A REVIEW OF ABC FOR RAILROAD BRIDGES

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ABSTRACT

For railroad bridge rehabilitation or bridge reconstruction projects, agencies typically allow railroad service to be shut down for only a few hours. Accelerated bridge construction (ABC) using prefabricated bridge components and systems is ideal for railroad bridge construction projects. This paper presents a review of accelerated bridge construction for several railroad bridge projects. Through these case studies, it is clear that ABC can be used to reduce railroad service shut-down time, which has tremendous economic impact on Class I railroad companies. Projects discussed in this paper include moving the longest and heaviest railroad truss bridge with self-propelled modular transporter (SPMT); using a conical connection system for steel pipe piles inserted into precast pile cap; replacing 100-year-old thru girder bridges in 20 hours; installing a Precast Bridge Slab with a rail-mounted launching truss/gantry crane (gantry crane); using new design technology – such as Hybrid-Composite Beam (HCB) – for lighter, safer, greener and quicker construction.

Keywords: Accelerated Bridge Construction, Railroad Bridges, ABC, SPMT, HCB.

INTRODUCTION

Accelerated bridge construction using prefabricated bridge components and systems has many advantages over conventional cast-in-place construction. Prefabrication speeds up construction and increases quality of concrete members by fabricating in a controlled plant environment with reduced dependency on weather. Prefabrication also increases construction safety by avoiding forming, rebar placement, concrete placement and curing at bridge sites. The reduction in the duration of traffic closures and a reduced negative impact on the environmental are other benefits for using ABC.

Railroad agencies typically allow service to be shut down for railroad bridge rehabilitation or reconstruction projects for only a few hours at a time. That's why accelerated bridge construction (ABC) using prefabricated bridge components and systems is ideal for railroad bridge construction projects. This paper presents a review of accelerated bridge construction for several railroad bridge projects. Through these case studies, it is clear that ABC can be used to reduce railroad service shut-down time, which has tremendous economic impact on Class I railroad companies. Projects discussed in this paper include moving the longest and heaviest railroad truss bridge with self-propelled modular transporter (SPMT); using a conical connection system for steel pipe piles inserted into precast pile cap; replacing 100-year-old thru girder bridges in 20 hours; installing a Precast Bridge Slab with a rail-mounted launching truss/gantry crane (gantry crane); using new design technology – such as Hybrid-Composite Beam (HCB) – for lighter, safer, greener and quicker construction.

PBES FOR RAILROAD BRIDGES

PREFABRICATED BRIDGE ELEMENTS AND SYSTEMS (PBES) used for railroad bridges are very similar to those used for highway bridges. Standard double-cell box and slab-girder-type spans are typically constructed in an accelerated "under traffic" situation. For longer spans, prestressed I-type girders or steel spans are used on the railroad. For these longer spans and short change-out work windows, steel spans are typically used rather than concrete.

A typical cross section of prestressed, precast, double-voided box girder is shown in Fig. 1[1]. The advantage of box girders is to eliminate cast-in-place concrete or steel deck plate that is required for I-section girders. Per Canadian National (CN) standards, box girder is applied to shorter spans ranging from 20 feet to 46 feet. The girder depth varies from 30 inches to 42 inches. In addition, Cooper E-90 is typically used for Class I railroad bridges.

