FEASIBILITY OF PRECAST PRESTRESSED CONCRETE PAVEMENTS

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ABSTRACT

As the number of vehicles continues to grow at an unprecedented rate, pavements continue to deteriorate faster, requiring rehabilitation and/or replacement. Pavement construction, however, can cause significant traffic delays, particularly in urban and densely populated areas. These traffic delays increase user costs in the form of increased fuel consumption and lost work time, among many other variables. A method for expediting construction of durable high performance pavements is, therefore, needed.

Under this preface, and due to the success of precast concrete techniques in the building and bridge industries, the feasibility of using precast prestressed concrete panels to expedite pavement construction was examined. The primary advantage of precast panels is that they can be set in place and assembled quickly, allowing traffic back onto the pavement almost immediately. This will allow pavement construction to be carried out in overnight or weekend operations, when traffic volumes are low, resulting in tremendous savings in user costs. Also, by incorporating prestressing, a precast pavement can be designed for an increased design life to that of a conventional pavement, with a significant reduction in pavement thickness. This will not only reduce the weight of the panels for transportation and handing, but will also allow the thickness of the pavement to be tailored to the specific application for which it will be used by simply adjusting the magnitude of prestress.

This paper will describe the key aspects of a concept for a precast prestressed concrete pavement which were generated through a feasibility study. As the feasibility of the proposed concepts will, ultimately, only be realized through actual implementation, this paper will also discuss a small-scale pilot project currently being undertaken to test and refine these concepts.

INTRODUCTION

Traffic congestion, which occurs as a result of closure of part or all of a roadway for rehabilitation or expansion, is quickly becoming a major issue in the transportation industry. Traffic congestion due to the presence of construction activities results in, among many other variables, increased fuel consumption and lost work time, or user costs. A method for expediting construction of durable pavements is, therefore, needed to allow for construction during off-peak travel periods, such as at night or over weekends.

This paper will discuss one such method for expediting construction of portland cement concrete (PCC) pavements though the use of precast prestressed concrete panels. The primary focus will be on large scale construction of new pavements or full replacement of existing deteriorated pavements, as opposed to smaller isolated pavement repairs using precast panels, which has been successfully accomplished in the past using slightly different methods(1).

In March 2000, the Center for Transportation Research (CTR) at the University of Texas at Austin, completed a feasibility study, sponsored by the Federal Highway Administration (FHWA) with support from the Texas Department of Transportation (TxDOT), to investigate the use of precast concrete panels to expedite PCC pavement construction. The feasibility study focused on full-depth pavement construction for three main pavement applications, including new pavements, unbonded overlays over an existing pavement, and removal and replacement of part or all of an existing pavement.

The proposed concept for a precast concrete pavement, presented below, evolved from several key aspects of the feasibility study, including a comprehensive literature review, previous experience of the researchers, and two expert panel meetings. As the amount of literature on precast pavements was limited, prior experience of the researchers and the expert panel meetings proved to be most valuable. Prior experience of the researchers included the successful use of precast panels for repairs of continuously reinforced concrete pavements near Mt. Pleasant, Texas(1), as well as the successful construction of a cast-in-place post-tensioned pavement in McLennan County, Texas(2). The expert panels consisted of various professionals from transportation agencies, the precast industry, post-tensioning industry, and concrete pavement industry(3). The input from the expert panels led to a final concept for precast pavement which should be appealing to contractors and transportation agencies.

PROPOSED CONCEPT

The proposed concept for a precast concrete pavement focuses on the use of full-depth precast panels. It is believed that a smooth enough riding surface can be obtained with strict thickness tolerances for the precast panels and proper alignment of individual panels. Occasional diamond grinding of the assembled panels, if necessary, could further improve the ride quality. The pavement will be prestressed to maximize the effective thickness of the pavement. Based upon prior experience with prestressed concrete pavements, prestress in both the longitudinal and transverse directions is essential. Previous prestressed concrete pavements, which did not incorporate transverse prestressing, experienced extensive longitudinal cracking and premature failure[4]. Transverse prestress will be incorporated by pretensioning the panels in the transverse direction during fabrication. In addition to counteracting stresses from environmental and wheel loading, this transverse prestress will also counteract the significant handling stresses generated in such large flat panels. Longitudinal prestress will be incorporated through post-tensioning all of the panels together after placement. Single or multiple-strand ducts will be cast into the panels during fabrication for the longitudinal post-tensioning strands. Strict tolerances on the side forms of the casting bed will ensure that the post-tensioning ducts will line up along the length of the pavement. Post-tensioning will not only provide prestress in the longitudinal direction, but will also provide a means for tying the individual panels together.

