ABC-UTC GUIDE FOR:

INTEGRAL ABUTMENT CONNECTIONS

April 2019

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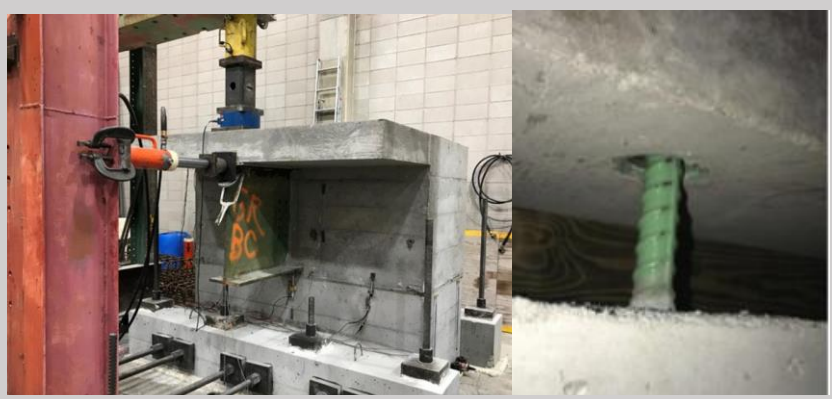
Performing Institutions:

Iowa State University

Name of PI(s):

Mr. Travis Hosteng

Dr. Behrouz Shafei



ACCELERATED BRIDGE CONSTRUCTION UNIVERSITY TRANSPORTATION CENTER

Iowa State University

University of Nevada, Reno

FIU Civil and Environmental Engineering

Washington

The University of Oklahoma

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ABSTRACT

This report summarizes the work activities undertaken in the study and presents the results of those activities toward development of this ABC-UTC Guide for Integral Abutment Connections. The information will be of interest to highway officials, bridge construction, safety, design, and research engineers, as well as others concerned with the connections of integral abutments utilizing ABC procedures.

ACKNOWLEDGMENTS

The research study resulting in development of this guideline was supported by the US Department of Transportation through the Accelerated Bridge Construction University Transportation Center (ABC-UTC).

1. INTRODUCTION

1.1. BACKGROUND

Accelerated Bridge Construction (ABC) has started to become the preferred construction procedure for many bridge engineering agencies and differs from conventional bridge construction by utilizing PBES and other technologies to lift, slide, and rotate parts of a bridge into connection. These connections have been, and still are being, researched and tested for many locations within a bridge. One connection still under research and testing is the integral abutment. An integral abutment is a connection composed of combined shear and moment connections between the bridge superstructure and substructure. This connection is appealing to bridge designers since it results in the elimination of the expansion joint, which typically is the common location of structural deterioration.

Since the reinforcement in an integral abutment can be highly congested to resist the different forces acting on both the substructure and superstructure, the issue of transporting and installing these elements govern the design in ABC applications. The issue of transporting comes from the weight of the specimen, and the installation issues are the result of the splices that will need to be connected after the lift, slide, etc., has been completed.

To alleviate these issues, cast-in-place integral abutments have been typical for this ABC connection. A great downside to this connection detail is the closure pour is typically consisting of High-Performance Concrete (HPC) or regular concrete. These materials need up to a week of curing time to be structurally safe for traffic and causes delays in opening up the bridge.

1.2. SCOPE OF THE GUIDELINE

The intention of this guideline is to provide concise design details of two integral abutment connections investigated by Iowa State University in the laboratory that could be implemented on bridge construction projects using ABC methodologies. Additional design, construction and testing information may be obtained from the project final report.

