

New Innovations in Precast Concrete Pavement

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Abstract

The need for rapid, long-lasting, sustainable concrete pavement rehabilitation strategies has never been greater for our ageing highway system. Work windows for pavement reconstruction and rehabilitation are often as little as 4-5 hours, limiting the options available for concrete pavement rehabilitation techniques. Recently, the California Department of Transportation (Caltrans), District 4, broke tradition from their traditional approach of concrete pavement rehabilitation by using prestressed precast concrete pavement to rehabilitate an existing concrete pavement on a very heavily travelled highway in the San Francisco Bay Area. The project incorporated a prestressed concrete pavement (PPCP) on a large scale. While the use of precast prestressed concrete pavement is not a new idea, some new innovations were incorporated into this project. These innovations included the use of two-way pretensioning (longitudinal and transverse directions), elimination of stressing pockets in the surface of the pavement, use of multi-strand post-tensioning ducts, and use of longer single-lane panels ranging in length from 5.5 to 11 m (18 to 36 ft). This paper discusses the development and deployment of precast prestressed concrete pavement technology on this project, including fabrication and installation issues, as well as challenges encountered throughout the project.

Introduction

California, like most states with densely populated areas has many urban high volume highways which are expected to last long, provide a smooth ride, and require little maintenance over their lifetime, minimizing any inconvenience to the traveling public for maintenance and rehabilitation. Rehabilitation of these highways poses a tremendous challenge to Caltrans, as current work windows are often limited to as little as 4-5 hours, and typically at night. In these short work windows, Caltrans is required to restore the pavement to a high level of service with a long-lasting pavement that will perform under the constant wear and tear from high traffic volumes, heavy truck loads, and varying weather conditions.

Caltrans generally rehabilitates concrete pavement on urban facilities using rapid strength concrete (RSC). RSC is typically used on projects where the majority of the concrete pavement is in relatively good condition with the exception of isolated slabs or locations. Typical RSC mixes achieve compressive strengths of around 17.2 MPa (2500 psi) in only 1.5 hours. Water reducing admixtures, plasticizers and accelerators are typically added to the mix to maintain workability of the mixture while expediting the strength gain. The durability and long-term performance of such materials, however, has come into question recently on many rehabilitation projects.

In Northern California, several projects completed over the past decade using RSC have underperformed and required further repairs and maintenance. There are instances where RSC was used on long-term rehabilitation projects and several

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sections failed in less than three years. Sections of the existing 30-40 year-old concrete pavement on these projects outlived the newly constructed RSC areas, and in many instances, continue to do so. Caltrans was at a crossroads, particularly within the District 4 Office in the San Francisco Bay Area. An alternate approach to RSC for concrete pavement rehabilitation had to be identified, or steps were going to be taken to potentially overlay all existing concrete pavements in the District with hot mix asphalt (HMA).

This led to a decision to examine precast concrete pavement as an alternate solution, primarily based on previous successful application of the technology in California and elsewhere. A major rehabilitation project on Interstate 680 provided the opportunity to evaluate precast concrete pavement as an alternative solution to RSC and HMA overlays.

Interstate 680 Project

The I-680 project is located 56 km (35 mi) east of San Francisco in the San Ramon Valley (see Figure 1), and was originally constructed in the 1960s. The existing pavement section is typically 200–230 mm (8-9 in) of jointed plain concrete pavement (JPCP) over 100–130 mm (4-5 inches) of cement treated base (CTB) over 300–360 mm (12-14 inches) of aggregate subbase (AS). Other characteristics of the I-680 project include:

- 8 lane concrete median barrier divided freeway that runs in the North/South direction with concrete auxiliary lanes intermittently throughout the project.
- 10 interchanges and 44 ramps
- Lane 1 is a 3.7 m (12 ft) wide HMA pavement with a 3.4 m (11 ft) wide HMA inside shoulder.
- Lanes 2, 3, and 4 are 3.7 m (12 feet) wide JPCP.
- The outside shoulder is HMA pavement varying in width from 2.4-3.7 m (8-12 ft).
- Average annual daily traffic (AADT) ranged from 145,000-171,000 in 2010 and is projected to rise to 171,000-199,000 by 2020 with 4.7% truck traffic.

The project entailed rehabilitation of 20 km (12.5 mi) of the existing pavement across four lanes in both the northbound and southbound directions. Included in the rehabilitation strategy was a combination of cast-in-place and precast concrete pavement for the southernmost 12 km (7.5 miles) of the project, and a crack-seal-and-overlay (CSOL) of the existing concrete pavement on northernmost remainder of the project.