Proper alignment of full-depth precast panels is essential for providing an acceptable riding surface. Continuous shear keys cast into the edges of the panels appear to be the most effective method for ensuring proper alignment of the panels. A male shear key will be cast into one side of the panel and a female shear key into the opposite side. These keys will interlock the panels together, ensuring a tight fit, and exact vertical alignment between adjacent panels. The panels will be placed on a thin (25 – 50 mm) asphalt leveling course, with a single layer of polyethylene placed over the leveling course to reduce the frictional resistance between the panels and the leveling course.

The panels will be placed transverse to the flow of traffic, with all of the panels being the same length (transverse pavement direction) to simplify the casting and assembly processes. The panel lengths should be selected such that the panel edges do not coincide with main wheel load paths, so as to minimize edge loading effects. Ideally, the panels should be long enough to provide shoulders in addition to the main lanes. As an example, a typical four lane interstate pavement might consist of 11.6 m (38 ft) long panels, which would correspond to the width of two 3.7 m (12 ft) wide lanes, a 3 m (10 ft) outside shoulder, and a 1.2 m (4 ft) inside shoulder. The panel width (longitudinal pavement direction) will depend on the panel type, limitations of the fabrication and handling equipment, and transportation restrictions. Handling and transportation of 200 mm (8 in) thick, 11.6 m (38 ft) by 3 m (10 ft) panels, for example, should not pose a problem as precast elements of this size and weight are commonly used in bridge construction. Furthermore, feedback from precast suppliers at both expert panel meetings indicated that handling precast panels of this size should not pose a problem.

Precast Panels

The proposed concept for a precast pavement consists of three types of panels, as shown in Figure 1. Base panels (Figure 1(a)) are the “filler” panels between the central stressing panels and joint panels. The number of base panels will depend on the slab length (between expansion joints). As described above, the base panels will be pretensioned in the transverse direction during fabrication, and will contain ducts for the longitudinal post-tensioning strands. Male and female continuous shear keys will be cast into the edges of the panels to ensure continuity and proper alignment of the panels when they are assembled.