2. CONNECTION DESIGN

2.1. INTEGRAL CONNECTION 1: GROUTED REINFORCING BAR COUPLER

The initial design of the grouted reinforcing bar specimen coupler (GRBC) specimen (Phase I) started with a typical cast-in-place integral abutment design and inserted a grouted reinforcing bar coupler at each reinforcing bar that provided continuity between the abutment pile cap and the abutment diaphragm. However, subsequent testing (Phase II) indicated that adequate strength and serviceability could be achieved by reducing the number of couplers by half, in this case to 8 (Fig. 2.1.1). The couplers were designed to be #8 epoxy-coated reinforcing bars with Dayton Superior D410 Sleeve-Lock Grout Sleeves filled with Dayton Superior D490 Grout. The overall size of the specimen and the distribution of the reinforcement is otherwise the same as the cast-in-place design. (Fig. 2.1.2 and 2.1.3)

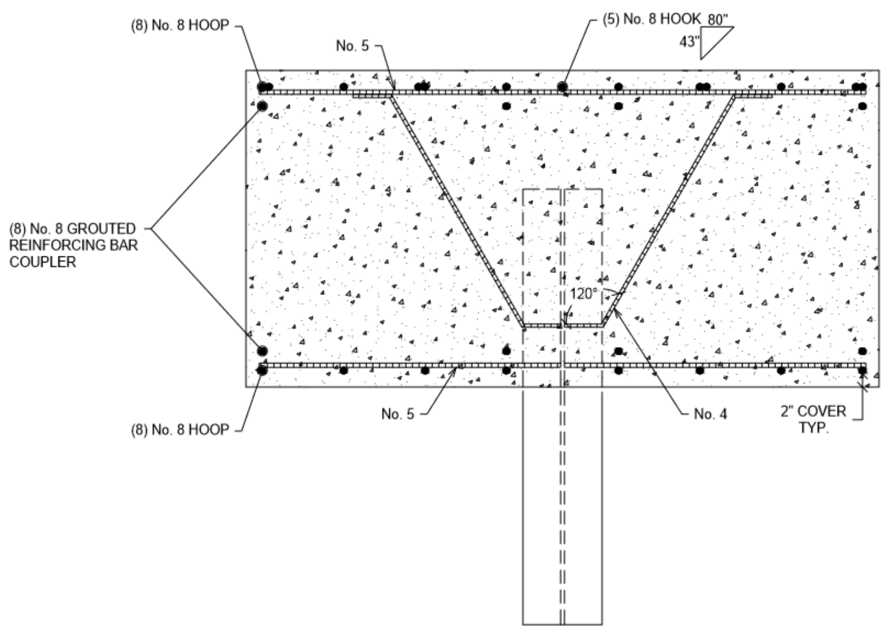


Figure 2.1.1. Plan view of GRBC specimen showing locations of couplers.

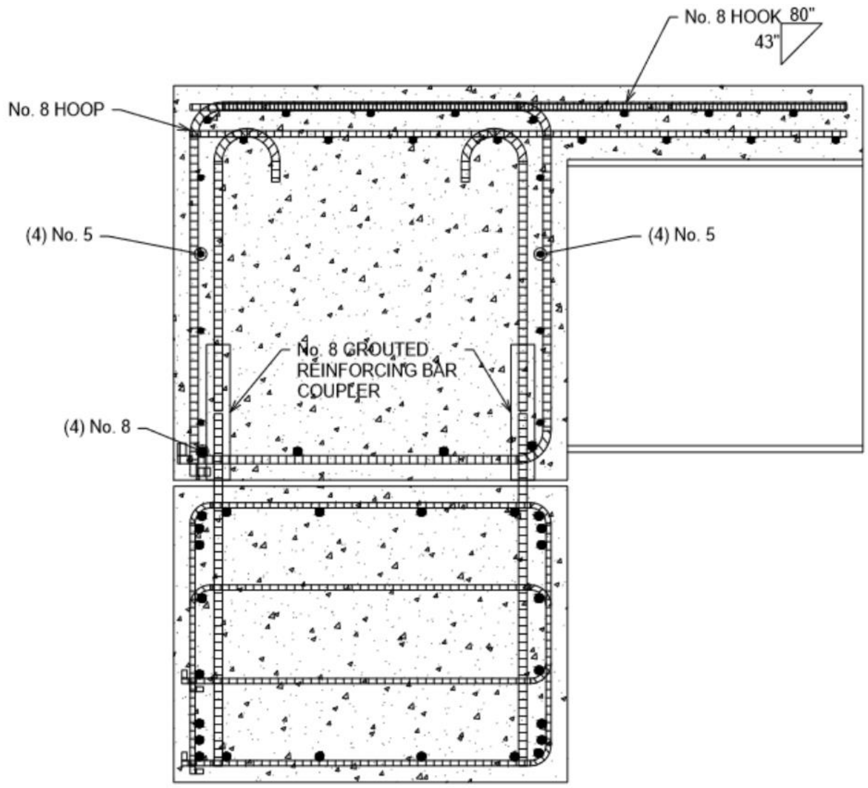


Figure 2.1.2. GRBC specimen section view through couplers.

