Erection Engineering Considerations for Curved Steel I-Girder Bridges

Brandon CHAVEL
Structural Engineer
HDR Engineering, Inc.
Pittsburgh, PA, USA
Brandon.Chavel@hdrinc.com

Shawn TUNSTALL
Structural Engineer
HDR Engineering, Inc.
Pittsburgh, PA, USA
Shawn.Tunstall@hdrinc.com

Jason FULLER
Project Manager
HDR Engineering, Inc.
Pittsburgh, PA, USA
Jason.Fuller@hdrinc.com

Matthew BUNNER
Structures Section Manager
HDR Engineering, Inc.
Pittsburgh, PA, USA
Matt.Bunner@hdrinc.com

Summary

The erection of horizontally curved steel I-girder bridges is inherently more complex than the erection of straight I-girder bridges of similar span lengths, which is a direct result of the natural behavior of curved steel I-girders. Bridge engineers must be aware of these complexities as they are more frequently being tasked with developing or reviewing erection plans for curved steel I-girder bridges. However, there is limited guidance given in design specifications and archival literature that illustrates what is required in the design and construction plans for curved steel I-girders during erection stages and the calculations that need to be carried out. Based upon the authors' experience, this paper will highlight aspects of curved steel I-girder bridge erection that should be considered by the design engineer and the contractor's engineer in the development of the steel erection plans, so as to provide for a successful bridge construction project.

Keywords: Curved I-girder Bridges, Steel Bridges, Erection Procedures, Construction

1. Introduction

This paper will highlight aspects of curved steel I-girder bridge erection that should be considered by the design engineer and the contractor's engineer in the development of the steel erection plans. Recently, AASHTO (American Association of State Highway Transportation Officials) and many state bridge design specifications have been updated to require that design plans for a horizontally curved steel I-girder bridge show at least one erection scheme that could be used to construct the bridge. This requires that the design engineer investigate the impact on, and the adequacy of the designed bridge, for that scheme. Additionally, the contractor is often directed to provide a construction plan, stamped and signed by a professional engineer (herein referred to as the contractor's engineer). The contractor's engineer must perform a more in-depth investigation of the steel erection sequence to be used in the field, detailing the steel erection procedure, and providing calculations that demonstrate the girders and bridge components meet stability and structural capacity requirements. The contractor's engineer must thoroughly investigate each stage of construction, ensuring the there are no girder overstresses, excessive displacements and/or rotations, or instabilities. It is imperative that the design engineer review the erection procedure and calculations provided by the contractor's engineer to verify that they are thorough, complete and result in a structure meeting the intent of the original design.

1.1 General Steel Erection Procedures

Procedures required for general steel erection of highway bridges is provided in the *Steel Bridge Erection Guide Specification* [1] developed through the AASHTO/NSBA Steel Bridge Collaboration. This document highlights minimum requirements for the development of steel erection procedures, including steel erection drawings and calculations. For example, the steel erection drawings should provide:

- a plan of the work area including permanent and temporary supports and obstructions such as roads and waterways;

https://doi.org/10.2749/222137908796293163

- erection sequence, including a narrative of the procedure, for all superstructure components, noting the use of temporary supports, lifting cranes, and holding cranes, as required;
- details of temporary support structures, tie-down devices, and blocking for the bearings;
- details of jacking devices, spreader beams and attachments, as well as the lifting weight of girder members including weights of the rigging and lifting attachments.

Fig. 1: Temporary Support

Fig. 2: Spreader Beam

Additionally, the contractor’s engineer may be required to submit calculations that provide the basis for the details and procedures provided on the erection drawings. These calculations should verify:

- the load capacity of the lifting and holding cranes;
- the load capacity and stability of the temporary support structures (typical temporary support is shown in Fig. 1);
- the structural adequacy and stability of the girders for each stage of the erection sequence;
- the load capacity of spreader beams (Fig. 2), beam clamps, stiffening trusses, or tie-down devices.

2. Considerations for Curved Steel I-Girder Bridge Erection Engineering

There are several aspects of curved steel I-girder bridge erection that the contractor’s engineer must consider when developing calculations and bridge erection plans. The contractor’s engineer is now often required to create a finite element model of the bridge, to investigate the step-by-step erection sequence. The analysis of the steel erection sequence will generally require a two-dimensional grid or a full three-dimensional finite element model. Unless instructed by the bridge owner, the contractor’s engineer must determine the appropriate level of analysis to be used.

The results of the chosen analysis are used to investigate the viability of the chosen erection sequence and methods. The investigation of the chosen erection sequence, and development of erection plans and calculations, should include, as minimum, the following:

- Girder stability during picking, with consideration given to the cantilever ends, positive bending between pick points, and girder rolling during lifting.
- In-place girder stability during erection, with consideration given to girder stability after a single girder has been erected, global system buckling, cross frame requirements, wind loads during steel erection, temporary hold loads during erection, and unbraced length considerations for erected girders.
- Construction aspects such as: crane access, capacity, radius and boom length; minimum bolting requirements for field splices and other connections; the alignment of field splices during steel erection; and the out-of-plane displacements that can occur during steel erection.
- The design of temporary support structures and applicable details.

In this paper, these considerations for curved steel I-girder bridge erection engineering are described further, with details and references provided where applicable.

3. Conclusions

It is hoped that this paper promotes awareness of the issues related to the erection engineering of horizontally curved steel I-girder bridges, so as to provide for successful bridge construction projects. Bridge engineers need to be aware of these specific erection engineering issues for curved steel I-girder bridges, and the requirements of what should be provided on the bridge erection drawings and supporting calculations. This paper highlights aspects of horizontally curved steel I-girder bridge erection that should be considered by the contractor’s engineer, and the reviewing design engineer, in the development of the steel erection plans and calculations.