The initial project plans incorporated a combination of a jointed precast pavement system (JPPS) and precast prestressed concrete pavement (PPCP). JPPS was specified for smaller (e.g., single slab) repairs and longer sections on non-tangent alignments, while PPCP was specified for longer stretches of pavement on tangent alignments. The JPPS concept is based on using heavily reinforced precast concrete panels with dimensions similar to the cast-in-place slab being replaced. PPCP utilizes precast panels that are pretensioned during fabrication and post-tensioned together in long sections after installation on site. The original project contract documents contained detailed drawings and specifications for the PPCP system and only provided performance requirements for JPPS, allowing any viable JPPS to be used so long as it met those requirements. The JPPS approved for the project by the District utilized a jointed precast prestressed concrete pavement (JPPCP) system. The JPPCP

system was developed by the precaster and featured some of the unique features of the PPCP system used on the project. Both systems will be discussed below.



Figure 1. I-680 Project Location

Table 1 summarizes the rehabilitation strategy for the existing pavement on I-680. The strategies were selected based on the level of distress of the existing pavement. Precast concrete was specified for areas where the condition of the majority of the existing pavement was satisfactory, with acceptable ride quality and exhibiting only moderate areas of distress in portions of various lanes. The CSOL strategy was used for areas that exhibited severe distress and poor ride quality over the majority of all lanes. The mill and overlay strategy was selected for Lane 1 since the existing pavement was asphalt in relatively good condition.

Location	Lane 1	Lanes 2 and 3	Lane 4
Alcosta Blvd to Diablo Blvd	200 mm (8 in) HMA mill and overlay	- Reconstruct with PPCP on tangent sections - Reconstruct with JPPCP on non-tangent sections	- Cast-in-place JPCP - Reconstruction with PPCP at ramp tapers
Diablo Blvd to northern project terminus	200 mm (8 in) HMA mill and overlay	Crack-seat-and-overlay existing JPCP	Crack-seat-and-overlay existing JPCP

Table 1. Summary of Rehabilitation Strategies for I-680

Pavement Evaluation

Initial project-level field condition surveys were used to evaluate the distress levels of the existing pavement in accordance with the Caltrans Maintenance Technical Advisory Guide (MTAG) for Rigid Pavements and the Caltrans Slab Replacement Guidelines. Distressed pavement was identified on plan sheets and the limits of precast pavement and other rehabilitation strategies identified. Distresses identified by the field surveys included longitudinal, transverse, and corner cracking, joint deficiencies, surface defects, spalling, faulting, and roughness. In addition to identifying severely distressed JPCP, areas that the District believed exhibited a high potential for failure within the next 5 years were also identified for rehabilitation. Falling weight deflectometer (FWD) testing was also conducted to evaluate the condition of the underlying subbase, such that the subbase could be reconstructed if necessary.

Original Design Details

As discussed previously, the precast pavement rehabilitation strategy utilized both precast prestressed concrete pavement and jointed precast pavement systems. The original plans called for non-prestressed (reinforced) precast panels for the jointed precast pavement sections, with the specific system to be used to be submitted for approval by the contractor.

The structure beneath the precast pavement is a typical Caltrans section, consisting of a lean concrete base over the existing aggregate subbase and subgrade. The existing cement treated base (where it existed) was to be removed with the existing concrete pavement. Due to the time constraints imposed for reconstruction, a rapid setting lean concrete base (LCB-RS) was specified beneath the precast pavement. The LCB-RS utilized a concrete mixture with Type III Portland cement, designed to achieve a minimum compressive strength of 5 MPa (725 psi) in 4 hours.

The concrete mix designs specified for both precast concrete systems followed requirements in the Caltrans Standard Specifications and used a Type II Portland cement. Other mixture design parameters were the same with the exception of microfibers required for the precast panels used for the PPCP system. The fibers were included to help reduce the probability of any early-age shrinkage cracking during fabrication or spalling of abutting edges as the panels were installed.

The precast panel layout originally specified for the PPCP system (Figure 2) followed the design methodology outlined by the FHWA from a previous project in California and from standard plans that were currently under development by Caltrans as follows:

- Panel Length (direction of traffic): 2.4 m (8 feet)
- Panel Width (transverse to traffic): 3.7 m (12 feet)
- Panel Thickness: 200 mm (8 in)
- Panel Layout: Use of joint panels, base panels, and central stressing panels (with blockouts cast into the top of panels) for post-tensioning
- Post-Tensioning Layout: Single strand 25 mm (1 in) diameter P-T ducts spaced at 0.6 m (2 ft) on center across width of panel.
- Post-Tensioning Strands: 15 mm (0.6 in) epoxy-coated strands stressed to 80 percent of ultimate tensile strength
- Pretensioning Strands: 13 mm (0.5 in) bare strand, 6 per panel

- Minimum and maximum length of post-tensioned sections: 19.5-46.3 m (64-152 ft)
- Longitudinal isolation joints (panels were not tied to adjacent lanes)