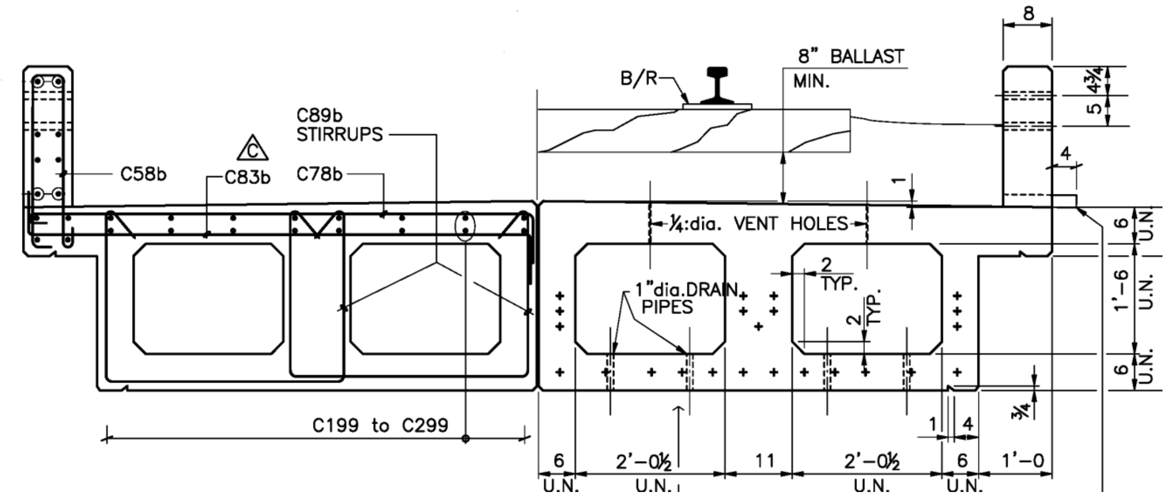

Fig. 1 Cross Section of Prestressed, Precast Double-Voided Box Girder (CN)

ROLL IN of RAILROAD TRUSS BRIDGE[2]

For the recent 130th Street and Torrence Avenue project in Chicago, the existing thru plate girder bridge was replaced with a 394-foot-long Warren Truss Railroad Bridge. In order to reduce railroad service shutdown time, the truss bridge was fully assembled near the bridge site. The 4.75-million-pound steel truss railroad bridge was moved from assembly site to bridge site using a self-propelled modular transporter (SPMT). The whole operation lasted less than eight hours, which was the allotted time for service to be shut down. Fig. 2 shows the path of truss bridge movement and Fig. 3 presents the SPMT set up for the truss bridge. As of today, this is the longest and heaviest railroad truss bridge that's been moved using SPMT.

Fig. 2 Path of Truss Movement (Chicago Department of Transportation)

Fig. 3 SPMT Set Up (CDOT)

CONICAL CONNECTION SYSTEM[3]

Conical Connection System (CCS) is a proprietary product developed by ENCON SOLUTIONS, LLC. Fig. 4 presents CCS connection detail. CCS consists of male and female components. The male component is welded to steel pipe piles.

This system was used for a recent CSX project in Illinois. Without interrupting train service, 30-inch diameter pipe piles were driven along outside of an existing timber trestle bridge. After the pipe pile was cut to the required elevation, a male half cone was welded to the top of each pipe pile with a full penetration weld. Once the welding was complete, concrete was poured inside of the cone. To ensure a proper fit between the piles and pile cap, cone measurements were taken and were forwarded to the precast manufacturer. Afterwards crews began replacing bridges at a rate of approximately one bridge per week. Figs. 5 and 6 show the construction sequence of the installation of driven piles, CCS, pile cap and prestressed, precast box beams.

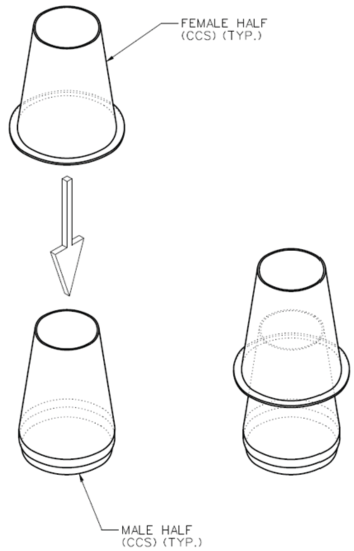

Fig. 4 CCS Connection (AREMA)