The GRBC design may not be able to utilize slide-in ABC methods without jacking up the diaphragm due to the coupler bars protruding from the pile cap, which cannot be modified due to the design of the couplers themselves. Alternative means of placing the precast elements, such as a crane or SPMT's, may also be effective. Regardless of the placement method, once all the protruding bars from the pile cap are aligned with the couplers, the diaphragm section is slowly lowered onto the pile cap section inserting the bars into the grout sleeves of the diaphragm and subsequently grouting the grout sleeves to complete the construction of this integral abutment connection.

2.2. INTEGRAL CONNECTION 2: UHPC JOINT

The Iowa DOT came up with the initial design of this detail, which is designed for use in ABC "slide-in construction" applications with the use of ultra-high performance concrete (UHPC). UHPC was chosen in lieu of concrete or a grouting material due to the increased flowability characteristic of UHPC, as well as its impermeability and high strength. The placement of reinforcement throughout the specimen was based on the joint reinforcement for the connection which utilized seventeen #7 reinforcing bars (Fig. 2.2.1 and 2.2.2).

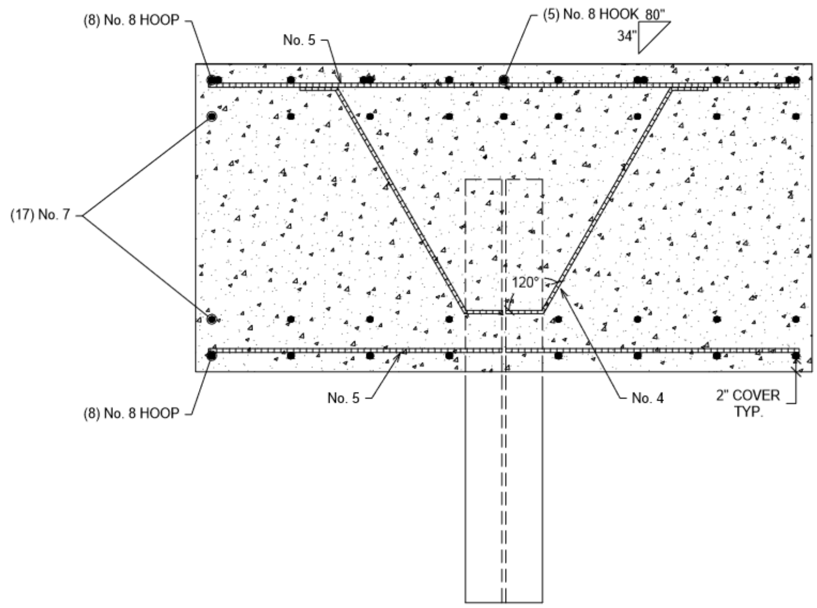
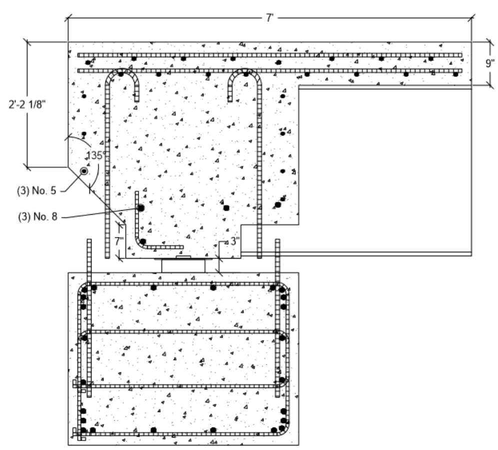
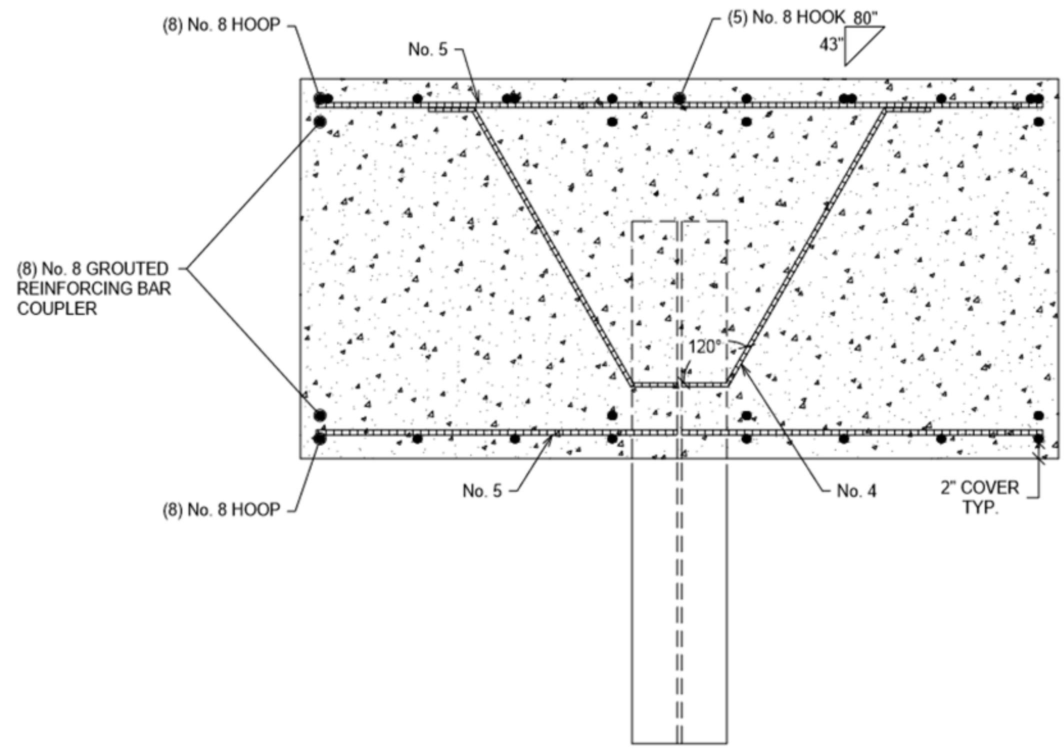


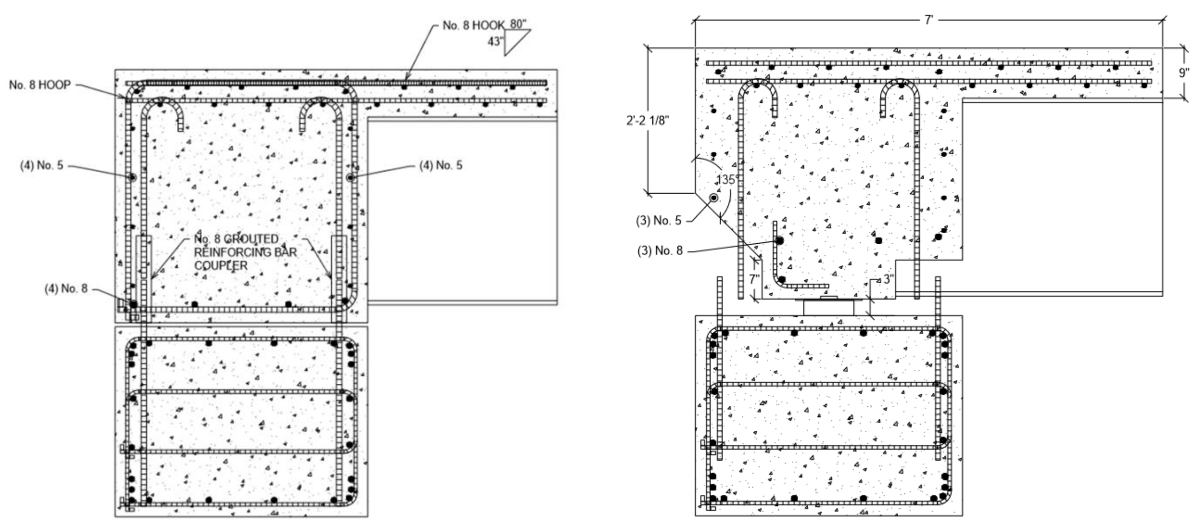
Figure 2.2.1. Plan view of UHPC-Joint specimen showing locations of connection bars.



