Florida Department of Transportation Research

Bridge Girder Drag Coefficients and Wind-Related Bracing Recommendations
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Modern bridges are constructed with massive preformed components. On a base of piles and piers, prestressed concrete girders — up to eight feet tall and 200 feet long, weighing many tons — are set on flexible bearing pads. These girders will support concrete slabs that form the road bed and stabilize the girders. Before the road bed is added, the girders — although massive — are susceptible to strong winds, which can cause a girder to list or collapse, potentially damaging the beam and support structures, and possibly toppling adjacent girders like dominoes, leading to costly delays and repairs. For this reason, girders are cross-braced to prevent toppling.

Cross-bracing between bridge girders.

However, wind flow over parallel girders is complex. The first girder in the wind's path receives its force directly, but the forces change for each successive girder. Lateral wind loads are generally calculated using a drag coefficient, which relates wind pressure on an object to its size and the wind's speed. Drag coefficients for most common bridge girders have not been adequately addressed in the literature, so it is unknown whether any particular cross-bracing design is sufficiently conservative.

In this project, University of Florida researchers quantified drag coefficients for common bridge girder shapes and the shielding effects due to aerodynamic interference between adjacent girders. With this, they developed conservative design parameters for computing lateral wind loads. Analytical models of braced girder systems were used to develop recommendations for temporary bracing of prestressed concrete girders subjected to the new design wind loads.

The researchers used wind tunnel testing of reduced-scale models of Florida-I Beams (FIB), plate girders, and box girder cross-sectional shapes to measure aerodynamic properties of individual girders and multiple girder systems. From these results, simplified models of wind loading for single and multiple girder systems and conservative equations suitable for use in bridge design were developed. Separate wind load cases were developed for assessing overall system stability and required brace strength.

The researchers also developed procedures for assessing temporary bracing requirements to resist wind load during bridge construction. Finite element techniques were used to evaluate the stability of FIB, both singly and in braced, multiple girder systems. A byproduct of this effort was a new way of estimating bearing pad roll stiffness, which affects girder stability during construction. After integrating the improved estimates of wind loads and bearing pad stiffness into finite element models of individual and multiple girder braced systems, several large-scale parametric studies were performed with varying FIB cross-section, span length, wind load, skew angle, anchor stiffness, and brace stiffness. Regression analyses of the parametric study results led to girder capacity prediction equations suitable for use in the design of temporary bracing for FIB during construction.

With cross-brace design on a more secure footing, there will be one less possibility for construction delays, resulting in more efficient and timely construction.

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