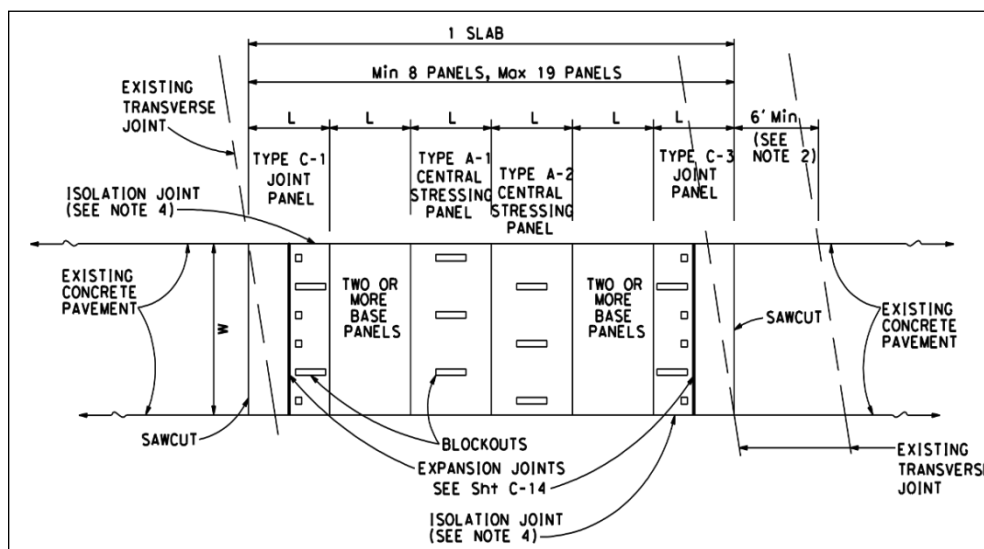


Figure 2. PPCP slab layout from project plans.

The PPCP panels were isolated from the adjacent lanes primarily because of differential movement between PPCP with longer joint spacing, and the existing JPCP with shorter joint spacing. Additionally, because replacement of existing pavement sections was not continuous throughout the entire project, Caltrans decided to keep precast and existing pavement independent of each other for ease of construction and the possibly future rehabilitation of the remaining JPCP. The combination of pretensioning and reinforcing around the perimeter of each panel, as well as the higher strength concrete (42.1 Mpa [6100 psi]) were felt to provide adequate capacity for anticipated edge stresses.

For the jointed precast pavement system to be used, the contractor was required to submit shop drawings for the proposed system. Selection of the JPPS was left to the contractor because there were several proprietary systems commercially available, and Caltrans did not want to specify or restrict the use of any particular system. Therefore, Caltrans provided some basic specifications and guidelines for the proposed system which specifically addressed California's minimum requirements for concrete (use of supplemental cementitious materials and Caltrans concrete mix design standard specifications), reinforcement, and load transfer devices, similar to the approach taken by other State Highway Agencies for projects of this nature.

Precast Pavement Design Changes

Soon after the contract for the I-680 project was awarded, the general contractor and precast supplier proposed design changes to the PPCP system shown in the contract documents. The main motivation was to better optimize the panel fabrication and installation procedures, thereby increasing production and saving time. Being an untested concept, this design change carried some risk, but demonstration of the concept at the precast plant showed that it was a viable alternative. The District accepted the proposal, but required the contractor maintained responsibility for

ensuring its successful deployment. The key design changes proposed for the PPCP system are summarized below.

Increased Panel and Slab Length As discussed previously, the original plans called for panels one lane wide and 2.4 m (8 ft) in length. The proposed design change increased the panel lengths to as much as 11 m (36 ft). This significantly reduced the number of precast panels to be fabricated and shipped, thereby greatly increased production during both fabrication and installation. While the original 2.4 m (8 ft) length was specified for panel shipment purposes, the increase in production both at the fabrication plant and on site more than offset the additional cost of oversize permits for shipping 3.7 m (12 ft) wide and (up to) 11 m (36 feet) long precast panels. Increasing the panel length also reduced the number of panel joints, thereby decreasing the number of joints which had to be epoxied during installation, and the number of post-tensioning ducts which had to be sealed with gaskets.

The District also permitted an increase in the post-tensioned slab length to up to 66 m (216 ft) in order to better align the maximum permissible slab length with a typical nightly production rate. This helped to maximize the contractor's installation production each night, reducing the number of nights required for construction of the project. Using 11 m (36 ft) precast panels, each post-tensioned slab consisted of up to 6 precast panels. This length, and the length of the individual precast panels was varied, however, to match the limits of the existing pavement to be removed.

