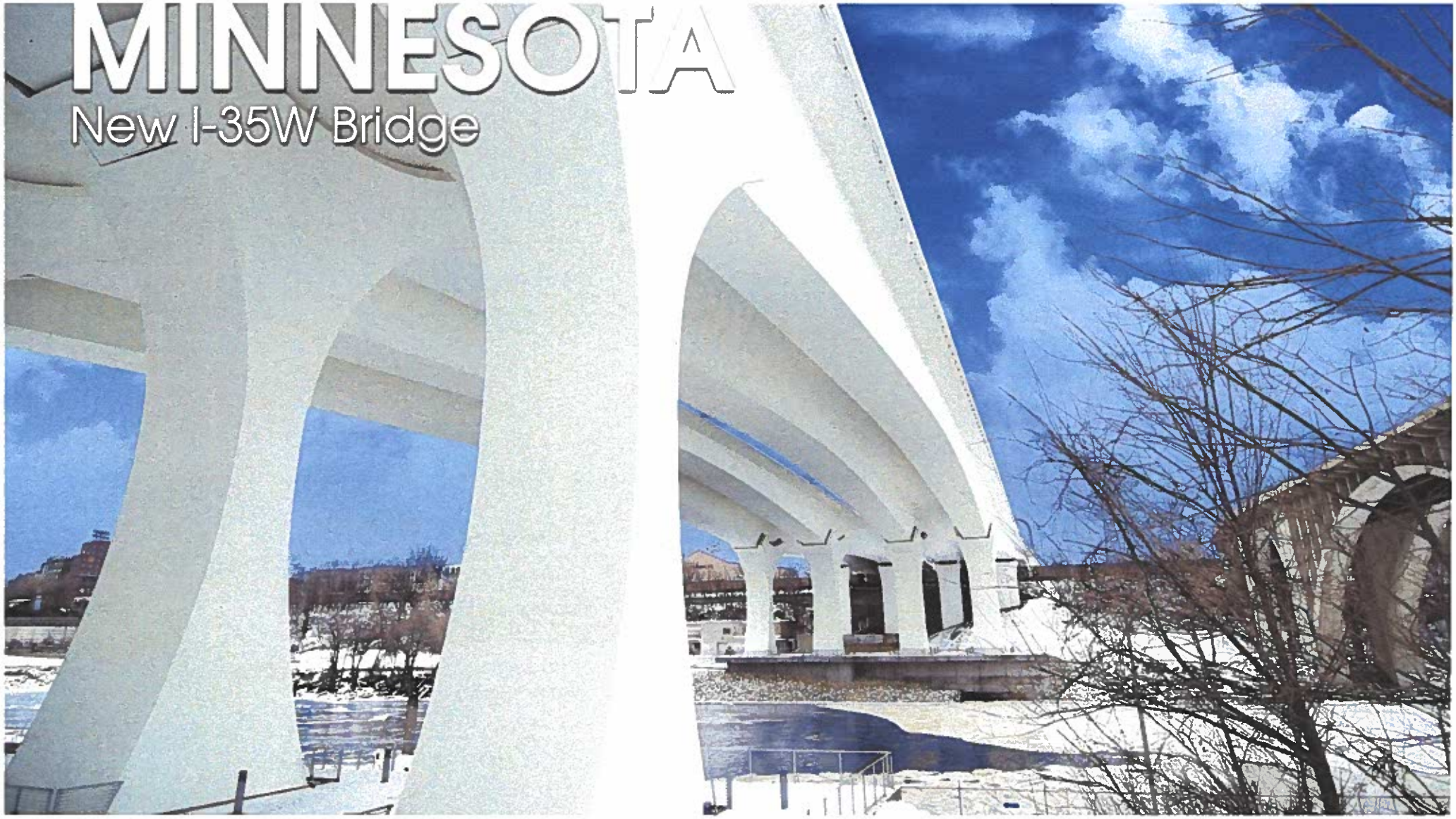
Accelerated Bridge Construction (ABC)



120 segments placed in 47 days over the Mississippi River creating a 10 lane interstate

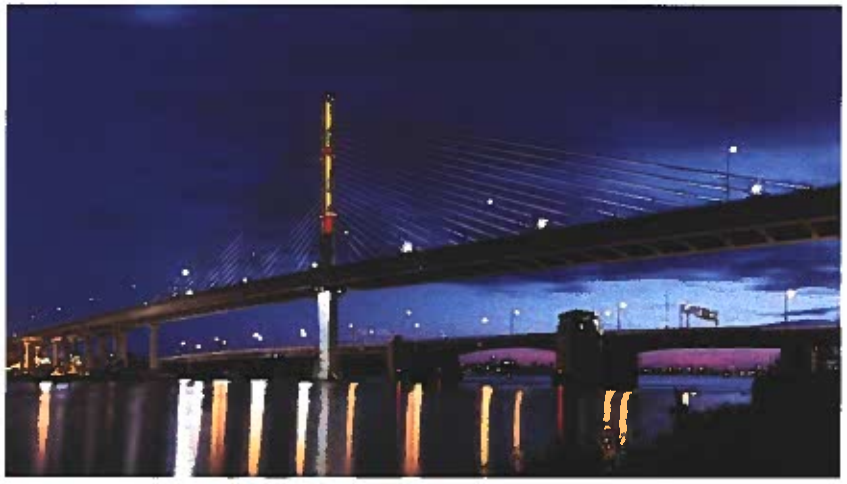
MINNESOTA

New I-35W Bridge



RAIL BRIDGES

ARCHES

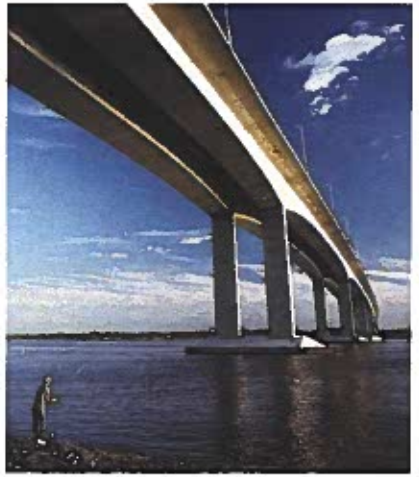


CABLE STAYED BRIDGES

ENVIRONMENTAL BRIDGES

URBAN BRIDGES

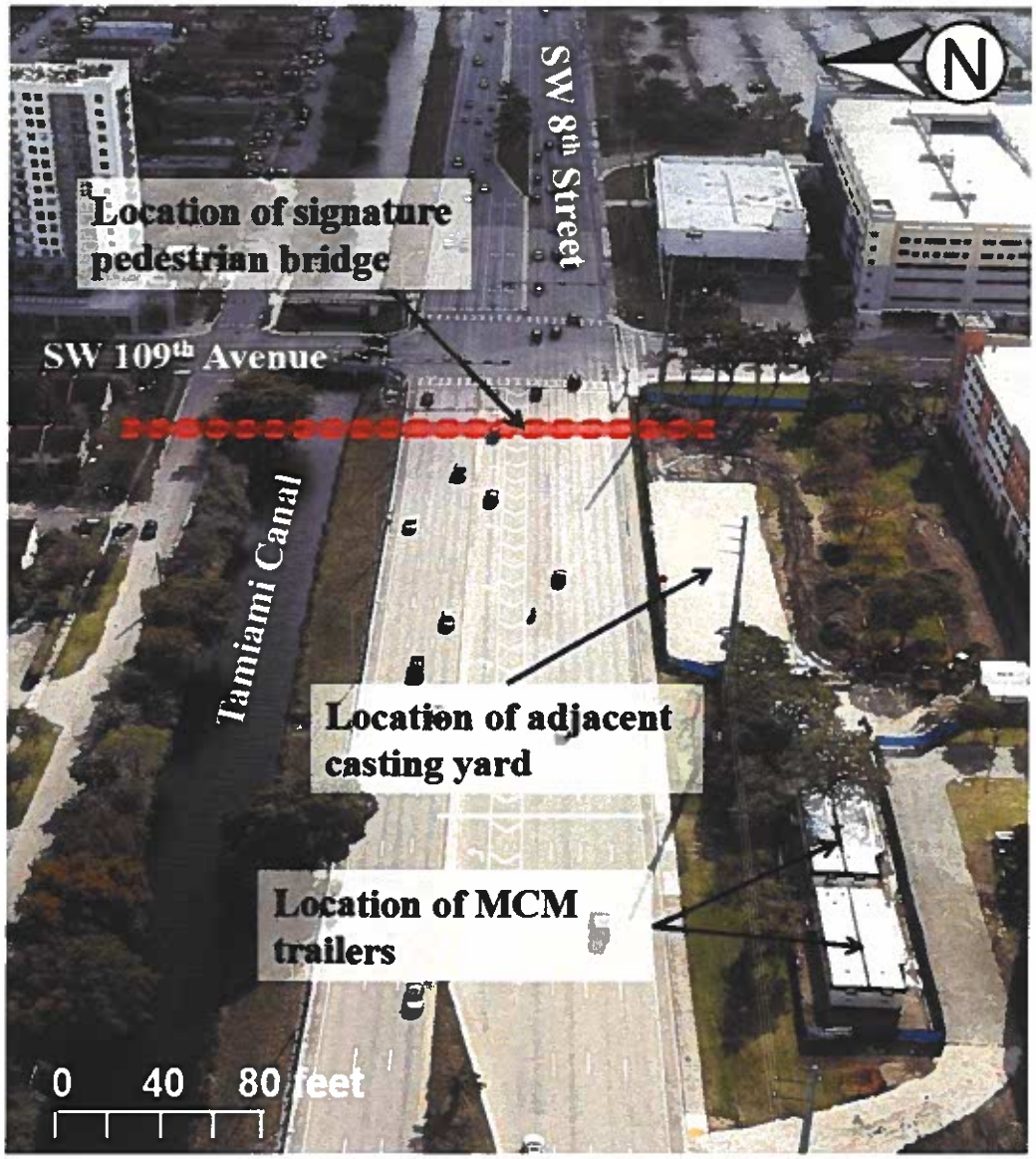
LONG BRIDGES OVER WATER



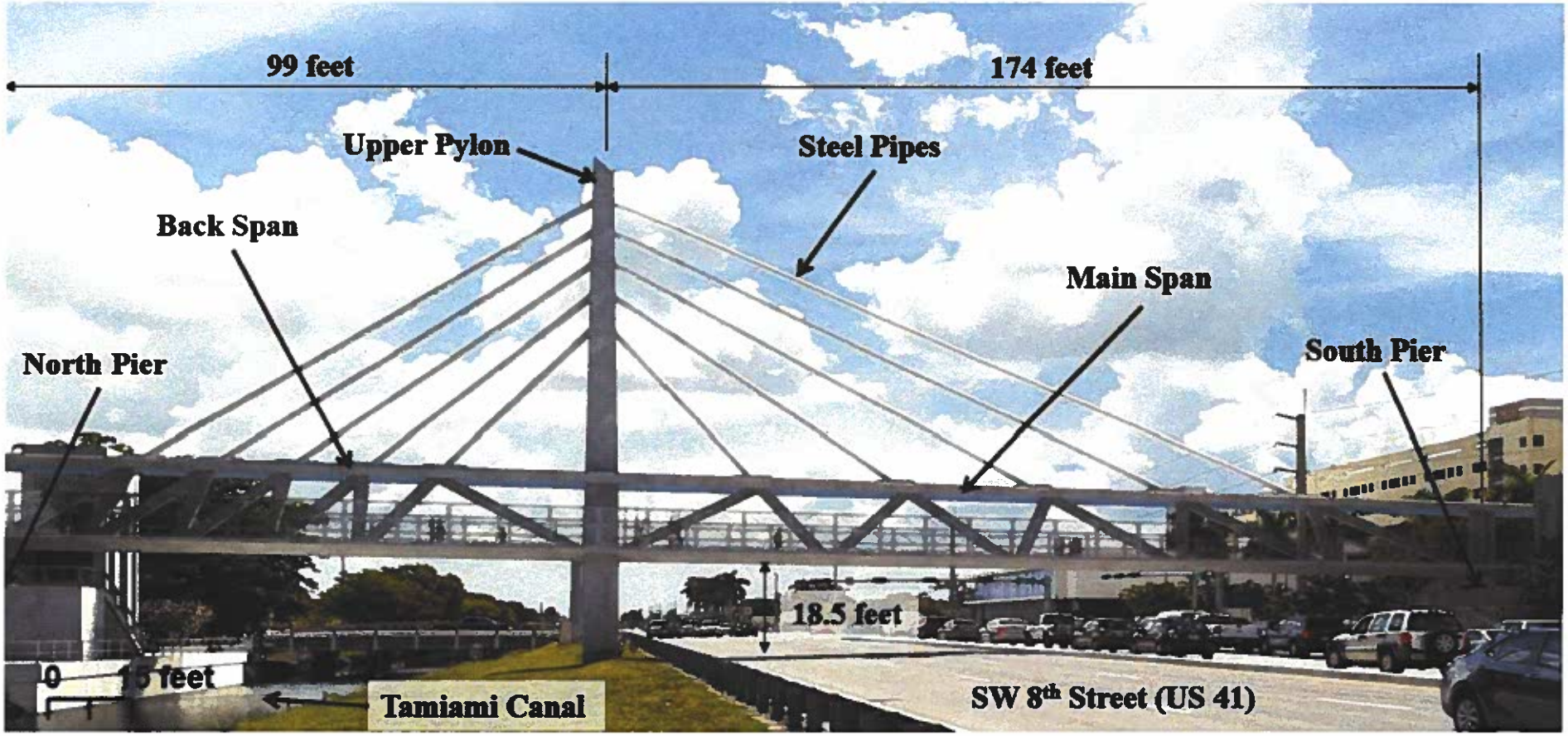
LONG SPAN BRIDGES

FIU UniversityCity Prosperity Pedestrian Bridge

Location of the signature bridge in red. Contractor's adjacent casting yard and construction trailers on 3/26/2017. (Source: NTSB Factual Report)



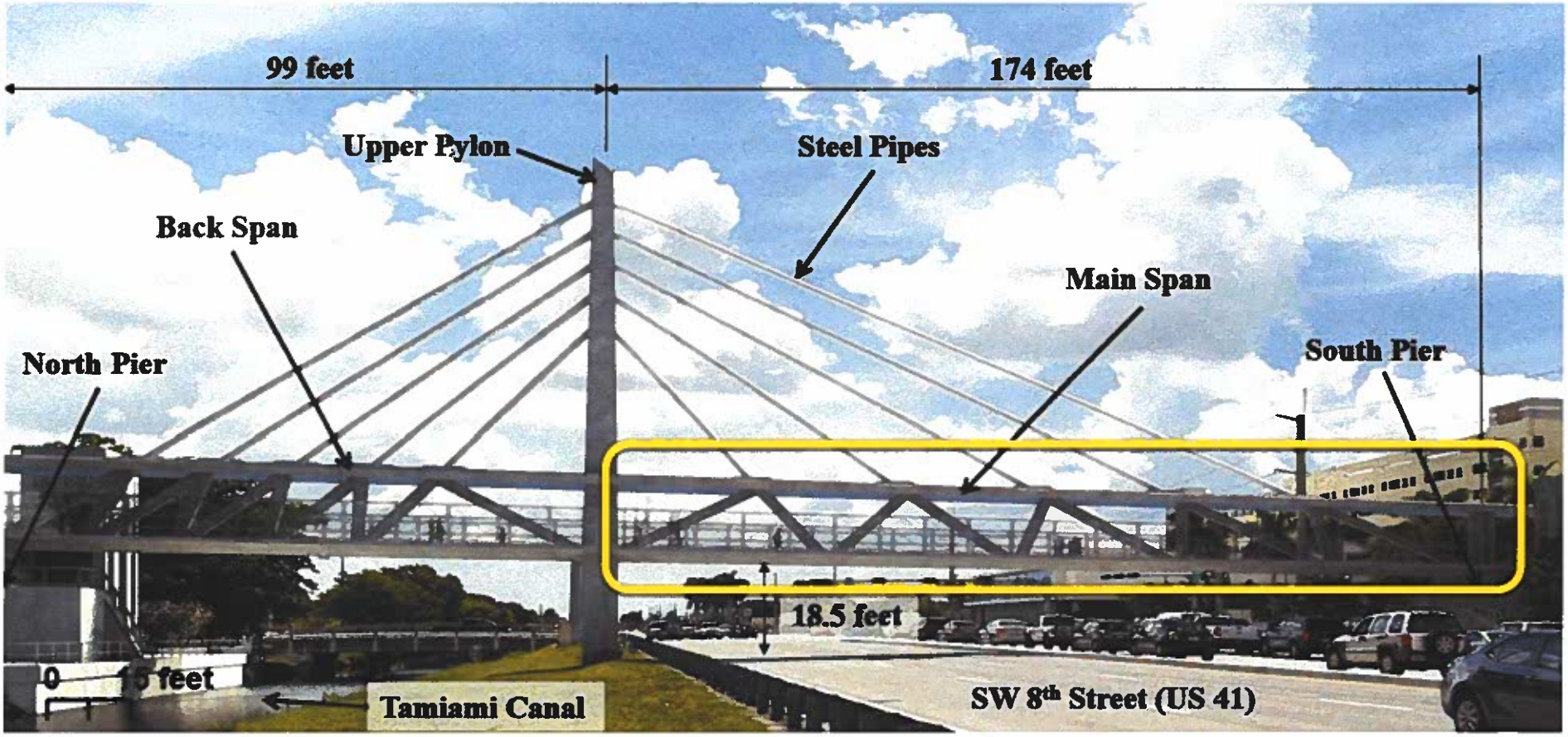
Rendering of Proposed Signature Pedestrian Bridge