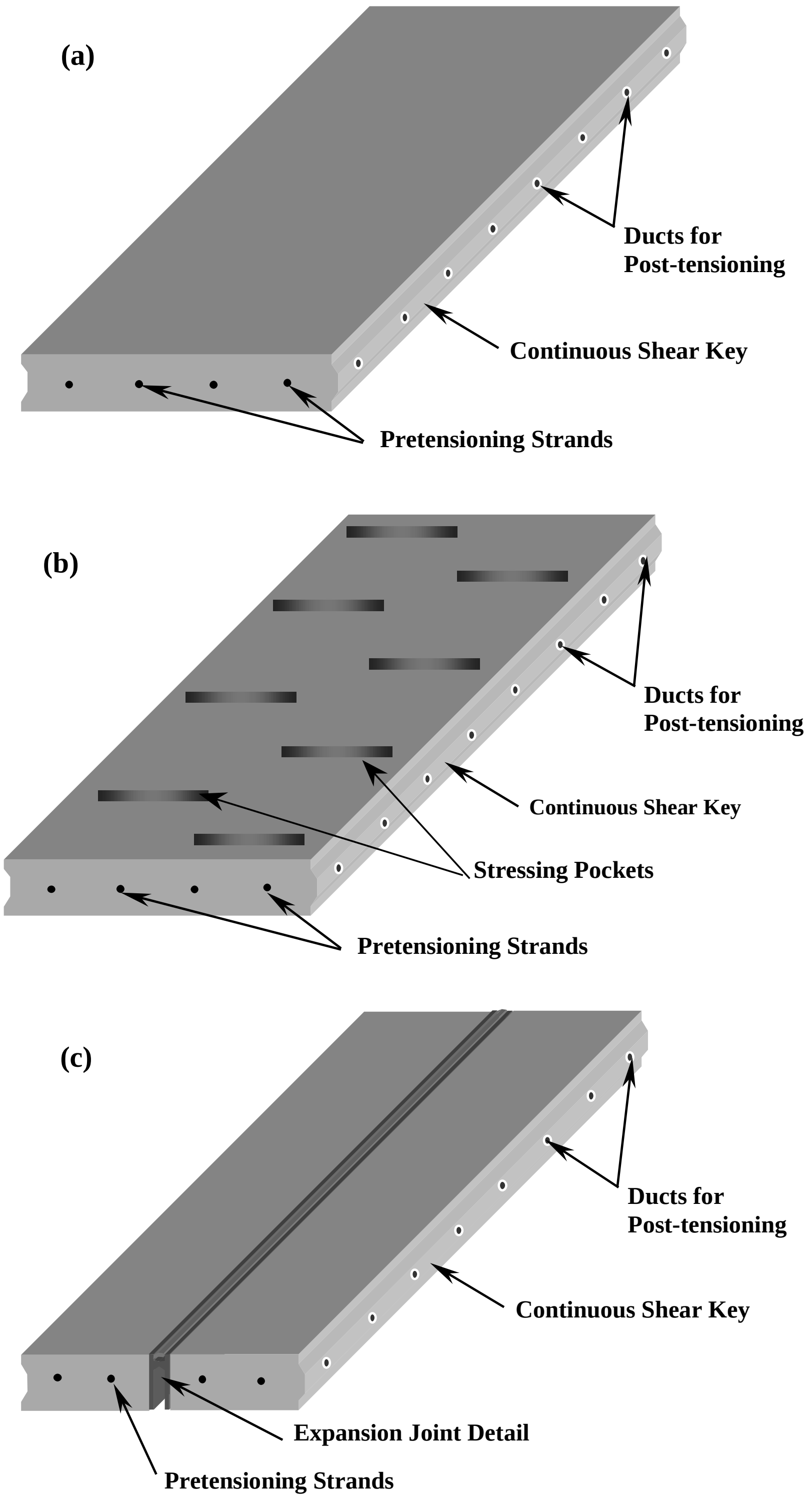

Figure 1 Three types of panels used for a precast pavement: (a) Base Panel, (b) Central Stressing Panel, (c) Joint Panel[3].

The central stressing panels (Figure 1(b)) will be similar to the base panels, with the addition of stressing pockets cast into the panels to accommodate the post-tensioning operation. The pockets will be staggered across the panel (Figure 1(b)) so that the panel will have sufficient rigidity for handling purposes. The idea of central stressing is one that was developed and successfully implemented in a cast-in-place prestressed pavement constructed on a one-mile section of Interstate 35 in McLennan County, Texas in 1985[(4)]. Central stressing allows for the post-tensioning strands to be anchored at the ends of the slab and post-tensioned from pockets at the middle of the slab. The advantage of using this technique is that access to the end anchorage is not needed in order to post-tension the slab. This allows for a more continuous pavement placement operation.

Finally, the expansion joint panels (Figure 1(c)), will contain the actual expansion joint detail (discussed later) as well as the anchorage for the post-tensioning strands. The expansion joint is needed in order to "absorb" the expansion and contraction movements of the pavement slab due to daily and seasonal temperature cycles, which can be quite significant for the length of slabs considered for precast/prestressed pavements. The joint panels will consist of two separate halves. Each half will be part of the slab on either side of the expansion joint.

Panel Placement

The panels will be placed sequentially, starting with a joint panel at the end of the slab, base panels, central stressing panel at the middle of the slab, additional base panels, and another joint panel at the end of the slab. A typical panel assembly is shown in Figure 2. The number of base panels between the joint panels and central stressing panel will depend on the length of the slab and the width of the panels. The post-tensioning strands will be inserted into the ducts, via the central stressing pockets, and threaded through the ducts to anchors in the joint panels. Once the strands have been tensioned from the central stressing pockets, the pockets will be filled with a fast-setting concrete, and the strands will be grouted in the ducts. Finally, if necessary, any uneven areas can be diamond-ground to improve ride quality, and any major voids beneath the pavement can be filled by grout or polyurethane foam injection.

For a removal and replacement application, it may not be possible to replace the full pavement width all at one time. Therefore, slight modifications will need to be made to the panels and assembly process just described. In addition to the longitudinal post-tensioning ducts, additional flat (3 – 4 strand) ducts will be cast into the panels in the transverse pavement direction. This will provide a means for tying two or more slabs, placed next to each other, together through post-tensioning. This will minimize the longitudinal joint width and maximize load transfer across the longitudinal joint. To ensure that the transverse post-tensioning ducts line up between slabs, new slabs should be placed from the center out (starting with the central stressing panels) since the center of the slab will not move during post-tensioning.

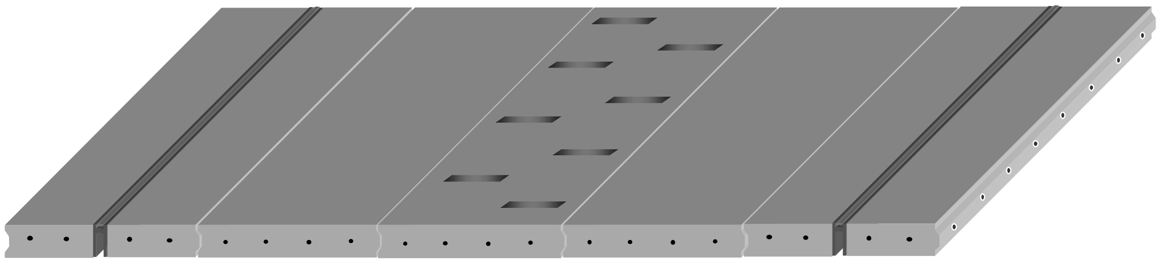

Figure 2 Typical precast pavement panel assembly[3].