Elimination of Post-Tensioning Blockouts The blockouts in the surface of the precast panels for post-tensioning were eliminated by specifying a post-tensioning system where the tendons were stressed from the ends of each post-tensioned section, at the vertical face of the panels (Figure 3). This greatly simplified fabrication of the panels and eliminated the need for filling the blockouts on site after post-tensioning had been completed.

Two-Strand Post-Tensioning Ducts Post-tensioning was further optimized by using larger 51-mm (2-in) diameter post-tensioning ducts (Figure 3), and installing two strands in each duct. This reduced the number of post-tensioning ducts and associated hardware by one half. It also reduced the number of duct openings at joints between precast panels, and the associated locations for potential grout leakage by one half.

Keyway Interrupts and Recesses for Gaskets To help ensure a tight seal between adjoining ducts at the panel joints, the tongue-and-groove keyway detail was interrupted at the duct locations to create butt joints. Additionally, a recess was created around each post-tensioning duct to receive the compressible foam gaskets (Figure 3). This combination of joint detail refinements helped to ensure virtually no grout leakage from the panel joints during the final tendon grouting operation.

Two-way Pretensioning Perhaps the most significant design change was the use of two-way pretensioning in the panels. This unique process is seldom used in the precast concrete industry due to the complexity of the casting bed required, and has never been used for previously for PPCP. PPCP panels are typically pretensioned only in the longer direction for handling purposes, and post-tensioned in the shorter direction on-site. For the proposed design change, pretensioning in the longer direction of the panel would have left no prestress in the shorter direction across the 3.6 m (12 ft) traffic lane. Two-way pretensioning ensured prestress in both directions,

even prior to installation of the panels on-site. While longitudinal pretensioning provided the prestress in the direction of travel, additional longitudinal post-tensioning was still incorporated in order to tie the individual precast panels together and to provide additional longitudinal prestress to achieve the levels specified in the original project plans.

Drop-in Panels In order to permit post-tensioning from the ends of each post-tensioned section of pavement, a 1.2-m (4-ft) wide gap was left between consecutive PPCP sections. This gap was later filled by a 1.2-m (4-ft) wide precast “drop-in” panel installed after post-tensioning was completed on the PPCP sections on either side of the gap. The drop-in panels were connected to the PPCP sections on either side of the gap using dowel bars extending from the ends of each PPCP section (Figure 3). Slots cast into the drop-in panels received the dowel bars and were subsequently grouted to encase the dowels. Temporary drop-in panels were used to temporarily fill the gap if the permanent drop-in panel could not be installed the same night as post-tensioning was completed. Figure 4 shows a typical (maximum length, 6-panel) PPCP slab with drop-in panels at either end of the section.



Figure 3. Blockouts and dowels on end panels only (left); Keyway and 51 mm (2-inch) diameter P-T ducts between PPCP panels (right)

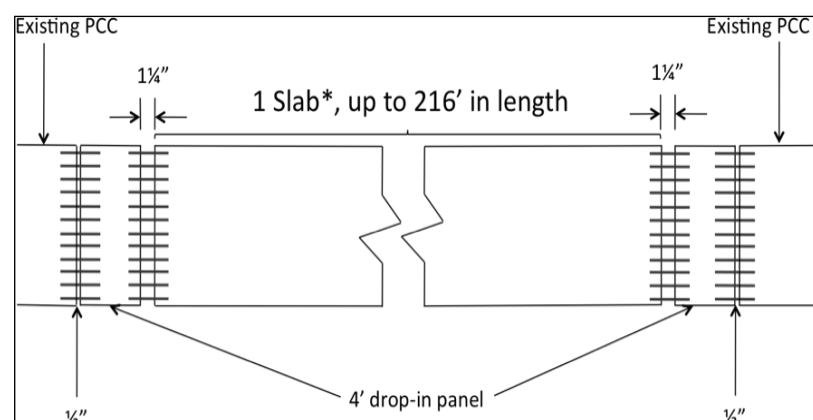


Figure 4. Modified PPCP panel layout.

Jointed Precast Prestressed Concrete Pavement For the jointed precast pavement sections of the project, the contractor and precast manufacturer proposed a system that utilized two-way pretensioned panels, similar to the PPCP panels, that were

interconnected to each other and with the abutting pavement using dowel bars. The pretensioning provided added flexural capacity (over conventionally reinforced precast panels) for handling, and permitted the use of longer panels, up to 11 m (36 feet) in length. Dowel bars were cast into the ends of the panels, and were grouted in place either in slots sawcut into the existing pavement or in slots cast into abutting precast panels.

One unique feature the JPPCP not employed for the PPCP was the use of trapezoidal shaped panels where they were installed on non-tangent sections. The transverse edges of the panels were tapered to create “pie shaped” panels such that the panels would match the horizontal curvature on the roadway. This required surveying of the non-tangent locations where the JPPCP panels were to be installed and fabrication of panels to match each specific location.

