Texas Department of Transportation

CENTER FOR TRANSPORTATION RESEARCH

PROJECT SUMMARY REPORT

0-7115: Investigate Live Load Distribution and Stability of Prestressed Concrete Girders

Background

Prestressed concrete girders are an efficient structural component widely used for bridge applications in the state of Texas. Historically, the concrete girders were primarily utilized in simply-supported bridge applications. However, recent advances have seen the use of spliced concrete girders resulting in multi-span units comprised of precast girder sections. The resulting span lengths are significantly longer than traditional applications of the precast girders. These longer span applications subsequently have more complex stages considering various erection sequences and as well as casting of the concrete bridge deck. The longer span applications result in questions regarding girder stability throughout the construction process. In addition, live load distribution in the longer girder systems is not well understood. Additional questions exist of the number of diaphragms that are required along the girder length.

What the Researchers Did

The researchers conducted extensive laboratory testing to obtain data on the flexural and torsional stiffness of typical precast girder segments utilized in Texas. Data was obtained in both the uncracked and cracked state considering various combinations of flexure and torsion on the girders. The experiments provided valuable data for validating the finite element analytical (FEA) models of the girder systems. The validated models were then utilized to conduct extensive parametric FEA studies on typical spliced-girder systems utilized in Texas. The parametric studies were used to quantify the stability behavior of these prestressed concrete girder systems during erection and casting of the concrete bridge deck. The analysis included both eigenvalue buckling and nonlinear geometrical analyses using both uncracked and cracked section properties. Detailed studies were also conducted considering the live load distribution of the bridge system in-service.

What They Found

The researchers found the following:

General Stability Recommendations for I-girders and U-girders:

Utilizing FEA models developed from laboratory experiments, the RT evaluated a the commonly utilized precast concrete girder sections in Texas had sufficient stability for the likely geometries in spliced concrete girder sections. Both erection and deck placement sequences were analyzed assuming a deadload factor of 1.4, which is consistent with AASHTO Section 3.4.2.1. Although the load factor of 1.4 is intended for steel superstructures, the factor accounts for uncertainty in the distribution of load during deck construction when stability limit states are critical. Therefore, utilizing the 1.4 load factor is consistent with the controlling lmit states being evaluated. Constructability concerns due to significant lateral displacement during deck construction should be considered. The researchers recommend providing cast-in-place concrete diaphragms at all permanent supports and at least one intermediate location between the supports. Texas bridges have made use of diaphragms at the splice locations and midspan. The researcher recommend

Research Performed by:
Center for Transportation Research

Research Supervisor:
Dr. Todd Helwig, CTR

Researchers:
Mojtaba Aliasghar-Mamaghani
Aidan Bjelland
Paul Tackett
Baran Koyuk
Bhushan Raj Selvaraj
Tanakorn Ngamjarungjit
Ryan Stevens
Matt Hebdon

Project Completed:
06-30-2025

diaphragms be utilized at all intermediate splice locations.

Effects of Crack Depth and Location on the Stability of I-girders and U-girders:
Although cracking likely to occur during transportation and erection are difficult to find since the prestressing closes the cracks, if cracks are found, the maximum crack depth in the positive and negative bending moment regions should not exceed that of the flanges to maintain sufficient girder buckling capacity. FEA solutions considering nonlinear geometrical effects demonstrated significant loss of stiffness as cracks propagate through the web towards the center of gravity. This loss of stiffness reduced the buckling capacity and amplified girder deformations. From laboratory testing, the results demonstrated that cracks may appear closed to visual inspection due to prestressing of the girders once the cracking load is removed.

Live Load Distribution Factor (LLDF):
Studies on the live load distribution between girders were conducted on the range of spliced-girder systems utilized in Texas with the different diaphragm configurations shown in Figure 1. The studies consisted of influence surface analyses with the AASHTO live loading conditions. The AASHTO LLDFs were generally conservative for bridge layouts with solid diaphragms at the supports and splices (Layout-2 in Figure 1). These additional diaphragms lead to improved bending moment, shear, and support reaction distributions and match the recommendations for girder stability.

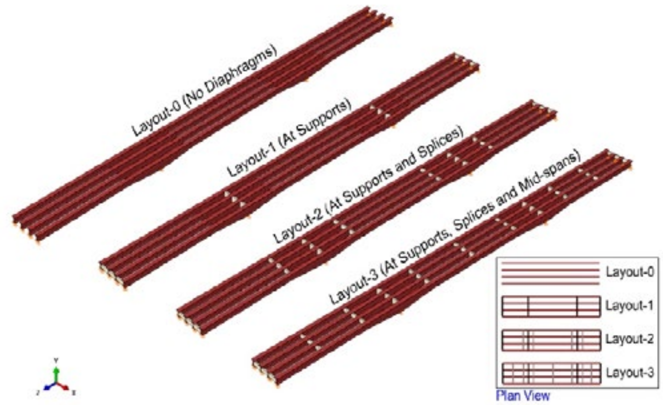

Figure 1: Diaphragm Layouts Considered

What This Means

While limited studies have been conducted on stability of prestressed concrete girders, the research conducted in this study provided insight into the behavior during erection and construction. Recommendations were provided for diaphragm spacing for both stability and live load distribution. Recommendations were provided for the stability evaluation utilizing a simple procedure utilizing closed-form buckling solutions as well as an alternate refined FEA analysis. The findings and recommendations provide confidence in the stability and live load distribution for spliced-concrete girder systems utilized in Texas.

For More Information

Project Manager:
Martin Dassi, RTI Martin.Dassi@txdot.gov

Research Supervisor:
Todd Helwig, CTR thelwig@mail.utexas.edu

Project Monitoring Committee Members:
Sara Watts, Bushra Islam, Chad Dabbs, Joe Roche, Miguel Cortes, Victoria McCammon

Research and Technology Implementation Division
Texas Department of Transportation
125 E. 11th Street
Austin, TX 78701-2483

www.txdot.gov
Keyword: Research

Technical reports when published are available at
https://library.ctr.utexas.edu.

This research was sponsored by the Texas Department of Transportation and the Federal Highway Administration. The contents of this report reflect the views of the authors, who are responsible for the facts and accuracy of the data presented here. The contents do not necessarily reflect the official view or policies of FHWA or TxDOT. This report does not constitute a standard, specification, or regulation, nor is it intended for construction, bidding, or permit purposes. Trade names were used solely for information and not for product endorsement.