Construction of The Precast Prestressed Pavement Installation on I-10 in El Monte, California

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Abstract

The section of prestressed/post tensioned pavement was constructed in the spring of 2004, in conjunction with reconstruction of a section of I-10 in the Los Angeles, CA area. While this technology has been used in the past, significant progress is being made in terms of practical application. The paper includes a discussion of concepts pertinent to this type of pavement as well as fabrication and construction details for delivery of the pavement.

This project utilized a specific geometric design so that the shoulder is included in the prestressed panels. Details of the fabrication process of the panels and field assembly are discussed. The paper describes details of panel fabrication and handling. It also addresses placement of the panels and the post tensioning operations. The details include those for jointing and post tensioning of slabs.

Advantages of this type of pavement construction include reduced field construction time and long anticipate service life. The nature of this pavement design makes it an excellent form of long-life pavement.

The significance of this research is the demonstration of successful application of precast post tension technology for pavement repair and construction.

Introduction

As traffic volumes grow, and user tolerance for delays seem to diminish, the highway community in the United States has increasingly focused on methods for accelerating the construction process. One part of this effort has been directed at the use of contract delivery methods which accelerate the contract time. Such techniques as lane rental and A+B (cost for both construction and work time are considered) bidding are intended to provide the contractor with incentive for reducing traffic disruption during construction. The other primary focus on reducing traffic delays has been to develop accelerated construction techniques. The FHWA spearheaded the development of accelerated rigid pavement techniques in the late 1980's with Special Project 201 focused on Fast Track Paving. More recently, they have supported work to develop precast pavement techniques. To date this work has focused around a project developed at the University of Texas at Austin to develop a

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precast/post tensioned pavement design concept. Subsequent to a pilot project on I-35 in Texas, this project on I-10 in Los Angeles County has been developed using the same design concepts (1).

Research Significance

Concepts. The concept of developing precast pavement sections has been around for at least two decades. Unfortunately, problems have persisted with the implementation of the concept, resulting is less than desirable field performance, and/or ride quality (2). More recently, alternative systems have been proposed which appear to have improved upon the initial concept.

The basis for design of this project incorporates the design concept for utilizing both precast and post tensioning technology. Precast fabrication is controlled by AASHTO (3). This document provides for construction controls, such as dimensional tolerance of individual pieces. Precast concrete segments are fabricated under controlled conditions enabling the achievement of tighter tolerances than normally accepted for field cast elements. Production to close tolerances assures the fit of individual pieces once the materials are delivered to the project.

The basis for prestress pavement design is well established. A design method was provided by the U.S. Navy pavement design manual (4). This design procedure addresses a fully supported slab condition, as differentiated from a simply supported beam. It provides for design of thickness and joint spacing, both of which are vital to the successful performance of prestress pavements. Other factors common to prestress concrete design, such as shrinkage, creep, prestress loss, etc. are treated as secondary in this method. The method also provides guidance for pavement joint design.

Slab thickness is designed on the basis of load stress, considering the effects of the prestress strands in supporting the load. This design was based on 1.4 MPa minimum final effective stress. Consideration of prestress related factors including concrete creep and prestress loss over time must be incorporated in the design process. Expansion joints are required at some spacing, as a function of slab thickness and number of prestress strands.

Design. The design of the pavement sections for this project was based upon the precast post tensioned design developed by Merrit for the Texas project. However, several significant differences were incorporated into the design. The pavement design section called for a grade break at the shoulder. This was accomplished by incorporating the grade change into the forms for the pavement panels. Panels were cast nominal 254 mm, increasing to 305 mm at the grade break. Slabs were placed on a single layer of polyethylene on lean concrete base course.

Figure 1. Shows Grade Break in Forms

The design includes the lifting pockets for handling the panels, tensioning pockets, and post tensioning grout ducts.

Figure 2. Configuration of Casting Bed

Surface texture was placed on the panels prior to curing.

