CENTER FOR TRANSPORTATION RESEARCH
THE UNIVERSITY OF TEXAS AT AUSTIN

Project Summary Report 1517-S
Project 9-1517: Feasibility of Precast Slabs in PCC Pavements

Authors: David K. Merritt, B. Frank McCullough, Ned H. Burns, and Anton K. Shindler

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PROJECT SUMMARY REPORT

Feasiblility of Precast Prestressed Concrete Panels for Expediting PCC Pavement Construction

The ever-increasing number of vehicles on America's roadways is causing pavements to deteriorate faster, requiring major rehabilitation or replacement. Rehabilitation or construction of new pavements, however, can cause significant traffic congestion, leading to a substantial increase in user costs.

Under this premise, and owing to the success of precast concrete technology in the bridge and commercial building industries, the Texas Department of Transportation (TxDOT) and the Federal Highway Administration (FHWA) commissioned research to investigate the feasibility of using precast concrete panels for pavement construction.

Pavement construction that makes use of precast concrete panels can take place during off-peak travel times, such as at night and over weekends. Such scheduling will significantly reduce traffic congestion resulting from construction activities, which in turn will greatly reduce user delay costs while also ensuring a durable, high-performance pavement.

What We Did...

The first objective of the research was to determine the current state of the art in precast pavement technology worldwide, as well as in the precast concrete and concrete paving industries in general. This was accomplished primarily through a comprehensive literature review. The second objective was to identify possible concepts for a precast pavement. As the amount of literature and experience with precast pavements was very limited, possible concepts were generated primarily through two expert panel meetings, one at the beginning of the project and one near the end of the project. The expert panels consisted of various professionals from transportation agencies, the precast industry, and the concrete paving industry.

The third objective of the research was to perform a feasibility analysis on the possible concepts that were generated through the literature review and expert panel meetings. The feasibility analysis examined the possible concepts from the standpoint of design, constructibility, economics, and durability. Finally, once a feasible concept for precast pavement was established, the final objective of the research was to make recommendations for future implementation and guidelines for performance monitoring of future precast pavement test sections.

What We Found...

The proposed concept for a precast pavement consists of full-depth precast, prestressed

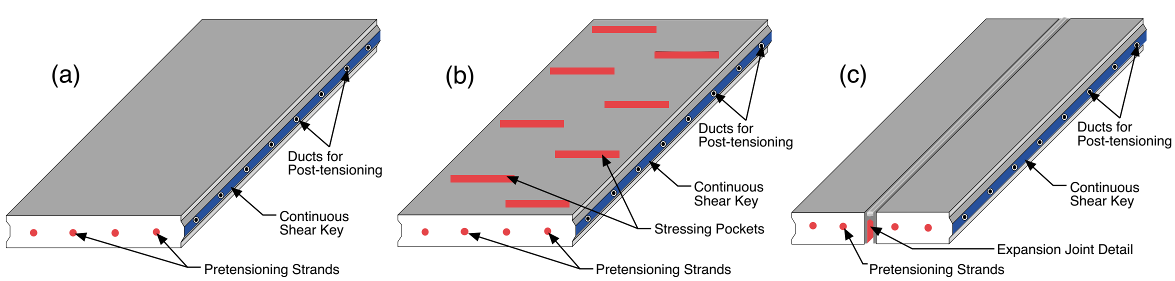

Figure 1. Three types of panels used for a precast pavement: (a) base panel, (b) central stressing panel, and (c) joint panel.

concrete panels. The panels will all be pretensioned in the transverse direction during fabrication and post-tensioned together in the longitudinal direction after placement. The advantage of using prestressed panels is a significant increase in the durability of the pavement, with a significant reduction in required pavement thickness. For example, an 8 in. thick precast, prestressed pavement can be designed for the same design life as a 14 in. thick continuously reinforced concrete pavement by simply adjusting the prestress level in the pavement. This adjustment will not only result in significant material cost savings but will also allow for more flexibility when pavements are constructed in areas with overhead clearance restrictions, such as under bridges.

The proposed concept consists of three different types of panels, as shown in Figure 1. The base panels (Figure 1a) are the “filler” panels between the joint panels and central stressing panel(s). The central stressing panel (Figure 1b) is a panel similar to the base panel, with the addition of pockets cast into the panel. These pockets will allow the post-tensioning strands to be stressed at the center of the slab, rather than at the anchorage, which will be cast into the joint panels. The joint panels (Figure 1c) will contain an expansion joint detail (Figure 2), similar to that of bridge expansion joints, which will absorb the significant expansion and contraction movements of the pavement with daily and seasonal temperature cycles.

