FHWA/AASHTO INTERNATIONAL SCAN ON PREFABRICATED BRIDGE ELEMENTS AND SYSTEMS

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Abstract

The aging highway bridge infrastructure in the United States is being subjected to increasing traffic volumes and must be continuously renewed while accommodating traffic flow. The traveling public is demanding that this rehabilitation and replacement be done more quickly to reduce congestion and improve safety. New bridge systems are needed that will allow components to be fabricated off-site and moved into place for quick assembly while maintaining traffic flow. To obtain information about technologies being used in other industrialized countries, a scanning tour of five countries was made in April 2004.

[Taken from the 3rd Draft (August 2004) Scan Team Report that is to be published.]

Introduction

The aging highway bridge infrastructure in the United States is being subjected to increasing traffic volumes and must be continuously renewed while accommodating traffic flow. The traveling public is demanding that this rehabilitation and replacement be done more quickly to reduce congestion and improve safety. Conventional bridge reconstruction is typically on the critical path because of the sequential, labor-intensive processes of completing the foundation, the substructure, the superstructure components (girders and decks), the railings, and other accessories. New bridge systems are needed that will allow components to be fabricated off-site and moved into place for quick assembly while maintaining traffic flow. Depending on the specific site conditions, the use of prefabricated bridge systems can minimize traffic disruption, improve work-zone safety, minimize impact to the environment, improve constructibility, increase quality, and lower life-cycle costs. This technology is applicable and needed for both existing and new bridge construction. The focus of this initiative is on conventional routine bridges that make up the majority of the bridges in the United States.

To obtain information about technologies being used in other industrialized countries, a scanning tour of five countries was made in April 2004. The overall objectives of the scanning tour were to identify international uses of prefabricated bridge elements and systems and to identify decision processes, design methodologies, construction techniques, costs, and maintenance and inspection issues associated with use of the technology. The scanning team was, therefore, interested in all aspects of design, construction, and maintenance of bridge systems composed of multiple elements that are fabricated and assembled off-site. The elements consisted of foundations, piers or columns, abutments, pier caps, beams or girders, and decks. Bridges with span lengths in the range of 6 to 40 m (20 to 140 ft) were the major focus, although longer spans were of interest if a large amount of innovative prefabrication was used.

The focus areas of the study were, therefore, prefabricated bridge systems that

1. minimize traffic disruption,
2. improve work zone safety,
3. minimize environmental impact,
4. improve constructibility,
5. increase quality, and
6. lower life-cycle costs.

The scanning tour was sponsored by the Federal Highway Administration (FHWA) and the American Association of State Highway and Transportation Officials (AASHTO) and organized by American Trade Initiatives, Inc. The eleven member team included three representatives from FHWA, four representatives from State DOTs, one representative from the National Association of County Engineers, one university representative, and two representatives from industry. The team visited Japan, the Netherlands, Belgium, Germany, and France and held meetings and site visits with representatives of government agencies and private sector organizations. The countries were selected because of their known use of prefabricated systems. Visiting Japan was particularly important because of their seismic design requirements.

Findings and Recommendations

At completion of the scanning tour, the team had identified 33 bridge technologies that, in one or more aspects, were different from current practices in the United States. Not all of these related to the primary objectives of the scanning tour. Using the six focus areas as selection criteria, the team identified ten overall technologies that are recommended for further consideration and possible implementation into United States practices. A brief description of each of the ten technologies is given in the following sections.

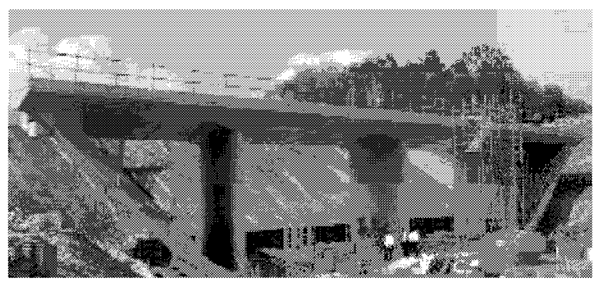
Movement Systems

During the tour, many different methods that can be used to remove partial or complete existing bridges and move bridge components or complete bridges into place were observed. These methods allow a new bridge to be built at one location near or adjacent to the existing structure and then moved to its final location in a few hours. Construction can, therefore, take place in an environment where construction operations are completely separated from the traveling public. These methods reduce traffic disruption times from months to days or hours, restore the use of existing highways in significantly less time, improve work zone safety, minimize environmental impact, improve constructibility, and lower life cycle costs. The controlled environment that is off the critical path also facilitates improved quality of components. This concept of building bridges off line and then moving them into place needs to be developed for use in the United States.