Figure 3. Broomed Surface

Fabrication Procedures. The panels for the project were fabricated in a precasting plant in Perris, CA in the spring of 2004. A total of 31 panels were produced of three basic types:

1. Typical (24 pieces)
2. Expansion Joint (3 pieces)
3. Stressing (4 pieces)

Each panel was 2.4 m by 11.3 m.

Shop drawings for each panel type were detailed to incorporate the mild steel reinforcing, pretensioning strand and post-tensioning details. These are shown in the Figures 4 - 8.

Formwork. The unique cross-section required the purchase of custom steel side-forms with a varying height to produce the non-prismatic panels. The side-forms were constructed with a tongue-in-groove shear key, which was positioned at a constant height from the soffit. The variable panel depth required unique pocket forms at each location which were fabricated out of wood.

The other unique feature of the forms was the introduction of the half round steel section welded to the form soffit. This detail left a half round channel in the bottom of the panels, which would later be used to pump grout under the slab after installation on the lean concrete base.

Tolerances. The steel side-forms allowed the fabrication of panels with tolerances as small as 3 mm. The alignment of the longitudinal post-tensioning ducts was also critical since the duct size was a 25mm I.D., into which a 15mm strand would be installed.

In order to achieve the crucial alignment, the ducts were mounted to the side-forms using a temporary rod running through the complete duct. A transition taper was also used to assist with the installation of the strand which was inserted after all of the panels were erected.

