Consideration of Construction Loads During Bridge Design

by Brian Witte, Parsons

Although design engineers are tasked with designing bridges based on current standards and specifications, they may overlook or not have a firm understanding of temporary loads and conditions during construction. Construction engineers develop the means and methods to safely build bridges and evaluate various components or partially completed bridges under construction loads. However, in some cases, construction loads may control aspects of the bridge design that can lead to schedule delays and claims if not addressed during design.

Article 1.3.1 of the American Association of State Highway and Transportation Officials' *AASHTO LRFD Bridge Design Specifications*[1] states, "Bridges shall be designed for specified limit states to achieve the objectives of constructability, safety, and serviceability..." Because bridge designers have to make assumptions about how a contractor will build a bridge, their design can satisfy this clause for one set of assumptions but may not satisfy it for another set of assumptions, especially for complex bridges, long-span bridges, or bridges with difficult site conditions. For this reason, aspects of safety, constructability, and stability during construction have traditionally been delegated to the contractor and the construction engineer, with the design engineer focused on specific code provisions and owner's guide specifications for the final in-place structure. However, awareness of construction challenges can help design engineers anticipate and mitigate potential issues during the design process. This does not alleviate the construction engineer's responsibility to consider temporary loads throughout construction. Some items are better addressed through construction submittals, as each contractor will have different means and methods. However, the following are a few temporary construction load conditions that should be considered and addressed, if needed, during the design phase.

Girder Stability

Girder stability is a significant concern during construction even before the girder is in place, especially as span lengths continue to increase. Article 5.5.4.3 of the AASHTO LRFD specifications states, "Buckling and stability of precast members during handling, transportation, and erection shall be investigated." Furthermore, the commentary states that lateral bending stability analysis should be based on PCI's *Recommended Practice for Lateral Stability of Precast, Prestressed Concrete Bridge Girders.*[2] This PCI publication, along with its companion publication, *User Manual for Calculating the Lateral Stability of Precast, Prestressed Concrete Bridge Girders*,[3] provides explicit guidance and spreadsheets for evaluating girder stability. Both PCI documents are available for free download in PCI's online bookstore. These are useful tools for owners, designers, construction engineers, and precast concrete manufacturers.

"Buckling and stability of precast members during handling, transportation, and erection shall be investigated..." — AASHTO LRFD specifications, Article 5.5.4.3

Wind Loads During Construction

Traditionally, wind loads are applied to a bridge after the deck is in place and the deck provides the benefit of bracing the

Erecting a 196-ft-long girder for the High Rise Bridge in Chesapeake, Va. Moving girder pick points in from the end of the girder, as can be seen in this photo, is one method of improving girder stability during erection. All Photos: Parsons.

girder top flange with diaphragm action. Although girders are most vulnerable to wind before deck placement, until recently there has been no specific guidance (other than some owners' design guides) regarding how to address wind loads during construction. This was remedied by the 2017 publication of the AASHTO *Guide Specifications for Wind Loads on Bridges during Construction*.[4] Although the projected wind area of a girder is smaller than the completed bridge cross section, studies found higher drag coefficients on individual girders and additional drag forces on leeward girders before the deck formwork is in place. These effects combine to generate higher wind pressures on girders before decking than would be predicted using the AASHTO LRFD specifications methodology for in-service loads. These wind loads during construction become increasingly important with very long precast concrete girders. Because these wind loads are applied to the erected girder before deck placement, temporary bracing may be required to resist these forces. Temporary cross-frame bracing (that is, a horizontal bracing system to resist lateral loads) is typically designed by the construction engineer; however, very long girders may require lateral plan bracing if exposed to high wind loads during construction. Because this type of bracing is uncommon for precast concrete girders, designers should identify whether lateral plan bracing is needed.

Overhang Falsework

Cantilever falsework brackets hanging from fascia girders are typically used to support deck overhang concrete, personnel live load, and the deck-finishing screed equipment during deck casting. Deck-finishing equipment typically consists of the deck screed, weighing 12 to 20 kips, followed by one or two finishing bridges, weighing 1 to 3 kips each, riding along the edge of deck formwork. The overhang brackets impose vertical and torsional loads on the exterior girder. The torsional loads are typically resisted by connections to interior girders through permanent or temporary intermediate bracing or end diaphragms. For small overhangs on short girders, this effect may be minimal; however, the influence of large overhangs or long girders is more pronounced and must be considered. Some owners have standard details for permanent intermediate bracing between precast concrete girders that have been evaluated for typical overhangs. However, there are situations in which typical permanent bracing details should be checked to ensure there is adequate capacity to resist loads from a large overhang, high wind loads during construction, or both. If permanent bracing is not required, the construction engineer must check the stability of the in-place exterior girder before and during deck concrete placement and provide temporary bracing if needed. In both cases, the design engineer needs to be aware of the temporary condition of the girders during construction and include these potential load cases in their calculations to ensure a constructable design. (PCI's *Recommended Practice for Lateral Stability of Precast, Prestressed Concrete Bridge Girders*[2] can be consulted for additional guidance.)

Some contractors prefer to install overhang brackets before erecting bridge girders to reduce worker exposure to heights. Although this approach improves worker safety, the construction engineer must evaluate the girder for the additional torsional moment and possible instability imposed by the overhang brackets while the girder is supported by cranes and after it is set on bearings. Because this situation depends on contractor preference, it would not be reasonable to expect a designer to consider this load case.

Bridge designers will seldom have a perfect understanding of how any given contractor will approach a construction project, and often that imperfect perspective will not affect the success of projects involving standard bridges of modest span lengths. However, most bridge projects will benefit if the designer considers temporary construction loads during the design phase to improve constructability and reduce the potential for schedule delays and claims.

References

1. American Association of State Highway and Transportation Officials (AASHTO). 2020. *AASHTO LRFD Bridge Design Specifications*, 9th ed. Washington, DC: AASHTO.
2. Precast/Prestressed Concrete Institute (PCI) Girder Stability Subcommittee. 2016. *Recommended Practice for Lateral Stability of Precast, Prestressed Concrete Bridge Girders*. Chicago, IL: PCI. https://doi.org/10.15554/CB-02-16.
3. PCI Girder Stability Subcommittee. 2020. *User Manual for Calculating the Lateral Stability of Precast, Prestressed Concrete Bridge Girders*. Chicago, IL: PCI. https://doi.org/10.15554/CB-04-20.
4. AASHTO. 2017. *Guide Specification for Wind Loads on Bridges During Construction*. Washington, DC: AASHTO.

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Erecting an exterior girder with preinstalled overhang brackets for the Kicking Horse Canyon project, Phase 4, in Golden, BC, Canada. Because the preinstalled overhang brackets impose vertical and torsional construction loads on the exterior girder, lateral stability of the girder must be investigated while the girder is supported by cranes and after it is set on bearings.