3. APPLICATION OF CONNECTIONS

The initial design of the grouted reinforcing bar specimen coupler (GRBC) specimen (Phase I) started with a typical cast-in-place integral abutment design and inserted a grouted reinforcing bar coupler at each reinforcing bar that provided continuity between the abutment pile cap and the abutment diaphragm. However, subsequent testing (Phase II) indicated that adequate strength and serviceability could be achieved by reducing the number of couplers by half, in this case to 8 (Fig. 2.1.1). The couplers were designed to be #8 epoxy-coated reinforcing bars with Dayton Superior D410 Sleeve-Lock Grout Sleeves filled with Dayton Superior D490 Grout. The overall size of the specimen and the distribution of the reinforcement is otherwise the same as the cast-in-place design. (Fig. 2.1.2 and 2.1.3)





a. Thru chimney b. Thru section

Figure 2.2.2. UHPC-Joint specimen section.

Figure 2.1.3. GRBC specimen section view through beam.

The GRBC design may not be able to utilize slide-in ABC methods without jacking up the diaphragm due to the coupler bars protruding from the pile cap, which cannot be modified due to the design of the couplers themselves. Alternative means of placing the precast elements, such as a crane or SPMT's, may also be effective. Regardless of the placement method, once all the protruding bars from the pile cap are aligned with the couplers, the diaphragm section is slowly lowered onto the pile cap section inserting the bars into the grout sleeves of the diaphragm and subsequently grouting the grout sleeves to complete the construction of this integral abutment connection.

3.1. INTENDED USERS

The connections discussed in Chapter 3 of this guideline are intended to be reviewed, considered, and implemented by bridge engineers and contractors for the design an construction of integral abutment bridges using ABC methodologies.