Self Propelled Modular Transporters:

In Europe, it was observed that large bridge components or even complete bridges weighing several thousand metric tons have been built at one location and then lifted and transported to their final location using a series of vehicles known as self propelled modular transporters (SPMTs). These multi-axle computer-controlled vehicles have the capability of moving in any horizontal direction with equal axle loads while maintaining a horizontal load with undeformed or undistorted geometry.

Other Bridge Installation Systems:



In addition to using SPMTs and conventional land or barge mounted cranes to erect large structures, other methods of moving bridge components included the following:

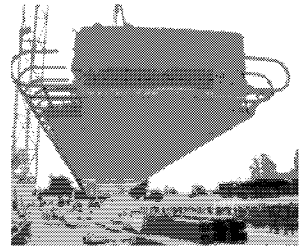
1. Horizontally skidding or sliding bridges into place
2. Incremental launching longitudinally across valleys or above existing highways
3. Floating bridges into place using barges or by building a temporary dry dock
4. Building bridges alongside an existing roadway and rotating them into place
5. Vertically lifting bridges

These systems can be used to minimize the time that an existing bridge is out of service while it is replaced, many within 3 to 48 hours.

Superstructure Systems

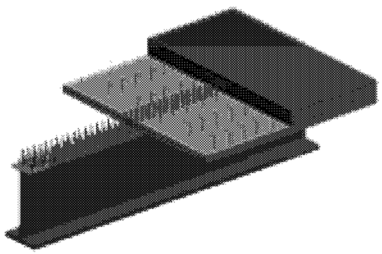
The typical sequence of erecting bridge superstructures in the United States is to erect the concrete or steel beams, place either temporary formwork or stay-in-place formwork such as steel or concrete panels, place deck reinforcement, cast deck concrete, and remove formwork if necessary. Elimination of the need to place and remove formwork for the deck after the beams are erected can accelerate on-site construction and improve safety. Three systems to accomplish this were identified during the tour.

Poutre Dalle System:



One method to eliminate formwork and provide a working surface is provided by the French system known as the Poutre Dalle system. In this system, shallow, inverted tee-beams are placed adjacent to each other and then made composite with cast-in-place concrete placed between the webs of the tees and over the tops of the stems to form a solid member.

Partial Depth Concrete Decks Prefabricated on Steel or Concrete Beams:



One system in Germany involved the casting of partial depth concrete decks on steel or concrete beams prior to erection of the beams. After the beams are erected, the edges of each deck unit abut the adjacent member and there is no need to place additional formwork for the cast-in-place concrete. This process speeds construction and reduces the potential danger of equipment falling onto the roadway below since a safe working surface is available immediately after beam erection.

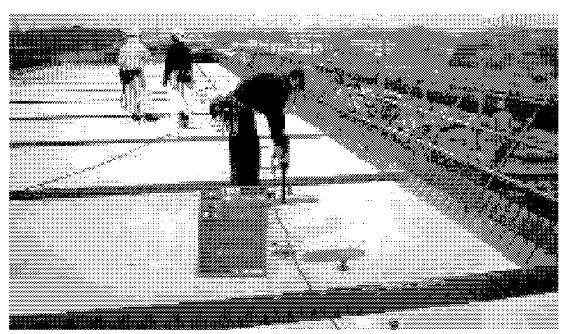
U-Shaped Segments with Transverse Ribs:

To reduce the weight of precast concrete segments, the Japanese use a segment in which the traditional top slab is replaced with a transverse prestressed concrete rib. After erection of the segments, precast, prestressed concrete panels are placed longitudinally between the transverse ribs. After a topping is cast on top of the panels, the deck is post-tensioned transversely.

