PUTTING RESEARCH TO WORK

BRIEF

Faster Bridge Construction Using Precast Substructures

Bridge replacement often requires road closures and detours that frustrate road users. It remains a key goal of Wisconsin DOT to reduce construction-related road use interruptions. This will be a challenge with bridges: Bridge inspections in 2007 identified 2,091 of Wisconsin's 13,798 bridges as deficient and possibly in need of replacement.

What's the Problem?

Constructing a new bridge or replacing an old one can consume many months and cause significant delays for the traveling public. Pouring concrete for bridge abutments and other elements that are constructed on-site requires time for forming and casting, and further time for curing. Weather delays and safety considerations for crew members working at heights may also add to construction time. Efforts to shorten these interruptions to road use often focus on construction management and materials selection.

Another approach to reducing construction time involves prefabrication of bridge components at an off-site location. Precast bridge elements, long used for decks and superstructure components, had yet to be used in Wisconsin in the bridge sub-structure. As Wisconsin faces the need to replace many of its bridges in the near term, increasing the use of precast elements offers a potential solution to minimize related construction. Using precast substructure elements may shorten substructure construction time, often the most time-consuming step in building a bridge. Construction using these precast elements poses fewer safety risks, and should be less affected by weather conditions.

Research Objectives

This study's objective was to develop a system for precast bridge substructure elements that would suit Wisconsin's needs. Based on literature review, data analysis, and use of precast substructures in field trials, researchers identified four needs for implementation of this accelerated construction approach. Such systems require:

- Standardization for optimal use of modules adaptable to various bridge sizes.
- Compatibility between manufacturer capabilities and WisDOT design and construction needs.
- Ease of handling in terms of size and shape to ensure elements are easy to transport and manipulate at the construction site.
- Elements that allow for quick and simple construction.

Methodology

Researchers evaluated four system components: spread footing foundations, columns, abutments and pier caps. Investigators identified efficient systems in terms of individual pieces and connections between components. They then recommended those most appropriate for Wisconsin.

During evaluation of systems suited to Wisconsin, investigators and the Wisconsin Highway Research Program Structures Technical Oversight Committee removed two components from further consideration: spread footings, which are rarely used in Wisconsin, and pier columns, which WisDOT feels can be efficiently constructed using current cast-in-place methods. It was agreed that an effective precast substructure system could still be put in place with the remaining two components.

After identifying promising systems during the research phase of the project, investigators worked with crews on the U.S. 63 bridge over the Rush River north of Baldwin, Wis. Stream crossings are by far the most common type of bridge project for WisDOT, and the Baldwin bridge was Wisconsin's first use of precast concrete abutments.

Investigator

"Substructures like this are used all over the world. We developed systems that appear to be a good fit for Wisconsin."

–Michael G. Oliva
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Precast abutments like these being placed at a bridge site near Baldwin, Wis., can reduce bridge construction time from two weeks to under two days.

Project Manager

"Research results were promising. Next we want to get a better feeling about how these perform and then consider trying other precast substructure elements in the future."

–Travis McDaniel
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Results

The Baldwin bridge project saved time using precast abutments. A cast-in-place system would have required two weeks of four workers' time to complete 96 linear feet of abutment. The precast concrete abutment system required only 10.5 hours to place the modules using the same number of workers, including time for erection, forming and grouting. The on-site time savings were substantial.

Costs were higher than anticipated at the Baldwin bridge due in large part to the need for a high-capacity crane to set the abutment panels. Investigators recommended lower element weights for future projects to allow the use of smaller cranes with lower equipment rental costs.

Precast substructure elements were found to have the additional benefit of higher quality as compared with cast-in-place elements. Casting concrete in well-controlled conditions such as a manufacturing facility produces more durable and consistent pieces than is possible in the field.

Researchers made the following specific recommendations for WisDOT's consideration:

- Use precast abutments in two standard height range configurations that allow for adjustable widths.
- Use rectangular section caps with either a grouted connection or with post-tensioning.

Implementation and Benefits

Costs will continue to drop as crews become more familiar with post-tensioning, an uncommon practice in Wisconsin. Post-tensioning allows control over stress cracking and water resistance, improving durability. Expertise in the method will improve with experience. WisDOT intends to try the new approach several times before moving on to precasting other substructure elements.

This brief summarizes Project 0092-07-08, "Rapid Bridge Construction Technology: Precast Elements for Substructures," produced through the Wisconsin Highway Research Program for the Wisconsin Department of Transportation Research Program, 4802 Sheboygan Ave., Madison, WI 53707.

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