# Concrete Panels Speed Bridge Deck Construction

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When better bridges are built, will they feature full-depth precast deck panels? That could very well become the standard construction method, both for new bridges and for deck replacement on older, worn-out structures.

That's the gist of a state-of-the-art report now being prepared by a large, multi-faceted team of researchers, consultants, state and federal engineers, academics and industry led by Joe Rose of Bayshore Concrete Products, Cape Charles, Virginia. The team is working as a task force of the Bridge Producers Committee of the Precast/Prestressed Concrete Institute (PCI), Chicago, Ill. The report strongly concludes that the use of such panels significantly reduces construction time while lessening the impact on traffic flow. Furthermore, the report states unequivocally that decks made with precast full-depth panels are superior to those employing more traditional cast-in-place concrete.

With an ever-increasing need to upgrade and replace substandard bridges throughout the country, the full-depth bridge panels promise a more timely solution to the problem.

To deal with the nation's transportation demands, bridges must be more durable. Furthermore, the traveling public is impatient with delays and the traffic congestion caused by construction. The demand for reduced delays and safety consideration make it imperative that one of two approaches be taken. Either work must proceed in off-peak travel hours, or ways must be found to accelerate the construction cycle to minimize the time that barriers are erected and traffic rerouted or slowed.

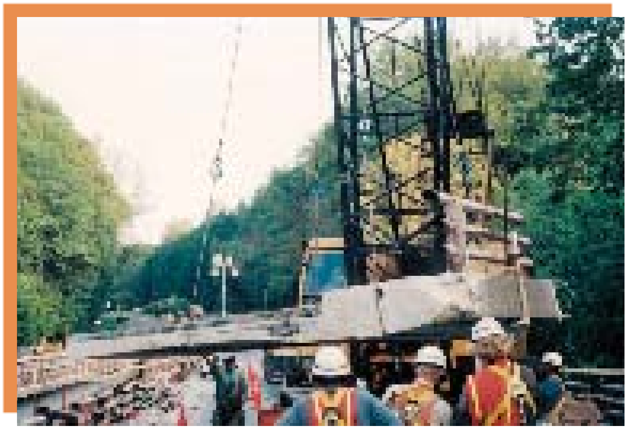
Bridge deck replacement projects employing full-depth precast bridge decks have been undertaken in more than 20 states. These projects clearly demonstrate that the method significantly reduces construction time and impact on traffic.

## The Precast Concrete Deck System

A full-depth precast concrete deck system comprises a series of precast concrete panels that are as thick as the full-depth required by structural design, with the length and width determined by the specific geometry of the individual bridge. The length along the roadway varies from eight to twelve feet. The width of the panels is generally equal to the full width of the bridge. Both the length and width are determined on the basis of handling and transportation requirements. Generally, speed and economy are achieved with use of the fewest number of panels on a given project... For bridges less than about 50 to 60 feet wide, the panels are cast to the full width of the bridge. For wider bridges, and for bridge replacement projects with construction phasing requirements, partial width panels are used.

The system consists of: 1) the precast panels, with voids (blockouts) along the girder lines to accept the shear connectors from the girders, 2) temporary panel supports, or shims, 3) grout between supporting girders and the panels, and 4) transverse joints between the precast panels, which are usually grouted but are sometimes match cast in a similar way to segmental box girder construction. The top surface of the bridge after the panels are installed is either ground to the required roadway profile, or overlaid with some type of overlay to achieve the required profile. Typically, the panels are pretensioned transversely in the plant. Often, longitudinal post-tensioning is used to tie the panels together and provide prestressing in that direction. A two-way precompressed concrete deck is designed to be crack-free for the service life of the bridge, an advantage that is not practical to achieve with cast-in-place decks. Currently, efforts are being made to develop new non-post-tensioned alternates to further minimize the field construction steps and speed up construction.

Precasters and contractors employing the system prefer to use transversely pretensioned panels, primarily to control cracking from handling and shipping the panels from the plant to the construction site. The stresses due to handling are often more severe than those



due to traffic loads. Thus, a precast system is inherently stronger than a cast-in-place system. Panels are generally designed for composite action with the supporting girders. Non-composite panels are sometimes employed, where possible, to simplify the design, fabrication and construction process. With non-composite panels, the voids (blockouts) and the shear connectors are eliminated, which simplifies forming and reduces work on the jobsite. This, however, requires that relatively large girders carry traffic loads without aid from the deck as in composite.

## A Multitude of Benefits

A strong case can be made for improved quality when employing precast concrete full-depth bridge decks. While cast-in-place decks are subject to the vagaries of environmental conditions, precast panels are produced in a plant under carefully controlled conditions. This allows panels to be produced to tight tolerances—width and length to within plus or minus a quarter inch and depths from plus a quarter inch to minus an eighth of an inch, for example. There is an intrinsic major weakness of cast-in-place decks for which a solution has not been found. When concrete is placed over relatively stiff girders, it becomes part of the girder/deck composite system when it begins to harden several hours after placement. At that time, its tensile capacity is small. Shrinkage in the first few hours after setting, and the temperature drop as the heat of cement hydration dissipates, causes a reduction in concrete volume that cannot be accommodated due to the restraint of the supporting girders. This often results in cracking, especially in the transverse direction that continues to develop with the concrete shrinkage. Most of the shrinkage occurs

in the first 60 days of the concrete age. Elimination of the volume change problem using precasting is, alone, enough to justify using precast concrete for bridge decks.

