Curved Precast Concrete Bridge Projects in Colorado

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Summary

Six bridge projects in Colorado are completed or are currently being constructed using curved, precast girders. In all cases, the girders were spliced and in most applications, post tensioned to accommodate spans up to 265’. These projects utilize plant manufactured precast concrete girders using standard cross sections. Of the six projects, two including the Ramp K and Ramp H Flyover Bridges, have been completed and are currently in service. The remaining projects have been designed and are at varying stages construction. The Ramp K bridge will be featured as case study to discuss the technical and constructability issues that are inherent in this type of construction. Other projects, currently under construction, will also be discussed. These projects had numerous design and construction challenges in difficult urban site conditions. Unique solutions for spliced girder technology that were developed during both design and construction will be discussed.

Keywords: bridge, curved, precast, concrete, girders, prestress, falsework, spliced, staged construction

1. Introduction

In the last four years, six bridge projects have been designed that utilize a unique concept that incorporates plant manufactured, curved precast girders. All of these bridges are part of major urban viaducts that require complex, curved geometrics to accommodate the roadways they support. These projects are expressions of the Colorado Department of Transportation’s desire to develop the use of precast concrete as an alternative solution for an application that has historically been built using steel girder construction.

These six projects incorporate 21,000 l.f. of curved, precast concrete girders that support over 400,000 s.f. of bridge deck. Of the six projects, two were design/bid/ build, two were Contractor Design Alternates and two were Value Engineering designs. In all cases the DOT was supportive and encouraged the use of this innovative type of construction. Two projects, referred to as the SH270 Ramp K and E470 Ramp H are in service; SH270 Ramp Y is nearing completion of construction. The remaining three projects, SH58 Ramp A, the Austin Bluffs Boulevard overpass in Colorado Springs, CO and the IH25 viaduct in Trinidad, CO are fully designed and are at various stages of construction.

Fig. 1: Ramp K Flyover Bridge

This paper will discuss the design features and construction solutions that have been utilized to successfully build these projects to date. Ramp K, the first of these bridges to be built, had numerous unique challenges that were successfully solved and will be introduced as a case study of this type of construction. Following completion of Ramp K, the Ramp A and Y bridges were constructed with design enhancements which will also be discussed.

2. Design

The design of curved precast girder bridges must consider all loading conditions through the construction process in addition to in place service and ultimate design loadings. All of the projects described utilized standard CDOT U girders that varied in depth from 78” to 84” with girder lengths up to 120’. The cross sections used were standard CDOT shapes with web thicknesses from 5” to 10”. Girders with ducts through the webs for final longitudinal post-tensioning had web thicknesses of 7 ½”, 9” and 10” depending on tendon sizes. These curved precast girders are large, heavy and inherently unstable. The precast girder shipping weights varied from 180 to 260 kips. Erected weights of several girders exceeded 330 kips.

The design of these bridges used current AASHTO LRFD code provisions for service and ultimate design considerations. Spliced construction was used to accommodate spans from 100’ to a maximum span of 235’ using a constant cross section depth. A maximum span of 265’ has been designed for the IH25 project in Trinidad using haunched construction. All girders are cast using normal-weight concrete with 28 day design strengths from 6500 to 9000 psi.

All bridges used spliced, continuous span construction. Most used longitudinal post-tensioning after splicing. Design of the final structure is very similar to other spliced, precast concrete construction with the added design consideration for torsion due to permanent dead load and live loads for conditions during both construction and in the permanent structure.

3. Construction

Lifting, shipping, erecting and providing temporary support and stability during construction presented numerous challenges. Stability must be considered at each stage of construction. Temporary structures must be designed to support the self weight of the girders and construction loadings prior to incorporation into the permanent structure. All projects were constructed in urban environments with constrained conditions and multiple traffic crossings. In many situations, placement of erection equipment in challenging site conditions required setting girders from existing bridges and behind tall retaining walls. Vertical support of the girders was accomplished using both falsework supported on grade and strong backs which suspended girders from previously erected spans. In addition, staged construction, field splicing and temporary post-tensioning was necessary to accommodate the site conditions.

4. Cost Effectiveness

The use of curved, spliced precast girders as an alternative to steel construction has become viable due to increases in steel costs in the last few years. Cost figures from competitive bidding of a concrete and steel alternate indicate a significant cost savings over steel on these projects.

5. Conclusions

The projects that are discussed have been conceived and constructed using materials and techniques that had not previously been used for curved, connector bridges with in the 200’ span range. The changing economic considerations of material costs and accelerated schedules have created an opportunity for new methods of bridge construction. These projects utilize proven design techniques and present new challenges in construction that require additional engineering support.

The six projects that are discussed all present an economical alternative to traditional types of construction that can fit in more rapid construction schedules. All projects have been successfully constructed to date without incident. Further projects are being planned in Colorado and we anticipate continuing success constructing projects using this technology.