Structures Congress 2018

Bridges, Transportation Structures, and Nonbuilding Structures

Proceedings of the Structures Congress 2018

- Fort Worth, Texas
- April 19–21, 2018

ASCE

EDITED BY

James Gregory Soules, P.E., S.E., P.Eng.

SEI STRUCTURAL ENGINEERING INSTITUTE

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SELECTED PAPERS FROM THE STRUCTURES CONGRESS 2018

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Preface

The Structures Congress has a robust technical program focusing on topics important to Structural Engineers.

The papers in the proceeding are on the following topics

- Advances in Structural Engineering Research
- Analysis, Design & Performance
- Avoiding Disproportionate Collapse
- Bridge Analysis, Design and Repair
- Bridge Management, Inspection and Sustainability
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- Materials- Design & Construction
- Natural Disasters - Moving Toward Improved Resilience
- Nonbuilding Structures and Nonstructural Components
- Special Topics in Structures
- Transformation in SE Education

Acknowledgments

Preparation for the Structures Congress required significant time and effort from the members of the National Technical Program Committee, the Local Planning Committee and staff. Much of the success of the conference reflects the dedication and hard work by these volunteers.

The National Technical Program Committee, the Local Planning Committee and staff would like to acknowledge the critical support of the sponsors, exhibitors, presenters, and moderators who contributed to the success of the conference through their participation.

Thank you for spending your valuable time attending the Structures Congress. It is our hope that you and your colleagues will benefit greatly from the information provided, learn things you can implement and make professional connections that last for years.

Sincerely,

J. G. (Greg) Soules, P.E., S.E., P.Eng, SECB, F.SEI, F.ASCE
CB&I, LLC
Chair, National Technical Program Committee

Contents

Dallas Horseshoe Project—Spliced Concrete Girder Design and Construction Overview

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ABSTRACT

Being only the third installation of spliced concrete girders in North Texas, the authors will highlight the unique aspects of these systems, and share some of the knowledge gained and experiences learned from involvement with this high-profile, complex long-span bridge design and construction project. Six long-span continuous concrete post-tensioned spliced girder bridges cross the Trinity River within the Horseshoe project, each with multiple spans of least 250 feet. These bridges span a long-planned, but as-yet unrealized chain of recreational lakes within the river levees, as well as many bike and pedestrian trails. The interrelationship of design and construction for these girder systems are explored and explained.

BACKGROUND

In 2012, TxDOT solicited design-build delivery proposals for the Dallas Horseshoe project, due to the complexity, scope, and context, and awarded a contract to Pegasus Link Constructors, LLC (PLC), a joint venture between Fluor Enterprises, Inc. and Balfour Beatty Infrastructure, Inc. PLC teamed with WSP USA, serving as lead designer, partnered with AECOM. The $800 million Horseshoe project earned its name from its U-shaped overall layout, with IH-30 forming one leg, IH-35E the other, and the downtown Dallas "Mixmaster" forming the apex (see Figure 1); some 450,000 to 500,000 vehicles each day pass through the various alignments.

TxDOT's goals were to replace the critical but obsolete IH-30 and IH-35E Trinity River bridges, and to improve traffic through all of downtown. Other improvements included numerous conventional bridges, many large retaining walls, and some 73 lane-miles of new roadway – along with construction of two "signature" steel arch pedestrian bridges, designed by Santiago Calatrava and Huitt-Zollars. In April 2017, the project achieved substantial completion, allowing drivers to experience improved safety, increased capacity, and improved mobility through the heart of Dallas.

A key part of the success of the Horseshoe stemmed from the PLC team's selection of continuous concrete post-tensioned spliced girders for the river crossings. The team considered continuous steel plate girders; instead, to minimize initial costs, reduce risk to the schedule from fabrication delays, to minimize life-cycle maintenance costs, and to eliminate environmental risk from later steel coating removal and replacement, the team elected to use spliced concrete girders. Fabricated in segments offsite, these girders are supported on temporary shoring and permanent bents, and stitched together on site with high-strength strands, to make them behave as single assemblies.