Because of the plant environment, curing is easily controlled to achieve the best material performance characteristics. A two-way pre-compressed concrete deck is expected to be crack-free for the service life of the bridge, an advantage that is not practical to achieve on cast-in-place decks. High performance concrete (HPC), with its high strength and low shrinkage, is required to carry repeated load cycles in severe environmental conditions. Plant casting provides greater assurance that the HPC characteristics will be achieved. For example, plant produced 8,000 psi concrete panels are just as easily produced as 4,000 psi concrete panels, while a cast-in-place concrete deck is hard to consistently produce at a strength higher than 4,000 or 5,000 psi. More important than strength in bridge decks, shrinkage and the associated cracking are greatly controlled. Plant casting will become more prevalent as labor shortages and turnover in the field bedevil contractors.

A multitude of projects stretching back nearly 40 years demonstrates a significant reduction in construction time. Documented reductions in construction time can range as high as 75 percent when compared with cast-in-place decks. The advantage comes by removing the field concrete placement and curing from the critical path, and replacing it with precast deck installation. Precast components also reduce the amount of site work required, thereby reducing safety risks to both workers and the traveling public. This greater flexibility also allows the contractor to focus on critical path items. On-site work can proceed while the panels are being cast in a plant. The use of precast deck panels allows placement to take place quickly during non-peak traffic hours (nights and weekends), and in winter months.

Another advantage offered by the use of full-depth bridge deck panels is the ability to reduce dead loads by employing lightweight concrete. The use of lightweight concrete is not exclusive to precast deck panels. Cast-in-place decks have also been built using lightweight concrete. A plant environment, however, makes the use of lightweight concrete more effective. Lightweight aggregate concrete is often associated with higher shrinkage and lower tensile strength than sand-gravel-rock concrete. With cast-in-place decks, having to contend with both disadvantages while concrete is curing at the site is a major challenge.

Additionally, the complexities of mixing, placing, finishing and curing lightweight concrete are easier to accommodate in a plant setting.

## Comparing costs

One of the perceived disadvantages of deck panels vis-à-vis cast-in-place bridge decks is the differential in costs. Currently, it is estimated that using precast full-depth concrete panels costs between 10 and 25 percent more than cast-in-place decks. The study by the University of Nebraska suggests that the cost differential resides primarily in the fact that the deck panel system has enjoyed limited use since its introduction to the market in the 1960s. The PCI State-of-the-Art Report predicts that as more bridge decks are constructed using panels, the cost differential will diminish, due to consistent detailing and uniform design. Also, precasters are involved in a variety of programs to seek ways to lower costs.

The study also suggests that initial costs are not the whole ballgame. When road user and maintenance of traffic costs are factored in, the total cost of the precast deck system greatly dips below that of cast-in-place. Currently, such costs run approximately 30 to 50 percent of the project construction cost. Completed projects show the benefits to contractors provided by precast decks in cases where incentive and disincentive clauses or time constraints exist. A recently value-engineered project by Tadros Associates, LLC of Omaha, Nebraska is the Arbor Road Overpass over I-80 near Lincoln, NE. For that bridge, the contractor, Cohron Construction Company of Atlantic, Iowa, opted to use a precast deck panel system rather than the original cast-in-place system to save time and girder bracing cost. Another bridge, the Skyline Bridge, in Omaha, was designed by the Nebraska Department of Roads and constructed by Hawkins Construction Company of Omaha. With its plate girders and precast deck panels, it had a total cost of less than $70 per square foot, comparable to similar bridges with cast-in-place decks, not to mention improved speed and quality. Both the precaster and contractor have indicated that the experience with this bridge would allow them further cost efficiencies on future projects.

## A practical alternative

Precast concrete bridge deck slabs provide a practical alternative to site-cast concrete bridge decks in a wide variety of situations. Existing decks can be replaced more quickly.

Many different types of systems have been employed. Some are conventionally reinforced while others are prestressed with either pretensioning or post-tensioning or both... A typical panel thickness is six to ten inches.

Both composite and non-composite designs and a variety of connection details have been used. However, whatever the system, engineers and owners concur that it is necessary to provide a smooth riding surface and protection against the intrusion of chlorides. The high performance concrete used in a precasting operation contributes significantly to protecting the deck from intrusion of chlorides. A cost effective way of providing a smooth riding surface is to provide extra concrete thickness and to grind the surface to

the required profile. Contractors indicate that grinding is common with cast-in-place decks as well, in order to meet owner's roadway profile specifications. Other, more expensive methods or protection include thin epoxy overlays, waterproofing membrane overlaid with asphalt, and 1½ to 2-inch concrete overlays.

The non-overlaid system employs low permeability concrete, a concrete cover over the top steel mat equal to the 2-inch AASHTO minimum corrosion protection requirement, plus ¾ to 1 inch of sacrificial thickness. Of that thickness, ¼- to ½-inches is ground out to provide a smooth surface at the time of construction, ½-inch is assumed to be a non-structural wearing layer that would be consumed over time, and the remaining 2-inch used to satisfy the AASHTO requirement. The diamond grinding can be conducted a lane at a time while other lanes continue to carry traffic.

Increased interest in the use of full depth precast deck panel systems has also prompted a 30-month research study funded by the National Cooperative Highway Research Program and conducted by George Washington University in Washington, D.C. That study is expected to be completed in 2006.

With the interest growing in precast full-depth concrete panels for bridge decks, an increasing number of precasters are now producing such units. Members of the Precast/Prestressed Concrete Institute who produce such units from their PCI certified plants can be found at the PCI website, **www.pci.org**.▪

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