Joints

Joints are an integral part of a precast pavement. The two types of joints of concern are the intermediate joints between the individual panels, and the expansion joints at the ends of the slabs. As mentioned previously, the intermediate joints will consist of interlocking shear keys cast into the panel edges. The shear keys will contribute somewhat to load transfer across the joints, but primarily will ensure proper vertical alignment between adjacent panels during assembly. After post-tensioning, a low viscosity liquid sealant will be poured or soaked into the intermediate panels joints to prevent intrusion of water and other corrosive agents, thus protecting the post-tensioning strands crossing the joints

The expansion joints at the ends of the slabs must "absorb" the significant expansion and contraction movements of the pavement. The expansion joints must also be able to withstand the forces from wheel loads while providing adequate load transfer between the slabs on either side of the joint. This requires hardware and a structure that is not susceptible to fatigue, while maintaining constructability and economic feasibility.

The proposed expansion joint detail is similar to that developed and successfully implemented in the cast-in-place prestressed pavement constructed in McLennan County, Texas[2], mentioned previously. This expansion joint detail, shown in Figure 3, utilizes a steel bearing structure similar to that of bridge joints, stainless steel plated dowel bars to provide load transfer across the joint, and a neoprene seal, which can accommodate large joint movements, to prevent material from falling into the joint. Two rows of 13 mm (0.5 in) Nelson deformed anchor bars, approximately 60 cm (2 ft) in length, tie the joint structure to the pavement and reduce "rocking" of the joint under traffic loading, thereby reducing fatigue on the welds in the joint. The upper and lower anchor bars are alternated over the length of the joint so that there is only one bar in every space. This joint detail has performed very well under heavy traffic loading (25-30% truck volume) after 15 years of service in the cast-in-place prestressed pavement in McLennan County, Texas.

One of the primary advantages of this expansion joint is that it can be pre-assembled as a single piece, reducing the chance that bars or dowels will be improperly positioned. For a precast pavement, this pre-assembled expansion joint detail will simply be cast into the joint panels during panel fabrication. The steel flanges at the top of the joint will be tack welded together, prior to casting the concrete, to ensure that the joint remains parallel during fabrication and placement of the panel. The welds will then be removed prior to post-tensioning. To protect the joint and to ensure good ride quality, the slab length should be selected such that the expansion joint will never close completely and will never be open more than 9 – 10 cm (3.5 – 4 inches).

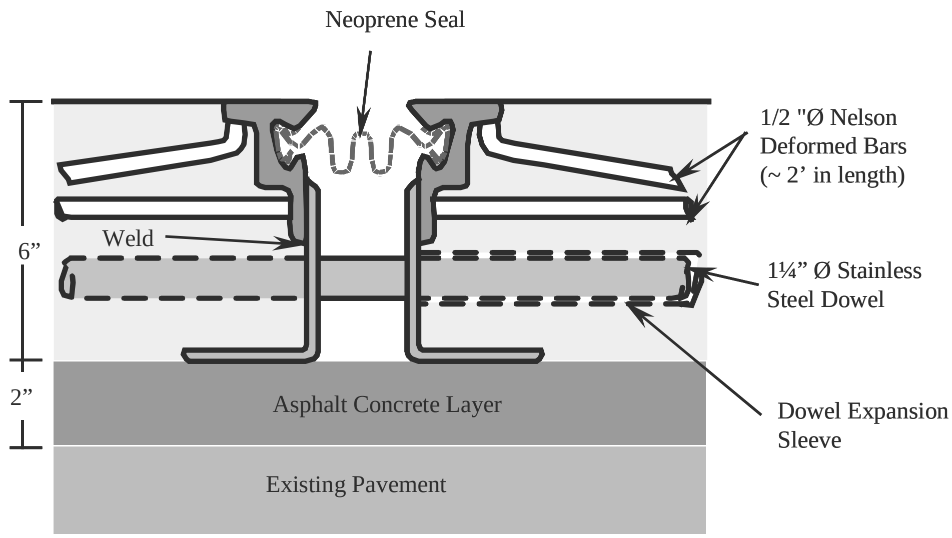

Figure 3 Expansion joint detail for the McLennan County prestressed pavement[2]
(Note: 1 in = 25 mm, 2 ft = 61 cm).

