Florida Department of Transportation Research

Axle Equivalent Transverse Loading on Segmental Bridge Decks
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Many bridges are constructed by spanning between columns with I-beams, on top of which concrete decks are poured. A commonly used alternative is the segmental box girder bridge. Generally, these bridges are made of precast, reinforced concrete segments which resemble a box open on two sides with a deck on top that extends well beyond the edges of the box. By placing several of these box girders end to end on top of columns, lengthy bridges can be built. An example is the Seven Mile Bridge in the Florida Keys.

Designers and load raters of box girders must analyze strength from one end to the other, along the line of travel (longitudinal dimension), and from side to side (transverse dimension). The latter is especially important because the bridge deck is cantilevered beyond the box and is subject to bending effects due to vehicle loads. Typically, designers determine bending effects using a Homberg chart, which match selected box girder design parameters. Available Homberg charts may not encompass the wide variety of truck weights and geometries that cross Florida bridges, yet each of these vehicles must be permitted by FDOT to cross specific bridges, which demands confident understanding of stresses that the vehicle will induce in the bridge structure. It is impractical to develop a Homberg chart for every vehicle or combination of vehicles for which a permit is sought. So in this project, Florida State University researchers used finite element modeling (FEM) to verify and extend current design and evaluation practice for box girder bridges, developing software for the FDOT Office of Maintenance to help in evaluating and permitting vehicles for crossing segmental box girder bridges.

The researchers used FEM to model the Channel Five Bridge located in the Florida Keys. Numerous virtual loading situations were applied to the model bridge to characterize stresses. The structural effects of expansion joints, barriers, barrier joints, and diaphragms were also considered. Results showed that bending moments found using Homberg charts were, in many cases, more conservative than those derived by finite element modeling. This was not unexpected because FEM is based on a more realistic box girder, compared to the Homberg charts, which are based on idealized structures. The effect of axle load spacing was also studied, in order to give insight into the Office of Maintenance's formerly used "8-foot rule."

Box girder segments are joined end to end to form bridges. Note the wings that extend to either side of the "box".

The researchers developed an Excel tool that automates locating the right Homberg chart. The tool includes many standard vehicle categories, but it can also work with a user-supplied truck description. The tool analyzes vehicle loads quickly, simplifying the comparison of effects of different vehicles. For example, vehicle effects analyzed in the designer's load rating could be compared to vehicles with axle weights and spacings that were not analyzed in the initial load rating. The final report for the project contains a tutorial about how to use the tool.

The products of this project will lead to a more refined permitting process, which will protect Florida box girder bridges from unnecessary damage and maintenance.

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