

SALIENT DETAILS OF A RECENTLY COLLAPSED PARTLY- CONSTRUCTED PEDESTRIAN BRIDGE AT FLORIDA

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(This article is prepared by Sh. Alok Bhowmick, Honorary Secretary, IAStructE by collecting available information in public domain (Source : Internet) and compiling the same sequentially. The information is shared in this newsletter with the objective of disseminating such useful technical information to the wider structural engineering profession so as to learn lessons from such failures and to prevent its reoccurrence. The source of these information is thankfully acknowledged and useful links are given at the end of this article for the benefit of readers, who would be interested to know more on the subject matter.*

On March 15, 2018, at 1:47 pm, a 53 m span, partly-erected structure of the Florida International University (FIU) pedestrian bridge collapsed onto the major highway (U.S. Route 41). The main span over highway, of span length 53m was rolled into place and set on support columns on March 10, five days before the collapse. The canal span, access ramps, and faux cable-stay tower had not yet been built. Pedestrian use was to begin when the whole project was complete. The school was on spring break at the time of collapse. The section of the bridge that collapsed weighed 860 metric tons and fell onto several vehicles on the roadway below. The Bridge failed catastrophically crushing rows of cars stopped at a red light on a busy thoroughfare. Six people were killed and 10 injured. The bridge was under construction by the Miami firm "Munilla Construction Management (MCM)" and the design was carried out by FIGG Bridge Engineers Inc. of Tallahassee, Fla.

Structural Arrangement of the Pedestrian Bridge

This 2 span bridge was an iconic structure in the making with very unique open concrete trussed arrangement. Architecturally the structure was made to appear like a cable stayed bridge with a central pylon. The span arrangement for the bridge comprise of 2 spans of length 99' (30.18m) and 175' (53.34m). The overall width of the bridge was 30' (9.15m). The bridge was to cross a major six lane busy roadway and a parallel water canal with two separate spans connected at a faux (cosmetic) cable-stay tower. The overall bridge length was 320' (98 m).

The cross section of this single plane central, open truss, comprised of a narrower top chord that served as a canopy over the wider bottom chord, which was to serve as the walkway. Pipes that would have the appearance of cables were to have extended downward from a 109'(33.22m) high central pylon, adding stability. As per MCM-FIGG's proposal, the concrete deck was to have two-way post-tensioning tendons. The concrete truss members including the canopy were to have been compressed with high-strength steel cable and bars. The bridge was to be the first in the world composed entirely of "self-cleaning" concrete with titanium dioxide. Fig.1 shows the 3D rendering of bridge cross section from the pedestrian's perspective.

Fig.2 below shows the artistic view of the bridge. The bridge was designed and being constructed using the concept of "accelerated bridge construction," or ABC, a technique of fast-tracked prefabricated concept that has been promoted aggressively

in USA, at both the state and federal levels. More than 1,000 bridges have been built with it, and it is ironical that FIU is one of the leading research centre for this kind of engineering.

The \$14.2 million project was funded with a \$19.4 million Transportation Investment Generating Economic Recovery (TIGER) grant from the United States Department of Transportation in 2013, along with state agencies. The bridge itself cost \$9.4 million to construct. When the bridge collapsed, the project was already running about \$2.6 million over its \$9.4 million initial budget. Originally scheduled to be completed in July, the finish date had been pushed back to January 2019.



Fig.1 3D rendering of bridge Cross Section

In their winning 2015 proposal, designers said the bridge provided "spectacular views" for both pedestrians using the bridge and drivers passing beneath it.

