Florida Department of Transportation Research

Determination of Brace Forces Caused by Construction Loads and Wind Loads during Bridge Construction

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Bridges are constructed in stages as pilings, columns, girders, decks, and other components are added. At each stage, the structure must be stable. Girders, which add significant weight to the developing structure, rest on elastomeric bearing pads which allow some flexibility under environmental conditions but also make them more vulnerable to wind loading — girders have been toppled by sufficient wind — and from loading due to subsequent construction stages. Girders are usually stabilized by braces until construction is complete. Design of these braces must be based on a thorough understanding of the forces involved.

In this project, University of Florida researchers had two objectives: first, develop procedures for determining bracing forces during bridge construction; and second, experimentally determine wind load coefficients (drag, torque, and lift) for common bridge girder shapes with stay-in-place formwork and overhang formwork in place, then develop recommended global pressure coefficients suitable for use in bridge design.

To determine bracing forces during bridge construction, the researchers developed numerical finite element (FE) models and analysis techniques to evaluate forces induced by construction loads acting on precast concrete girders (Florida-I Beams) in systems of multiple girders braced together. A large-scale parametric study was performed with both unfactored and factored construction loads. Over 450,000 three-dimensional structural analyses were conducted considering different Florida-I Beam (FIB) cross-sections, span lengths, girder spacing, deck overhang widths, skew angles, number of girders, number of braces, and bracing configurations. Additionally, partial coverage by wet (non-structural) concrete load and variable placement of deck finishing machine loads were considered.

Results from the extensive FE analyses were stored in a database indexed by the many

The cross-braces between these girders stabilize them against loading from the wind and the construction activities that will take place on top of them.

parameters considered. As complete FE analysis is not practical for day-to-day design, researchers developed software in MathCad so that design factors for new projects could be developed from this database by interpolation. The accuracy of the database program was assessed by using it to predict end-span and intermediate-span brace forces for parameter sets not explicitly contained in the database, and then comparing the predictions to results obtained by using the same parameter set in a finite element analysis. In a majority of cases, the database-predicted brace forces erred less than ten-percent (10%).

Reduced-scale models of FIB, plate girder, and box girder cross-sectional shapes with stay-in-place formwork were tested in a wind tunnel to measure aerodynamic forces acting on individual girders in the bridge cross-section. Tests were conducted at multiple wind angles. Corresponding tests were conducted with and without overhang formwork. Test data were used to develop conservative procedures for calculating global pressure coefficients.

Through this project, software tools were created that will produce better bracing designs for bridge construction. This will help to further improve the safety and efficiency of FDOT construction projects.

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For more information, visit http://www.dot.state.fl.us/research-center