SOURCE: NTSB Factual Report

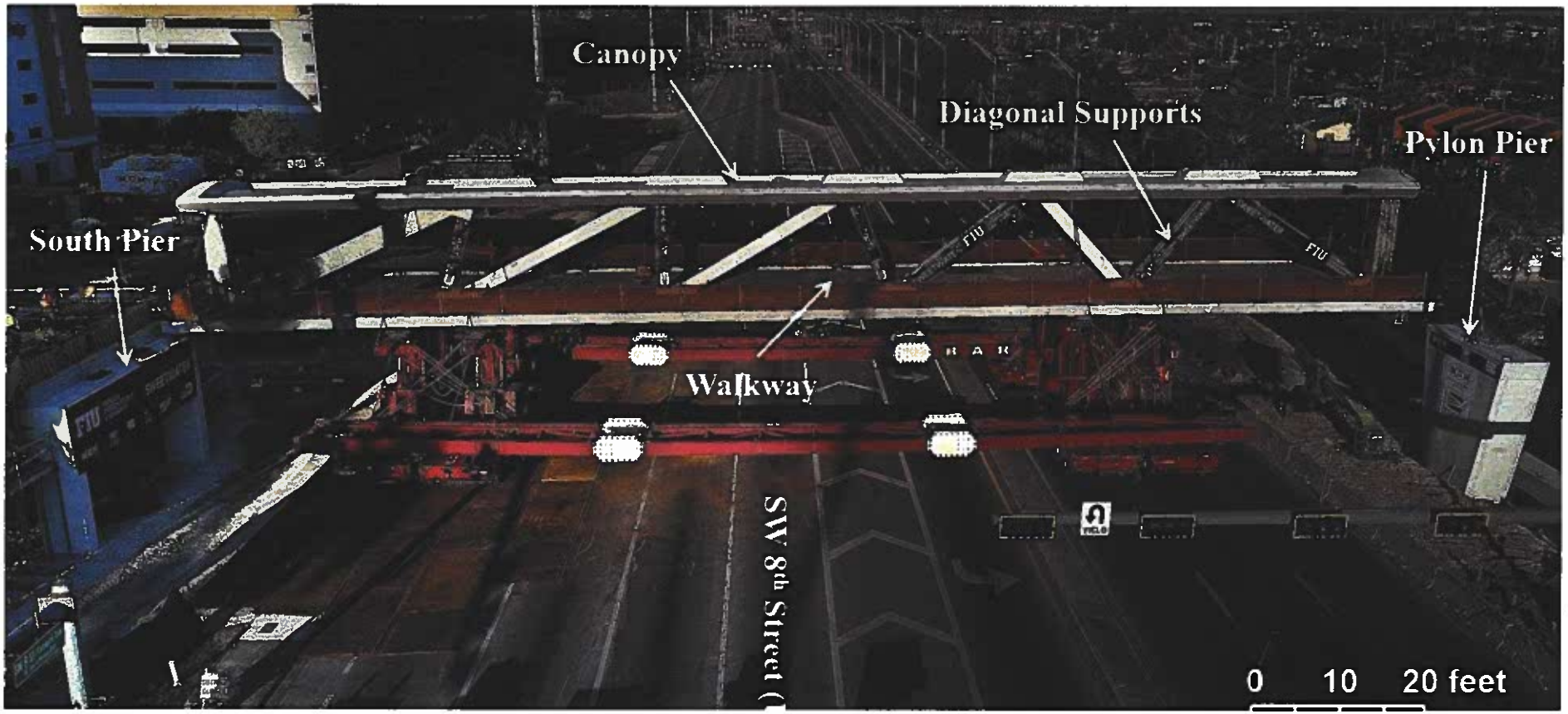
Location of Main Span

Main span was precast on land parallel to highway. Then, over part of weekend, it is moved into place as one piece and placed on piers



SOURCE: NTSB Factual Report, with added outline

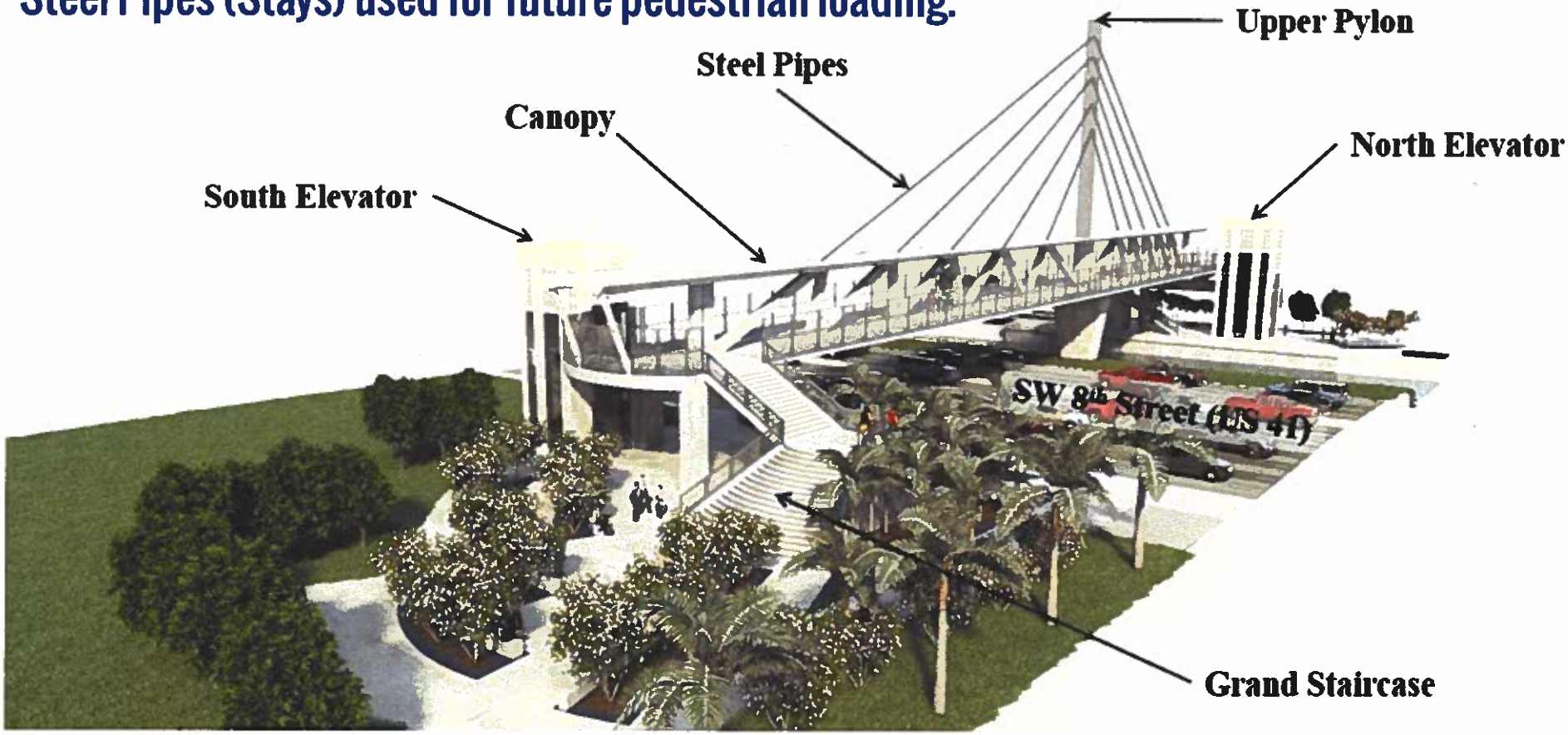
Moving Main Span Into Place on March 10, 2018



SOURCE: NTSB Factual Report

Rendering View of Bridge Looking Northwest

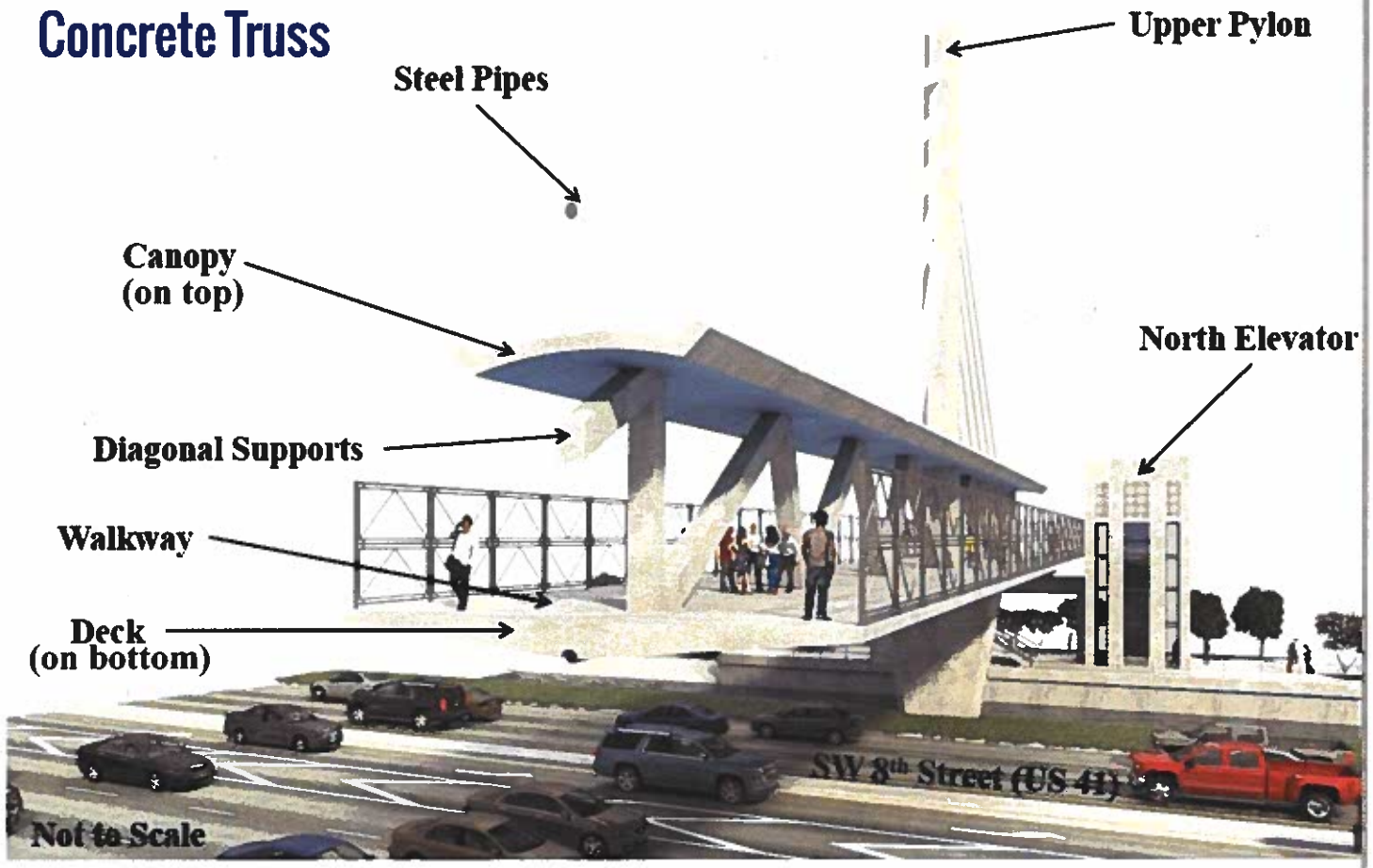
Steel Pipes (Stays) used for future pedestrian loading.



SOURCE: NTSB Factual Report

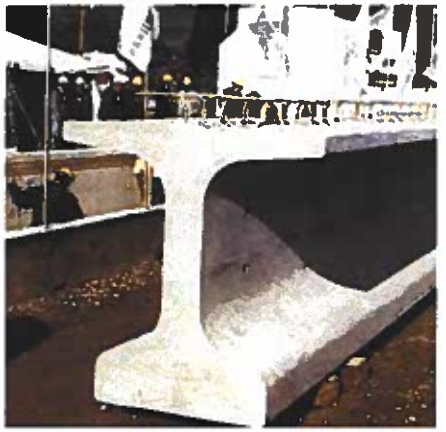
Rendering of Bridge Cross Section

Concrete Truss

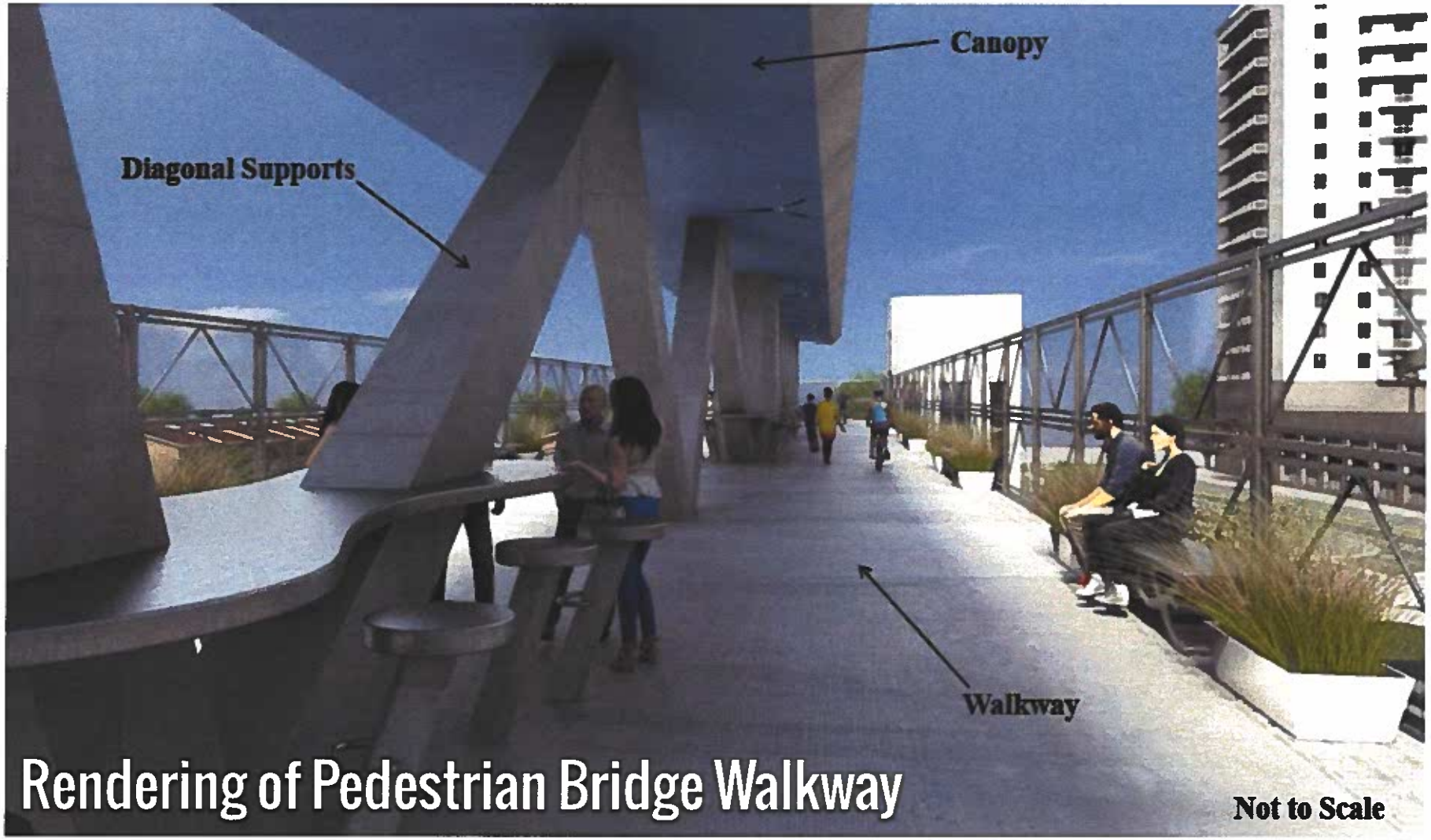


SOURCE: NTSB Factual Report

Analogous to large concrete beam with struts running along centerline



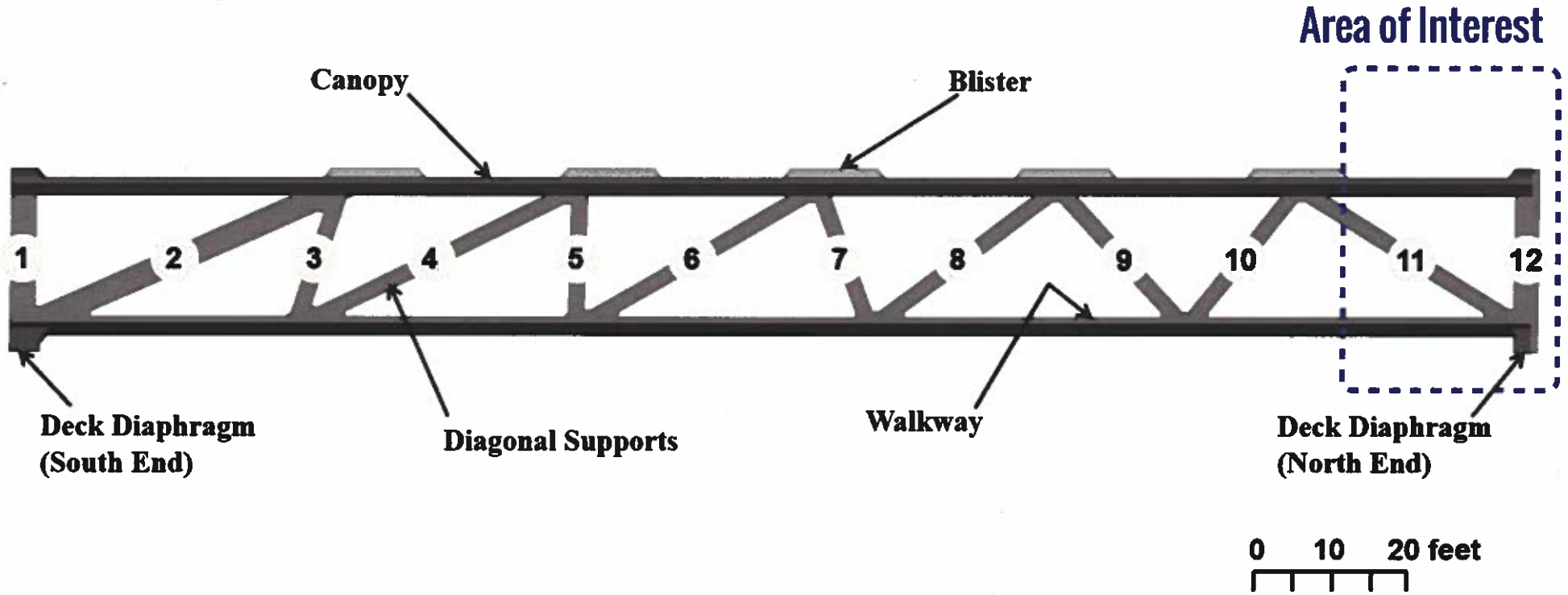
Typical Precast Concrete I-Beam



Rendering of Pedestrian Bridge Walkway

Not to Scale

Map Illustrating Nomenclature of the Diagonal and Vertical Members of the Bridge Main Span