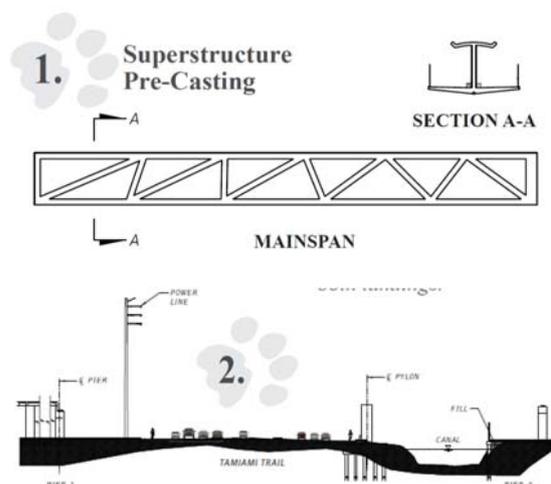


Fig.2 Elevation of the proposed Pedestrian Bridge at FIU

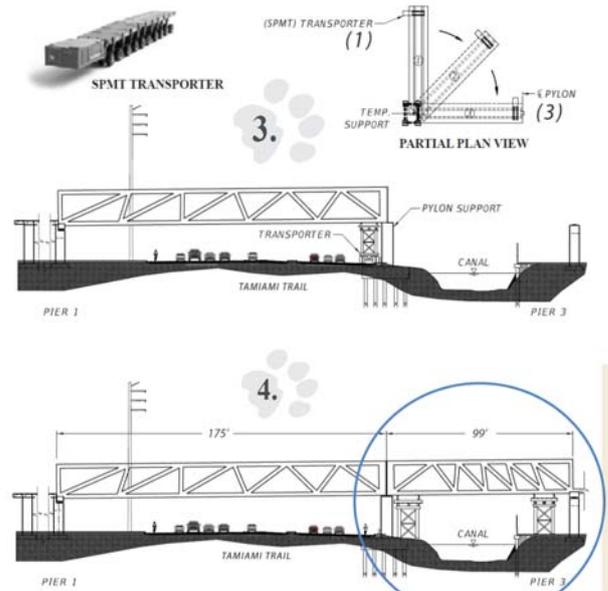
Proposed Construction Scheme

The step by step construction methodology proposed to be adopted for this bridge is as described hereunder with sketches:

- STEP 1: Superstructure Precasting :** Cast main span superstructure including deck and canopy. Pre casting is carried out beside the actual site, but in a direction perpendicular to the axis of the bridge. Stress below slab longitudinal and transverse post tensioning cables.



2. **STEP 2: Substructure casting in-situ** : Build all footings and base of pylon. Build column frame for both landings.
3. **STEP 3: Position Main Span** : Rotate main span from casting position to final position. Build all footings and base of pylon. Install bearing pads in Pier 1 and remove temporary support. Secure truss at pylon support next.
4. **STEP 4: Casting of Back Span** : Erect temporary falsework on banks of canal. Install bearing pads at pier 3. Cast deck, truss and canopy. Rotate main span from casting position to final position. Build all footings and base of pylon. Install bearing pads in Pier 1 and remove temporary support. Secure truss at pylon support next.



Stage of Construction at the time of collapse

The schematic arrangement of the 2 span structure and the status of construction at the time of collapse is given in Fig. 3 below.

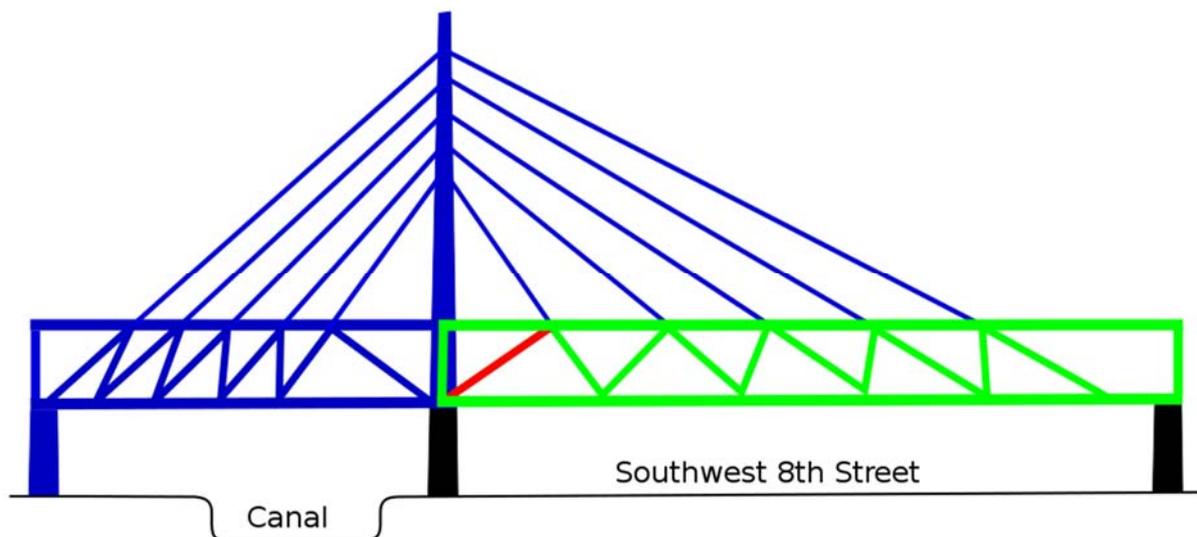


Fig. 3 : Schematic General Arrangement of the bridge.

LEGEND :

- Green: indicates collapsed parts,*
- Blue: indicates not installed at the time of the collapse.*
- Red : Indicates the diagonal beam that was undergoing post-tension cable/rod adjustment at the time of the collapse.*

The 862-tonne, 174' (53m) pedestrian bridge had been newly erected on 10th March 2018, in just six hours. The span was positioned by rotating the entire precast span using SPMT transporter (Fig.4). 2 days before the collapse, the engineering company, FIGG Bridge Engineers reported about some cracks in the bridge structure at the north

end, near support. The matter was however deliberated and FIGG reportedly delivered a technical presentation on the crack to the Client, and concluded that there were no safety concerns and the crack did not compromise the structural integrity of the bridge. Dashcam videos of collapse show that the concrete, prefabricated segment of the bridge started crumbling on the same end of the span.