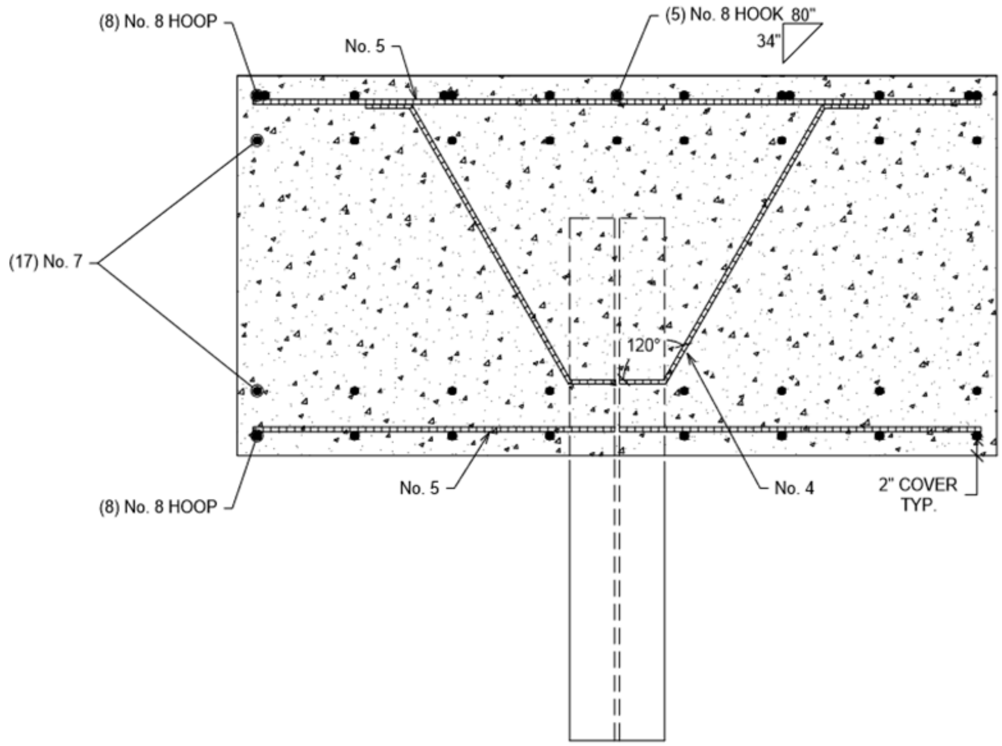
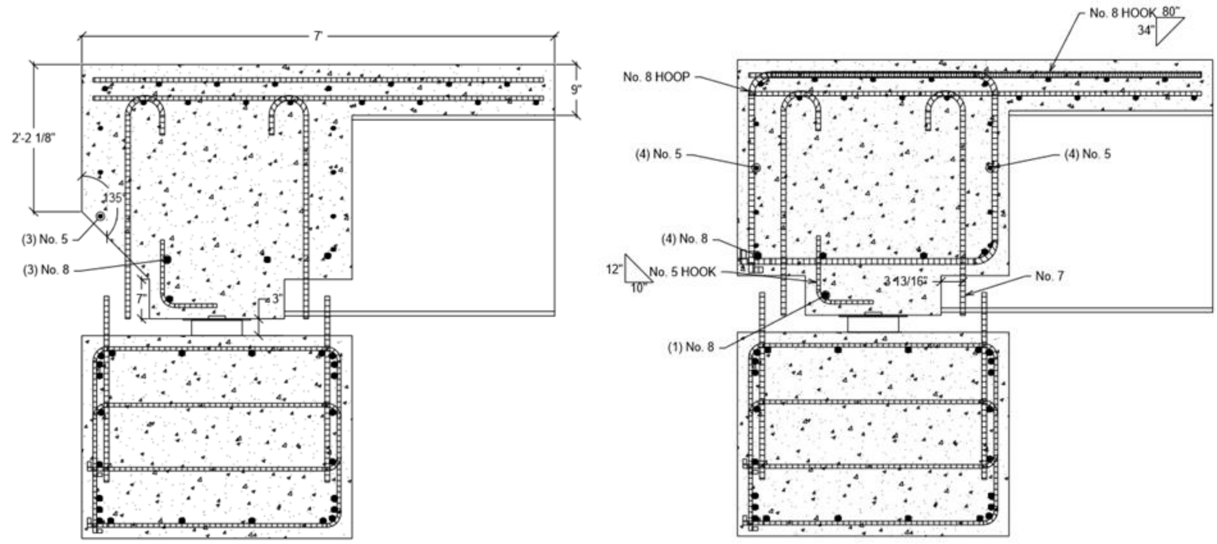