The District quickly realized the benefits of the changes to both the PPCP and jointed precast pavement systems, and accepted the proposed changes. Of particular interest to the District were the benefits of reducing in the number of joints (due to the longer panel lengths), and the elimination of blockouts on the top of panels (due to end stressing).

However, the changes did come with some apprehension. There was the issue of ensuring the longer panels would fit in the excavated areas within the tolerances specified particularly along the isolation joints. Additionally, there was concern with handling of the larger dimension panels and whether the underlying LCB could be placed to such a tolerance that there would not be any high points that could cause the longer panels to flex when installed. Another unknown was the long-term performance of the 1.2 m (4-foot) drop-in panels. It was felt that these panels were susceptible to cracking due to the number of slots on either side of the panel (Figure 4), especially near the ends of the panels. Pretensioning and additional reinforcement in the drop-in panels helped to alleviate this concern. In the end, the District was enthusiastic about the potential increase in productivity and optimization of the process demonstrated by the design modifications.

Installation of PPCP and JPPCP Systems

The installation procedure established by the contractor and their subcontractors was loosely based on the procedure outlined in the special provisions of the contract. Below is a step-by- step procedure of the PPCP installation, with differences for the JPPCP system discussed at the end.

- 1. Removal of existing pavement and CTB** Removal of the existing pavement and CTB was completed using the “lift out” method. Sawcutting of the limits of removal was completed 1-2 days in advance of pavement removal. An excavator equipped with a slab crab was used to lift out the existing pavement mostly intact. The excavator was then used to remove any remaining CTB and level the subbase as much as possible. Figure 5 demonstrates the pavement removal process.



Figure 5. Removal of distressed pavement and underlying base.

2. **Grading and compaction** The second step was to proof-roll the remaining subbase material in preparation for rapid setting lean concrete base material, as shown in Figure 6. After rolling, nuclear gauge density tests were used to verify compaction levels of the remaining subbase.



Figure 6. Grading and compaction of subbase

3. **Install dowels, place longitudinal joint filler material, and set grade for LCB-RS** After compaction, several simultaneous activities took place. A gang drill was used to drill holes for the dowel bars in the existing pavement, and the dowel bars were subsequently epoxied in place. Also, a 13-mm (0.5-in) thick foam filler was placed along the longitudinal isolation joint between lanes to separate the LCB-RS from adjacent lane(s). Finally, guide rails were set up for screeding the LCB-RS to the appropriate elevation and cross slope. Figure 7 shows the dowel drilling and guide rail setup processes.

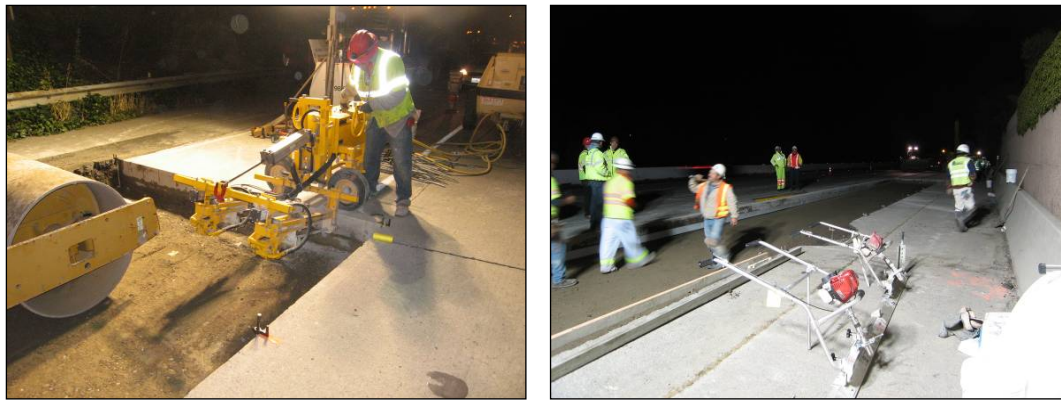


Figure 7. Drilling dowel slots, and setting grade for LCB-RS.

4. ***Place and screed LCB-RS*** The next step was to place the 150 mm (6-in) thick LCB-RS over the existing subbase. The LCB provided the platform for supporting the precast panels and was therefore graded to a very precise tolerance and continually checked with a straightedge. Although physical dimensions weren't specified for the tolerance, the engineer required spot grinding of high spots and filling of depressions larger than 6.35 mm (0.52-in). The LCB-RS was required achieve a compressive strength of 5 MPa (725 psi) prior to opening to traffic, which was typically achieved within 4 hours. Figure 8 shows the placement of the LCB-RS.



