RAPID REPLACEMENT OF COUNTY BRIDGES UTILIZING HIGH-STRENGTH CORROSION-RESISTANT STEEL

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INTRODUCTION

Many of the US county bridges are in a state of functional obsolescence and structural deficiency. Repair is not an attractive option in terms of speed and cost-effectiveness for most of these small bridges. Yet, counties need to have these bridges replaced as quickly and cost-effectively as possible.

This paper presents a new concrete bridge system and a method for rapid replacement of short span county bridges. An example is given to show typical application. It is a 62-ft span county bridge in Buchannan County, Iowa. The design utilizes a single tee girder shape with high-strength, corrosion-resistant steel. Speed of construction comes from eliminating the need for prestressing or post-tensioning, thus allowing the county crews or their local contractors to produce the bridge girders without outside help. The single tee flange is wide. The flanges are set next to each other with a narrow longitudinal ultra-high-performance concrete, in order to eliminate the need for time consuming cast-in-place decks or composite topping. It is possible that the old bridge can be removed, and the new bridge constructed in several days, as all the new components are prefabricated.

TYPE, SIZE, AND LOCATION

The exiting through-type steel truss bridge is deemed deficient and scheduled to be replaced with concrete girders. Figure 1 shows the existing truss and the proposed concrete girders. This bridge is located on Daniel Ave. in Buchanan County, Iowa, spanning the Spring creek as shown in Figure 2. The existing bridge has a span of 62 ft and width of 24 ft. It was envisioned to provide a replacement option, which can be constructed by the local crew with minimal roadway closure. Therefore, precast conventional concrete girder was considered as an ideal candidate for this project to avoid the need for prestressing facility. The authors proposed precast superstructure system utilizing high-strength corrosion resistance steel instead of the prestressing steel. The girders can be cast on a storage area next to the bridge location to be lifted up and placed on the abutment in short time. This should accelerate the construction and reduce the cost of shipping and handling the girders.