Project Participants

OWNER
Florida International University (FIU)

STATE AGENCY SUPPORT
Florida Department of Transportation (FDOT)
OVERSIGHT OF LOCAL PROJECT

ON-SITE

CONSTRUCTION

OWNER'S CONSTRUCTION ENGINEERING & INSPECTION
Network Engineering Services, Inc. d/b/a Bolton-Perez and Associates (BPA)

CONTRACTOR FOR PROJECT DESIGN-BUILD
Munilla Construction Management, LLC (MCM)

CONSTRUCTION
MCM

CONCRETE SUBCONTRACTOR
The Structural Group of South Florida, Inc (TSG)

FORMWORK SHORING SUBCONTRACTOR
RC Group, LLC (RCGROUP)

CRANE SUBCONTRACTOR
George's Crane Service (George's Crane)

OTHER SUBCONTRACTORS

POST-TENSIONING SUBCONTRACTOR
Structural Technologies, LLC (Structural or VSL)

BRIDGE MOVE SUBCONTRACTOR
Barnhart Crane and Rigging, Co. (Barnhart)
with Subcontractors
Bridge Diagnostics, Inc. (BDI)
RLT Engineering Solutions, LLC (RLT)

OFF-SITE

DESIGN

DESIGN CONSULTANT / ENGINEER OF RECORD (EOR)
FIGG Bridge Engineers, Inc. (FIGG)

Design Management
Bridge Design
Submittal reviews at design office and occasional site visits during construction as requested by MCM

INDEPENDENT PEER REVIEW
The Louis Berger Group, Inc. (Louis Berger)

Independent Engineering Analysis and review of bridge design

Roles and Responsibilities - ON-SITE

To Build Approved Plans and follow Florida DOT's standard Construction Specifications

Concrete Casting and Finishing
The Structural Group of South Florida, Inc.

Formwork Shoring
RC Group, Inc

Moving the Span
Barnhart Crane and Rigging, Co.

Engineering Support
RLT Engineering

Sensors/Monitoring & Engineering
RLT Engineering

Post-Tensioning of Concrete
Structural Technologies (aka: VSL)

CONTRACTOR FOR PROJECT
Design Build

MCM
Management
Construction Quality Control
Safety

Owners Oversight

Construction
Engineering & Inspection
FDOT Certified Inspectors

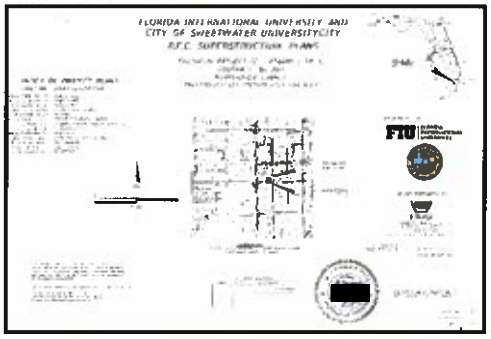
BPA
Certified Concrete Inspectors

Corradino
Certified Post-Tensioning Inspectors

Roles and Responsibilities - OFF-SITE

To Design Project following National & State Codes and Florida Standard Construction Specifications

FDOT rules: Engineer of Record (EOR) is not permitted to have an inspection role during construction with full time oversight
(Safety Recommendation is to change this)



FLORIDA
DEPARTMENT
OF
TRANSPORTATION

Centennial FDOT 1915 ★ 2015

STANDARD SPECIFICATIONS
FOR
ROAD AND BRIDGE
CONSTRUCTION

JULY 2015

Design Consultant/Engineer of Record (EOR)

FIGG Bridge Engineers Inc.
Design Manager
Bridge Design
Submittal Reviews at design office
Occasional site visits during construction as requested by MCM

Independent Peer Review

The Louis Berger Group
Letters stated all design requirements were met
Review Plans & Specifications

Contract Between Design-Builder (MCM) and Designer (FIGG Bridge Engineers, Inc) Uses Standard Form of Agreement Created by Design Build Institute of America (DBIA) A National Industry Standard With Consensus

Section 2.7.9 States:

"Design Consultant's provision of the Construction Phase Services shall not be construed to make Design Consultant responsible for

(i) The acts or omissions of Design-Builder, any Subcontractors, or any Sub-Subcontractors,
(ii) The means, methods, sequences and techniques of construction of the Project or
(iii) Safety precautions and programs in connection with the construction of the Project.

Nothing in this Agreement shall create any legal or contractual relationship between Design Consultant and any Subcontractor or Sub-subcontractor."

DBIA

Standard Form of Agreement Between Design-Builder and Design Consultant

This document has important legal consequences. Consultation with an attorney is recommended with respect to its completion or modification.

This **AGREEMENT** is made as of the 20 day of April in the year of ~~2015~~ 2016, by and between the following parties, for services in connection with the Project identified below:

DESIGN-BUILDER: *(Name and address)*	**Munilla Construction Management, LLC d/b/a MCM** 6201 SW 70th Street, 2nd Floor Miami, Florida 33143 Tel: 305.541.0000/Fax: 305.541.9771
DESIGNER: (Name and address)	**FIGG Bridge Engineers, Inc.** **424 N. Calhoun St.** Tallahassee, Florida 32301 Tel: 850.224.7400
PROJECT: (Include Project name and location as it will appear in the Contract Documents)	**UniversityCity Prosperity Project, BT-904** **Florida International University** SW 109th Avenue & SW 6th Street **Miami-Dade County, FL**
OWNER: (Name and address)	**Florida International University** 11200 SW 8th Street Miami, Fl. 33199

Preeminent Forensic Structural Engineering Experts

Wiss, Janney, Elstner Associates, Inc. (WJE)

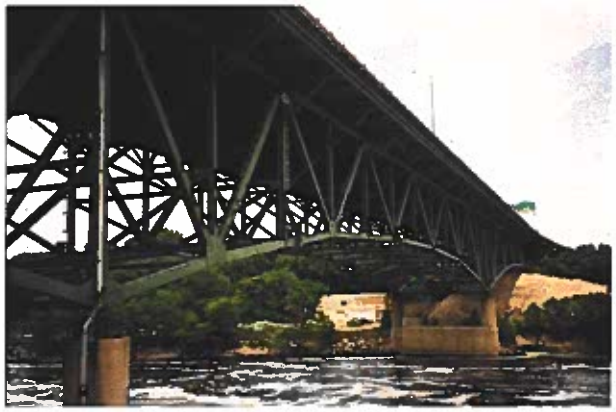
WJE

Gary J. Klein, P.E., S.E.
Executive Vice President and Senior Principal

Bachelors and Master in Civil Engineering

Professional Engineer in Florida

NTSB investigation of I-35W, Minnesota



Since 1979 Gary has investigated hundreds of structures

I-35W Bridge collapse in Minnesota
State investigation coordinating with NTSB on Final Results

Serves on 6 Technical Committees for American Concrete Institute

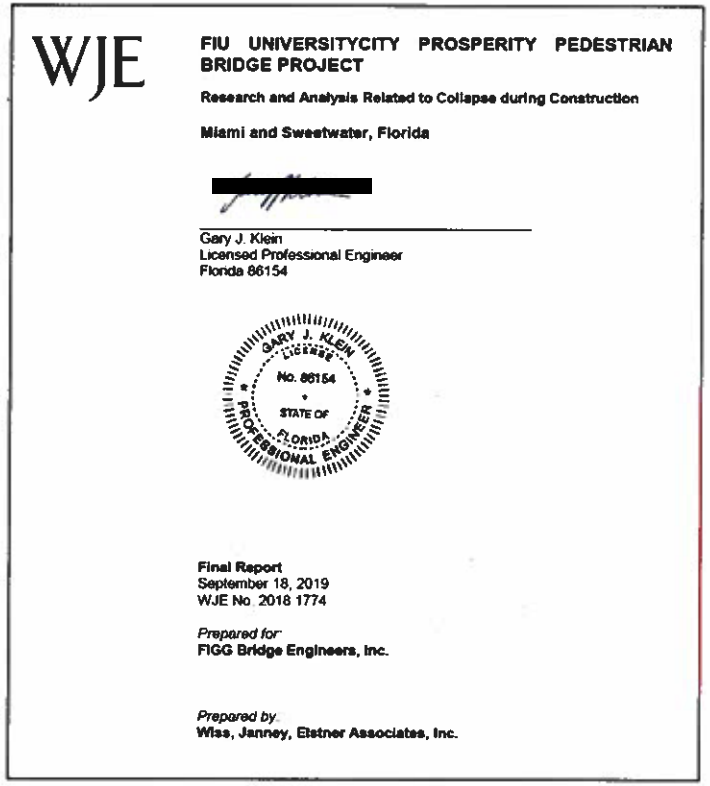
Named to prestigious National Academy of Engineering in Washington, D.C.

Preeminent Forensic Structural Engineering Experts

Wiss, Janney, Elstner Associates, Inc. (WJE)

WJE

Report Signed and Sealed by Professional Engineer Gary J. Klein, P.E., S.E.



WJE

FIU UNIVERSITYCITY PROSPERITY PEDESTRIAN BRIDGE PROJECT

Research and Analysis Related to Collapse during Construction

Miami and Sweetwater, Florida

[redacted]

Gary J. Klein
Licensed Professional Engineer
Florida 86154

GARY J. KLEIN LICENSE No. 86154 STATE OF FLORIDA PROFESSIONAL ENGINEER

Final Report
September 18, 2019
WJE No. 2018.1774

Prepared for
FIGG Bridge Engineers, Inc.

Prepared by
Wiss, Janney, Elstner Associates, Inc.

Research and Analysis Related to Collapse During Construction (128 pages)

Evaluation of failure pattern

Evaluation of construction joint conditions

Full scale concrete specimen testing in laboratory on construction joint and FDOT Standard Construction Specifications

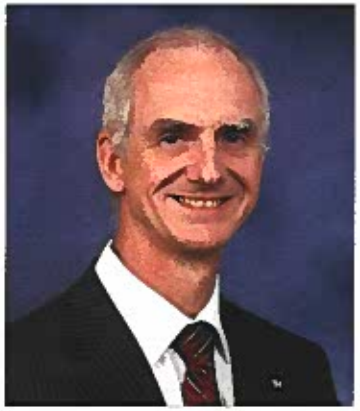
Structural Analysis
- a) Design Code
- b) Construction Conditions

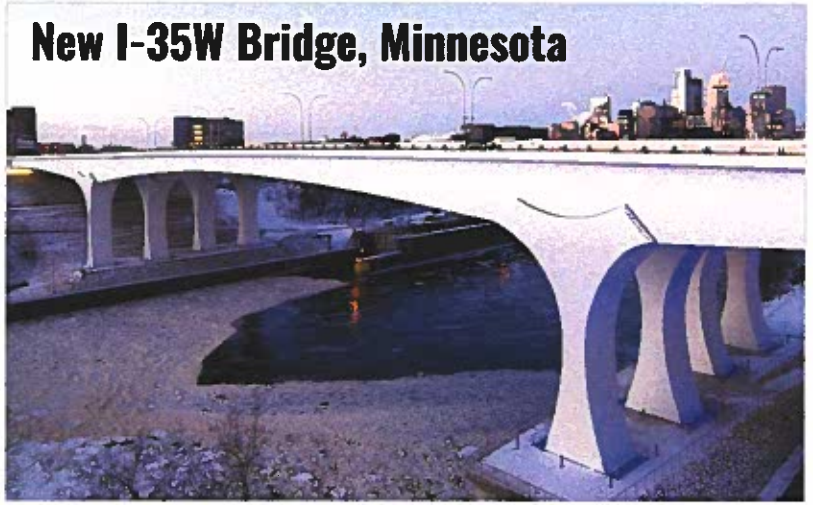
Twist of main span during transport

Post-tensioning operation monitoring at time of construction accident

+ more

FIGG Party Representative to NTSB





Alan Phipps, P.E., S.E.
Senior Vice President/
Director of Operations

BS Civil Engineering (BSCE)
Masters in Civil Engineering (MSCE)
Professional Structural Engineer (S.E.) Professional Engineer (P.E.)
Professionally Registered in 17 states including Florida

38 years bridge engineering design and management of major bridges.
Long Span Cable-Stays, Urban Viaducts, Major River Crossings and more.

35 years, $14 billion in bridge construction with FIGG
(Design and Construction Engineering & Inspection)

New I-35W Bridge in Minnesota - Design Leader and Manager

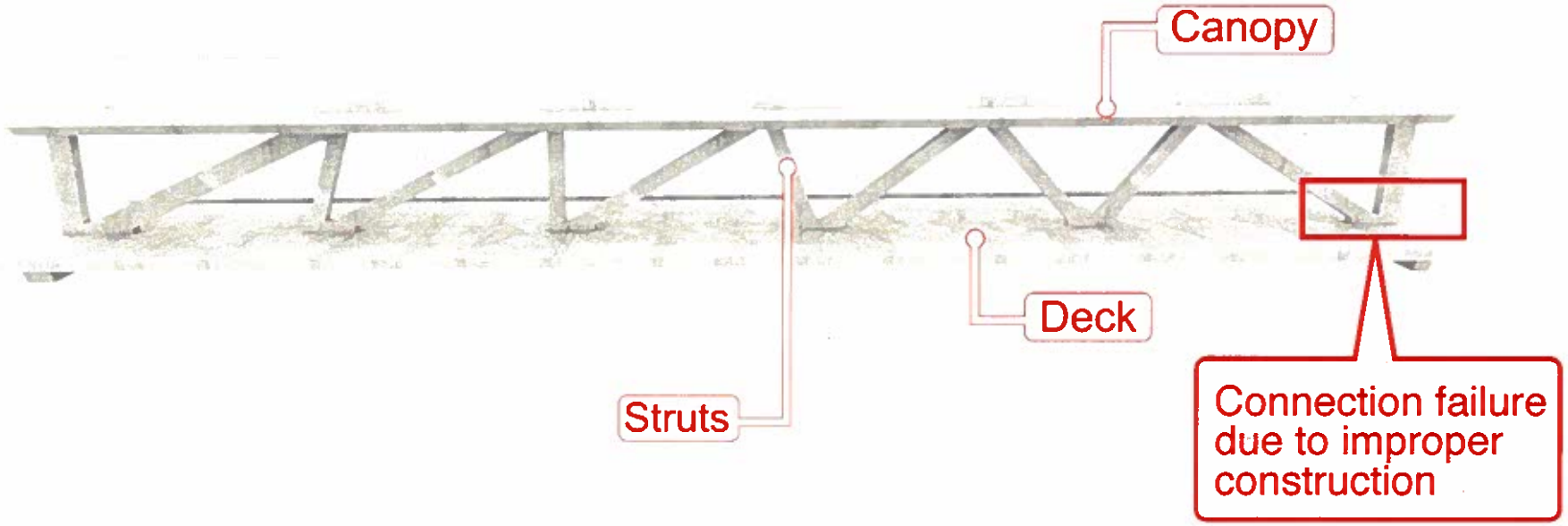
CREATING BRIDGES AS ART® FIGG

OVERVIEW

Cause of Accident

Probable Cause:

Failure of Contractor to properly construct the joint between the deck and truss members in accordance with the plans and Florida DOT Standard Construction Specifications.



Cause of the Accident

Contributory Causes

Damage sustained in moving the span from casting area to the piers - twisted by 168% of the limit (unknown by FIGG).

Miscommunication between the Contractor at the site and the design engineer 500 miles away.

Failure by contractor and others to close SW 8th Street while investigating and when restressing truss member.

Failure by Contractor and others to closely monitor cracks, as instructed by FIGG, while restressing truss member.

Excluded Cause

The bridge design was not a cause of the accident

The design shown in the Released for Construction (RFC) plans met Project requirements, design codes, and industry standards.

Forensic Engineer Wiss, Janney, Elstner (WJE) concluded that the member 11/12 joint design complied with the AASHTO LRFD Bridge Design Specifications.