Figure 8. Placing and grading LCB-RS

5. ***Place bond breaker/friction reducing membrane, joint filler, and install PPCP panels*** Once LCB-RS had reached a compressive strength of at least 0.69 MPa (100 psi), typically within 2 hours after placement, a single layer of polyethylene sheeting was placed as a bond breaker and friction reducing membrane over the LCB. A 13 mm (0.5-in) joint filler was also installed along the edge of the existing pavement for the longitudinal isolation joint. Installation of the PPCP and JPPCP panels followed immediately. For the PPCP panels, epoxy was applied liberally to the keyways, and the compressible foam gaskets were installed around the post-tensioning ducts. As each PPCP panel was installed, the post-tensioning strands were pushed through the ducts. Two “temporary” post-tensioning strands were then tensioned in order to pull the joint between the panels tightly closed. After tensioning, the temporary strands were released and

the next panel was installed. Figure 9 shows the installation of PPCP panels over the bond breaker/friction reducing membrane.



Figure 9. Installation of PPCP panels over LCB and friction-reducing membrane

6. ***Final post tensioning and placement of drop-in panels*** After the last panel of a PPCP section was placed, the temporary post-tensioning strands were removed and the permanent post-tensioning strands were anchored and stressed. The permanent post-tensioning strands were epoxy-coated for corrosion protection, and “bite-through” wedges were used for the anchorage. After completion of post-tensioning a temporary drop-in panel was typically installed in the gap between post-tensioned sections until grouting of the post-tensioning ducts was completed during a subsequent night. After grouting, a final drop-in panel could be installed. Figure 10 shows the post-tensioning installation and placement of the temporary drop-in panels. At this point, the pavement can be opened to traffic at the end of the work shift.

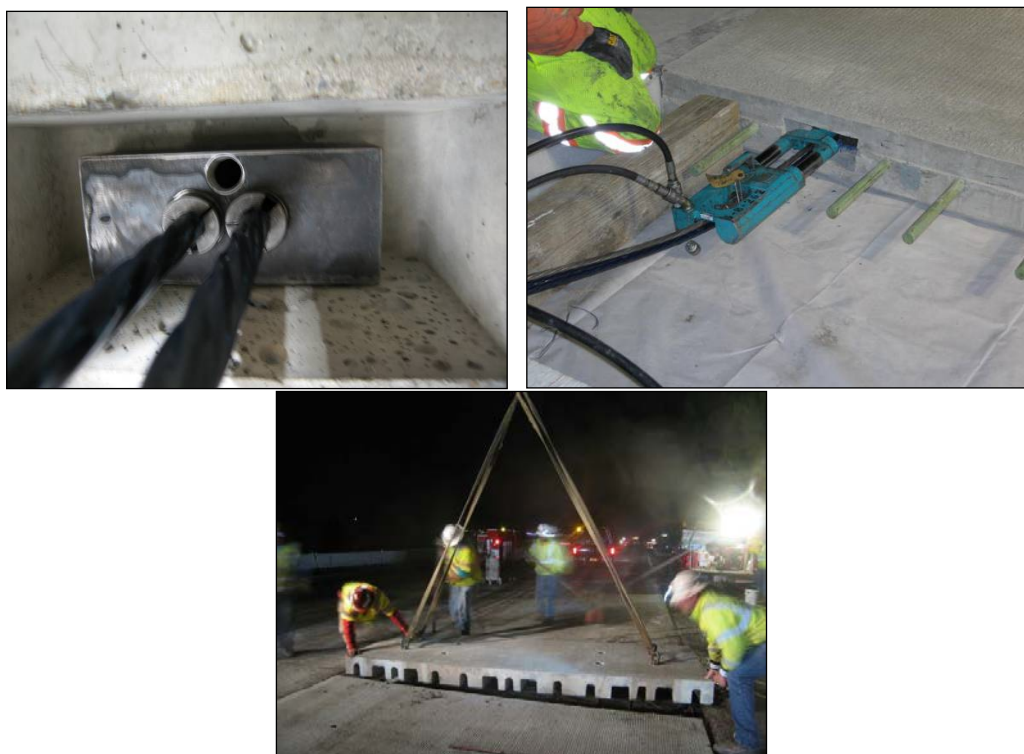


Figure 10. Final post tensioning and placement of temporary drop-in panel.

7. **Post-Tensioning tendon and underslab grouting** Typically, the night following panel placement and post-tensioning, the temporary drop-in panels were removed and the post-tensioning tendons were grouted. Following completion of tendon grouting, underslab grouting was completed by pumping grout beneath the precast panels through ports cast into each panel to help provide full contact between the precast pavement and LCB. The underslab grouting operation used minimal pressure (< 34.5 kPa [5 psi]) since low viscosity grout was being used to fill any voids beneath the precast panels. Once grout would exit an adjacent port or backflow from the port being grouted, any voids in the vicinity of the ports were considered filled and grouting was moved to another port until the entire panel was grouted. Figure 11 shows the post-tensioning and underslab grouting operations.



