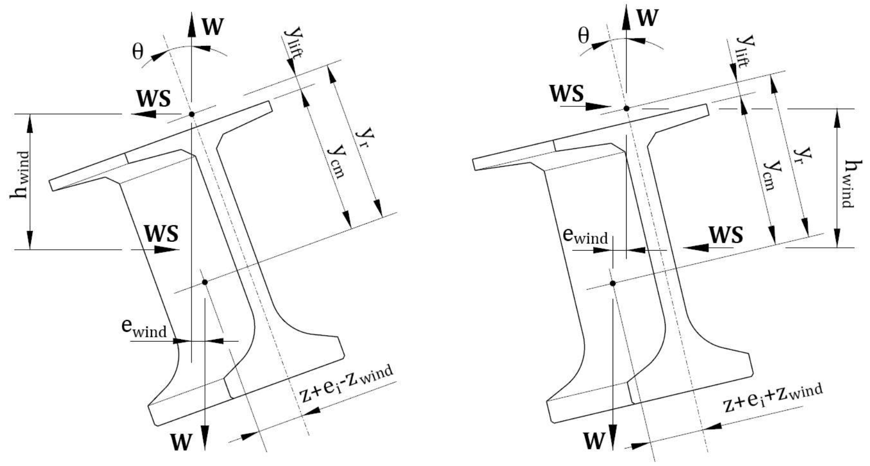
New Recommended Practice for Lateral Stability of Bridge Girders

by Glenn Myers, Atkins

The industry practice for precast, prestressed concrete bridge girders has evolved over the last 10 years to include higher concrete strengths and optimized girder sections, which allows spans exceeding 200 ft. These long and slender sections challenge the industry to produce girders that are laterally stable during production, transportation, erection, and during bridge deck construction. The PCI Committee on Bridges and the PCI Bridge Producers Committee recognized the need to develop and disseminate information about the lateral stability of prestressed concrete girders. They also wanted to provide recommendations to practitioners throughout the industry including designers, manufacturers, and owner agencies. The PCI Committee on Bridges established the Girder Stability Subcommittee consisting of a select group of industry stakeholders to create these recommendations.

Reliable analysis tools to evaluate lateral stability have now been developed and published in the PCI *Recommended Practice for Lateral Stability of Precast, Prestressed Concrete Bridge Girders*. These guidelines provide the tools to aid fabricators, transporters, erectors, and engineers for the evaluation of stability at all phases of the girders life from bed-to-bridge, including transfer of prestressing force, lifting from the casting bed, transporting to the yard storage area, supporting conditions in the yard storage area, transporting to the project site, erecting at the project site, and bracing requirements during girder setting and bridge deck construction. Once the girders are incorporated into the bridge with the concrete deck, stability of the girder is no longer an issue. The recommended practice also introduces the concept of a stability engineer. The term stability engineer is used to emphasize that the stability of the girder in all phases of construction needs to be evaluated or reviewed by a responsible professional.



Typical free body diagrams provided in the *Recommended Practice for Lateral Stability of Precast, Prestressed Concrete Bridge Girders.*

The stability engineer may be associated with any one of the entities that designs or handles the girders.

The analysis tools developed in the recommended practice build on the ground-breaking work of Robert Mast in the late 1980s and early 1990s. The equilibrium conditions developed by Mast have been enhanced to include external forces such as wind force, centrifugal force, and dynamic impact. These forces add additional deflection and overturning moments that must be accounted for in the stability analysis. The enhanced equilibrium equations are developed from free body diagrams to establish the overall girder rotation and factors of safety against cracking, failure, and overturning. The following figures are typical of the free body diagrams that are found in the document. These particular figures illustrate the lifting condition where bidirectional wind can either increase or decrease the girder rotation. The wind force also causes a lateral deflection of the beam that add to or subtract from the lateral dead load deflection of the beam in the rotated condition. These are two different conditions that must be evaluated to properly evaluate the effects of wind on the stability of the girders. Specific equations for these two conditions are derived in the recommended practice.

The free body diagrams provide the user the background to make adjustments for specific load cases that are not anticipated by the recommended practice, allowing greater flexibility in the analysis tools. A variety of conditions are evaluated, including lifting with vertical cables, lifting with inclined cables, lifting from one end of the girder while the other end is seated, transporting, seating on bearings, and maintaining stability during deck construction.

Strategies to improve the stability of girders are also presented. The methods include increasing the concrete strength, extending an embedded stiff lifting apparatus above the top of the girder, increasing the distance from the end of the beam to girder lift or transport bunking points, adding temporary post-tensioning in the top flange of the girder, increasing the rotational constant of the spring support of transport vehicles,

Lifting of a 209-ft-long Florida I-beam. Photo: Lane Construction.

increasing the width of the bearings under a seated girder, and providing bracing or other means to restrict rotation of the girder. Recommendations on the successful implementation of these strategies are included in the document.

General criteria provide guidance in establishing assumed design and construction loads, material properties, fabrication tolerances for construction, stress limitations, and overall factors of safety. Tolerances to be considered for stability include strand and prestressing force eccentricity, sweep and lateral deflection (fabrication tolerance), camber variation from design camber, and transverse and longitudinal location of lifting devices. Design loads that may be applied to the girder before full incorporation into the bridge include permanent loads such as dead load and effective prestress, and transient loads such as dynamic impact, centrifugal force, wind loads, and construction live loads.

Additional considerations for stability are also presented to describe construction processes affecting stability during girder manufacture, transportation to the bridge site, erection at the bridge site, and stability during the construction of the bridge deck. As an example, the addition of temporary post-tensioning to add compression into the top flange is described, which will increase the factor of safety against cracking. For girders supported on elastomeric bearings, the degradation of the roll stiffness due to bearing uplift or skewed bearing orientation is described. This degradation significantly reduces the roll stiffness and stability factors of safety.

Example calculations are provided to illustrate many of the conditions encountered including lifting with vertical cables, lifting with inclined cables, seated during transport, single girder seating on bearings, and stability during deck construction. In the lifted condition, varying degrees of wind load and dynamic impact are calculated to show the sensitivity of these factors on the resulting factors of safety including a comparison of the factors of safety between lifting with vertical cables.

The PCI *Recommended Practice for Lateral Stability of Precast, Prestressed Concrete Bridge Girders* is an essential resource for stability engineers to aid fabricators, transporters, erectors, and engineers for the evaluation of stability at all phases of the girders life from bed-to-bridge.

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EDITOR'S NOTE

Recommended Practice for Lateral Stability of Precast, Prestressed Concrete Bridge Girders *is available through the PCI bookstore in hard-copy and as an e-Pub at www.pci.org.*