Texas Department of Transportation

CENTER FOR TRANSPORTATION RESEARCH

**PROJECT SUMMARY REPORT**

# 0-7093: Refined Design Methods for Lean-On Bracing

## Background

Cross-frames are critical for the stability of steel I-girder bridges during erection and construction and also play an important role for completed bridges. In addition, the bracing members require significant handling and processing during fabrication and represent one of the most expensive components per unit weight on the bridge. The cross-frame brace locations have historically been regions of fatigue concerns. Cross-frames are also often comprised of single angle members, which have the worst fatigue rating with a Category E′ detail. Therefore, there are significant economic and structural performance benefits to minimize the number of cross-frames on a bridge. Lean-on bracing concepts reduce the number of cross-frames on a bridge by replacing full cross-frames in certain bracing lines with top and bottom struts, allowing a cross-frame to brace several girders. In heavily skewed systems, the cross-frames can be selectively placed to reduce fatigue induced stresses from truck traffic. Figure 1 illustrates conventional versus lean-on bracing systems. Lean-on bracing concepts were developed for TxDOT in the early 2000s. While this previous study developed design guidelines, recent applications of lean-on bracing on two TxDOT bridge designs demonstrated the need for improved efficiency and clarity.

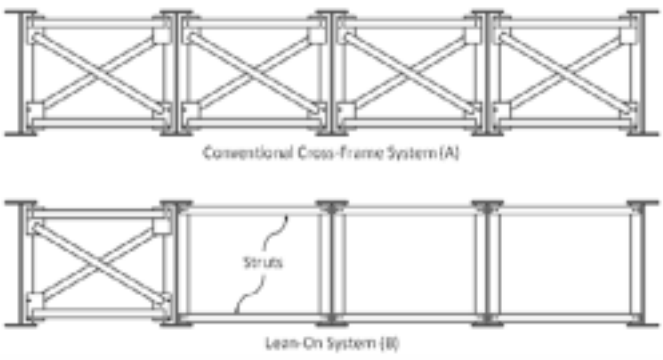


*Figure 1. (A) Conventional Bracing Cross-Section (B) Lean-On Bracing Cross-Section*

## What the Researchers Did

The researchers carried out parametric finite element analyses (FEA) and field monitoring to develop improved guidelines for the widespread use of lean-on bracing applications in Texas bridges. Researchers instrumented and tested two existing bridges with lean-on bracing. Strain and displacement measurements from the completed bridges and existing data from a lean-on bridge during construction were used to validate FEA models. The validated modeling procedures were applied to a parametric study to evaluate the behavior of bridge systems with various lean-on bracing layouts. Additionally, design equations were derived resulting in improved accuracy and streamlining of the design process. The revised design procedures are summarized and demonstrated with accompanying examples.

**Research Performed by:**
Center for Transportation Research

**Research Supervisor:**
Dr. Todd Helwig, CTR

**Researchers:**
Claire Gasser
Aidan Bjelland
David Fish
Matthew Yarnold
Stefan Hurlebaus
Michael Engelhardt
Matthew Hebdon
Eric Williamson
Sunghyun Park
Shrey Patel

**Project Completed:**
1-31-2024

## What They Found

The researchers found the following:

*Measured Performance of Lean-On Bracing:*
The data from truck loading of existing bridges and the concrete deck pour of a bridge in construction results in improved behavior relative to conventional bracing and had good performance both during construction and in the completed bridge.

*Recommended Cross-Frame Layouts:*
The researchers observed that improved behavior can be achieved with strategic placement of cross-frames in combination with lean-on struts. Some of the layouts considered are illustrated in the Figure 2 framing plans, where the vertical solid lines represent cross-frames, and the dashed lines represent struts. The project developed specific recommendations for varying numbers of girders and support skew angles.

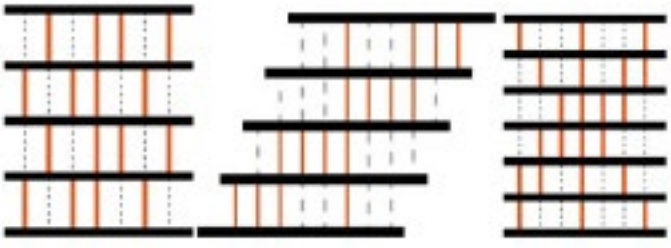

*Figure 2. Examples of Recommended Lean-On Layouts Plan View*

*Refined Design Methods:*
Design equations for stiffness and strength components of lean-on systems (in-plane girder stiffness and brace stiffness) were revised and validated with FEA models. The recommended expressions clarify the variables in the equation and allow for greater applications. A complete methodology for lean-on bracing design, along with several detailed design examples are provided.

*Value of Research:*
The research team prepared a Value of Research (VoR) report containing economic-based calculations, the economic variables used, and the qualitative values of TxDOT's selected benefit areas.

## What This Means

The capability to accurately predict friction at a Refined design methods for lean-on bracing are ready for implementation by TxDOT to improve the economy and application of lean-on bracing to Texas bridges. Reducing the number of cross-frames per bridge with lean-on bracing provides significant savings for fabrication and construction as well as improvements in the fatigue behavior. The refined design methods expand the application and precision of design equations, allowing engineers to design lean-on systems effectively.


### 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:**
Jamie Farris, Addisu Tilahun, David Fish, Rostam Mahbod

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.