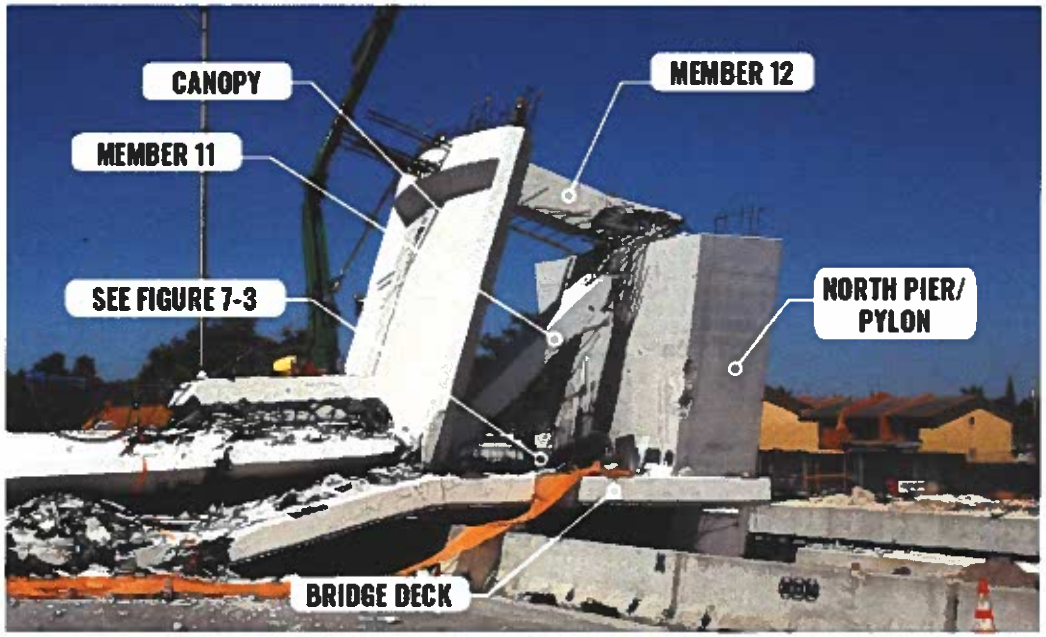
Full-sized specimen tests by WJE prove the member 11/12 joint would not have failed if constructed per Florida DOT Standard Specifications.

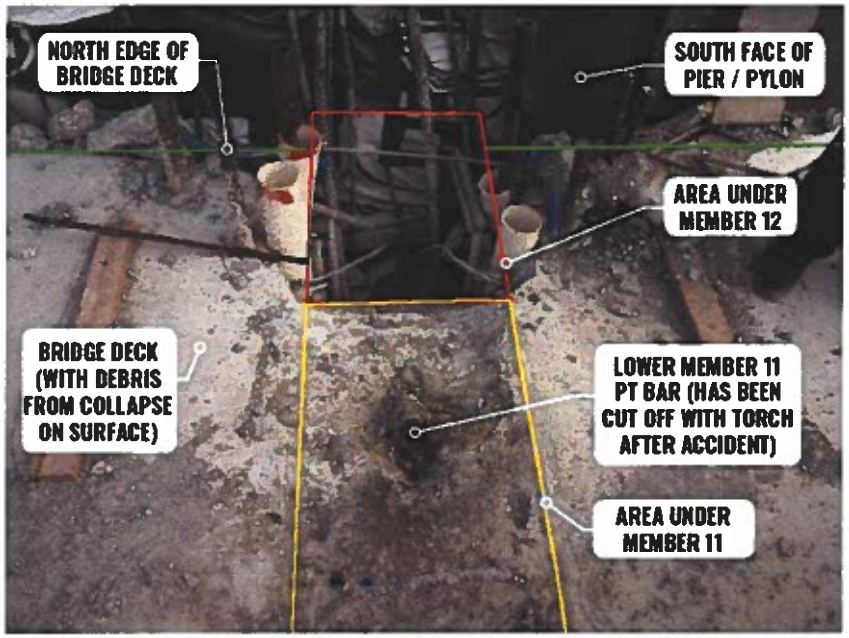
PROBABLE CAUSE

Probable Cause - Failure to Roughen Construction Joint

Accident Analysis -

Failure of construction joint between members 11/12 and the bridge deck at the north end.





Probable Cause - Failure to Roughen Construction Joint

Plans and specifications required construction joint roughening.

Contract between FIU and MCM required use of Florida Department of Transportation (FDOT) Specifications. "FDOT specifications may not be modified or revised" (RFP, Section VI.H).

RFC Plans require adherence to FDOT construction specifications - First note on general notes sheet.

CONSTRUCTION SPECIFICATIONS:

1. *FLORIDA DEPARTMENT OF TRANSPORTATION STANDARD SPECIFICATIONS FOR ROAD AND BRIDGE CONSTRUCTION 2015.*
2. *AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO) LRFD BRIDGE CONSTRUCTION SPECIFICATIONS, SECOND EDITION, 2004 WITH INTERIMS THROUGH 2006.*

DESIGN SPECIFICATIONS:

1. *AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO) LRFD BRIDGE DESIGN SPECIFICATIONS SEVENTH EDITION WITH 2015 INTERIMS.*
2. *FDOT STRUCTURES DESIGN MANUAL, JANUARY 2015.*
3. *AASHTO LRFD GUIDE SPECIFICATIONS FOR DESIGN OF PEDESTRIAN BRIDGES, SECOND EDITION (2009).*
4. *CEB-FIP MODEL CODE, FIRST EDITION, 1990, TIME DEPENDENT BEHAVIOR OF CONCRETE, CREEP AND SHRINKAGE.*
5. *AASHTO/AMERICAN WELDING SOCIETY (AWS) D1.5 BRIDGE WELDING CODE (2005).*
6. *28 CODE OF FEDERAL REGULATIONS PART 36, 2010 AMERICANS WITH DISABILITIES ACT (ADA) STANDARDS FOR ACCESSIBLE DESIGN.*
7. *AASHTO GUIDE FOR THE DEVELOPMENT OF BICYCLE FACILITIES, 1999.*
8. *BUILDING CODE REQUIREMENTS FOR STRUCTURAL CONCRETE, ACI 318-14.*
9. *BUILDING CODE REQUIREMENTS FOR MASONRY STRUCTURES, TMS 402-13 CODE.*

Probable Cause - Failure to Roughen Construction Joint

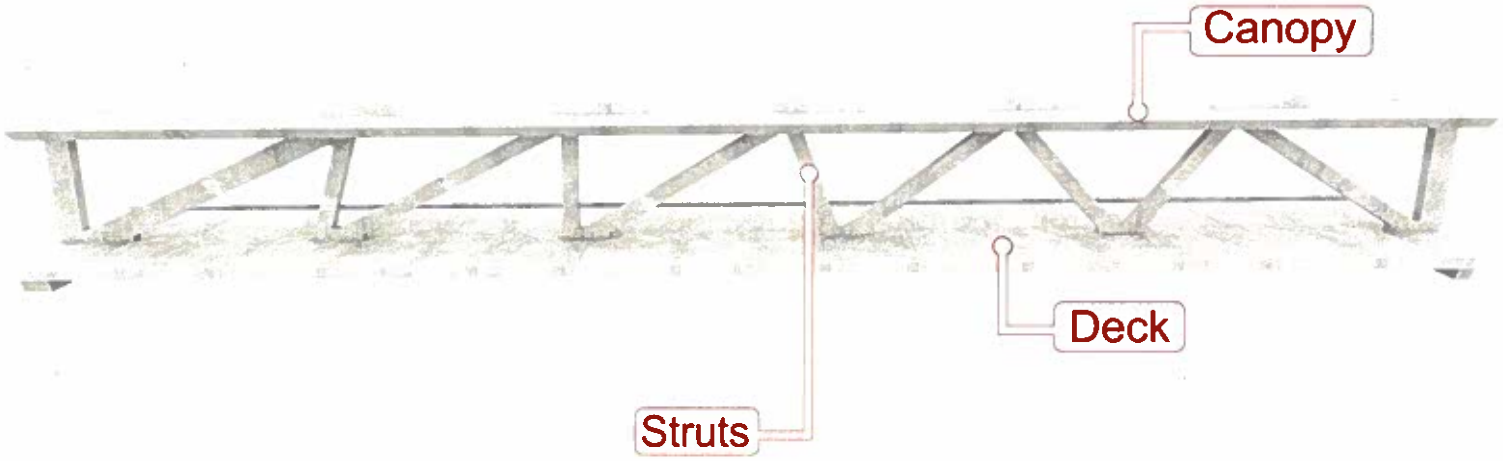
FDOT Standard Specifications 400-9 States:

400-9.3 Preparation of Surfaces: *Before depositing new concrete on or against concrete which has hardened, re-tighten the forms. Roughen the surface of the hardened concrete in a manner that will not leave loosened particles, aggregate, or damaged concrete at the surface. Thoroughly clean the surface of foreign matter and laitance, and saturate it with water.*

Probable Cause - Failure to Roughen Construction Joint

Construction Joints in the Main Span Truss

Contractor Preference to Pour Concrete in 3 stages



Probable Cause - Failure to Roughen Construction Joint

Common Roughening Tool - Electric Chipping Hammer

Un-Roughened

Tool

Roughened per FDOT Specifications

* See samples of roughened and un-roughened concrete

Probable Cause - Failure to Roughen Construction Joint

Requirement to roughen joints was reiterated by FIGG in a series of emails between the contractor, the Quality Inspector and FIGG prior to precasting the main span

June 12 at 10:06 a.m. – MCM's Project Engineer to BPA's Project Administrator and others at BPA and MCM:

"Please clarify if you are referring to construction joints or cold joints. For construction joints we will roughen the surface of the hardened concrete and remove loose particles prior to placing new concrete."

June 12 at 10:10 a.m. - BPA's Project Administrator to MCM's Project Engineer and others at BPA and MCM:

"Yes, I am referring to construction cold joints on structural elements, please get an answer from FIGG of the appropriate treatment."

June 12 at 10:15 a.m. – MCM's Project Engineer to BPA's Project Administrator, FIGG's Project Manager and others at BPA and MCM:

"I spoke with FIGG and they advised us to follow FDOT specs which is as follows..."

Probable Cause - Failure to Roughen Construction Joint

Requirement to roughen joints was reiterated by FIGG in a series of emails between the contractor, the Quality Inspector and FIGG prior to precasting the main span

June 13 at 7:48 a.m. - BPA's Project Administrator to FIGG's Project Manager and MCM's Project manager with copy to BPA's Senior Project Engineer:

"Please make sure we have FIGG blessing for the construction cold joints treatment..."

June 13 at 7:56 a.m. – FIGG's Project Manager to BPA's Project Administrator and MCM's Project Manager with copies to BPA's Sr. Project Engineer and others at FIGG:

"We have had previous communications with MCM regarding this topic and the FDOT specification referenced below was to be followed. Let us know if you have any further questions."

June 13 at 8:04 a.m. - BPA's Project Administrator to FIGG's Project Manager:

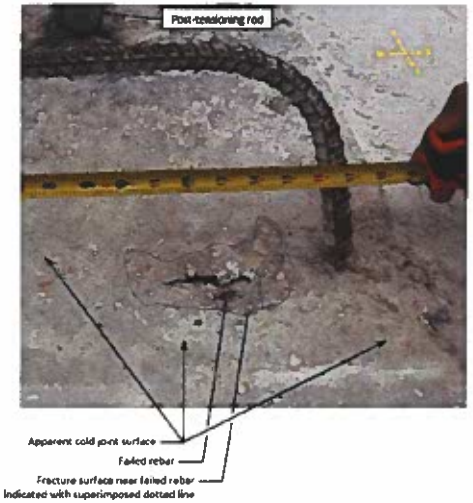
"Thank you."

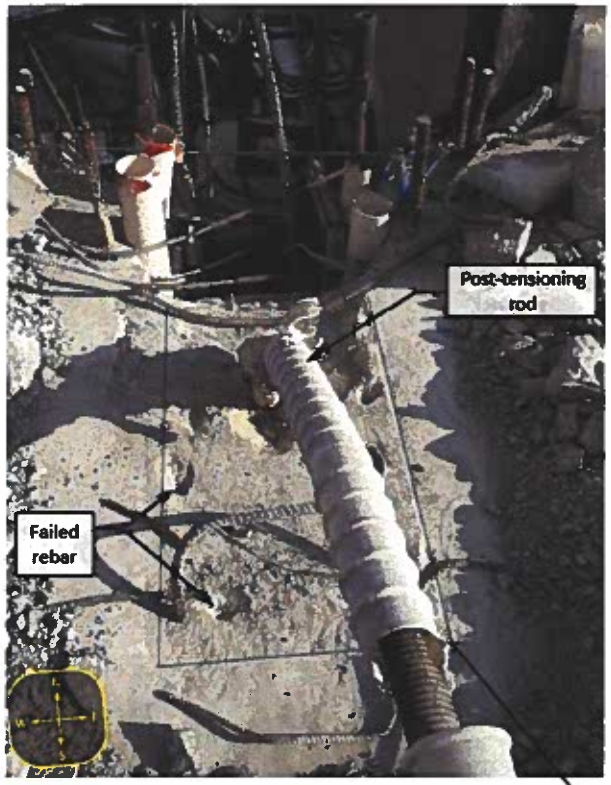
Probable Cause - Failure to Roughen Construction Joint

The NTSB investigation determined that the construction joint was not roughened

1. FHWA Turner Fairbank Highway Research Center Factual Report "Concrete Interface Under Members 11 and 12"

"...the failure interface coincides with the original cold joint and that the cold joint was not intentionally roughened".



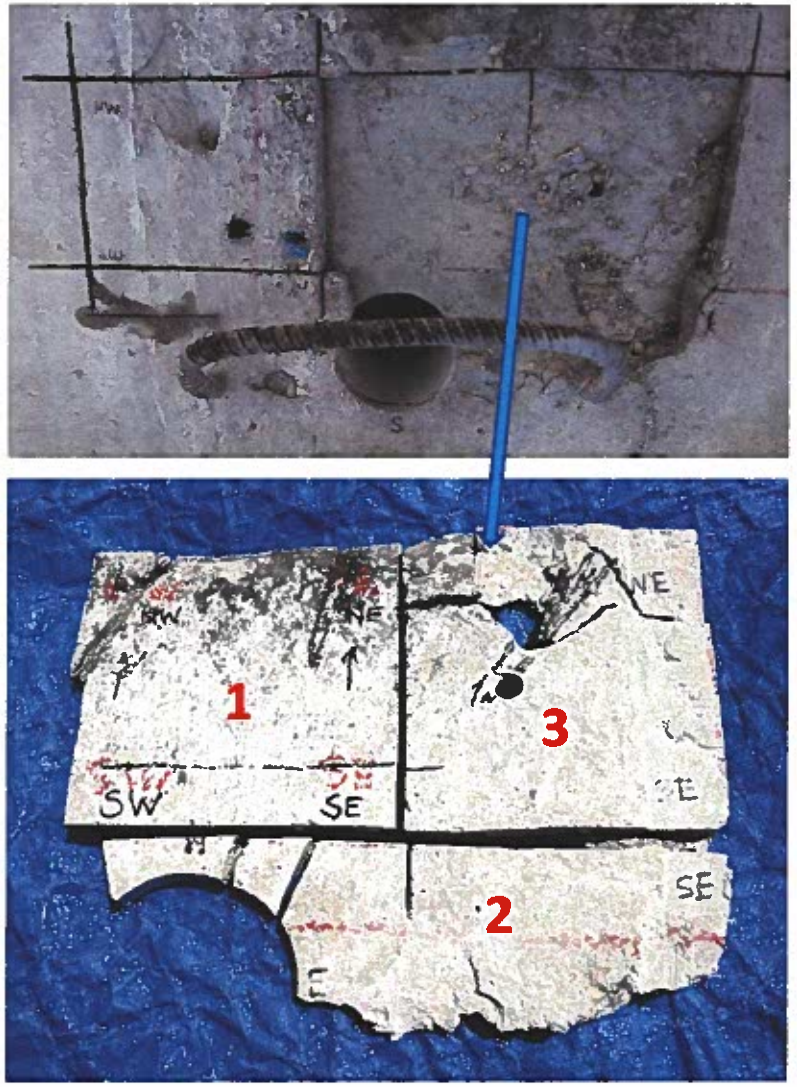


Probable Cause - Failure to Roughen Construction Joint

The NTSB investigation determined that the construction joint was not roughened

2. NTSB Materials Laboratory Study Report No. 19-043 discusses results of a laser scan of the construction joint post-accident:

   "The average S_a (roughness measurement) for the flat areas evaluated on both the Member 11 pieces as well as the Member 12 surface was approximately 1mm (0.04 in.)…"



Probable Cause - Failure to Roughen Construction Joint

The NTSB investigation determined that the construction joint was not roughened

3. Witness statements to NTSB

NTSB interview with concrete subcontractor:

Q. Was any surface prep required for the interface for the diagonal hit, the bottom slide?

A. Yes.

Q. And how did you – just try all buffing or –

A. Yeah, we just left it like it was…

Q. So, it's just as it settles.

A. Yes.

Q. So, it wasn't prescribed – sometimes you get surface (Indiscernible) so they kind of ask you to roughen it to a certain but it was just don't finish it.

