

# FIU Pedestrian Bridge Collapse



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# Engineering Disasters – FIU Pedestrian Bridge Collapse - Quiz

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1. The NTSB investigation focused on all of the following except:
  - a. Peer review of complex bridge designs
  - b. Bridge design and construction plan errors
  - c. A comparison to international design standards
  - d. Redundancy guidelines
  
2. True or False: Clamping force is the compression (vertical) force that contributes to interface shear.
  - a. True
  - b. False
  
3. What most accurately describes interface shear surface?
  - a. The area of the web member connecting to the truss chord.
  - b. The contact area between two concrete elements that transfers opposing forces across the joint.
  - c. The area of the chord member in compression near the joint.
  - d. The sum of the area of all members combining at a truss joint.
  
4. What was the primary cause of the FIU pedestrian bridge collapse?
  - a. Poor design standards.
  - b. A poor peer review.
  - c. A failure to understand the severity of the cracking.
  - d. Calculation errors made by FIGG Bridge Engineers, Inc.
  
5. Contributing to the severity of the collapse outcome was the failure of MCM; FIGG; Bolton, Perez and Associates; FIU; and FDOT to cease bridge work when structural cracking reach unacceptable levels and to take appropriate action to close SW 8<sup>th</sup> street.
  - a. True
  - b. False

6. The bridge deck was \_\_\_\_\_ wide?

- a. 32 feet
- b. 25 feet
- c. 15 feet
- d. 10 feet

7. Emergency response units arrives at the scene of collapse within \_\_\_\_\_.

[Keyword: 911]

- a. 3 minutes
- b. 5 minutes
- c. 7 minutes
- d. 15 minutes

8. How many people were killed when the bridge collapsed?

- a. 3
- b. 6
- c. 9
- d. 12

9. Why did each diagonal web member have a different angle and length?

- a. So the bridge could aesthetically resemble a cable-stayed bridge
- b. To create a stronger design
- c. To create a safer bridge
- d. To increase the redundancy of the bridge

10. All truss members including the top chord, bottom chord, and all diagonal web members were to be permanently post tensioned.

- a. True
- b. False

11. A typical truss bridge has \_\_\_\_\_

- a. Redundant using two parallel trusses
- b. Similar triangular sections created by evenly space web members
- c. Steel members
- d. All of the above

12. It was the North end of the bridge that collapsed and hinged at member 10.
- True
  - False
13. The costs for the peer review according to the request for proposal was to be incurred by the \_\_\_\_\_.
- FIU, the owner
  - Bridge engineering firm
  - design-build firm
  - FDOT
14. The bridge was to be constructed in \_\_\_\_\_ stages.
- two
  - four
  - six
  - eight
15. The main bridge was to be constructed in three separate concrete pours. The surface between two castings is referred to as a "\_\_\_\_\_".
- cold joint
  - pour stop
  - critical joint
  - casting joint
16. The FIGG plans did not specify the interface surface at the cold joint between the deck and members 11 and 12 be intentionally roughened.
- true
  - false
17. Member 11 once in its final constructed state was going to be in compression. However during transport of the bridge the temporary shore locations caused the member to be in tension. The solution was to temporarily post-tension member 11.
- true
  - false

18. After the main span was permanently placed on the south and pylon piers, and the SPMT supports were removed, the PT rods in diagonals \_\_\_\_ and \_\_\_\_ were detensioned as specified in the plans.

- a. 11 and 12
- b. 8 and 12
- c. 5 and 6
- d. 11 and 2

19. In late February, a crack has been observed in the truss member 11 and 12 nodal region. This was before the truss was transported.

- a. true
- b. false

20. The collapse occurred immediately after the retensioning of member 11 \_\_\_\_\_ .

- a. post tension
- b. mild steel
- c. drainage duct
- d. all of the above.

21. Cracks had begun to appear up to three weeks before the bridge collapse. Employees from the following entities had taken photographs of the cracking.

- a. FDOT
- b. FIU
- c. FIGG
- d. MCM
- e. All of the above

22. Per table 2, how many times did FIGG engineers express that the cracking in nodal region 11 and 12 did not pose a safety issue?

- a. 1
- b. 3
- c. 7
- d. 10

23. What was the stated reason by Figg, that the change in the build/construction of retensioning member 11 was not peer reviewed?

- a. This was not a design change
- b. Because they were moving the member back to a pre-existing state
- c. Peer reviews are not required after the plans are permitted per FDOT
- d. The Peer review engineer was out of town.

24. When calculating nominal interface shear resistance, the Value of  $P_c$  the maximum load factor that should be applied is 0.9 as recommended by FHWA. The maximum that can reasonably be applied is 1.0 for this type of calculation. FIGG used a load factor of \_\_\_\_\_.

- a. 0.9
- b. 1.0
- c. 1.25
- d. 1.6

25. Per the "Plans Preparation Manual", the peer review is intended to be check of the engineer of record's plans and calculations and does not require the reviewer perform independent calculations.

- a. True
- b. False

26. Louis Berger performed the peer review, however it only checked the design in its completed state. Louis Berger did not consider sequencing in its review. It also did not check the \_\_\_\_\_.