Base/Surface Preparation

Using full-depth precast panels requires a flat and smooth surface to place the panels on so that they are properly supported and voids beneath the panels are minimized. A thin, 25 – 50 mm (1 – 2 inch), asphalt leveling course appears to be the most efficient and economical method for providing this flat, smooth surface. Based upon profile measurements of a newly placed asphalt pavement in Austin, Texas[3], it appears that an asphalt leveling course can be placed smooth enough and flat enough to provide proper support for full-depth precast panels. If necessary, the leveling course can be planed to smooth out any irregularities. In addition to the economic benefits and speed with which an asphalt leveling course can be placed, a major advantage of using an asphalt leveling course is that it can be placed well in advance of the precast panels. This will allow for the leveling course to be placed all at once rather than just prior to the placement of the panels. Traffic allowed onto leveling course, prior to panel placement, should not have a detrimental effect as long as the precast panels are placed within a reasonable amount of time after the asphalt leveling course.

In addition to providing a smooth and flat surface for the precast panels, a friction reducing medium is needed beneath the pavement in order to reduce prestress losses (during post-tensioning), and tensile stresses generated in the pavement due to the frictional resistance between the slab and supporting layer (asphalt leveling course). Extensive testing by CTR of different friction reducing materials revealed that a single layer of polyethylene sheeting is one of the best materials for use as a friction reducing medium from the standpoint of both constructibility and effectiveness in reducing friction[5]. A single layer of polyethylene sheeting was used successfully during construction of the cast-in-place prestressed pavement in McLennan County, Texas, mentioned previously[2].

Another consideration for precast pavement, with respect to surface preparation, is a mid-slab anchor. A mid-slab anchor will secure the center of the pavement (at the stressing pockets) to the subbase. This will restrict movement of the center of the slab so that the slab will expand and contract outward from the center, ensuring uniform expansion joint widths over the length of the pavement. Without a mid-slab anchor, some expansion joints could open or close more than others. One method for anchoring the middle of the slab may be to use concrete lug anchors, similar that that used for CRC pavements. Trench-type or cylindrical (drilled) lug anchors could be formed in the subbase during placement of the base panels with 38 mm (1.5”) dowel bars cast into them to receive the pockets in the central stressing panels. When the stressing pockets are subsequently filled with the fast-setting concrete, the slab would be anchored in place. Whatever method is used to anchor the middle of the slab, it is important that the anchor is not set until the slab has been post-tensioned. This will ensure that the middle of the slab is in its final position before being anchored.

POST-TENSIONING

Post-tensioning is one of the most important aspects of the precast pavement concept presented herein. Post-tensioning not only ties all of the panels together to form a continuous slab, but more importantly, it induces a precompressive stress (prestress) in the concrete. This prestress greatly reduces the required slab thickness and enhances the durability of the pavement.

Strand Placement/Anchorage

The post-tensioning strands will be anchored at the expansion joints using post-tensioning anchorage hardware cast into the joint panel. Since there will be very limited, if any, access to the strand anchors after the precast panels are set in place, a spring-loaded, self-locking anchor should provide the best means for anchoring the post-tensioning strands. A spring-loaded anchor, similar to that shown in Figure 4, currently exists and is produced as a fully encapsulated anchor, which will protect it from any possible corrosion. The spring-loaded wedges will automatically grip the post-tensioning strands when they are inserted into the anchors, unlike that of standard post-tensioning anchors wherein the wedges must be set manually. This will allow the strands to be inserted blindly into the anchors, most likely from small pockets cast into the joint panel, as shown in Figure 5.

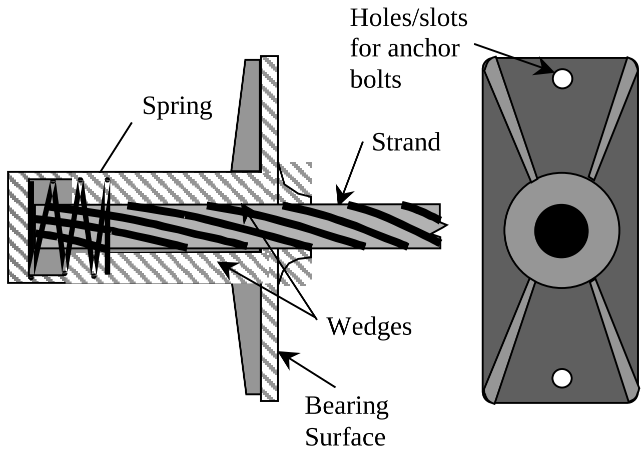

Figure 4 Spring-loaded post-tensioning anchor for precast pavements[3].