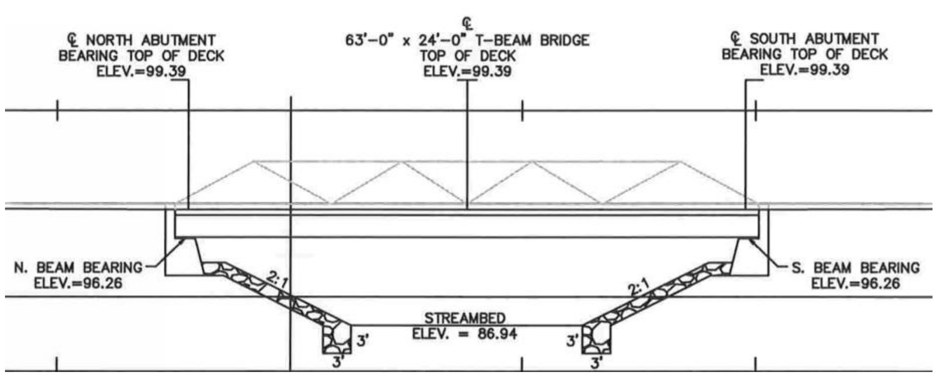

Figure 1- Existing Bridge Elevation

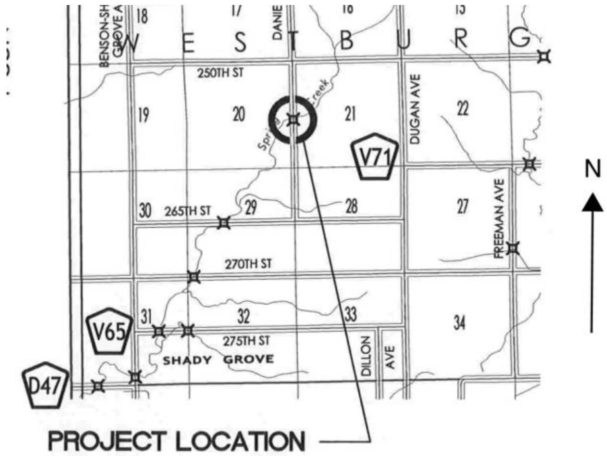

Figure 2- Bridge Location

BRIDGE REPLACMENT

While the substructure was rated to be in a good condition, the replacement girders were proposed to be placed on the existing abutment maintaining the original span and width. The replacement bridge cross section consists of four tee beams spaced at 6 ft as shown in Figure 3. It was planned to provide lateral continuity between the girders to prevent relative vertical displacement at the interface between the adjacent beams. Therefore, the girders top flanges have projected transverse reinforcements to be spliced after placing the girders on the bearings. The splice was designed utilizing cast-in-place (CIP) ultra-high-performance concrete (UHPC) longitudinal joints. Utilizing UHPC allowed minimum joint width.

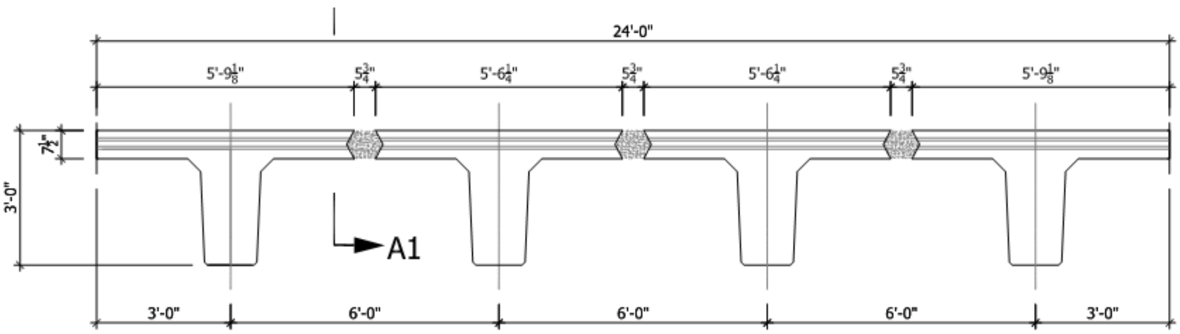

Figure 3-Replacement Bridge Cross Section

Each beam was designed to be conventionally reinforced with high-strength ASTM A1035 Gr. 100 reinforcement due to the high flexure demand. Tension bottom reinforcement consists of 14#11 rebar to satisfy the flexural reinforcement. This bottom rebars attributed to increase the effective moment of inertia of the cracked section satisfying the AASTO LRFD live load deflection recommendation. Shear force demand also was satisfied using #4 with variable spacing along the beam. Top and bottom transverse slab reinforcement were designed to be #3 at 6 in. spacing in both directions. Figure 4 shows the reinforcement details for the Tee-beam.