A typical panel assembly is shown in Figure 3. The slab length (between expansion joints) will be varied by an increase in the number of base panels between the joint panels and central stressing panels. After all of the panels are set in place, the post-tensioning strands will be inserted into the ducts via the central stressing pockets and threaded through all

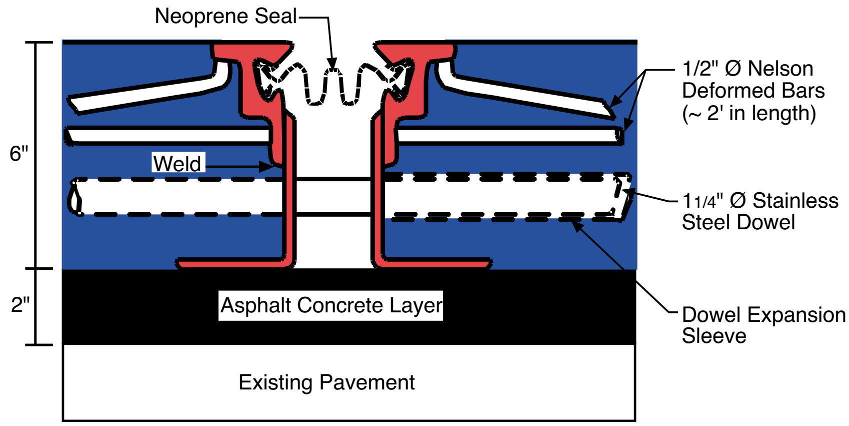

Figure 2. Expansion joint detail to be cast into the joint panels.

of the panels to self-locking, spring-loaded post-tensioning anchors cast into the joint panels. The use of self-locking anchors will allow the strands to simply be pushed into the anchors from some point along the pavement, most likely from small pockets cast into the joint panels.

After the post-tensioning strands are tensioned from the central stressing pockets, the pockets will be filled with a fast-setting concrete, which will have sufficient strength by the time traffic is allowed back onto the pavement. The strands will then be grouted in the ducts via inlets/vents located at the expansion joints and at the stressing pockets. The intermediate joints between the individual panels will then be sealed with a low-viscosity, liquid sealant. If needed, the pavement can then be diamond-ground to smooth out any major irregularities, and any major voids beneath the pavement can be filled by standard grout injection or expansive polyurethane foam.

To obtain a smooth riding surface over the assembled pavement, continuous shear keys will be cast into the panel edges, as shown in Figure 1, to ensure exact vertical alignment of the panels as they are set in place. Additionally, the panels will be placed over a thin, 1 to 2 in. thick, asphalt leveling course, which should provide a smooth, flat surface on which the panels can be placed to minimize the amount of voids beneath the panels. A single layer of polyethylene sheeting will also be placed over the asphalt leveling course to reduce the friction between the leveling course and the precast panels.

Through the feasibility study described above, the researchers developed a feasible concept for a precast concrete pavement. This concept should meet the requirements for both expedited construction and increased durability, which will result in both tremendous savings in user costs and an increased design life.

With respect to expedited construction, the proposed concept has many features that will allow for construction to take place during overnight or weekend operations. First, the asphalt leveling course can be placed well in advance of the precast panels. This will allow for the entire asphalt leveling course to be placed at one time, rather than just prior to the placement of the precast slabs. Traffic on the leveling course should not have a detrimental effect as long as the panels are placed within a reasonable amount of time after the leveling course. Second, neither the stressing pockets nor the post-tensioning ducts must be filled or grouted prior to exposure to traffic. The pockets can simply be temporarily covered and the strands can be grouted during a subsequent construction operation. Finally, tem-

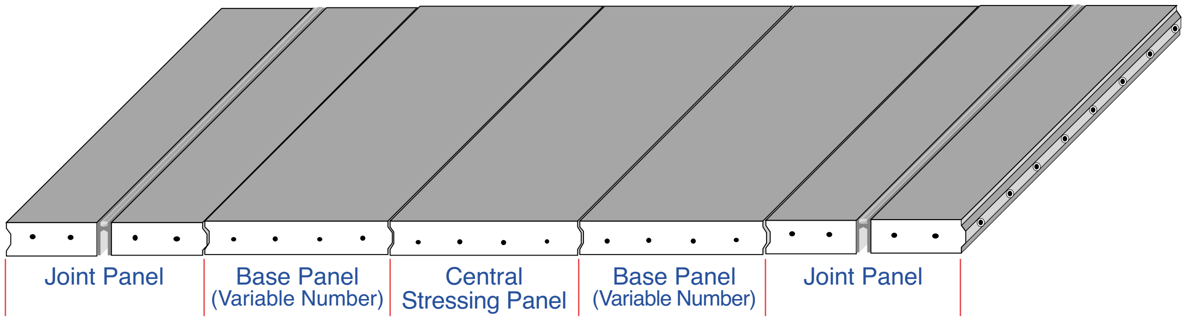

Figure 3. Typical panel assembly.

porary precast ramps can simply be placed at the end of the slab to provide a transition for traffic onto and off the new pavement. These ramps can then be reused during subsequent operations.