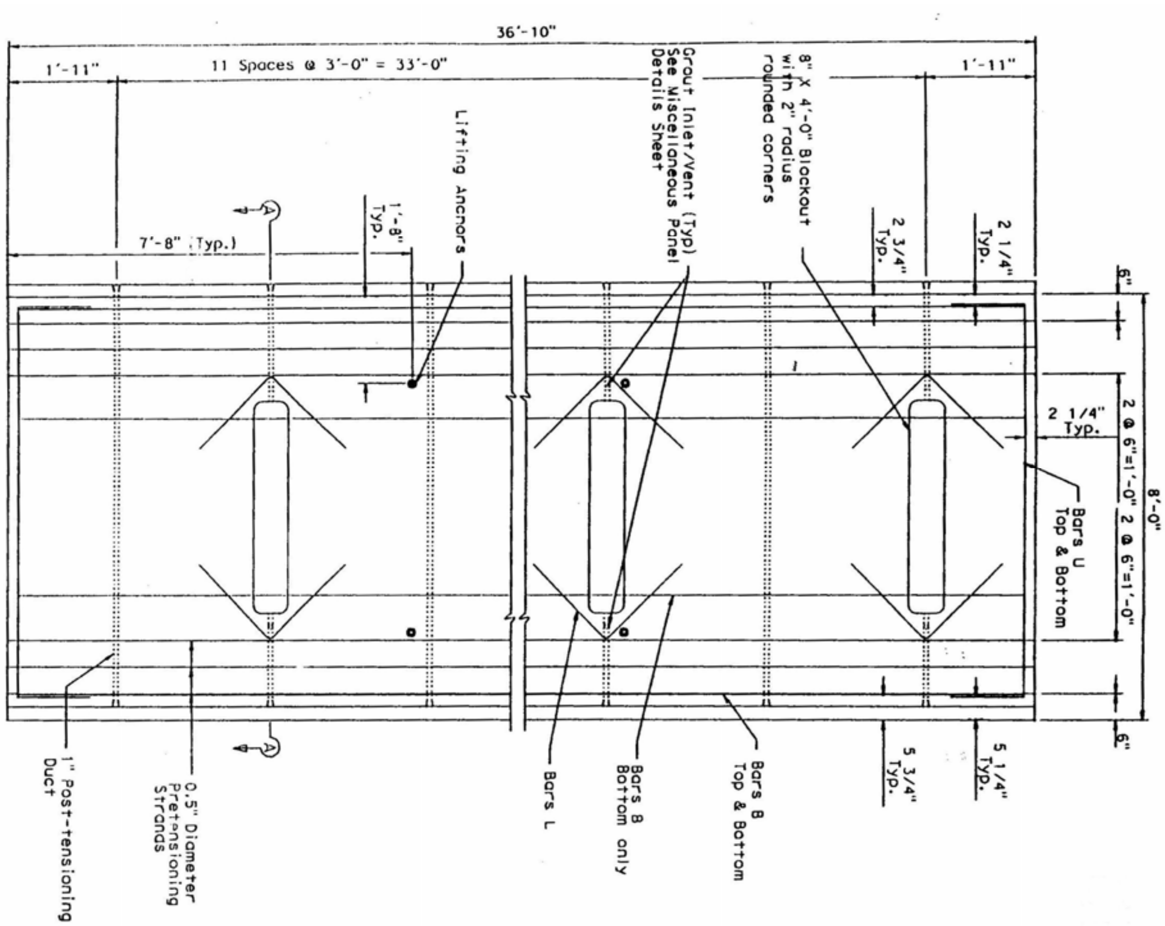

Figure 4. Central Stressing Panel

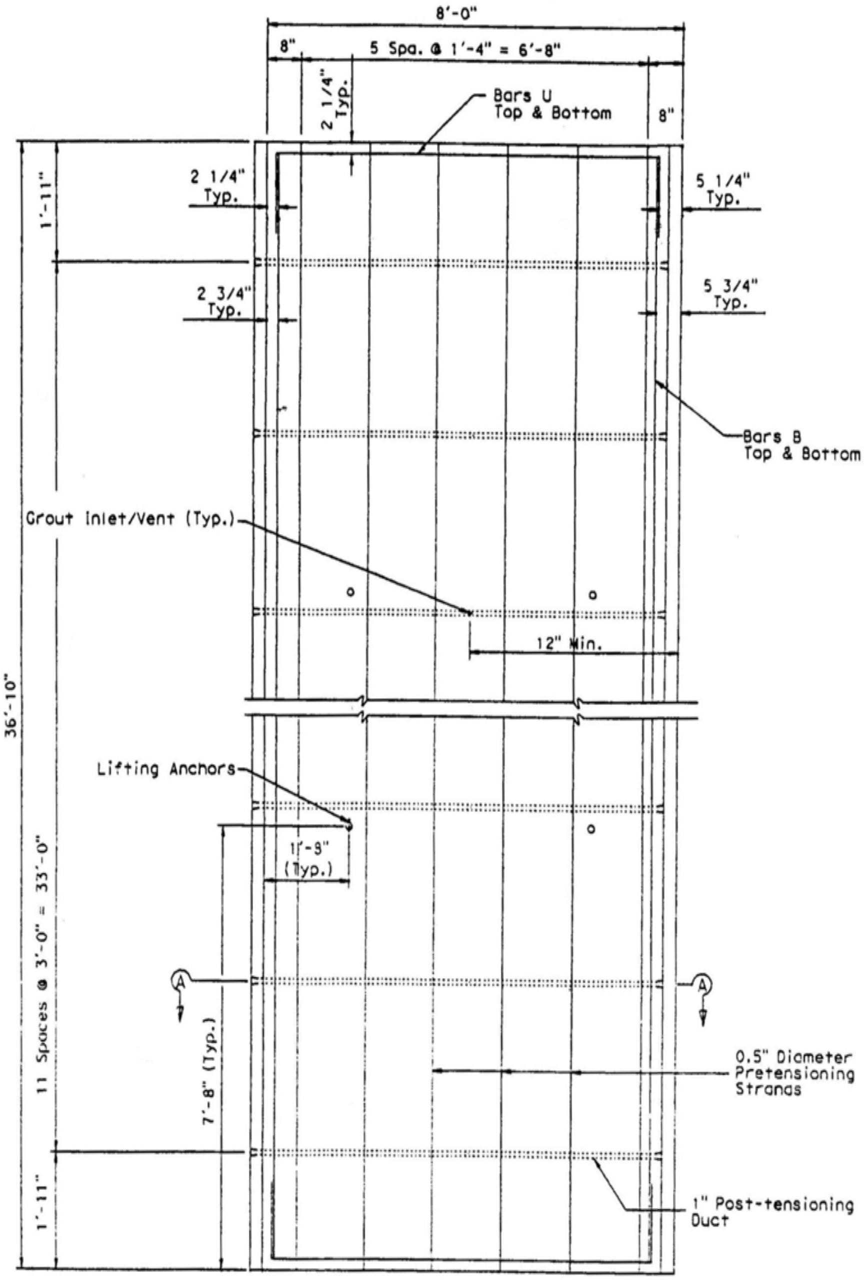

Figure 5. Base (Typical) Panel, Type B

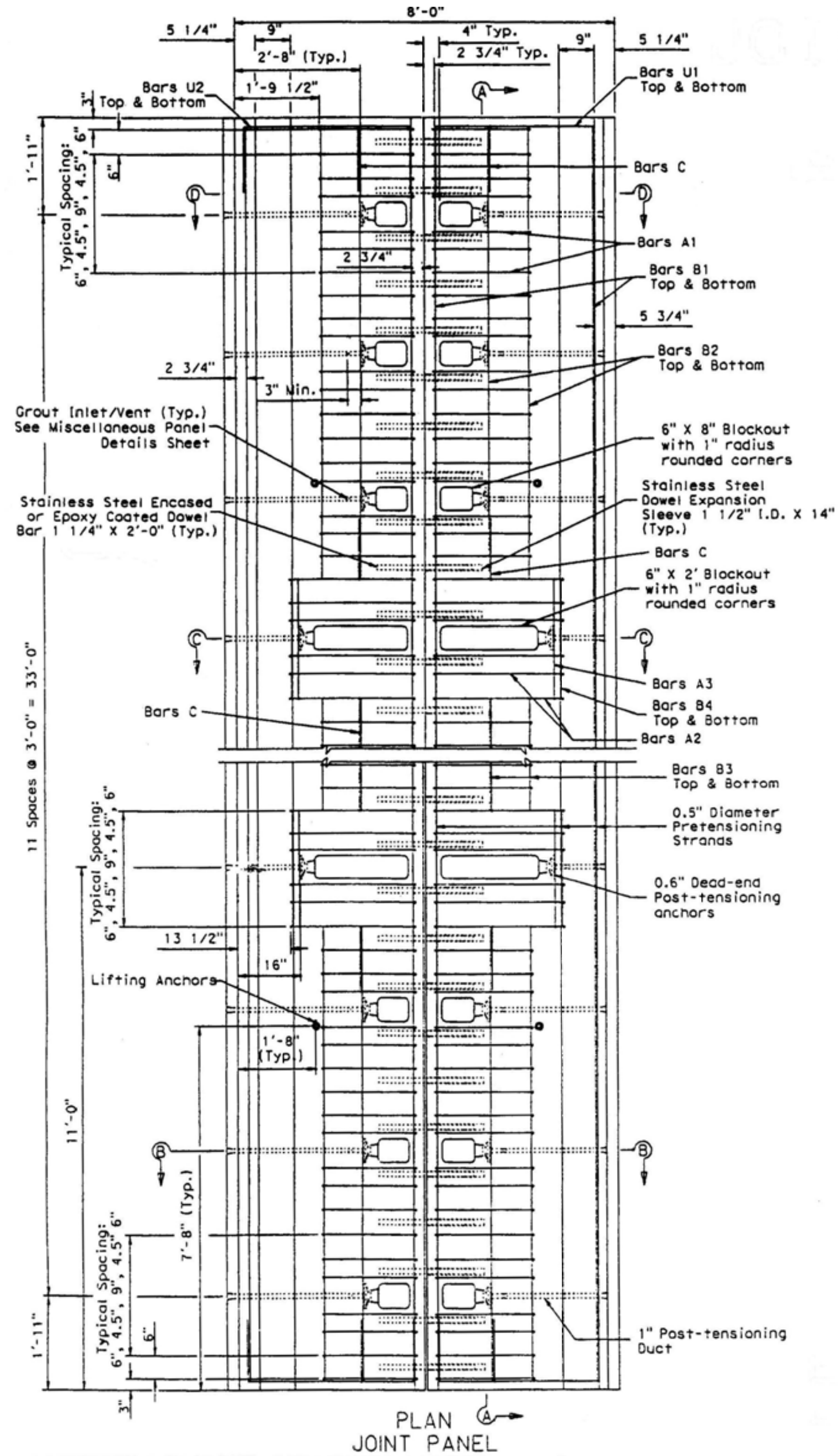

Figure 6. Joint (Expansion) Panel, Type C1

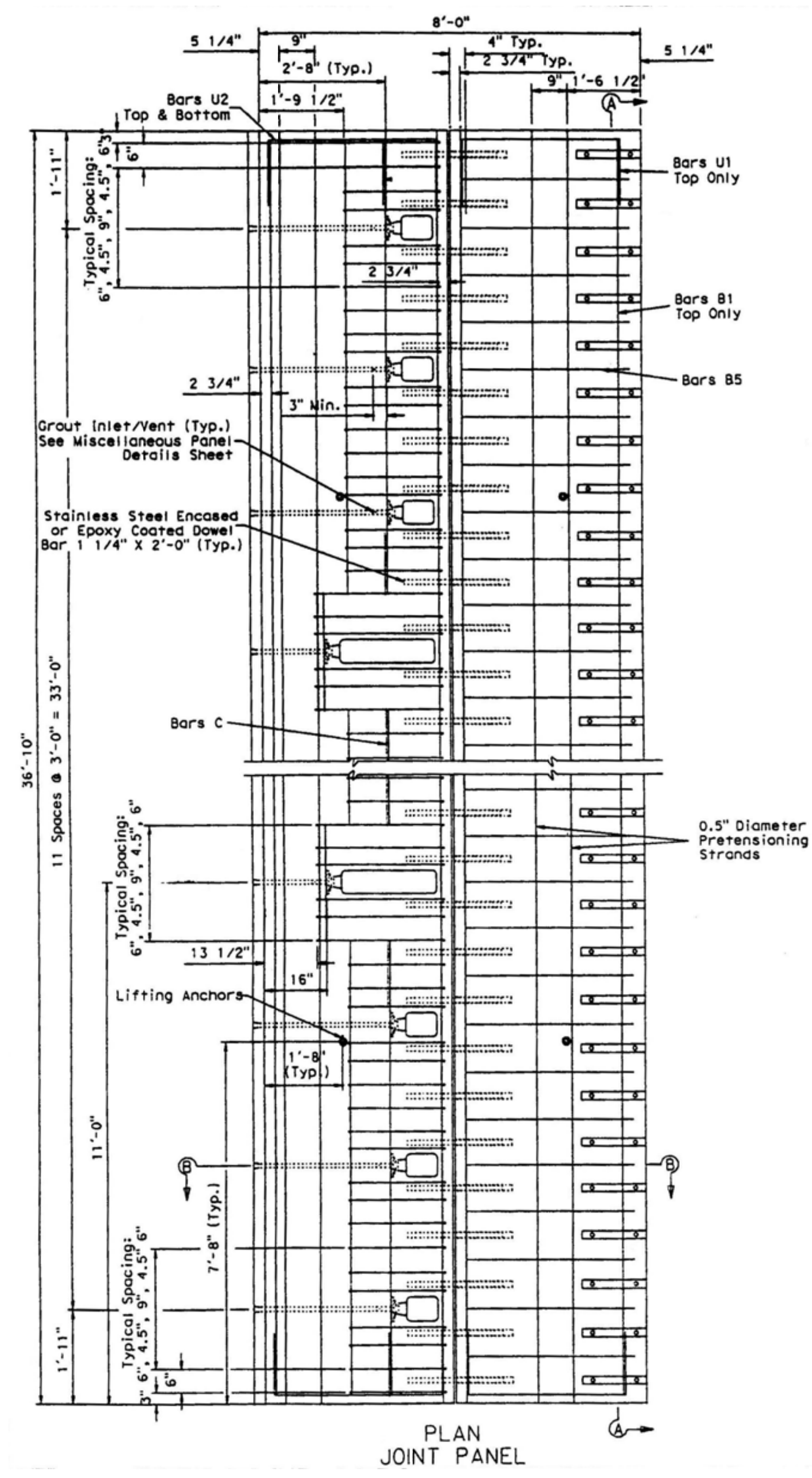

Figure 7. Joint (Expansion) Panel, Type C2

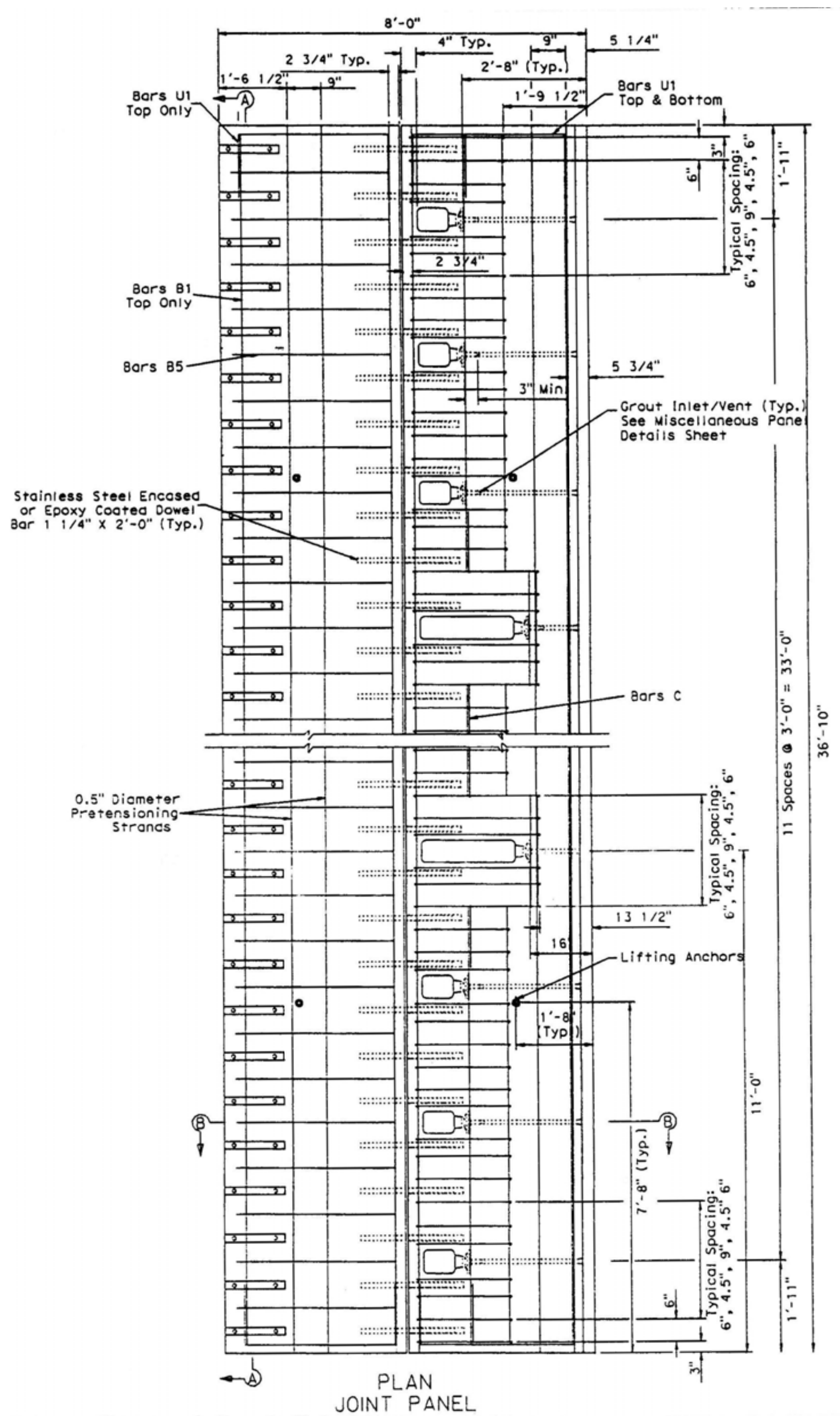

Figure 8. Joint (Expansion) Panel, Type C3

Casting. The panel production took place at a rate of two panels per day due to the relatively small quantity of panels required for the project.

Figure 9. Casting of Two Slabs in Bed

On a larger project panel production would be increased to 20 to 30 panels per day. The long line casting method was used where panels are placed end for end in the casting bed. This allows the pretensioning strand to extend through all panels in a bed and are then anchored to an abutment.