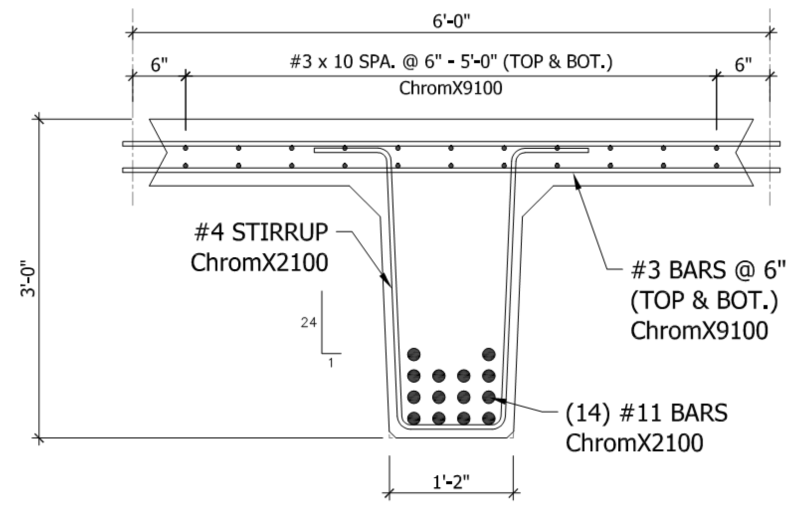

Figure 4- Typical Beam Reinforcement

ASTM A1035 CL rebars were utilized for the bottom tension and shear rebars. These rebars have chromium percentage of 2-4%. ASTM A1035 CS rebars were utilized for the deck transverse rebars. These rebars have chromium percentage of 8-11%. This, in turn, provide high corrosion resistance for the deck reinforcement, which is exposed to more severe exposure to pooling and deicing salts than the web of the beam. A longitudinal joint width of 5¾" was found adequate to splice #3 transverse bars providing embedment length more than 10 d_b (FHWA) in UHPC as shown in Figure 5. FHWA research project concluded that any precast element interfaces to bond with CIP UHPC shall include female–female shear keys. The shear key is simplified based on investigating different practice by different departments of transportation as shown in Figure 6. The early high strength of UHPC allows to open the bridge for traffic within two weeks.

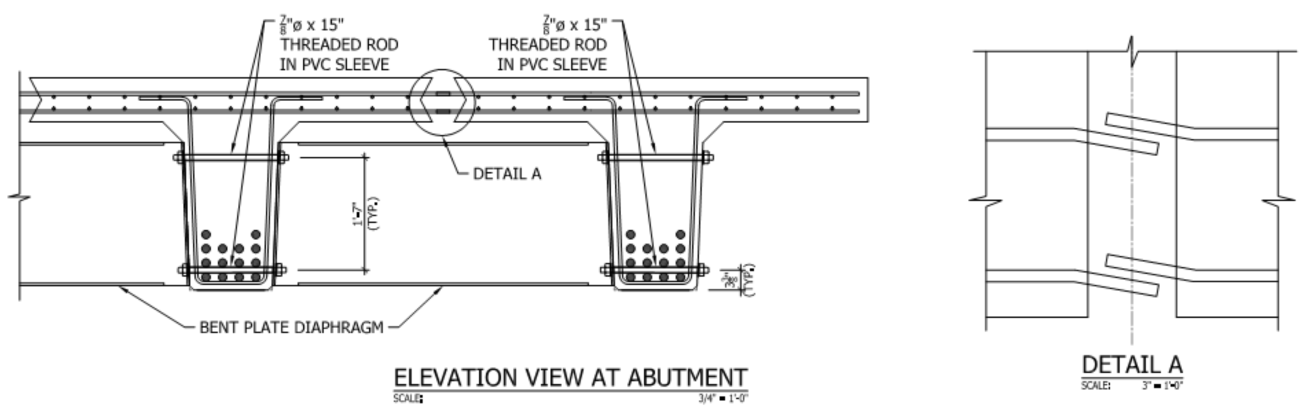

Figure 5- transverse rebar splice in UHPC Joint

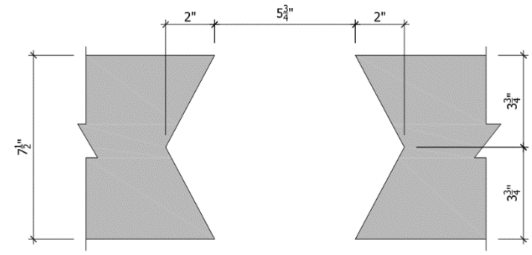

Figure 6-Shear Key Detail

CONCLUSION

Precast concrete girders reinforced with high strength steel can effectively accelerate the bridge construction due to eliminating the need for prestressing or post-tensioning, thus allowing the county crews or their local contractors to produce the bridge girders without need to specialty.

The wide flange of the tee beam eliminates the need for time consuming cast-in-place decks or composite topping.

REFERENCES

Graybeal, B. (2014). "Design and Construction of Field-Cast UHPC Connections," Federal Highway Administration, U.S. Department of Transportation, Report No. FHWA-HRT-14-084, McLean, VA.