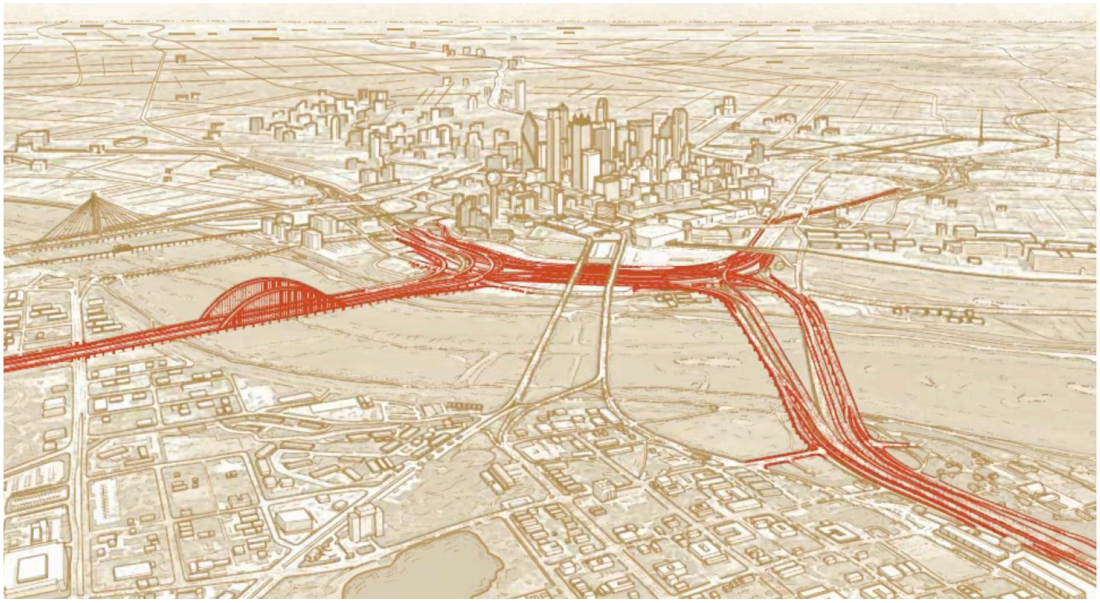

Figure 1 – Rendering of the overall Dallas Horseshoe project, looking northeast from Oak Cliff (image courtesy of TxDOT).

Being only the third installation of spliced concrete girders in North Texas, this paper will highlight the unique aspects of these systems, and relate some of the knowledge gained and experiences learned from involvement with this high-profile, complex long-span bridge design and construction project.

DESIGN

Six long-span continuous concrete post-tensioned spliced girder bridges cross the river within the Horseshoe project, each with multiple spans of 250 to 260 feet, forming units (sections of bridge between expansion joints) of 1000 feet or more.

Of particular importance in the design of spliced concrete girders, is construction (or erection) sequencing and the companion analyses. Due to the these stages, the analysis model must be performed in steps, considering the conditions of support, continuity, the boundary conditions, and the temporary loading. The member forces and element stresses are not identical to those predicted by a classical, continuous analysis, in which continuity and loading are known from the outset, and do not change over the course of the analysis.

Although one could perform the analyses of these structures without the use of specially-adapted software, the authors recommend using a program that can account for the following:

- Time-dependency,
- Incremental summation of construction staging,
- Accommodation to changes in the static system,
- Ability to place and remove temporary supports,
- Field post-tensioning effects and secondary forces,
- The ability to place the bridge deck in stages, and
- Non-linear temperature gradients.

Not long ago, there were few commercially-available software programs capable of such analyses. However, today there are multiple programs on the market with such capabilities.

The AASHTO LRFD Bridge Design Specifications have made significant progress in the last