Figure 10. Prestress Bed Anchor

All panels were cast in one operation except for the expansion joint units. These panels made use of a two-part pour in which the first half was placed and poured using a temporary wood bulk-head running the length of the panel. Once the concrete had cured, the bulkhead was removed and the second half of the panel was match cast to the first portion.

Figure 11. Casting Slabs

The pretensioning strands were placed above and below the longitudinal post-tensioning ducts which were located at the center of gravity of the 10" section. By staggering the pretensioning strands equally on either top or bottom of the duct, the prestressing force was located at the center of gravity of the concrete section reducing any induced camber or curvature.

With all of the panel materials installed, they were poured using approximately 11 yards (8.41 cubic meters) of concrete per panel. The concrete was screeded off, trowelled and a medium broom finish was applied as the driving surface. The broom finish was applied parallel to the direction of travel. The panels were then covered with an insulated curing blanket and moisture-laden steam was introduced into the enclosure after initial set of the concrete. The maximum curing ambient temperature was approximately 130 degrees Fahrenheit.

Figure 12. Completed Panels

After 12 hours of steam curing, the concrete strength was verified by cylinder test, after which the curing blanket was removed. The side-forms were released and the prestressing force was transferred to the panels. Straddle carriers then removed the panels from the casting bed using the same recessed lifters that would be later used to erect the panels in the field.

Figure 13. Straddle Carriers

Field Construction. At the same time the panels were being fabricated in the precasting yard, 60 miles (96.56 kilometers) away at the project site, the Lean Concrete Base (LCB) was being placed. On top of the LCB a single layer of polyethylene was placed to allow the panels to move under the post-tensioning forces without inducing any cracking due to frictional restraint forces between the panels and the base.

Figure 14. Lean Concrete Base

The panels were installed as part of the construction of a new ramp to an existing freeway. As such the actual test section was located behind a