Deck Systems

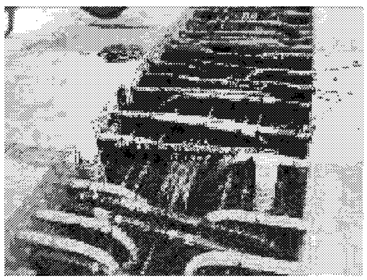
Four innovations for bridge deck systems were identified and are recommended for implementation in the United States.

Full Depth Prefabricated Concrete Decks:



The use of full depth prefabricated concrete decks in Japan and France reduces construction time by eliminating the need to erect deck formwork and provide cast-in-place concrete. The deck panels are connected to steel beams through the use of studs located in pockets in the concrete deck slab. The use of full depth prefabricated concrete decks on steel and concrete beams provides a means to accelerate bridge construction using a factory produced product.

Deck Joint Closure Details:

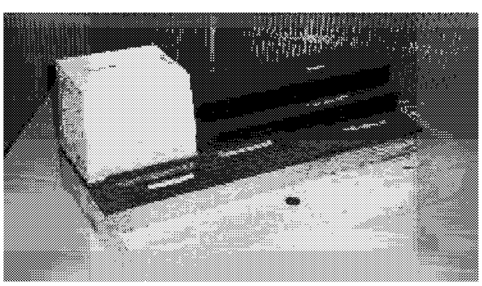


Prefabricated deck systems require that longitudinal and transverse joints be provided to make the deck continuous for live load distribution and seismic resistance. This is accomplished by using special loop bar reinforcement details in the joints. Various joint details observed during the tour should be developed for use in the United States to facilitate the use of prefabricated full depth deck systems.

Hybrid Steel-Concrete Deck Systems:

The Japanese have developed hybrid steel-concrete systems for bridge decks. The steel component of the system consists of bottom and side stay-in-place formwork and transverse beams. The transverse beams span over the longitudinal beams and cantilever beyond the fascia beam for the slab overhang. The bottom flanges of the transverse beams support steel formwork for the bottom of the slab while the top flanges support the longitudinal deck reinforcement. When filled with cast-in-place concrete, the system acts as a composite deck system. The system allows rapid placement of a lightweight deck stay-in-place formwork system complete with reinforcement using a small capacity crane.

Multiple Level Corrosion Protection Systems:

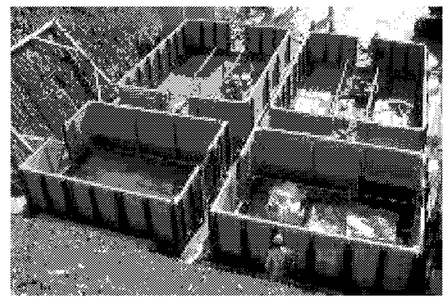


In Japan, Germany, and France, concrete bridge decks are covered with a multiple level corrosion protection system to prevent the ingress of water and deicing chemicals. The systems generally involve providing adequate concrete cover to the reinforcement, a concrete sealer, waterproof membrane, and two layers of asphalt. This type of corrosion protection system may be beneficial with prefabricated systems as a means of protecting the joint regions from potential corrosion damage, thereby ensuring a longer service life. The system may also be used to extend the service life of existing bridges.

Substructure Systems

One substructure system is recommended for implementation in the United States.

The SPER System:



The SPER system is a Japanese method of rapid construction of bridge piers using stay-in-place, precast concrete panels as both structural elements and formwork for cast-in-place concrete. Short solid piers have panels for outer formwork, whereas tall hollow piers have panels for both the inner and outer formwork. Segments are stacked on top of each other using epoxy joints and then filled with cast-in-place concrete to form a composite section. Experimental research in Japan has demonstrated that these piers have similar seismic performance to conventional cast-in-place reinforced concrete piers. The system has the advantage of reduced construction time and results in a high quality, durable external finish.

Implementation Activities

In 2004 and 2005, the scanning team plans numerous written papers and technical presentations at national and local meetings and conferences to describe the overall results of the scanning tour and details on specific technologies. The scanning team has also prepared a Scanning Technology Implementation Plan for each of the ten technologies described above.

In general, the strategies involve obtaining more information about the technologies from the host countries, making this information available on FHWA or other web sites, seeking demonstration or pilot projects, and holding workshops in association with the pilot projects.