A. Don't finish it, yeah.

Probable Cause - Failure to Roughen Construction Joint

The NTSB investigation determined that the construction joint was not roughened

Interview with MCM Quality Technician

Q. Was any special treatment made to the finish at the, at the 1 deck surface where the diagonals came in and connected to the –

A. No, just to cover where instead of using the special products…

Q. Was that, was that surfaced roughened in any way or prepped in any way?

A. No. After the finish, that was it.

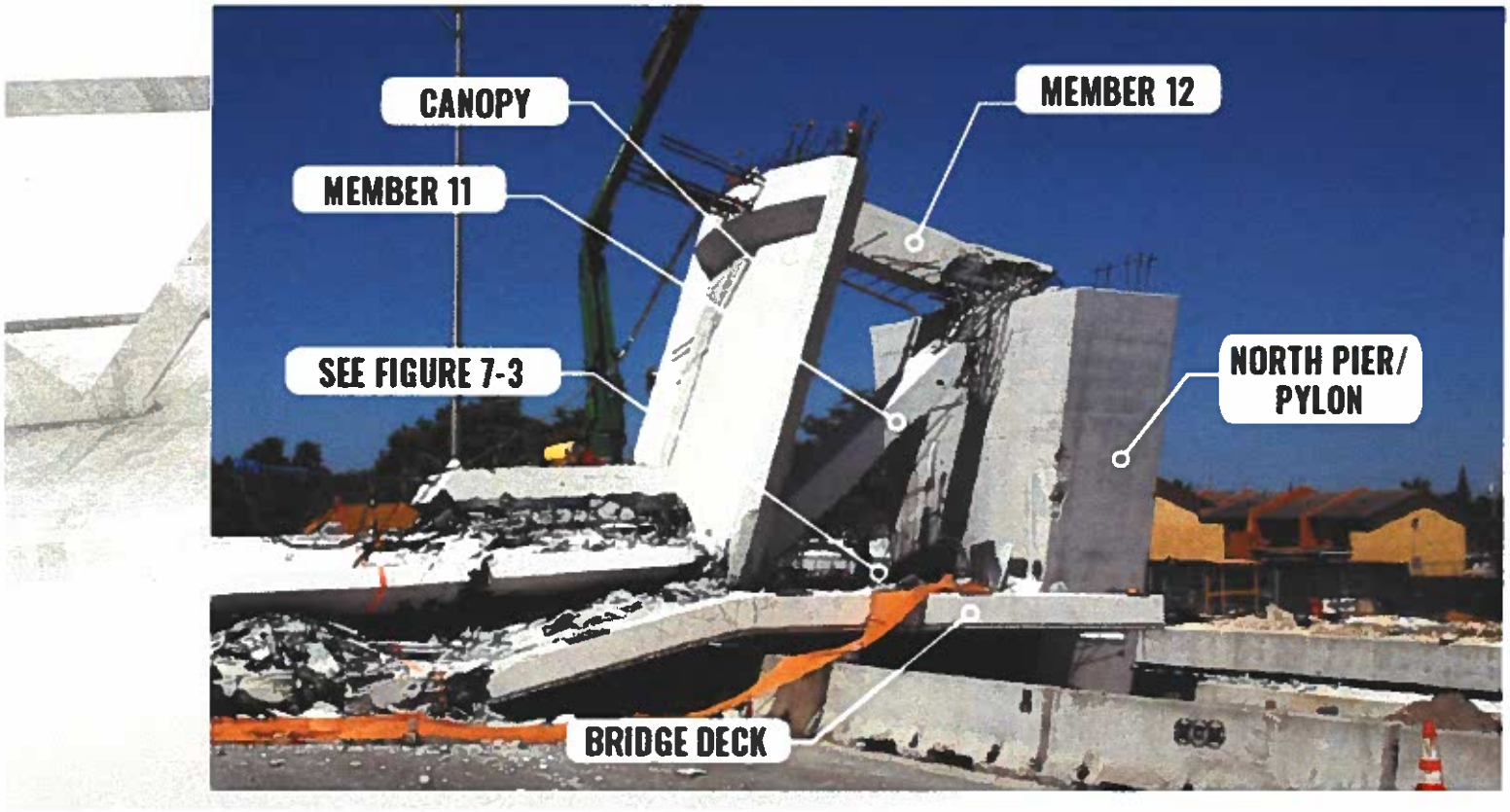
Q. So it wasn't finished. It was just covered and –

A. Just covered. Yes.

Note: Statement made by MCM Quality Technician September 2019 contradicts his NTSB Interview, the other witness interview and laboratory findings

Probable Cause - Failure to Roughen Construction Joint

Non-roughened construction joint is consistent with forensic analysis of failure mode by Wiss, Janney, Elstner (WJE)



Probable Cause - Failure to Roughen Construction Joint

Full-size specimen tests by Wiss, Janney, Elstner (WJE) prove that if the construction joint had been roughened in accordance with FDOT Standard Construction Specifications as required, the accident would not have happened.

Construction Joint Sliding Tests by WJE

Six (6) Full-sized specimens replicating the Truss Member 11 connection to the bridge deck.
Three (3) specimens had construction joints roughened per FDOT Specifications.
There (3) specimens had non-roughened construction joints (as-placed)

Construction Joints

Roughened per
FDOT Specifications

Non-Roughened

Construction Joint Sliding Tests by WJE

Roughness of the Construction Joints was measured with a laser scanner and compared to FIU Bridge sample:

Joint Sample	Roughness Amplitude *
Roughened specimen	0.16 in.
Non-roughened specimen	0.07 in.
FIU Bridge (Member 11) (scan data from NTSB)	0.06 in.

*Defined as - 2 x The Standard Deviation

Construction Joint Sliding Tests by WJE

Specimens tested with same loads as FIU Bridge experienced and then to failure

Completed test specimens

Testing machine at University of Illinois Urbana-Champaign

Construction Joint Sliding Tests by WJE

Test Results: No failure if construction joint is roughened per FDOT Specifications

Specimen	Peak Load (Average)	Member 11 Load at Failure	%
Roughened	2,594 kips	1,743 kips	149%
Non-roughened	1,455 kips	1,743 kips	83%

Note: 1 kip = 1,000 lbs.

Specimen at Failure Load

Construction Joint Sliding Tests by WJE

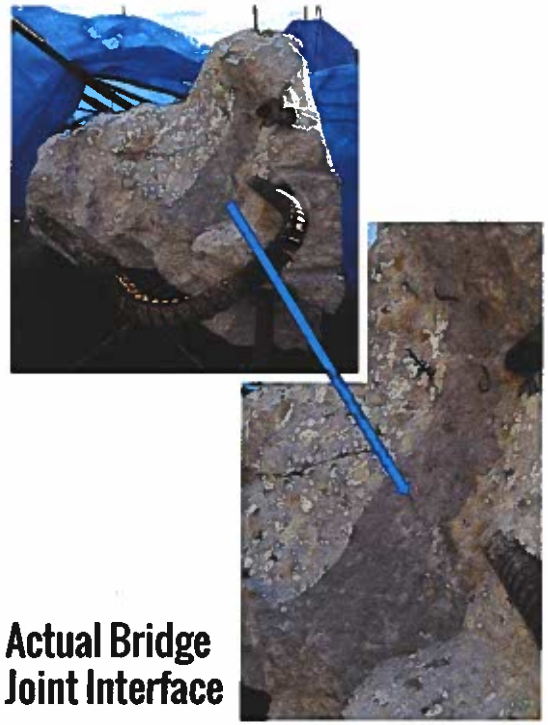
Actual FIU Bridge failure surface is consistent with non-roughened test specimen, further proving construction joint was not roughened

WJE Full Scale Test Specimen

Fractured Aggregate
Roughened Joint Interface

No Fractured Aggregate
Non-roughened Joint Interface

No Fractured Aggregate
Proves actual bridge joint was non-roughened



Actual Bridge Joint Interface

Construction Joint Was Not Scraped Smooth During Accident

WJE analysis concludes the bottom of Member 11 broke into small pieces

Lack of fractured aggregate across construction joint

No scrape marks on surface

FHWA Turner Fairbanks Interface Report indicates joint non-roughened

Probable Cause

Failure by the Contractor to roughen the construction joint between Members 11/12 and the bridge deck as required per FDOT Standard Construction Specifications (as shown by NTSB/FHWA laboratory testing and witness statements).

Failure of Contractor's Quality Control or Owner's Independent Construction Quality Inspectors to enforce FDOT Specifications, despite email discussions with Designer emphasizing requirements.

Collapse would not have happened if joint was roughened in accordance with FDOT Specifications as proven by WJE testing.

CONTRIBUTORY CAUSES

Cause of the Accident

Contributory Causes

Damage sustained in moving the span from casting area to the piers - twisted by 168% of the limit (unknown by FIGG)

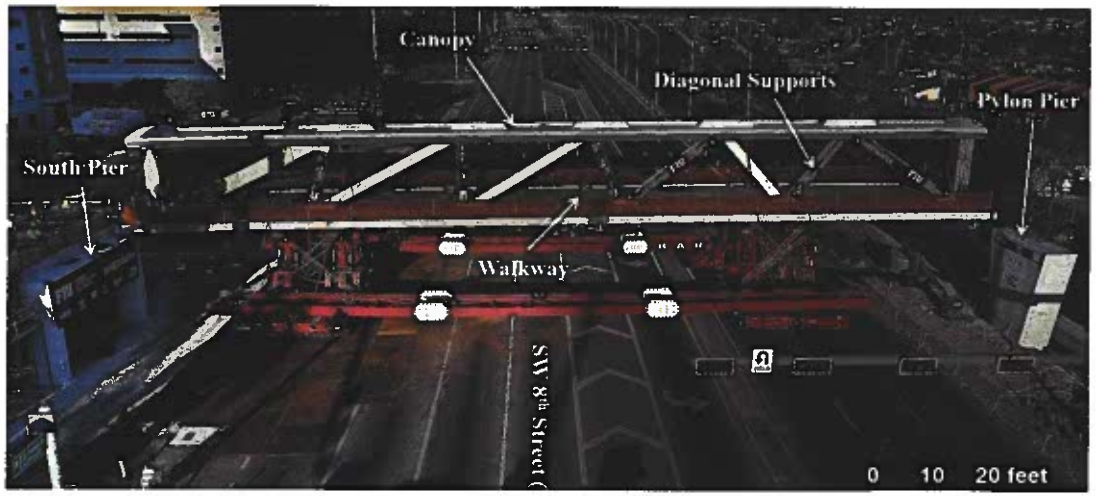
Miscommunication between the contractor at the site and the design engineer 500 miles away

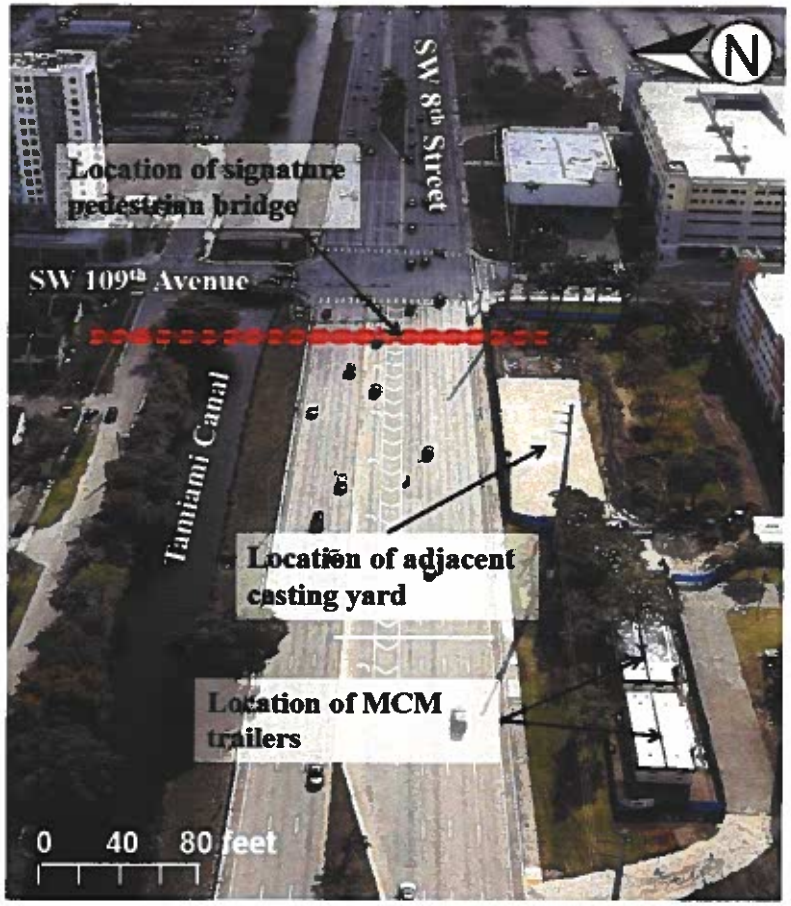
Failure by contractors and others to close SW 8th Street while investigating and when prestressing truss member

Failure by contractor and others to closely monitor cracks, as instructed by FIGG, while restressing truss member

Contributory Cause - Damage From Bridge Move

Main span moved from precast area using transporters to permanent piers over SW 8th Street

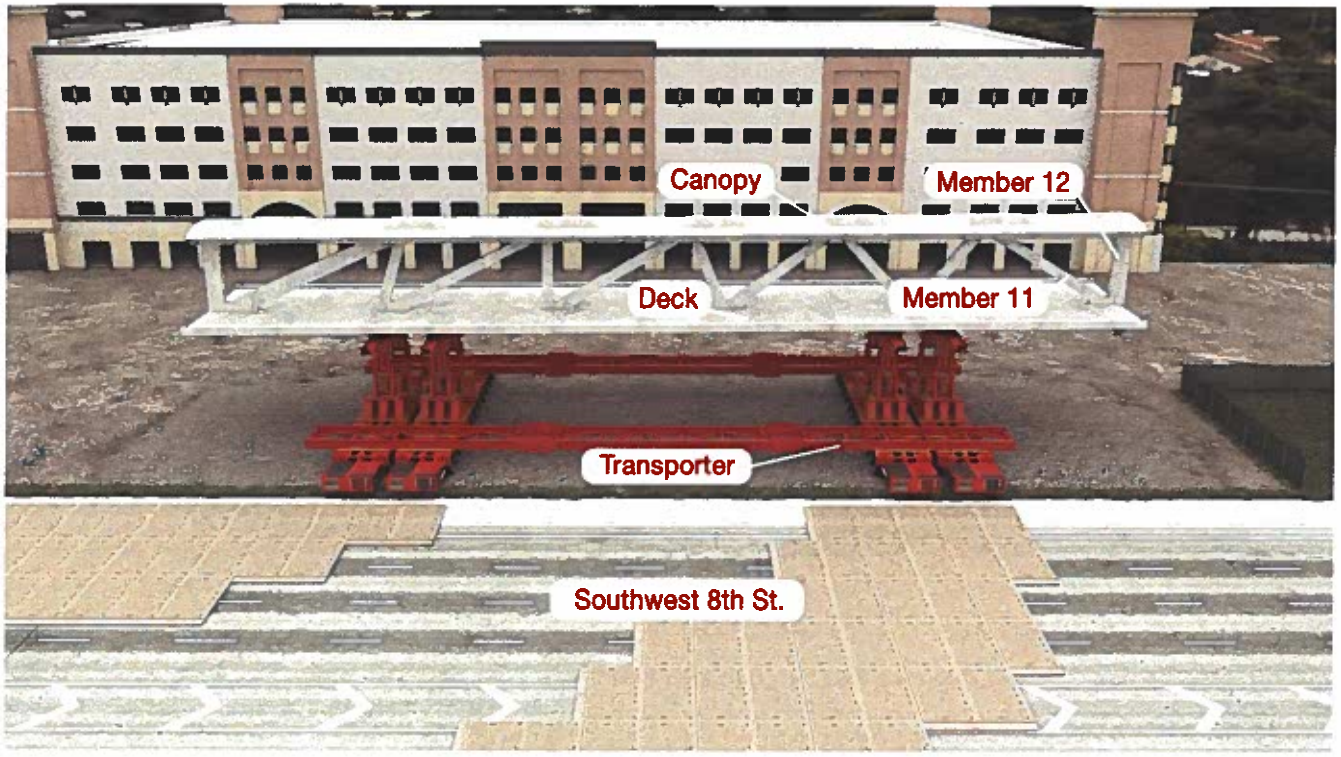




Contributory Cause - Damage From Bridge Move

Limit set by FIGG of 0.5 degrees maximum twist

Span instrumented and monitored by subcontractor during move



Contributory Cause - Damage From Bridge Move

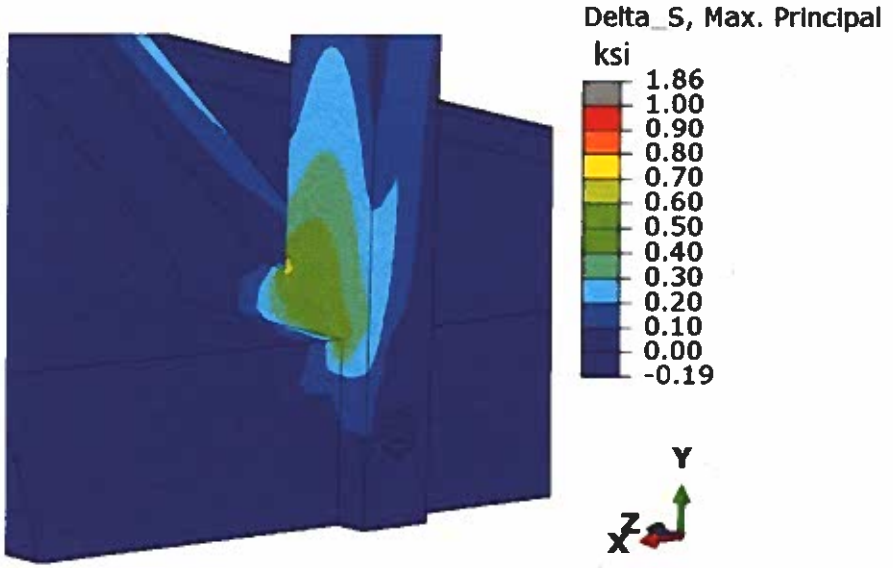
No exceedances reported during move

Report issued by subcontractor 20 days after accident showed twist limit exceeded multiple times with twist up to 168% of limit

WJE analysis shows twist results in high stress in Member 11/12 connection region

Looking southwest at north end and east face. Green color indicates more than 500 psi tensile stress.