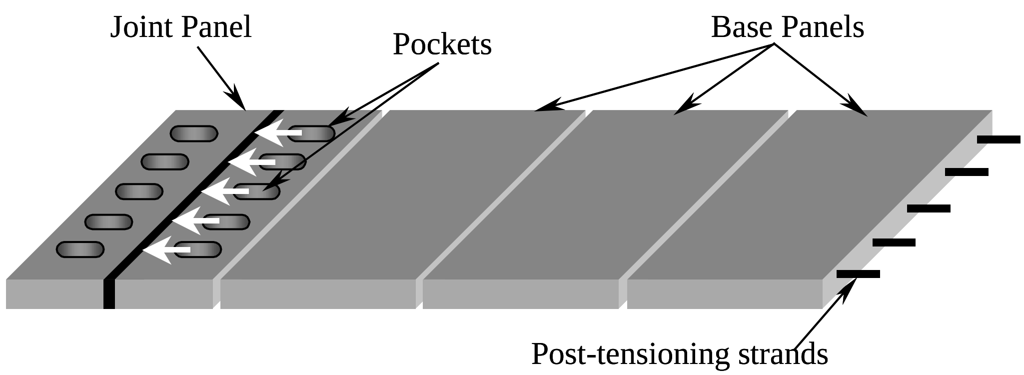

Figure 5 Method for inserting post-tensioning strands into spring loaded anchorage in the joint panel.

The self-locking anchors will be bolted to the bearing plates in the expansion joint. This will ensure that the anchors are properly positioned and stay in place while the concrete is cast for the joint panel. Bolting the anchors to the bearing plates will also force the bearing plates to contribute in transferring prestress to the concrete. The anchors will be spaced such that they to not coincide with the location of the dowel bars or Nelson deformed bars in the joint detail.

Post-tensioning Procedure

Strict tolerances on the casting beds and side forms used to cast the panels will ensure that all of the post-tensioning ducts line up over the length of the slab. Single or multiple-strand ducts may be used to reduce the number of stressing and grouting operations required. However, multiple-strand ducts will require special attention to ensure the strands do not become twisted together in the duct. The post-tensioning strands will be stressed from the central stressing pockets at the center of the pavement slab. A portable hydraulic jacking device, similar to that used for circular tanks, which essentially stresses both strands coming into the central stressing pockets at the same time, may be used for the post-tensioning operation. Stressing should start with the strands at the center of the slab and alternate out to the strands at the slab edges. A coupler device, similar to that shown in Figure 6, will be used for stressing and coupling the strands in the central stressing pockets. This coupler device grips both strands, coming into the pocket from either side of the slab, simultaneously. The stressing ram pulls one strand while reacting against the other strand, thus tensioning both strands at the same time.

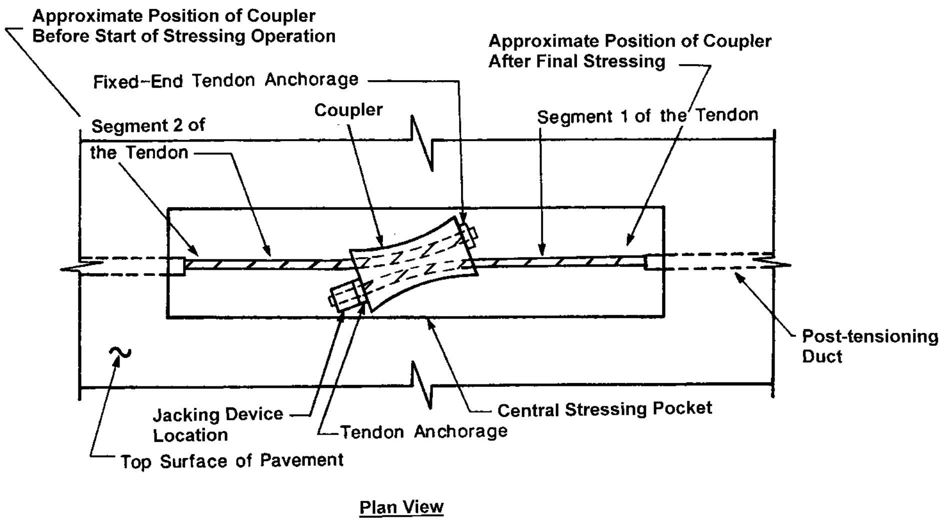

Figure 6 Plan view of a typical stressing pocket and coupler device for stressing the post-tensioning strands(2).

A fast setting concrete will be used to fill the stressing pockets after all of the strands have been stressed. It should be noted, however, that the pockets do not have to be filled at the same time the pavement is post-tensioned. It should be possible to place temporary steel cover plates over the pockets if time constraints do not allow the pockets to be filled before traffic is allowed onto the pavement. It is essential, however, that the post-tensioning strands are stressed prior to exposure to traffic.