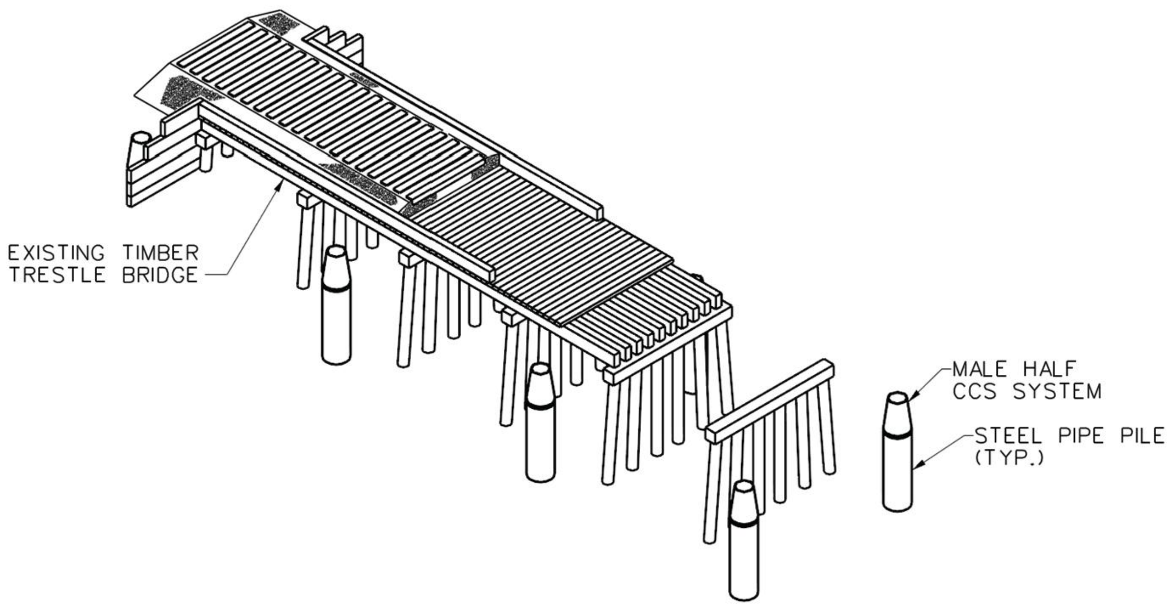

Fig. 5 Drive Piles and Attach Male Half of CSS (AREMA)