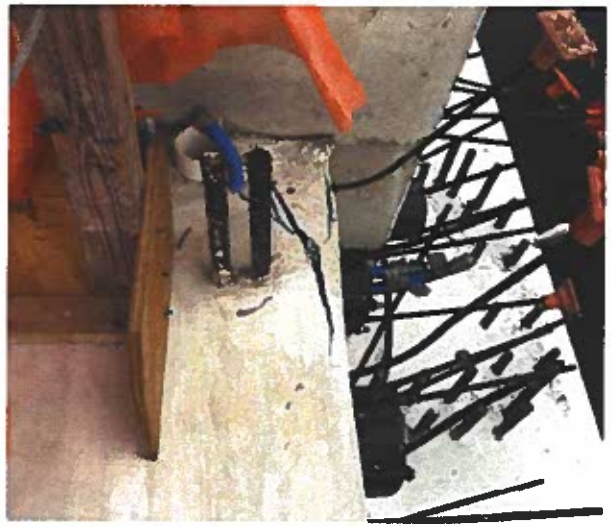
Dark blue areas have zero tensile stresses or they are compression dominant



Contributory Cause - Damage From Bridge Move

Cracks in Member 11/12 connection increased dramatically in afternoon after the bridge move

Stress from excessive twist contributed to damage in Member 11/12 connection region

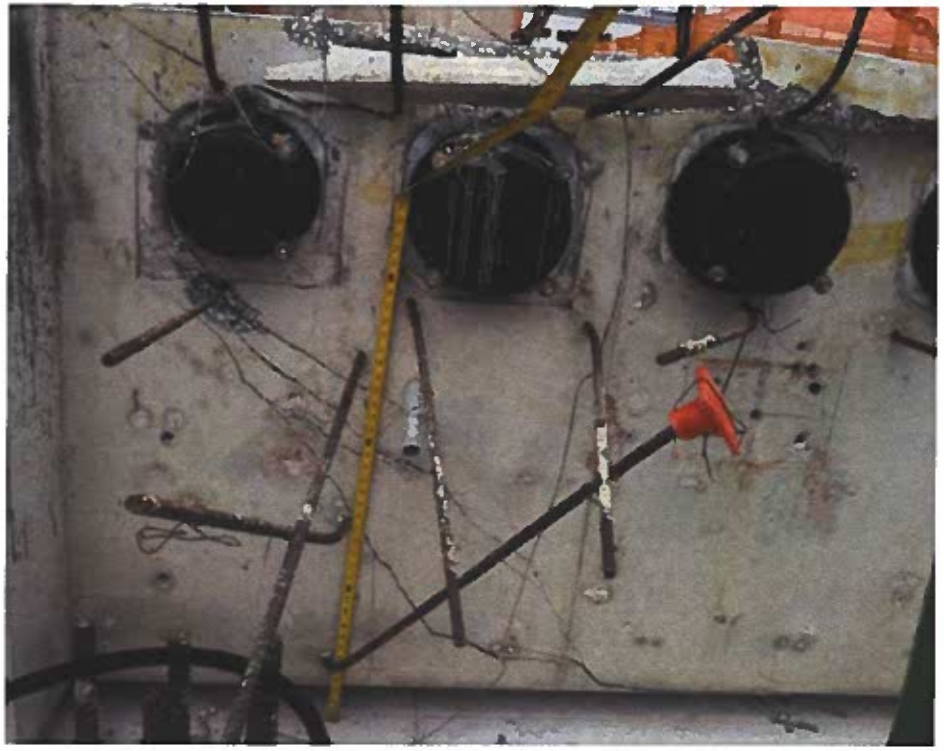


Contributory Cause - Inaccurate, Misleading and Untimely Information From Construction and Inspection Team On-Site to Designer Off-Site

FIGG did not have a person on-site except for occasional visits - relied on Contractor for information

No information on cracking after bridge move on March 10 provided to FIGG until late on March 12 - pertained almost exclusively to the north diaphragm

FIGG was unaware that the construction joint had not been roughened or that the twist limit had been exceeded



Concrete Cracking

Unlike Metals such as steel, it is not uncommon for concrete to crack as part of normal structure behavior

Concrete is strong in compression but weak in tension

Steel reinforcing and/or post-tensioning is typically embedded in concrete to resist tension

Significance of concrete cracking depends on location, size and progression

Contributory Cause - Inaccurate, Misleading and Untimely Information From Construction and Inspection Team On-Site to Designer Off-Site

FIGG (Designer)

On-Site Construction/Inspection

SAT 3/10

SUN 3/11

MON 3/12

FIGG staff at site observe no change from pre-move. Leave site at 12:40pm

Bridge move complete 12:30 pm

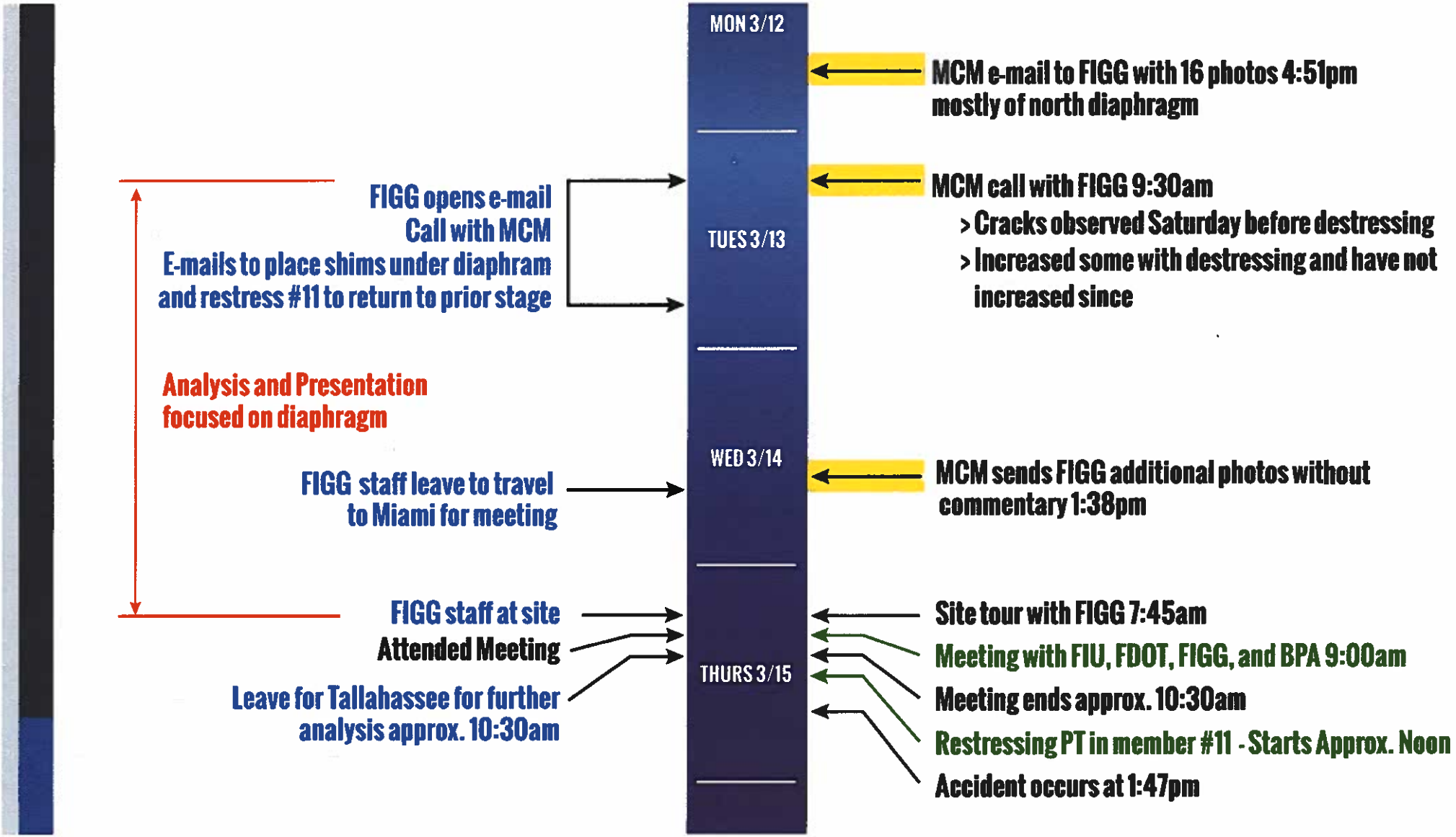
BPA finds significant change in cracking 3:00pm

Member #11 PT bar destressed 4:30pm

SW 8TH Street opened to traffic 6:00pm

Subcontractor text to coworker:
"It cracked like hell" 7:08 pm

MCM e-mail to FIGG with 16 photos 4:51pm
mostly of north diaphragm


MON 3/12
TUES 3/13
WED 3/14
THURS 3/15
MCM e-mail to FIGG with 16 photos 4:51pm mostly of north diaphragm
MCM call with FIGG 9:30am
> Cracks observed Saturday before destressing
> Increased some with destressing and have not increased since
FIGG opens e-mail
Call with MCM
E-mails to place shims under diaphram and restress #11 to return to prior stage
Analysis and Presentation focused on diaphragm
FIGG staff leave to travel to Miami for meeting
MCM sends FIGG additional photos without commentary 1:38pm
FIGG staff at site
Attended Meeting
Leave for Tallahassee for further analysis approx. 10:30am
Site tour with FIGG 7:45am
Meeting with FIU, FDOT, FIGG, and BPA 9:00am
Meeting ends approx. 10:30am
Restressing PT in member #11 - Starts Approx. Noon
Accident occurs at 1:47pm

Contributory Cause - Failure To Close SW 8th Street While Investigating

FDOT, FIU, MCM and BPA had the authority (alone or collectively) to close traffic.

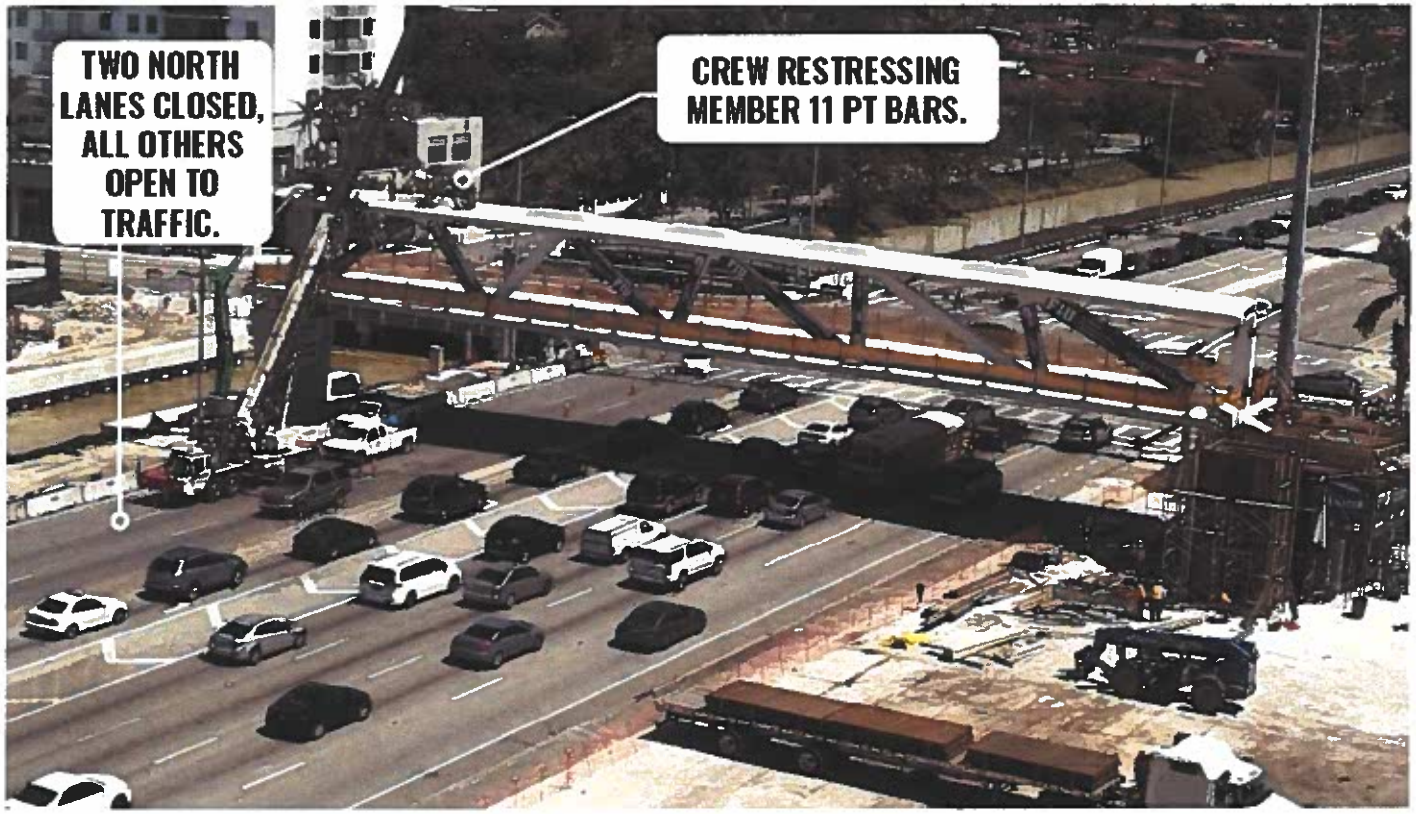
MCM opened traffic at 6:00 pm on March 10 despite observed worsening cracking. Text at 7:08 pm: "It cracked like hell".

From March 12 through March 14, MCM and BPA had full-time site presence and were monitoring cracking. No actions to close traffic.

Contributory Cause - Failure To Close SW 8th Street While Investigating

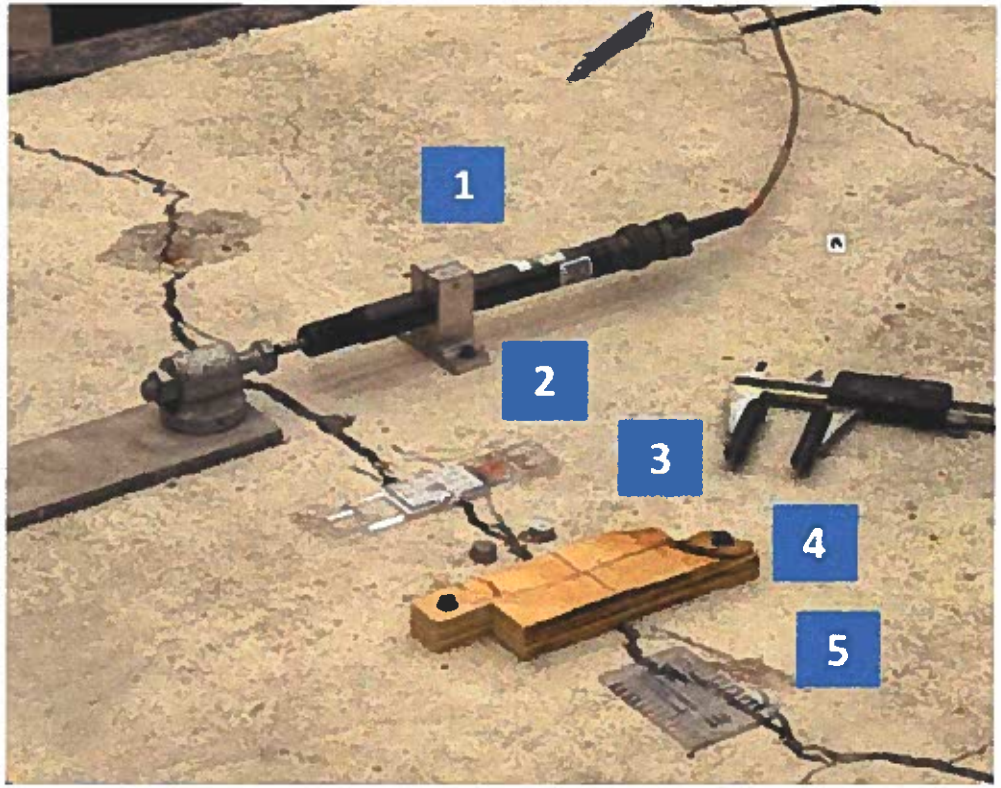
No one at the March 15 meeting the morning of the accident suggested closing SW 8th Street.

Subcontractor restressing PT bars in Member #11 only defined the work zone as the north two lanes.