- a. rebar
- b. truss member connections.
- c. concrete deck
- d. concrete canopy

27. Louis Berger submitted a bid for the peer review work. They informed FIGG that they were prequalified for work type 4.3.1, complex bridge design-concrete. FDOT's website also listed Louis Berger as prequalified for work type 4.3.1. However FDOT's website was \_\_\_\_\_.

- a. incorrect
- b. correct

28. The post collapse concrete samples confirmed that the compressive strength and the air content of the concrete met project requirements.

- a. True
- b. False

29. The NTSB concludes that the concrete and steel materials used during the construction of the pedestrian bridge, were not a factor in its collapse.

- a. True
- b. False

30. NTSB had to develop independent analytical models to determine the design loads imposed on the failed node because \_\_\_\_\_.

- a. the software FIGG used was too old.
- b. FIGG failed to provide the calculations.
- c. there was an insufficient level of detail in the FIGG design calculations.
- d. calculations for the second stage were never performed.

31. FIGG incorrectly determined that the bridge was a redundant structure and used a redundancy factor of \_\_\_\_\_

- a. 0.95
- b. 1.0
- c. 1.05
- d. 1.25

32. FHWA and the NTSB concluded that the bridge was not redundant because it had a \_\_\_\_\_ load path.

- a. singular
- b. parallel
- c. dual
- d. alternative

33. The mechanics of interface shear can transfer shear forces across a cold joint. The resistance is provided by friction, chemical bond, and force \_\_\_\_\_ the two surfaces together.

- a. pulling
- b. shearing
- c. bonding
- d. compressing

34. FIGGS plans did not specify that the joint at node 11/12 be intentionally roughened to a 0.25 inch amplitude though it appears that FIGG calculations assumed the joint would be roughened.

- a. true
- b. false

35. When calculating the permanent net compression  $P_c$ , for calculating the clamping force across a joint the maximum recommended load factor to use with  $P_c$  is \_\_\_\_\_.

- a. 0.6
- b. 0.9
- c. 1.0
- d. 1.25

36. When calculating interface shear capacity the load factors used in the calculation should \_\_\_\_\_ interface shear capacity.

- a. minimize or reduce
- b. maximize or increase

37. FIGGS error in calculating the interface shear capacity at node 11/12 overestimated the joints interface shear capacity by approximately \_\_\_\_\_.

- a. 10%
- b. 25%
- c. 50%
- d. 75%

38. When determining the clamping axial load  $P_c$  both dead loads and live loads can be used.

- a. true
- b. false

39. FHWA's models show that FIGG underestimated interface shear demand at nodal region 1/12 by approximately \_\_\_\_\_ percent in their design of the node.

- a. 10
- b. 33
- c. 39
- d. 46

40. To counteract the failings of FIGG failings, the NTSB recommends that AASHTO provide additional guidance for \_\_\_\_\_.

- a. reasonable estimates for interface shear demand
- b. contributions of cohesion and friction contributions to interface shear capacity
- c. clamping force across the interface shear surface
- d. all of the above

41. During the process of progressively removing the falsework, on February 24<sup>th</sup>, loud, distinct cracking noise was heard and a \_\_\_\_\_ was found in the member 11/12 nodal region.

- a. crack
- b. stain
- c. hole
- d. spot

42. Another contribution to the failure of nodal region 11/12 was the embedment of was the presence of four hollow vertical pipe sleeves and the horizontal \_\_\_\_\_.

- a. confinement reinforcement.
- b. post tensioning duct
- c. rebar
- d. drain pipe

43. NTSB concludes that the progression of the cracking should have alerted both FIGG and MCM that the structure was progressing towards failure.

- a. true
- b. false

44. FIGG's attempted solution of retensioning the post tensioning, \_\_\_\_\_ the overstressed state of nodal region 11/12 with the bridge in the simply supported position.

- a. improved
- b. worsened

45. In addition to Louis Berger not being qualified to perform the peer review, they also failed to complete their scope of work which included analysis and checking of the \_\_\_\_\_.

- a. connection nodes and cold joints
- b. member stresses
- c. cost analysis
- d. team qualifications

46. The cracks apparent before failure exhibited the following characteristics: \_\_\_\_\_
- sizes well beyond any level of acceptability
  - widths that were indicative of reinforcement steel yielding and potentially complete fracture of the reinforcement
  - cracks that per FDOT standards required an engineering evaluation by the bridge design and EOR firm, FIGG
  - all of the above
47. Because of the failure of Bolton Perez, FIU, FIGG, or FDOT to close the bridge, the NTSB concludes that LAP agreements require stronger language to clarify that the certified local agency has the authority to immediately close a bridge when structural cracks are first detected or in situations that require further investigation to protect the health, safety, and welfare of the public.
- true
  - false
48. FDOT should have provided greater \_\_\_\_\_ of this complex local agency program project to ensure that all safety issues were identified and addressed.
- latitude
  - oversight
  - reviews
  - cost overage allowances
49. NTSB recommends that FDOT revises the *Plans Preparation Manual* to require that the qualified independent peer review for category 2 bridge structures include checking and verifying the design calculations used for all \_\_\_\_\_ forces.
- axial
  - tension
  - both a and b
  - nodal
50. NTSB recommends that the FHWA add a discussion about \_\_\_\_\_ in the LRFD Bridge design specifications and the LRFD Guide Specifications for the Design of Pedestrian Bridges.
- redundancy
  - corrosion
  - voids in concrete
  - curing methods