Grouting

After the post-tensioning strands have been stressed, the strands will be grouted in the ducts via grout inlets/vents located at the expansion joints and at the central stressing pockets. Grouting will bond the strands to the pavement, providing continuity between the concrete and the strands, which will greatly reduce, if not eliminate, the amount of non-prestressed reinforcement required in the pavement. In addition, grouting the strands will prevent any damage or significant loss of prestress if a strand is inadvertently cut. Most importantly, however, the grout will provide an additional layer of protection from strand corrosion, particularly where the strands cross the panel joints. Similarly to filling the stressing pockets, grouting does not have to be completed before traffic is allowed back onto the pavement. Grouting can be done at a later time if construction time constraints do not allow grouting to be completed immediately after post-tensioning. Although grouting does add additional cost and an additional process to the construction sequence, the advantages of increased durability and corrosion protection will outweigh the added construction requirements.

BENEFITS

Expedited Construction

There are numerous benefits to using precast pavement construction over conventional pavement construction. The most obvious benefit is the speed of construction. While it is anticipated that the rate of pavement placement may be slower using precast panels than with conventional pavement techniques such as slip-form placement (as a rough estimate, it may only be possible to place 152 m (500 ft) of precast pavement in a daily operation, as opposed to 762 m (2,500 ft) of conventional pavement.), traffic can be allowed onto a precast pavement almost immediately after placement, in contrast to several days or weeks with conventional pavement. This allows for construction to take place in overnight or weekend operations, resulting in tremendous savings in user costs, as demonstrated below.

Reduced User Costs

Construction during off-peak travel times, such as at night and over weekends, significantly reduces traffic delays normally caused by construction. This results in tremendous savings in user costs, which are costs incurred by the users of the roadway, such as increased fuel consumption and lost work time, due to the presence of construction activities.

To demonstrate the savings in user costs with precast pavement construction, the computer program QUEWZ, developed by the Texas Transportation Institute (College Station, Texas) and modified by Transtec, Inc. (Austin, Texas), was used to calculate expected user costs for conventional pavement construction (24 hour/day traffic diversion) versus precast pavement construction (traffic diversion from 8 PM – 6 AM only). The user cost model contained in this program takes into account several factors when computing user costs, such as roadway type (arterial, collector, etc.), closure strategy, closure time, roadway capacity, free flow and queue speeds, vehicle costs, fuel and oil costs, tire costs, vehicle emissions, and average time value for vehicle passengers.

Using this model, user costs for conventional pavement construction were estimated at approximately $383,000 per day, versus only $1,800 per day for precast pavement construction. This significant savings in daily user costs will far outweigh any additional construction time for precast pavement construction. For more information on the assumptions made in the user cost model, the reader is referred to CTR Research Reports 1739-1(6) and 1517-3(3).

Reduction in Pavement Thickness

In addition to expedited construction and reduced user costs, another major benefit of the proposed concept for precast pavement is a reduction in required pavement thickness. A reduction in pavement thickness is not only important in terms of material savings, but is also beneficial for situations where the pavement/overlay thickness is governed by overhead clearance restrictions, such as under bridges. To demonstrate this reduction in required pavement thickness, an example design was completed as part of the feasibility study. However, due to the nature of the example design presented in the feasibility study, which is beyond the scope of this paper, the details of the design procedure will not be presented here.

The basis for the example design was to compare the required thickness of a precast /prestressed pavement to that of a 355 mm (14 in) continuously reinforced concrete (CRC) pavement currently under construction on Interstate 35 in Hill County, Texas(7). The precast pavement was designed for an equivalent 30-year design life, in terms of expected 4.4 kN (18-kip) ESAL applications, to that of the 355 mm (14 in) CRC pavement. Elastic design for fatigue loading and elastic design for environmental stresses were used to determine the prestress requirements, for a precast pavement of varying thickness, as well as the limits for slab length (between expansion joints) based upon maximum joint width requirements.

The example design revealed that a 200 mm (8 in) precast/prestressed pavement can be designed for an equivalent design life to a 355 mm (14 in) CRC pavement with only 1.3-1.7 MPa (195-255 psi) longitudinal prestress, depending upon slab length, and 0.7-1.2 MPa (100-170 psi) transverse prestress. Maximum slab lengths, based upon a maximum joint width requirement of 10 cm (4 in), were computed to be 104 m (340 ft) for pavement placed under extreme Texas "summer conditions," and 134 m (440 ft) for pavement placed under extreme Texas "winter conditions" (3). Although there were many assumptions which went into this example design, it demonstrates the significant reduction in pavement thickness possible with precast/prestressed concrete pavement, which translates into substantial material savings. For more information on the example design, the reader is referred to CTR Research Report 1517-3 by Merritt et al (3).

Increased Durability

One other very significant benefit of precast pavement is increased durability. Precast pavement panels can be cast in a controlled environment, ensuring high quality concrete and ideal curing conditions. A controlled environment will allow for the use of high performance concretes, lightweight concretes, and other concretes which require special attention during mixing, casting, and curing.