Contributory Cause - Failure To Monitor Cracks While Restressing Member #11

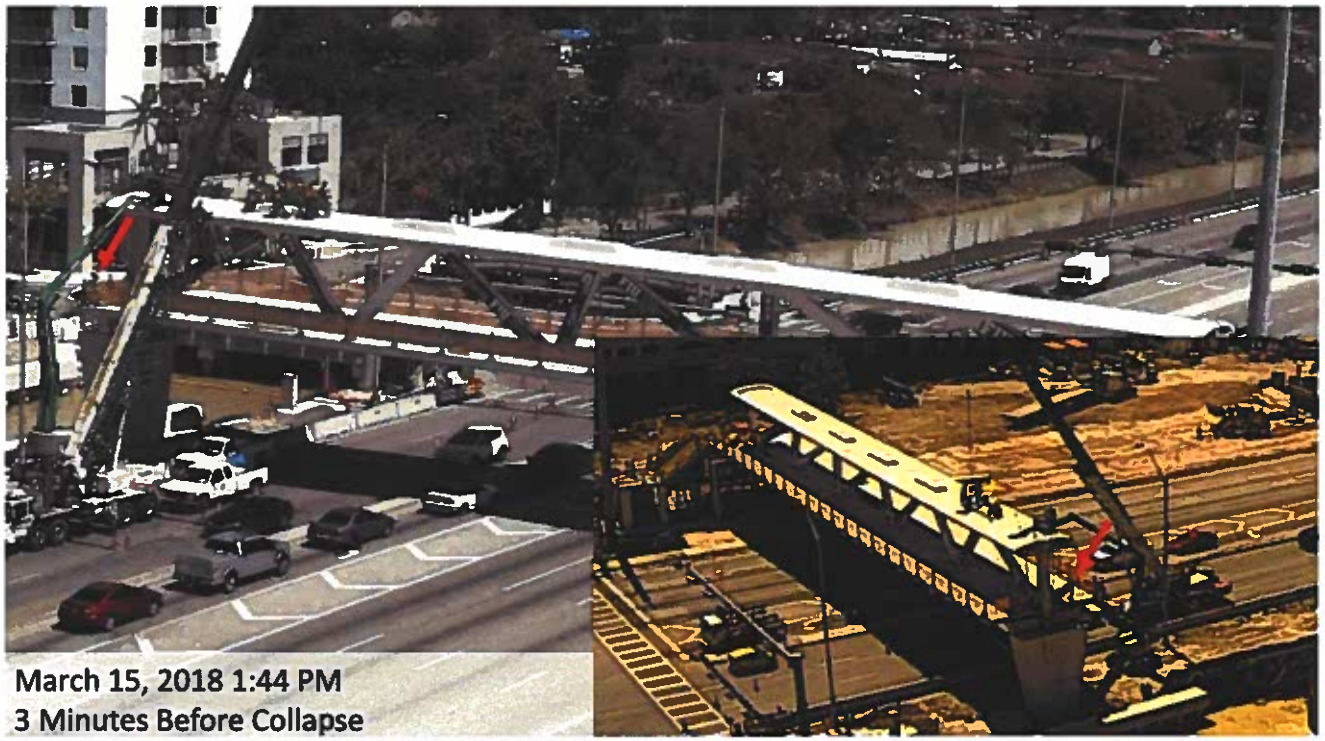
- FIGG provided instructions to MCM for restressing Member #11
  - 12 incremental steps
  - Closely monitor cracks
  - Immediately stop and notify FIGG if cracks get larger
- PT subcontractor's shop drawings also required stopping if cracks increased
- Proper crack monitoring instruments were not used



Contributory Cause - Failure To Monitor Cracks While Restressing Member #11

Construction webcam video indicates cracks were not closely monitored during restressing

Had proper crack monitoring been performed, the accident may have been prevented



March 15, 2018 1:44 PM
3 Minutes Before Collapse

EXCLUDED CAUSE - DESIGN

All Aspects of the Design by FIGG Were the Subject of Numerous Governmental, Contractor, and Peer Reviews Over a 14 Month Period.
All Accepted Before Construction Started

9 Submittals to FDOT for Review at 30%, 90%, 100% Design Plans

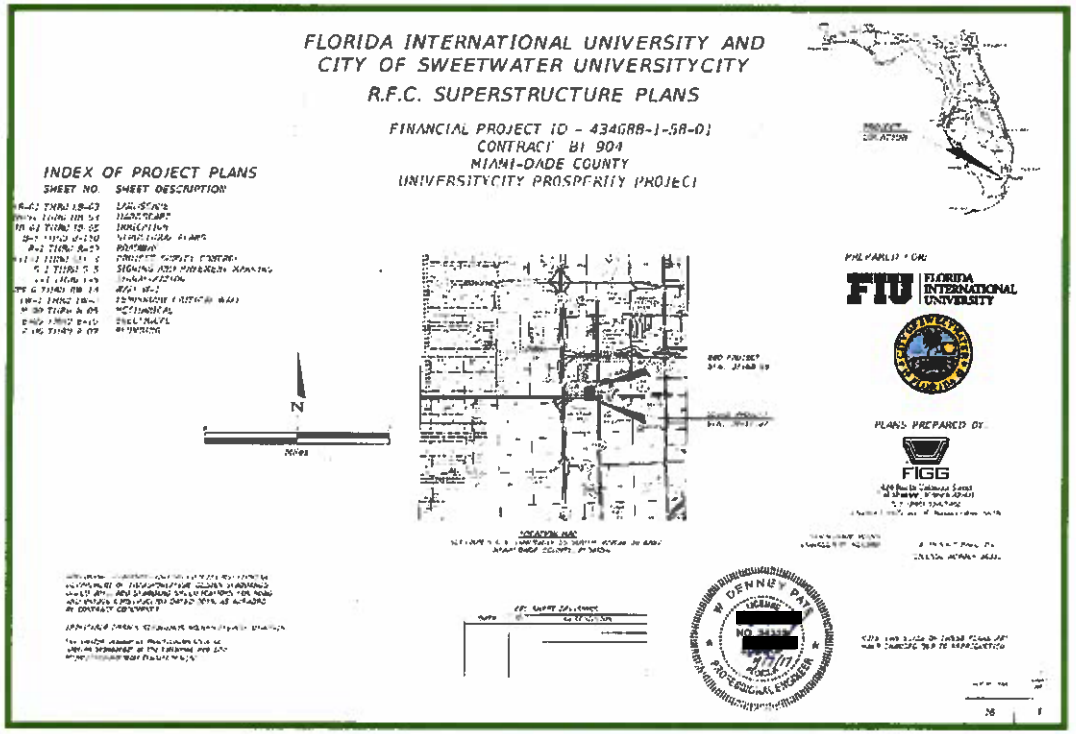
32 Reviews FDOT With 3 Outside Consultants

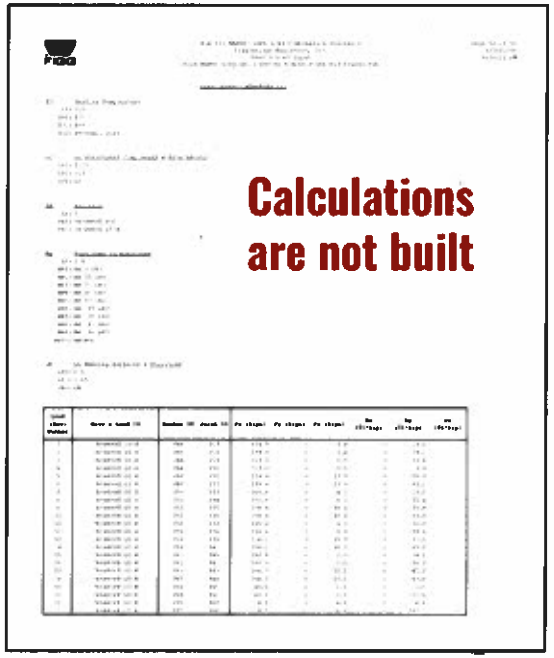
Over 340 Written Comments (Electronic Review System) Resolved To Acceptance Before Release for Construction Plans Issue

37 Reviewers - FIU, FDOT, FHWA, Miami-Dade County

Final Design Is Shown in the Approved Release for Construction (RFC) Plans

RFC PLANS ARE BUILT


FLORIDA INTERNATIONAL UNIVERSITY AND
CITY OF SWEETWATER UNIVERSITYCITY
R.F.C. SUPERSTRUCTURE PLANS
FINANCIAL PROJECT ID - 434088-1-58-01
CONTRACT BI 904
MIAMI-DADE COUNTY
UNIVERSITYCITY PROSPERITY PROJECT
INDEX OF PROJECT PLANS
SHEET NO. SHEET DESCRIPTION
PREPARED FOR:
FIU FLORIDA INTERNATIONAL UNIVERSITY
PLANS PREPARED BY:
FIGG



Release for Construction (RFC) Plans incorporate calculations, comments, constructibility comments, final decisions, etc.

1st Page of Approved RFC Plans Is General Notes that Apply to Entire Set of Construction Drawings (Standard Industry Practice)

CONSTRUCTION SPECIFICATIONS:

1. FLORIDA DEPARTMENT OF TRANSPORTATION STANDARD SPECIFICATIONS FOR ROAD AND BRIDGE CONSTRUCTION 2015.
2. AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO) LRFD BRIDGE CONSTRUCTION SPECIFICATIONS, SECOND EDITION, 2004 WITH INTERIMS THROUGH 2006.

DESIGN SPECIFICATIONS:

1. AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO) LRFD BRIDGE DESIGN SPECIFICATIONS SEVENTH EDITION WITH 2015 INTERIMS.
2. FDOT STRUCTURES DESIGN MANUAL, JANUARY 2015.
3. AASHTO LRFD GUIDE SPECIFICATIONS FOR DESIGN OF PEDESTRIAN BRIDGES, SECOND EDITION (2009).
4. CEB-FIP MODEL CODE, FIRST EDITION, 1990, TIME DEPENDENT BEHAVIOR OF CONCRETE, CREEP AND SHRINKAGE.
5. AASHTO/AMERICAN WELDING SOCIETY (AWS) D1.5 BRIDGE WELDING CODE (2005).
6. 28 CODE OF FEDERAL REGULATIONS PART 36, 2010 AMERICANS WITH DISABILITIES ACT (ADA) STANDARDS FOR ACCESSIBLE DESIGN.
7. AASHTO GUIDE FOR THE DEVELOPMENT OF BICYCLE FACILITIES, 1999.
8. BUILDING CODE REQUIREMENTS FOR STRUCTURAL CONCRETE, ACI 318-14.
9. BUILDING CODE REQUIREMENTS FOR MASONRY STRUCTURES, TMS 402-13 CODE.

FLORIDA
DEPARTMENT
OF
TRANSPORTATION

Centennial FDOT 1915 ★ 2015

STANDARD SPECIFICATIONS
FOR
ROAD AND BRIDGE
CONSTRUCTION

JULY 2015

Contractors and Certified Inspectors are Required to Follow the FDOT Standard Specifications for Construction

FDOT certifies inspectors for ensuring quality in:

Concrete inspection (including joints)

Post-Tensioning Operations

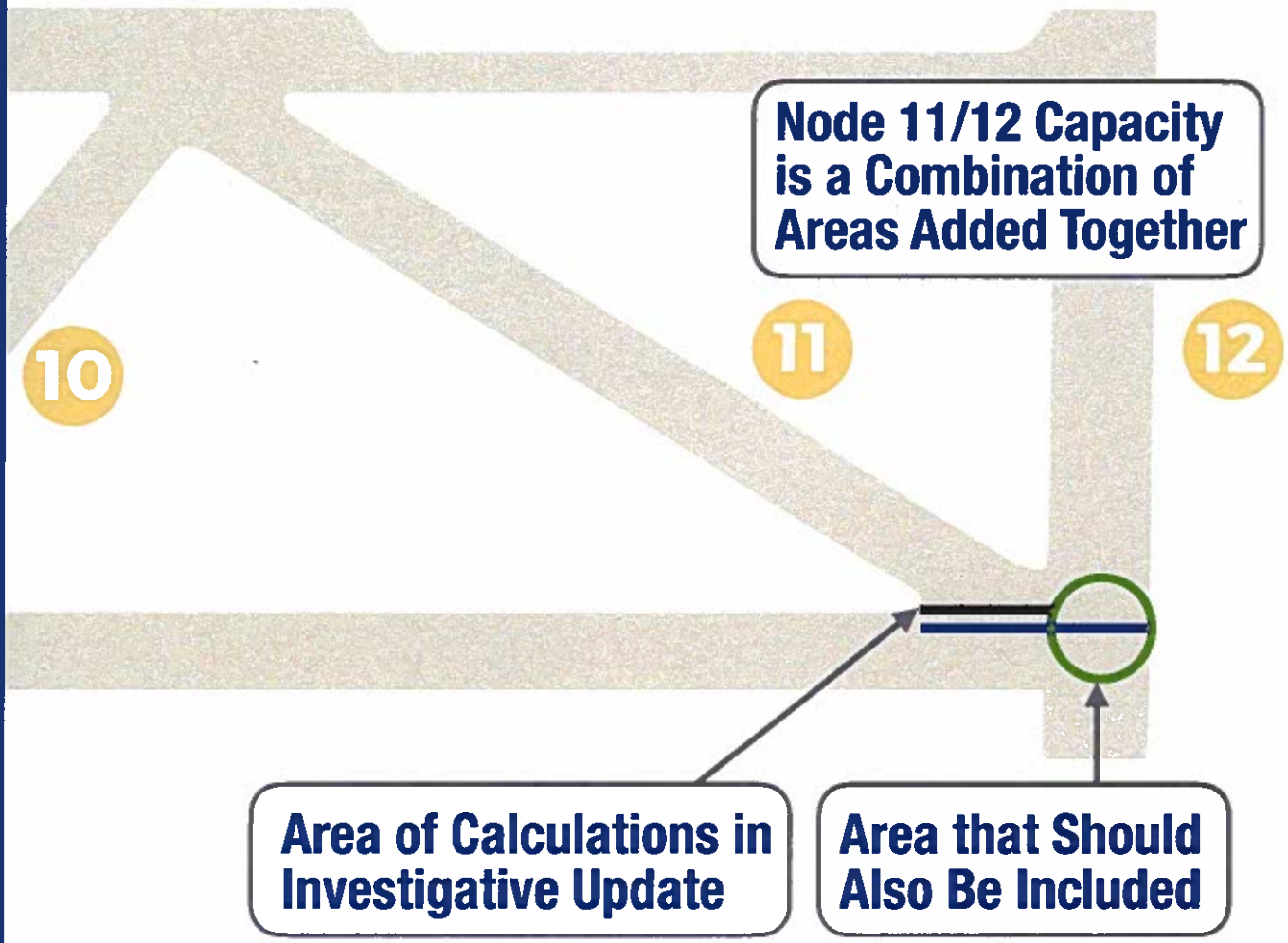
FLORIDA
DEPARTMENT
OF
TRANSPORTATION

STANDARD SPECIFICATIONS
FOR
ROAD AND BRIDGE
CONSTRUCTION

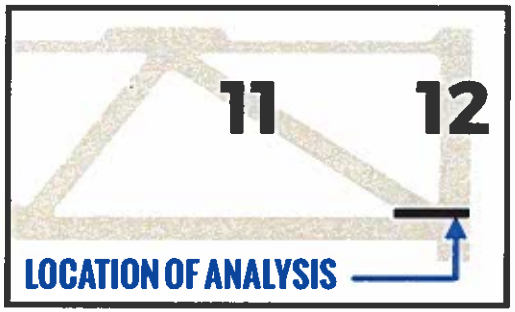
JULY 2015

FULL FINAL DESIGN IS REFLECTED IN RELEASED FOR CONSTRUCTION (RFC) PLANS

(RFC Plans approved by FDOT before construction)



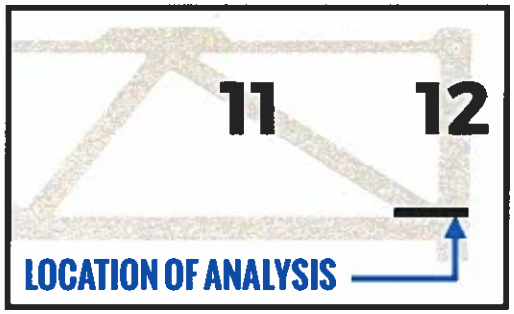
Roughened Construction Joint Surface Following FDOT Standard Construction Specifications



	CAPACITY	>	LOAD	=	SAFETY	
METHOD OF DETERMINING CAPACITY	MEMBER 11/12 CONNECTION SHEAR CAPACITY (KIPS)		SHEAR LOAD ON MEMBER 11/12 CONNECTION (KIPS)		FACTOR OF SAFETY	GOOD
WJE - Preeminent Forensic Structural Engineers						
AASHTO Design Code	2389	>	1677		1.42	✓
Full Scale Laboratory Specimen - Test Results	2485	>	1677		1.48	✓
FIGG						
AASHTO Design Code	2084	>	1661		1.25	✓

Additional information in Party Submission

Non-Roughened Construction Joint Surface Not Following FDOT Standard Construction Specifications



	CAPACITY		LOAD	≠ SAFETY	
METHOD OF DETERMINING CAPACITY	MEMBER 11/12 CONNECTION SHEAR CAPACITY (KIPS)	<	SHEAR LOAD ON MEMBER 11/12 CONNECTION (KIPS)	FACTOR OF SAFETY	NOT GOOD
WJE - Preeminent Forensic Structural Engineers					
AASHTO Design Code	1285	<	1677	0.77	✗
Full Scale Laboratory Specimen	1677	≤	1677	1	✗
FIGG					
AASHTO Design Code	1374	<	1661	0.83	✗

Additional information in Party Submission

Excluded Cause - Design

FDOT Standard Construction Specifications: "Roughen the surface of the hardened concrete"

versus

AASHTO LRFD Bridge Design Code: "intentionally roughened to an amplitude of 0.25 in."

WJE Concludes:

"...AASHTO does not provide specifics on preparation of the joint (including intentional roughening of hardened concrete) or how roughness is measured. The FDOT Standard Specifications, as proven by laboratory testing, achieves the requirements of AASHTO Code."