Figure 11. PT duct and underslab grouting.

8. **Install permanent drop-in panel and grout dowel bars** After post-tensioning and grouting operations were complete, dowel bars were epoxied into the existing pavement (if not already in place), and the permanent drop-in panels were installed. The dowel slots were then grouted to fully encase the dowels and provide load transfer between the drop-in panels and precast panels or existing pavement. The only remaining operations were diamond grinding of the pavement surface for ride quality, and sealing of the transverse expansion joints and longitudinal isolation joints. Figure 12 shows the dowelled pavement ready to receive the drop-in panel and a final drop-in panel ready for installation.



Figure 12. Dowels installed in existing pavement (left); permanent drop-in panel (right).

9. ***Diamond grind pavement and seal joints*** After all precast pavement on the I-680 project had been installed, the final steps included diamond grinding and sealing the expansion joints and longitudinal isolation joints. Diamond grinding is an essential step for achieving the final ride quality requirements by evening out transitions over transverse and longitudinal joints between precast panels and between the precast pavement and existing pavement. Joint sealing, likewise, is a critical step as it prevents incompressible materials from filling expansion joints, and seals longitudinal isolation joints from moisture intrusion beneath the pavement. Figure 13 shows a finished PPCP section prior to grinding. Once the grinding operation was complete, a profilograph was used to evaluate the overall smoothness. The requirements included not having individual high points exceeding 7.6 mm (0.30-in) within the 7.6 m (25-ft) profilograph baselength. Most areas fell within these tolerances; however some areas exceeded the smoothness requirement because of the precast panel proximity to bridge approach slabs. Areas where tolerances were exceeded were diamond ground, which was acceptable as the precast panels were designed with an additional 13 mm (0.50-in.) thickness to account for grinding.



Figure 13. Completed PPCP section prior to grinding.

The installation procedure for the JPPCP panels was very similar to the PPCP process, with the exception of the post-tensioning and tendon grouting processes, and the exclusion of drop-in panels. JPPCP sections were typically short enough that all panels could be installed in a single night. Similarly to the PPCP system, dowels were drilled and epoxied into the existing pavement prior to placing the JPPCP panels. All JPPCP panels were cast to fit the excavation area and dowel bar slots were typically grouted the same night as installation of the panels. Figure 14 shows typical JPPCP panels in place. The contractor elected to perform underslab grouting on several panels at once, typically once a week.



Figure 14. Completed JPPCP panels.

Fabrication Challenges

Typical installation production rates were on the order of 91 linear meters (300 linear feet) during each 8-hour work window for PPCP, and 45.7-61 linear meters (150-200 linear feet) for JPPCP, depending on repair area proximity to one another. This rate of production required careful scheduling by the precaster, particularly during the initial phases of the project, to ensure the general contractor could maintain their installation timetable. Initially, the new proposed design was still in the approval process once the construction project officially began, so the window to stay ahead of installation became smaller each day. Construction of two separate fabrication beds permitted the precaster to keep up with the panel installation schedule.

Weather also played a role in fabrication, as the panels were produced on outdoor casting beds, particularly at the beginning of the project with numerous rain delays. A mobile shed was developed and used as a traveling cover when absolutely necessary to keep production (e.g., casting bed preparation) going during rain events.

Additional challenges came from the concrete mixture itself. With the inclusion of fiber reinforcement in the mix design, initially there were inconsistencies with the mix ranging from very wet, to dry, and finally “sticky.” The precaster worked with industry experts to successfully resolve this issue and provide a consistent, workable fiber reinforced mixture. This problem did not exhibit itself in the mix for the JPPCP since fibers were not required.

Installation Challenges

Being the first project of its kind in District 4, the installation and inspection of these systems provided numerous challenges. Summarized below are some recommendations based on observations and challenges faced during the entire PPCP and JPPCP installation.

Accuracy of longitudinal and transverse sawcuts During nighttime operations, the contractor should ensure adequate lighting is provided to enable accurate sawcuts. This will help minimize meandering of the sawcut and provide a consistent width on all the joints.

Loss of epoxy coating on strands Noticeable loss of epoxy coating on the post-tensioning strands was observed due to abrasion from edge of corrugated metal P-T duct as the strands were inserted into the ducts. Use of either plastic ducts or having a plastic cover over the edge of the corrugated metal duct to allow strands to move freely into opening without abrading the epoxy coating is recommended.

Check for grout leaks at ends of P-T ducts and at the joints between panels While this has been an issue on many previous PPCP projects, grout leaks were almost nonexistent due to the improvements made in the joint/duct coupling detail along the mating panel edges.

