FHWA Assessment of FIGG Factor of Safety Presentation and Calculations

Miami, FL

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(3 pages)

At the request of the National Transportation Safety Board (NTSB), the Federal Highway Administration conducted a cursory review of the slides and information presented by FIGG Bridge Engineers, Inc. at NTSB Headquarters in Washington, DC, on March 13, 2019, and titled:

> *FIU Pedestrian Bridge, Miami, Florida*
> *Factual Information from Released for Construction (RFC) Plans*
> *Pylon End of Main Span Superstructure*

As stated in the slides, the objective of the FIGG effort summarized by the presentation was to "Extract the actual forces and capacities of the main span as shown in the RFC plans, independent of submitted design calculations." When asked what was intended by "actual forces and capacities," FIGG responded that actual force was an unfactored nominal force and that the actual capacity was the nominal (unfactored) capacity as calculated using the AASHTO LRFD Bridge Design Specifications (AASHTO LRFD). When asked what the nominal capacity represented, FIGG responded that the nominal capacity is a lower bound of resistance.

As defined by the AASHTO LRFD, the nominal resistance is the "resistance of a component or connection to force effects, as indicated by the dimensions specified in the contract documents and by permissible stresses, deformations, or specified strength of materials." In general, nominal resistance equations produce estimates of resistance that represent a body of experimental data. In the AASHTO LRFD, these representative values are not a lower bound and, although generally close, are not necessarily a mean due to the bias created by the estimate of the nominal resistance equation compared to the individual experimental results.

More importantly, the nominal resistance equations of the AASHTO LRFD were not designed to be used outside of the framework in that specification. LRFD is an acronym for load and resistance factor design and is a limit state design methodology. The Strength Limit State of the AASHTO LRFD hangs on a statistically based backbone calibrated to result in achieving a target level of reliability. That is, the resistance factors that are applied to the nominal resistances and the load factors that are applied to the unfactored or nominal loads are selected to result in a target reliability index. The reliability index establishes the probability of failure of a component for the force effect being resisted. What is most important to understand is that these four parameters (nominal resistance, resistance factor, nominal load and load factor) were intended to be used together. When unfactored, a comparison of the nominal resistance to the nominal load produces an unknown level of reliability that is less than the established standard for safety.

Although the bridge was designed using the AASHTO LRFD, FIGG employed an engineering factor of safety (FOS) approach to assess the details shown on the RFC plans for this presentation. On the slide titled *Approach to the Factual Checks*, FIGG defined the FOS as the ratio of capacity (unfactored, nominal capacity) to load (unfactored, nominal load). The nominal capacity equations used produce representative capacities of the full strength of the component.

FHWA found this approach to be deficient for 2 reasons; (1) when combined in this fashion, the unfactored representative values used produce an unknown and unconservative level of reliability, and (2) the nominal capacity equation relied on the full strength of the materials used in the construction of the component and not some significantly lower working or allowable strength that is the hallmark of FOS approaches. When asked if the FOS approach was adequate to insure a safe design, FIGG responded no. As a result of these deficiencies, FHWA found that the presentation only brought additional confusion to the understanding of the origin of the design errors identified and the justification for the inaction by FIGG to the severe cracking that ultimately led to the collapse of the bridge.