temporary barrier, isolated from active traffic. The panel delivery was accomplished by capturing the one traffic lane immediately beyond the barrier. The crane used for erection was located behind the barrier and hoisted the units from the trucks into the work zone.

Figure 15. Crane Working Behind Temporary Barrier

Delivery. The panels were shipped from the plant to project site on timber dunnage on top of flat deck trailers. At 44,000 pounds (19.96 metric tons) each, the panels were loaded one panel per truck.

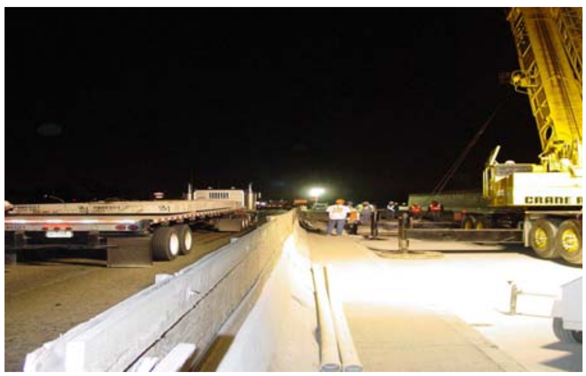

Figure 16. Unloading Slabs From Truck

Delivery was staged with panels arriving every 10 minutes. A maximum of 16 panels were delivered each night, although for larger projects, this could easily be increased to accommodate the contractor's schedule.