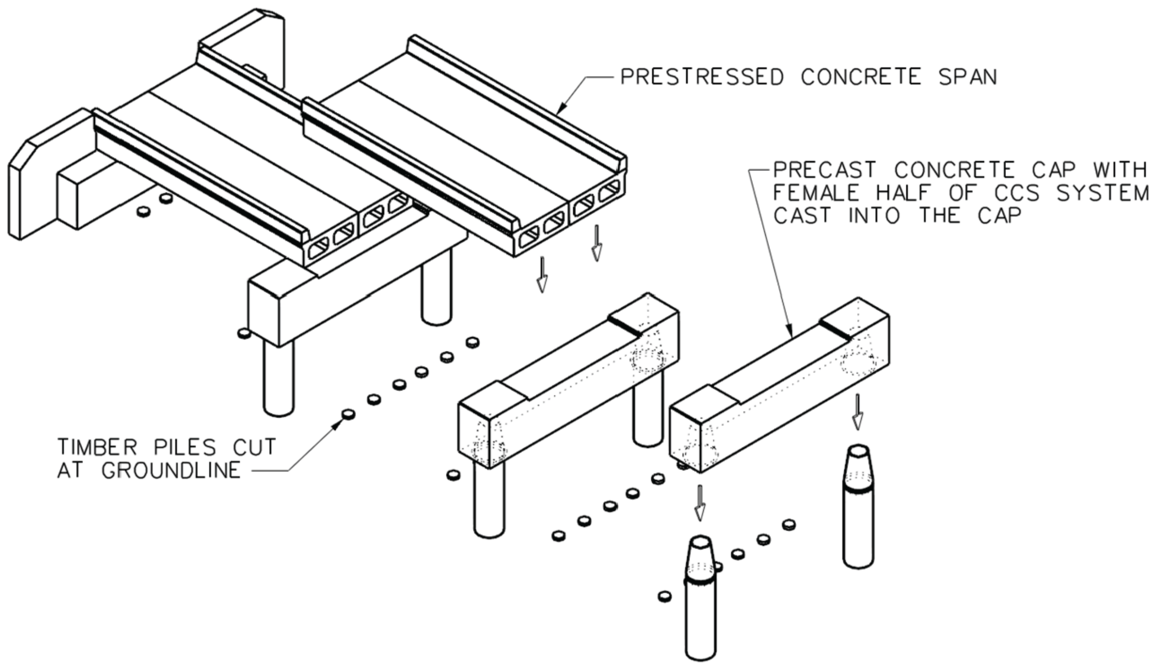

Fig. 6 Install Pile Cap and Precast Box Beam (AREMA)

REPLACEMENT OF TWO AMTRAK BRIDGES[4]

In a recent project, two Amtrak bridges were replaced simultaneously in a marine environment during a 20-hour rail shutdown. The existing bridges were single-span (66-ft, 77-ft), steel plate through girders with ballasted concrete decks. The new bridges are single-span (86-ft, 98-ft), steel plate through girders with ballasted steel decks, as shown in Fig. 7.

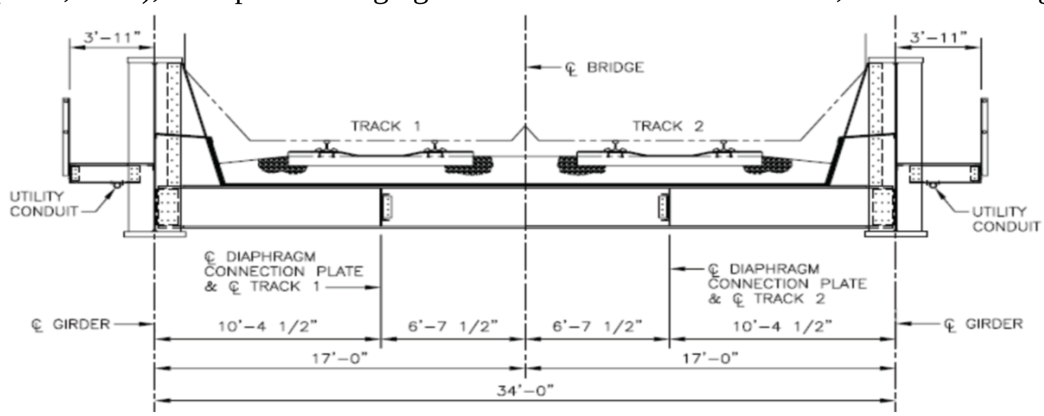

Fig. 7 New Bridge Cross Section (AREMA)

Prior to the 20-hour rail shutdown, several pre-shutdown works were completed as follows:

- Installed temporary bridges that allowed rail traffic to continue undisturbed during construction of the new abutment foundation
- Drilled new micro piles for the new bridge abutments
- Constructed new abutment seats or pile caps
- Installed the falsework that would be used during the roll-in/roll-out procedure for the bridge replacement outage
- Assembled new bridges nearby

During the 20-hour rail outage, the existing bridges were rolled out and the new bridges were rolled in as shown in Fig. 8. The project utilized 150-ton capacity Hilman rollers with Accu-Roll guide.

Fig. 8 Existing Bridge Rolled Out and New Bridge to Be Rolled In (AREMA)

REPLACEMENT OF TIMBER APPROACH TRESTLES OF NS BRIDGE[5]

The existing timber trestle approach spans for Norfolk Southern (NS) were replaced with ballasted, single-track, prestressed concrete spans ranging in length from 14 feet to 28 feet. Individual spans were replaced within a typical track outage of only six hours.