Fig.4 Photograph of the span being positioned over support.

Fig. 5 shows some of the photographs of collapsed bridge.

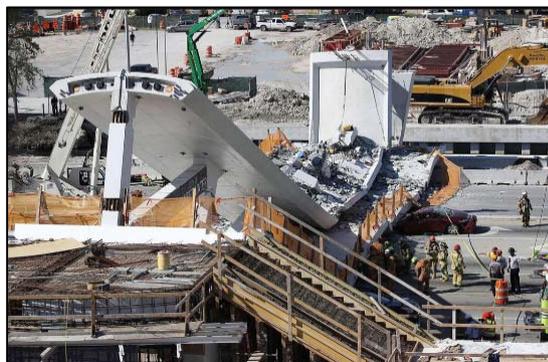
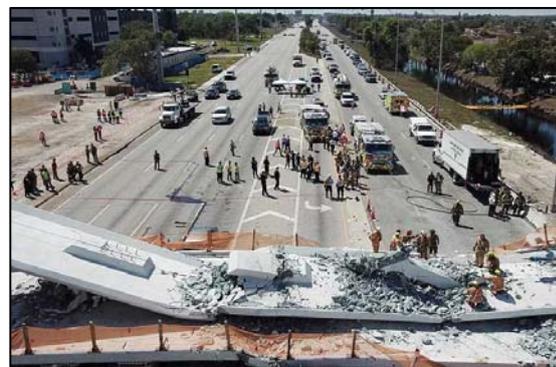


Fig.5 Few Photographs of the collapsed bridge site

Post Disaster Investigation

Florida Bridge Collapse has moved into investigation phase. National Transportation Safety Board (NTSB) are entrusted with the task. They are collecting samples of materials from the bridge to test for their physical properties. They will be reviewing drawings and plans, and examining both industry standards and site engineers' calculations to understand what was supposed to be built – to compare with what was actually constructed. They'll look at photographs and videos of the collapse to identify the sequence of events and locations of key problems. Of course, they'll also talk to witnesses to find out what workers and passers-by saw and heard around the time of its collapse. Then they'll combine and analyse all that data and information to identify as clearly as possible what went wrong, in what order. Often there are many factors,

each leading to or amplifying the next, that ultimately caused the disaster. Putting that puzzle together is a key part of the forensic engineer's role.

Collapse theory's doing the rounds

While the actual investigation is in progress, there are several possibilities which are being discussed by forensic experts as cause of the failure. One such possibility as envisaged suggests that post-tensioning triggered the failure that brought down the structure. According to the theory, collapse, occurred while a crew was post-tensioning bars in a diagonal member at the north end of the concrete truss that was the bridge's main element. The post tensioning compressed the diagonal so that it overstressed a joint in the top chord, triggering hinge failure at a connection in the lower chord and resulting in the catastrophic failure of the rest of the 53 m long structure. Fig. 6 shows one of the possible theory for collapse.

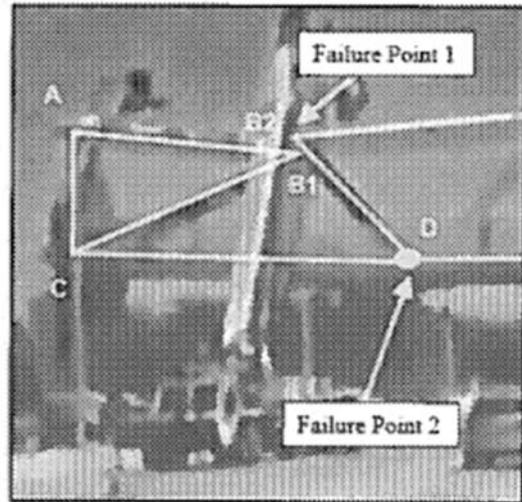


Fig.6 Possible cause of collapse

Acknowledgement

I acknowledge with thanks the informations available in following links, which has formed the basis of this report on the bridge collapse.

1. Link for dashcam video of collapse : <http://www.nydailynews.com/news/national/dashcam-video-shows-deadly-florida-bridge-collapse-killed-6-article-1.3888934>
2. CBS News dated 20th March 2018 : <https://www.cbsnews.com/news/florida-bridge-collapse-fiu-florida-state-university-project-behind-schedule-over-budget-updates-2018-03-20/F>
3. WALL STREET JOURNAL NEWS : <https://www.wsj.com/articles/florida-bridge-collapse-moves-into-investigation-phase-1521406355>
4. MCM-FIGG PROPOSAL-WALKTHROUGH : https://www.youtube.com/watch?v=5Y_71L35Cv
5. SEFI FORUM