Excluded Cause - Design / Redundancy

Redundancy: "...the capability of a bridge structural system to carry loads after damage to or failure of one or more of its members." (AASHTO)

Types of redundancy (FHWA)

- Internal (member with multiple parallel elements)
- Structural (continuous members, fixed connections)
- Load path (more than two primary load carrying members)

Excluded Cause - Design / Redundancy

Numerous redundancy provisions in AASHTO Design Code for steel bridges - none specifically for concrete bridges

Florida Structures Design Guidelines have increased load factors for certain types of steel bridges - none for concrete bridge superstructures

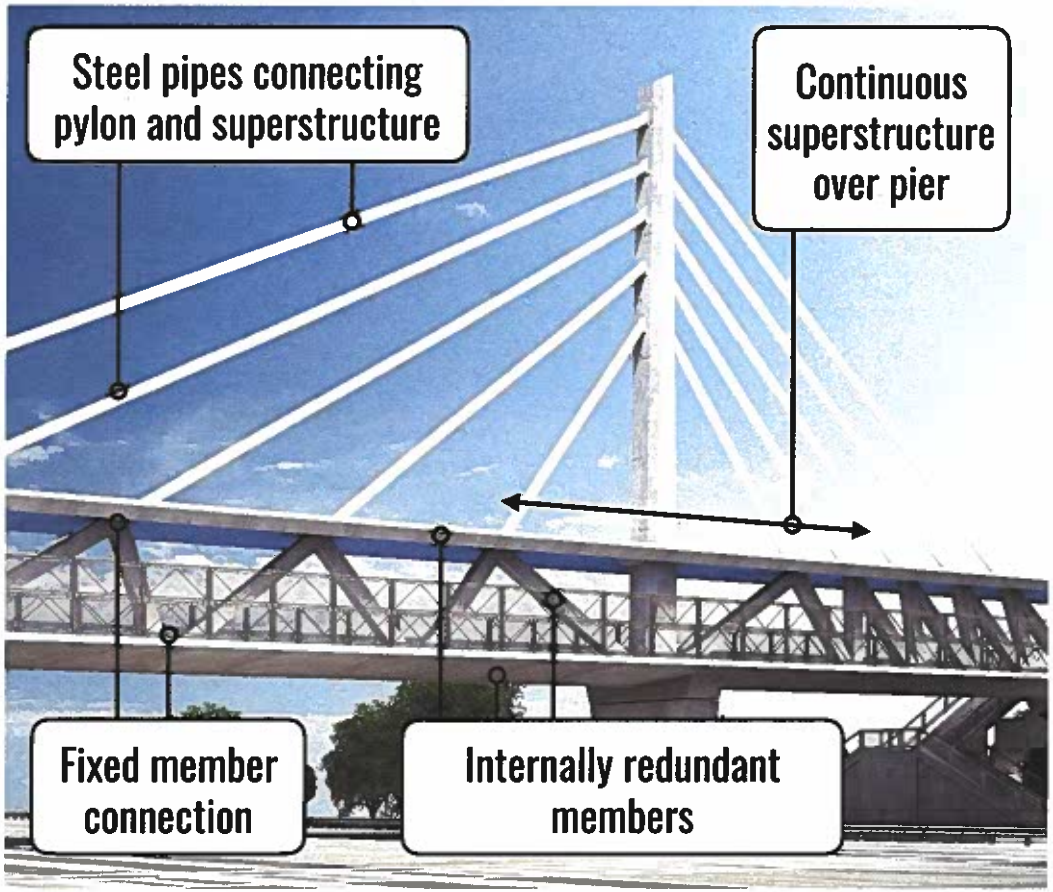
AASHTO Design Code general provision for less redundant bridges is to increase design loads by 5%

There were no documented design review comments by FDOT, FHWA or others on the subject of redundancy

Excluded Cause - Design / Redundancy

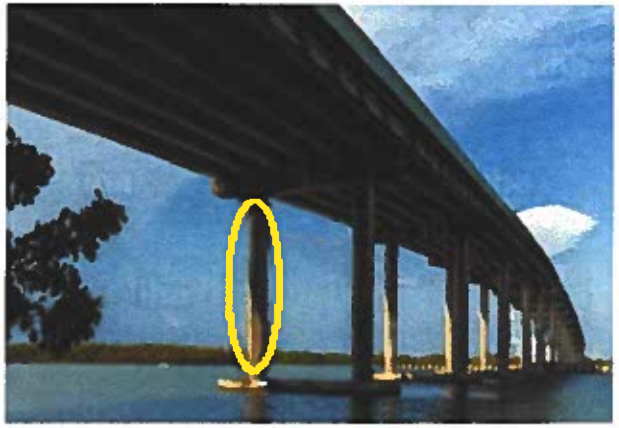
Redundant features of FIU Pedestrian Bridge

Internal Redundancy



Excluded Cause - Design / Redundancy

Common examples of less redundant bridges



Excluded Cause - Restressing Member #11

RFC Plans gave a construction sequence

Destressing the Member #11 PT bars was a step shown in the plans and carried out on March 10

MCM reported that cracking worsened after the destressing

Restressing Member #11 was reversing the previous construction step

Bridge was supported the same way with the same members stressed previously for two weeks in the precast area with satisfactory performance

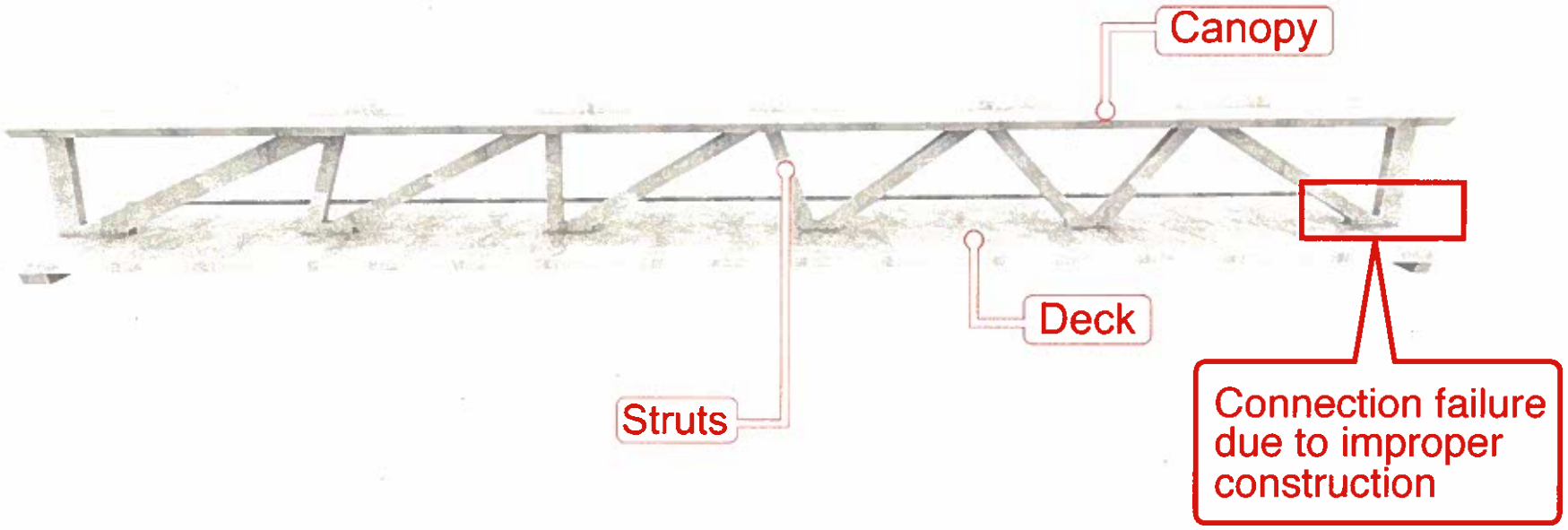
WJE tests proved that the Member 11/12 connection would not have failed with the PT bars restressed if the joint was roughened as required by FDOT Specifications

SUMMARY

Cause of Accident

Probable Cause:

Failure of Contractor to properly construct the joint between the deck and truss members in accordance with the plans and Florida DOT Standard Construction Specifications.



Cause of the Accident

Contributory Causes

Damage sustained in moving the span from casting area to the piers - twisted by 168% of the limit (unknown by FIGG).

Miscommunication between the Contractor at the site and the design engineer 500 miles away.

Failure by contractor and others to close SW 8th Street while investigating and when restressing truss member.

Failure by Contractor and others to closely monitor cracks, as instructed by FIGG, while restressing truss member.

Excluded Cause

The bridge design was not a cause of the accident

The design shown in the Released for Construction (RFC) plans met Project requirements, design codes, and industry standards.

Forensic Engineer Wiss, Janney, Elstner (WJE) concluded that the member 11/12 joint design complied with the AASHTO LRFD Bridge Design Specifications.

Full-sized specimen tests by WJE prove the member 11/12 joint would not have failed if constructed per Florida DOT Standard Specifications.

About the National Transportation Safety Board

Our Mission

"Making transportation safer by conducting independent accident investigations, advocating safety improvements…"

Source: NTSB.gov with underline added

Safety Recommendations detailed in Section 9 of Party Submission

INTEGRITY

TRANSPARENCY

INDEPENDENCE

EXCELLENCE

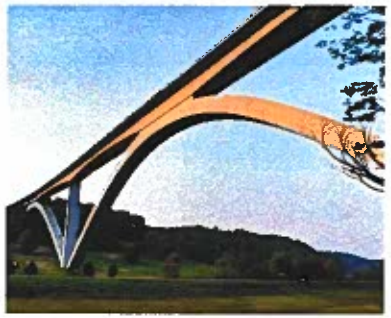
Safety Recommendations

9.1 Role of Engineer of Record (EOR) during construction

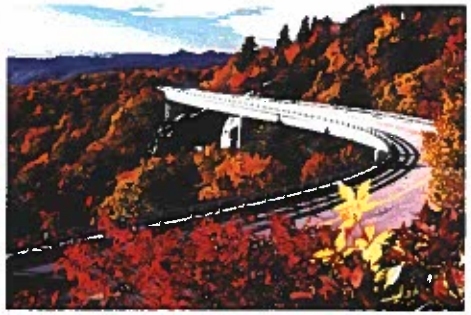
FDOT and a few other DOT's do not support EOR's on-site active oversight during construction. This is harmful to construction success.

Bridge Owners should support and require on-site inspection roles during construction for EOR.

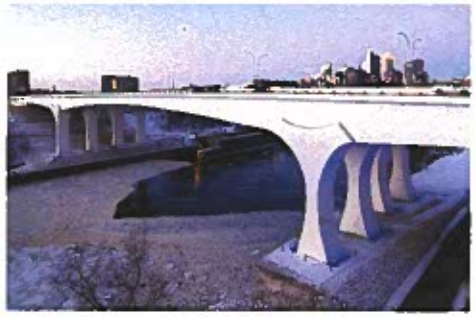
- ✦ Real-time communications
- ✦ Real-time verification of information
- ✦ Quality assurance sign-offs
- ✦ Participate in construction change information.



Natchez Trace Parkway Arches, TN
FHWA & National Park Service



Blue Ridge Parkway, NC
FHWA & National Park Service

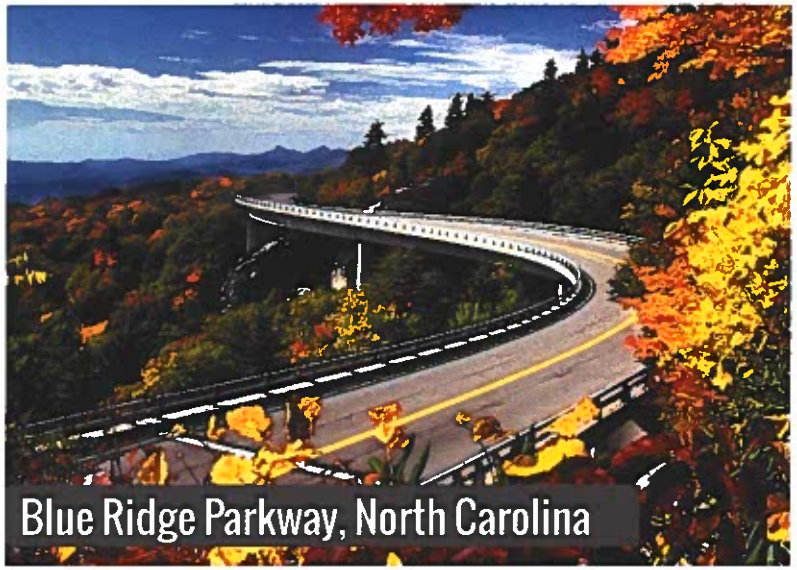


New I-35W Bridge, MN
MnDOT

Victory Bridge, NJ
NJDOT

Successful Bridges - Engineer of Record
On-Site With Active Oversight During Construction
Design-Bid-Build Bridge Examples:


Natchez Trace Parkway Arches, Tennessee


Blue Ridge Parkway, North Carolina

FIGG Designed for FHWA and the National Park Service
FIGG Oversight during construction. On-Site for the Owner Reviewing Important Aspects

Successful Bridges - Engineer of Record
On-Site With Active Oversight During Construction
Design-Bid-Build Bridge Examples with Accelerated Bridge Construction (ABC)

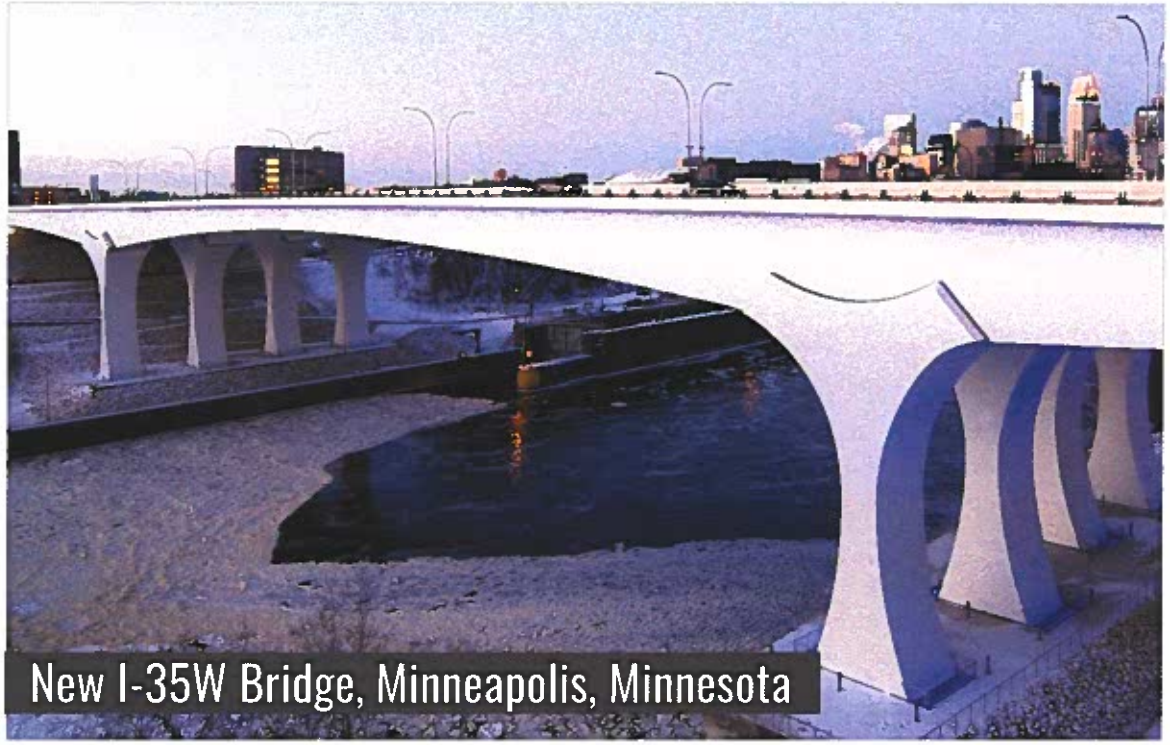
FIGG Provided design to contractor for MnDOT

MnDOT had FIGG responsible for final on-site sign off on construction quality assurance prior to construction activities

25 Awards

10-lane interstate bridge

Designed and built in 11 months, 3 months early



New I-35W Bridge, Minneapolis, Minnesota

Successful Bridges - Engineer of Record
On-Site With Active Oversight During Construction
Design-Bid-Build Bridge Examples - FHWA "Highways for Life" Program Success

FIGG designed bridge for New Jersey DOT

FIGG led the Construction Engineering & Inspection during construction for the New Jersey DOT.

Victory Bridge, New Jersey

9.2 Training for Contractors and Inspectors of Concrete Construction Joints

Encourage more training and certifications for both inspectors and construction quality manager on concrete construction joints

Expand FDOT's established Concrete Inspectors Training Certifications for FDOT Standard Construction Specifications

EXAMPLE OF INTENTIONALLY ROUGHENED CONCRETE SURFACE (ROUGHENED JOINT)

per Florida Department of Transportation's Standard Construction Specifications

1. Hands-on training and photographic examples
2. Physical specimen examples for visual inspection. Create test questions on which samples meet the Standard Construction Specifications.
3. Hands on practice sessions with various on-site tools.
4. Industry presentations on lessons learned.
5. Share the FDOT program with other states nationally including benefits to the training and certifications.

9.3 Personal Safety Equipment

Support, encourage, and require construction industry change to improve protective helmets, or hard hats, for construction workforce to enhance head protection in falls and to protect the wearer from rotational injuries from an impact.

Better hard hats could possibly have prevented the fatality and severe injuries of 2 workers on the bridge

President of Structural Group shared at Industry Meeting

Clark Construction has been a leader in new hard hats with chin straps

CURRENT CONSTRUCTION HARD HATS

PROTECTIVE HEAD GEAR WITH CHIN STRAP

BIKIING

MOUNTAIN CLIMBING

SKIING

U.S. Centers for Disease Control and Prevention
...that asserts that "the construction industry has the greatest number of both fatal and nonfatal traumatic brain injuries (TBI) among U.S. workplaces," and which further states that from 2003 to 2010, 25% of all construction fatalities were caused by a TBI

> **The recommended solution is to require that all construction hard hats include a mandatory chin strap device that will securely hold the hard hat in place, and mandatory friction layer in the liner that allows for sliding movement.**

NTSB's strong voice for a national initiative on more advance hard hats can save workers from future injuries involving construction accidents.

Featured Exhibits of FIGG Party Submission

Exhibit A – WJE : Research and Analysis Engineering Report (128 pages)

Exhibit B – FHWA Turner-Fairbank Highway Research Center Factual Report
Concrete Interface Under Members 11 and 12
October 19, 2018 (15 pages)

Exhibit C – NTSB Office of Research and Engineering
Materials Laboratory Division
Selected surfaces on Member 12 and the deck under Member 11
August 27, 2019 (16 pages)

Exhibit D – BDI report on Monitoring of Lift and Move Procedures
April 4, 2018

QUESTIONS?