Fig. 9 shows the construction sequence, including the pier caps installed under the existing timber superstructure, cutting and removing existing timber stringers, timber bent caps and bracing and extracting existing timber piles. The installation of a new precast pier cap under an existing bridge is shown in Fig. 10.

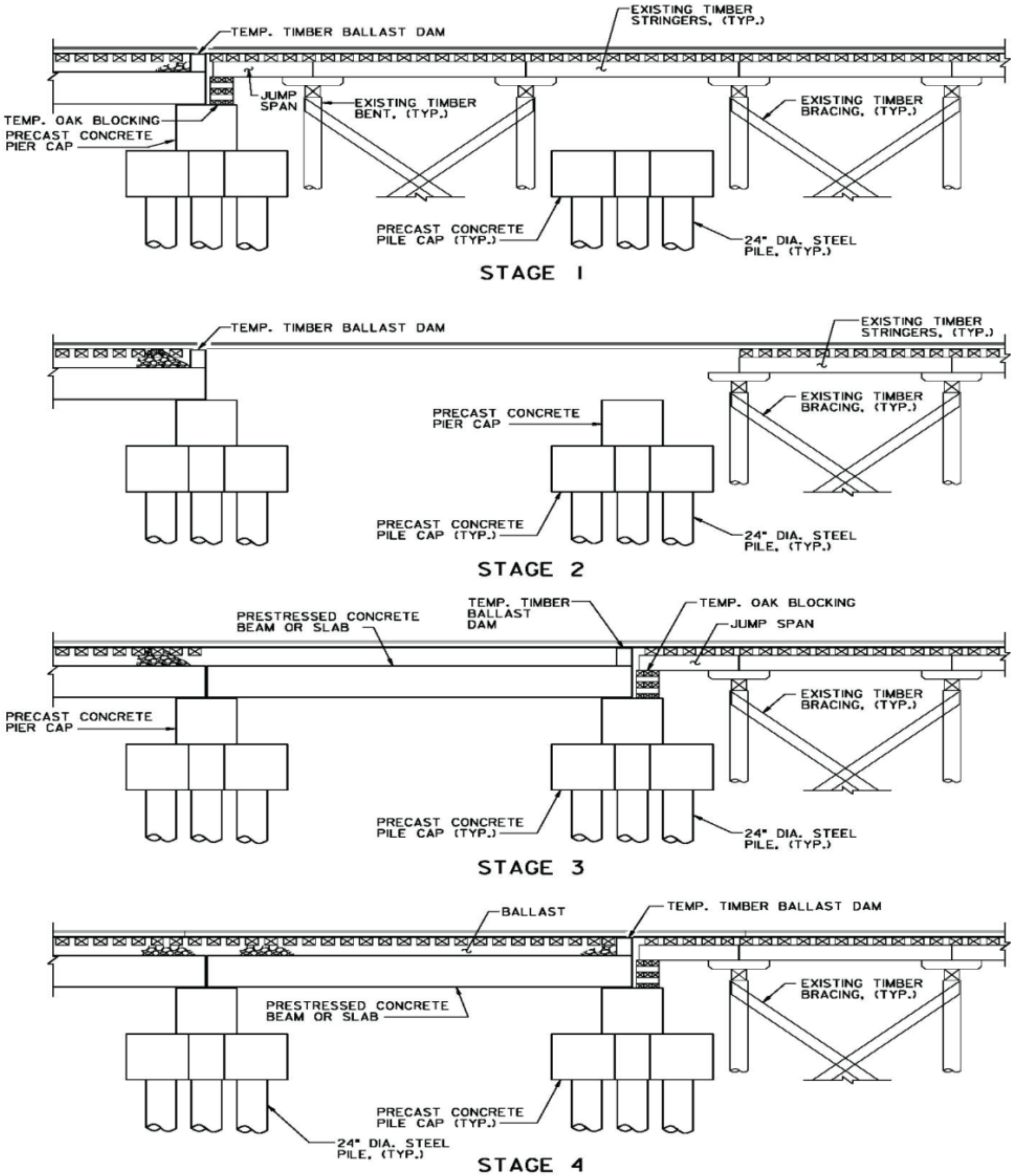

Fig. 9 Construction Sequence of Bridge Replacement (AREMA)