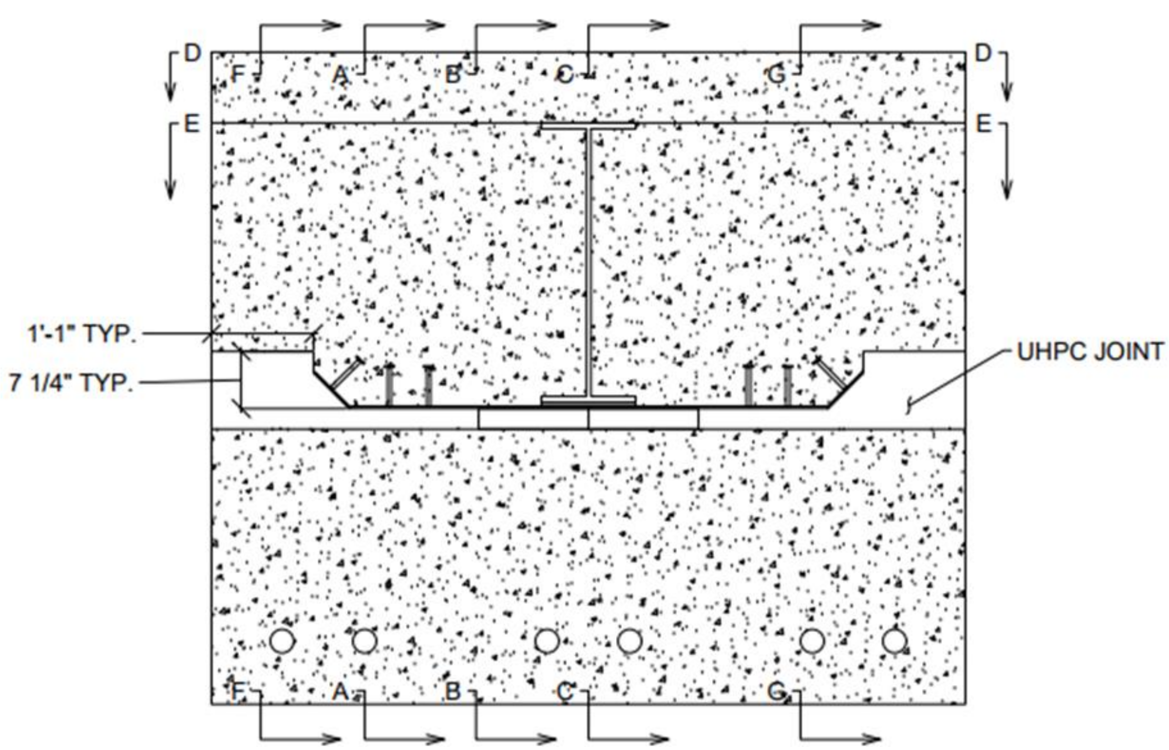
Figure 2.2.1. Plan view of UHPC-Joint specimen showing locations of connection bars.



a. Thru chimney
b. Thru section

Figure 2.2.2. UHPC-Joint specimen section.

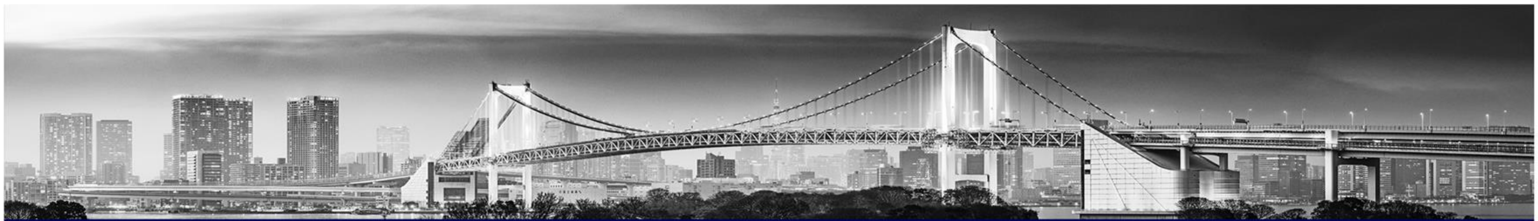
Design of this specimen included use of a mechanical coupler, specifically Dayton Superior D310 Taper-Lock Standard Couplers, on the eight #7 reinforcing connection bars on the front face of the pile cap of the specimen to eliminate the issue of the protruding bars from the pile cap interfering with the steel beam during the slide. The UHPC-Joint specimen would utilize the ABC application of "slide-in construction," using Laminated Neoprene Pads with Teflon and stainless-steel sliding "shoes" (Fig. 2.2.3).



After the specimen is slid into its final position, the eight #7 mechanical couplers were installed per manufacturer's instructions into the pile cap at the designed locations. Form work was then installed around the joint for placement of the UHPC. After the design strength of the UHPC has been met, formwork shall be removed, and this integral abutment connection is complete.

3.2. PROPOSED USERS

The primary use of these connections is for integral abutments using stub-type integral abutments installed onto a single row of H-piles orientated for weak-axis bending. The connections may also be considered for other superstructure-substructure connections such as the pier cap-pier connection.



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