Placement. Since the demonstration project was new pavement, the existing concrete removal was not required. With the single layer of polyethylene sheeting in place, the first panel was set to the survey mark. An epoxy was then applied to the tongue-in-groove which ran perpendicular to the direction of traffic. A foam rubber seal in the shape of a doughnut was placed around each post-tensioning duct to act as a seal for the grouting operation.

Figure 17. Keyway Fit

While the epoxy was being applied, the next panel was being hoisted from the truck and positioned adjacent to the first panel. To insure a tight joint between each slab, temporary strands were placed in two of the longitudinal post-tensioning ducts. These strands were then fed through successive slabs and tensioned to pull the slabs together while the crane still had a portion of the load. These two strands also served to align successive panels, so that the longitudinal ducts were in line.

The field crews quickly assigned the routine tasks to individual workers and by the second night were consistently placing approximately 1800 square feet (167.23 m^2) of panel per hour. The test section was completed in two night shifts.

Figure 18. Placement of Slabs

Post-tensioning. As mentioned previously, this project was an installation of new panels on new LCB behind a temporary barrier. This allowed a second crew to install the post-tensioning tendons during the daylight shift.

Figure 19. Post Tensioning Operation

Due to the short length of the test section, the individual strands were installed by hand. It was decided as an extra measure of safety against corrosion, the strand used would be epoxy coated. In aggressive environments the coated strand would allow the contractor some leeway in the completion of the post-tensioning operations without a detrimental effect on the long term performance of the panels.

With the strand installed, the stressing operation was performed at the middle of the test section; a section being defined as the group of panels between expansion joints. By applying the post-tensioning forces in the middle of the section, the overall shortening was split in half, allowing the two ends to move towards the center. A unique dog-bone shaped post-tensioning anchor was used that allowed the strand in both directions from the center stressing panel to be stressed simultaneously in one operation.

Once the tendon stressing was completed, the stressing and dead end anchor pockets were then filled with concrete. Grout vents were installed on both the post-tensioning tendons and the under slab grouting channels. Both grouting operations were then accomplished in one mobilization. The final step was the removal of and patching of the grout vents.

Conclusions

Although this was a short pavement segment, this project successfully demonstrated that:

- -Precast technology can be adapted to a wide variety of highway design conditions
- -Fabrication can accomplish required features and design criteria
- -Construction can be accomplished under high traffic conditions

This design can be expected to perform well under heavy traffic for several decades without rehabilitation, as it will sustain very high load repetitions.

The construction of this I-10 pavement segment has successfully demonstrated the application of precast post tensioned slabs for use as quick assembly pavements. Additional pavement sections utilizing this concept are being contemplated. From the experience learned on this and the previous Texas project, a better understanding has been gained as to how this design can be adapted to various geometric conditions. Potential future improvements in the design can also be envisioned for future applications.

While TexDOT and Caltrans have endorsed the prestress post tensioned concept, other highway agencies will benefit from its use for high volume pavement construction and repair applications in the future. When user delay cost are considered, the use of prestressed/post tensioned pavements can be used successfully for high volume highway construction.

Acknowledgments

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References

Merrit, D.K., B.F. McCullough, N.H. Burns, “Feasibility of Precast Prestressed Concrete Panels to Expedite Construction of Portland Cement Concrete Pavements”, Transportation Research Record 1761, Transportation Research Board, Washington, D.C.

Elkins, McCullough, Hudson, “Precast Repair of Continuously Reinforced Concrete Pavement” ACI Journal, Texas Research Report 177-15, 1979.

AASHTO Guide Specification for Precast Concrete Products

Unified Facilities Criteria (UFC) Chapter 16, June 20, 2001, UFC 3-260-02