Fig. 10 Precast Pier Cap Installation (AREMA)

RAIL-MOUNTED LAUNCHING TRUSS/GANTRY CRANE[6]

In a recent project for Amtrak's Empire Line, a Rail-Mounted Launching Truss/Gantry Crane was used to install Multiple Deck-Girder Bridge Spans. Multiple bridges were constructed during a 4-week period.

In the fall of 2011, Amtrak utilized a rail-mounted launching truss/gantry crane (gantry crane) as shown in Fig. 11 for the first time to install multiple bridges during a 4-week period on Amtrak's Empire Line in upstate New York. The use of a rail-mounted gantry crane in this instance was an economical and safe choice for Amtrak versus using conventional crane equipment. The erection of a precast slab using a gantry crane is shown in Fig. 12. Pre- and post change-out sequencing is presented in Fig. 13.

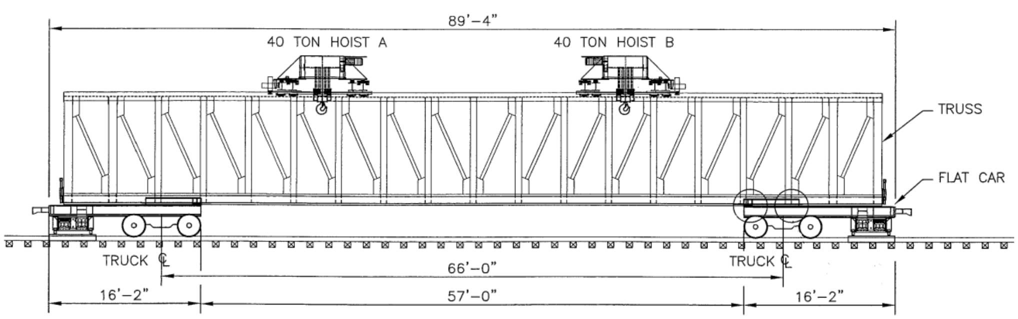

Fig. 11 Elevation View of Gantry Crane (AREMA)

Fig. 12 Precast Bridge Slab Installation (AREMA)

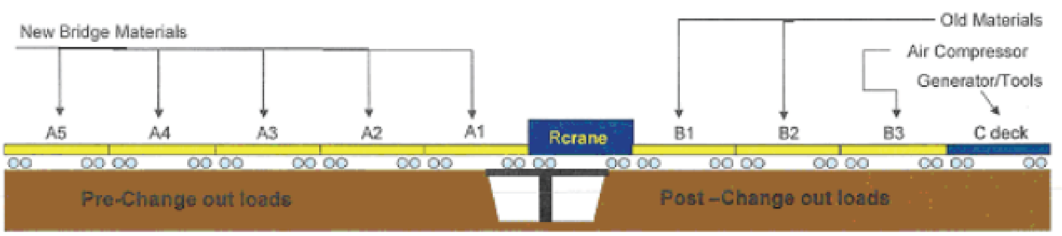

Fig. 13 Pre and Post Change-out Sequencing (AREMA)

HCB RAILROAD BRIDGES[7]

A Hybrid-Composite Beam (HCB), invented by John Hillman**,** is a structural member akin to a prestressed concrete or steel beam, as shown in Fig. 14. The FRP (Fiberglass Reinforced Polymer) outer shell provides shear strength and encapsulates the tension and compression elements. The compression element is a concrete arch. The tension element is steel reinforcement that runs the length of the beam and ties the two ends of the concrete arch together. Essentially, the HCB is a tied arch in a fiberglass box where 90 percent of the strength is provided by steel and concrete. The encapsulating FRP shell provides maximum protection from the elements for the steel and concrete ensuring an extended service life and minimal maintenance.