The durability of a precast pavement is also enhanced through prestressing. Prestressed pavements are designed such than no cracking will occur in the pavement under normal traffic/environmental loading conditions. Prevention of cracking will eliminate pavement distresses and failures, such as spalling and punchouts. More importantly, however, the post-tensioning strands will be completely protected if cracking is prevented.

Another consideration, with respect to pavement durability, is a significant reduction in "built-in curl" prevalent in cast-in-place pavements. As precast pavements will generally be thinner than conventional pavements, and as there will be greater control over the temperature gradient in the precast panels when they are cast in a controlled environment, they will be less susceptible to built-in curl when the concrete is fully cured. This will significantly reduce stresses induced in the pavement due to temperature curling.

IMPLEMENTATION

The feasibility of precast concrete pavement construction will, ultimately, only be realized through actual implementation of the concepts presented herein. A staged implementation strategy is, therefore, recommended as the best means to test the proposed concepts, and slowly introduce this new construction technique into current pavement practices. Staged implementation will start with small-scale pilot projects to evaluate and refine the overall concepts and work out the procedural details on projects which will have very minimal impact on traffic. Small-scale pilot implementation will be followed by larger scale rural pavement implementation, under simulated construction time constraints, in order to further streamline the construction process. Finally, urban pavement implementation, which will present the most challenges and time constraints to precast pavement construction, will complete the staged implementation strategy.

Currently, the Center for Transportation Research is working on an FHWA sponsored pilot project with the Texas Department of Transportation to construct 0.7 km (2,300 ft) of 200 mm (8 in) thick precast pavement on a section of frontage road along Interstate 35 near Georgetown, Texas. The precast pavement will consist of both full width (11 m) panels, as well as partial width (5 m + 6 m) panels tied together transversely. As part of this project, laboratory testing will be conducted in order to test the panel placement procedure, strand anchorage procedure, joint sealant, and anchorage strength, prior to construction of the frontage road pavement.

Preliminary first cost estimates for the Georgetown pilot project are approximately $203/$m^2$ ($170/$yd^2$). In contrast, a conventional pavement of equivalent thickness (355 mm) might only cost $36 - $48/$m^2$ ($30 - $40/$yd^2$). However, as demonstrated above, even with the additional construction costs, savings in user costs will result in an overall lower cost for precast pavement versus conventional pavement. It should also be noted that the Georgetown pilot project is experimental in nature, and therefore, construction costs are expected to be high. Over time, as transportation agencies and contractors become familiar with precast paving techniques, the cost of precast pavement will be significantly reduced, as demonstrated in the past with the introduction of other new paving techniques, such as continuously reinforced concrete paving. The success of pilot projects such as that in Georgetown, however, will ultimately help to determine the viability of future precast pavements.

CONCLUSIONS

Precast concrete panels appear to be a viable method for expediting construction of portland cement concrete pavements. The use of precast panels allows for construction of pavements to take place during off-peak travel times, such as at night and over weekends. This significantly reduces user delays caused by construction, and hence user costs. Additionally, by incorporating prestressing, significant advantages will be realized in the form of increased durability and reduced pavement thickness.

The concept for a precast pavement, described in this paper, has many aspects that are favorable for separate (overnight or weekend) construction operations. First, the asphalt leveling course can be placed well in advance of the precast panels, allowing traffic onto the leveling course prior to panel placement. Secondly, the post-tensioning strands do not have to be grouted before traffic can be allowed back onto the pavement. Grouting can be done at a later time, during a subsequent operation. The stressing pockets, also, do not have to be filled before traffic is allowed onto the pavement.

Initial construction costs for precast pavements are expected to be significantly higher than conventional pavements, as shown by preliminary cost estimates from the pilot project in Georgetown, Texas. These higher costs stem primarily from unfamiliarity with precast paving techniques on the part of transportation agencies and contractors. Over time, however, initial construction costs should become more competitive with that of conventional pavements as precast paving is used more frequently. The real economic benefits of precast pavement construction will be realized through savings in user costs (lost work time, increased fuel consumption, etc.). By limiting construction to an overnight or weekend timeframe, user delay costs will be significantly reduced. Although it may not be possible to place as much precast concrete pavement as conventional pavement in a daily operation, the user cost savings will far outweigh the additional time needed for construction and higher initial construction costs.

While the construction process for precast pavement is quite different from that of conventional pavements, the concepts should be easily adaptable to current practices. The feasibility of precast concrete pavement construction, however, will only ultimately be realized through actual implementation. A staged implementation strategy is, therefore, recommended as the next step in the development of precast pavements. In the end, a simple concept, which is appealing to contractors and transportation agencies, is desirable. A concept which is easily adaptable to existing techniques, but not restricted by current practices, will ultimately ensure the viability of precast concrete pavements.

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