User delay costs can be substantially reduced by limiting construction to an overnight or weekend timeframe. As an example, the computer program QUEWZ was used to compute and compare user delay costs for precast pavement construction and for conventional pavement construction. For conventional pavement construction, wherein traffic is diverted through the construction zone for 24 hours per day until construction is complete, the user delay costs were computed as approximately $383,000 per day. On the other hand, precast pavement construction, wherein traffic is only diverted from 8 p.m. to 6 a.m. daily, results in user delay costs of only $1,800 per day. Although it may not be possible to place as much precast pavement as conventional pavement during one day, the savings in user costs far outweigh any additional construction time.

In addition to expedited construction, precast pavement also offers enhanced durability. First, the panels will be cast in a controlled environment at a precast yard. This will allow for flexibility with the concrete mix, making the use of lightweight, high performance, and other concretes possible. Second, because prestressing will be incorporated, cracking in the pavement can be prevented. This will reduce, if not eliminate, spalls and punchouts during the design life of the pavement. Prevention of cracking will also protect the post-tensioning strands in the pavement. The cast-in-place prestressed pavement constructed in 1985 on Interstate 35 in McLennan County, Texas, is a testament to the increased durability of prestressed pavements. Finally, because the precast panels will generally be thinner than conventional pavements, and because there will be a great deal of control over the temperature gradient in the precast panels during casting, "built-in curl" will be significantly reduced, if not eliminated. This will greatly reduce temperature curling stresses in the pavement.

The Researchers Recommend...

The proposed concept appears to be a feasible method for expediting construction of portland cement concrete (PCC) pavements. However, the true feasibility of this concept will be realized only through actual implementation. Therefore, a staged implementation strategy is recommended for testing these concepts and slowly introducing this new construction technique into current practices.

Staged implementation will begin with small pilot projects aimed at refining the proposed concepts and streamlining the construction process. The pilot projects should be constructed on pavements that can be closed during construction with a very minimal impact on traffic, such as certain frontage roads or rest area roads. Any necessary laboratory testing should be completed prior to the construction of the pilot projects to ensure the viability of certain aspects, such as the spring-loaded anchors and strand placement procedures.

The pilot projects will be followed by rural implementation, wherein the construction process will be further streamlined under simulated time constraints. As with the pilot projects, rural implementation should be undertaken on pavements that will not have a very significant impact on traffic if problems occur during construction. Rural implementation should take place, however, on a road that will experience significant traffic loading, such as a rural interstate.

Finally, after rural implementation, urban implementation will present the most challenges to precast pavement construction. Urban implementation should take place on an urban intersection or major arterial where road closure must be limited to overnight or weekend operations. By the time urban implementation is undertaken, however, the construction process should be fully streamlined to accommodate strict time constraints.

Implementation will ultimately determine the feasibility of the precast concrete pavement concepts presented in this report. In the end, a simple concept that is easily adaptable to existing techniques yet not restricted by current practices will ensure the viability of precast concrete pavements.

For More Details ...

Research Supervisor: B. Frank McCullough, Ph.D., P.E., phone: (512) 232-3141, email: bfmccullough@mail.utexas.edu

TxDOT Project Director: Gary Graham, P.E., phone: (512) 467-5926, email: ggraham@dot.state.tx.us

The research is documented in the following report:
Report 1517-1, *The Feasibility of Using Precast Concrete Panels to Expedite Highway Pavement Construction,* Draft January 2001

To obtain copies of the report, contact: CTR Library, Center for Transportation Research, phone: (512) 232-3138, email: ctrlib@uts.cc.utexas.edu.

TxDOT Implementation Status
July 2001

The precast, post-tensioned pavement developed under this research project is being implemented with IPR 5-1517. This IPR covers the construction of two sections at the frontage road of IH-35 north of Georgetown. One section has a length of 1,230 LF with 36 foot wide panels and the second has a length of 1,000 LF with 20 and 16 foot wide panels. These sections will be used to complete the feasibility study of this type of pavement construction. The Austin District is the Office of Primary Responsibility (OPR) for this project.

For more information, please contact Dr. German Claros, P.E., Research and Technology Implementation Office (512) 467-3881 or email at gclaros@dot.state.tx.us.

Your Involvement is Welcome!

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