HCB is more sustainable, lighter, safer and provides a smaller carbon footprint than conventional prestressed concrete beam because it requires less cement. HCB can serve as a component of a prefabricated bridge element and system (PBES). It’s also ideal for Accelerated Bridge Construction (ABC).

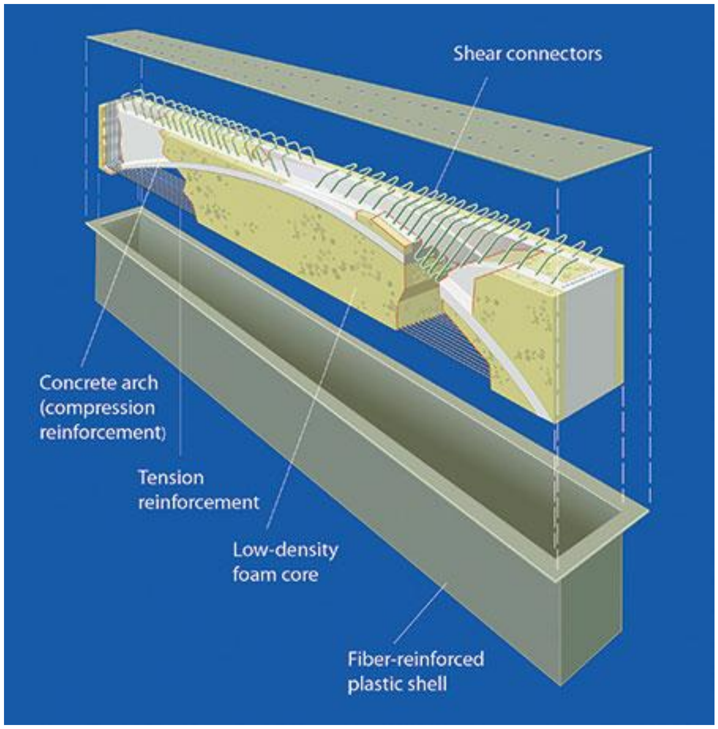

Fig. 14 Fragmentary perspective of the hybrid-composite beam (HC Bridge Company)

Fig. 15 presents the First Composite Railroad Bridge in the world. The bridge consists of 30-a feet-long, 17-feet-wide span comprised of eight hybrid composite beams.

Fig. 15 First HCB Railroad Bridge (HC Bridge Company)

CONCLUSIONS

Accelerated bridge construction using prefabricated bridge components and systems has many advantages over conventional cast-in-place construction. Prefabrication speeds up construction and increases quality of concrete members by fabricating in a controlled plant environment with reduced dependency on weather. Prefabrication also increases construction safety by avoiding forming, rebar placement, concrete placement and curing at bridge sites. Reduced durations for traffic closures and environmental impact are other benefits for using ABC.

For railroad bridge rehabilitation or bridge reconstruction projects, only a few hours shut down of railroad service is typically allowed by the agencies. Accelerated bridge construction (ABC) using prefabricated bridge components and systems is ideal for railroad bridge construction projects. In this paper, a review of accelerated bridge construction for several railroad bridge projects is presented. The case studies are presented in this paper including moving the longest and heaviest railroad truss bridge with self-propelled modular transporter (SPMT); using conical connection system for steel pipe piles inserted into precast pile cap; replacing 100 years old, thru girder bridges in 20 hours; installing Precast Bridge Slab with a rail-mounted launching truss/gantry crane (gantry crane); using new design technology such as Hybrid-Composite Beam (HCB) for lighter, safer, greener and quicker construction. Through these case studies, it is clear that ABC can be used to reduce railroad service shut down time, which has tremendous economic impact on Class I railroad companies.

ACKNOWLEDGEMENT

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