Carefully inspect LCB-RS surface To ensure the panels sit flush with adjacent roadway and that there are not undulations that could cause the panels to crack as they are installed, the surface of the LCB-RS should be carefully inspected so corrections can be made. Spot grinding was required for high spots and depressed areas in an effort to minimize voids beneath the panels. This became less of an issue over the course of the project as the contractor became more comfortable with placing and grading the LCB-RS.

Properly secure joint filler material Ensure that the joint filler material in the isolation joints is properly secured to the pavement/base edge using either concrete nails or tape.

Monitor precast panels for sag Precast panels should be checked for sag at the precast plant. Sag can occur if adequate dunnage is not provided between precast panels. Fortunately, the I-680 precast panels had very little sag, but were still inspected for assurance.

Spalling due to handling and demolition of adjacent existing pavement. A few panels were rejected on the I-680 project due to spalling along edges and corners due to issues with handling the precast panels and removal of the existing pavement. This forced the contractor to ensure better care during handling.

Varying isolation joint widths At some locations on the I-680 project, the existing lane widths and joints were not consistent, leading to varying widths in an excavation. This resulted in some isolation joint widths of up to 63.5 mm (2.5-in) after precast panel installation. To address this issue, additional panels were cast to different widths. Although the contractor wanted to cast a one-size-fits-all panel to ensure fit in all excavations, the variability of excavations precluded this. Measurements must be precise and consideration must be given to casting varying width panels to accommodate meandering or incorrectly measured joints and sawcuts.

Additional Challenges

As the project progressed through construction and the contractor became more and more comfortable with the installation operation, Caltrans and the contractor decided to test the versatility precast concrete pavement by using it to address some of the more challenging locations on the project. Below are some innovations implemented successfully in challenging locations on the project.

Installation of PPCP under a structure One of the sections of the project for rehabilitation was beneath a bridge overpass with only 5.2 m (17-ft). Due to the size of the equipment required to lift and handle the “full-size” PPCP panels, it was not possible to use these panels beneath the overpass. The contractor and the District agreed to use smaller 2.4 m by 3.7 m (8-ft by 12-ft) precast panels for this location in order to reduce panel weight such that an excavator could be used to install the panels

beneath the bridge overpass, as shown in Figure 15. A total of 27 panels were fabricated and installed for a total length of 65.8 m (216-ft) in a single (extended) 10-hour night shift (Figure 15).



Figure 15. PPCP installation under a structure (17' clearance)

Use of tapered panels to correct varying width joints As discussed previously, in a few locations lane widths were not the standard 3.7 m (12-ft) dimension. To address this, the precaster was asked to fabricate tapered “transition” panels that would carry the joint out and increase the lane width to the standard 3.7 m (12-ft) width, as shown in Figure 16.

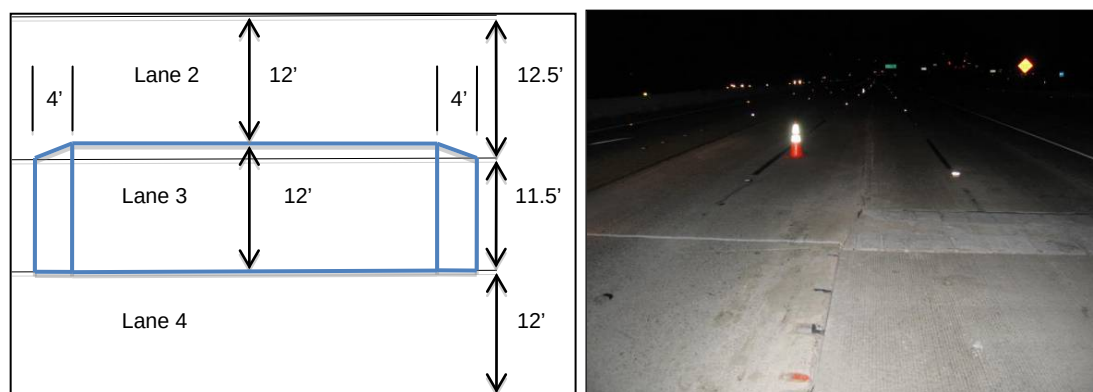


Figure 16. Tapered panels to accommodate varying lane widths (left) and installed tapered panel (right).

Custom-sized JPPCP panels to accommodate varying lane widths In several instances, the lane widths varied slightly from 3.7 m (12-ft), up to 3.72 m (12.2-ft). Caltrans and the contractor realized that they could not use a “one size fits all” panel, and required custom-sized panels to be fabricated to fit the varying lane widths. Originally Caltrans agreed to use a fixed 3.6 m (11.92-ft) width panel to fit 3.7 m (12-ft) wide excavations. As the project progressed, they opted to for two different dimensions, 3.6 m (11.92-ft) and 3.7 m (12-ft) to accommodate the varying widths.

Installation of JPPCP panels on non-tangent sections JPPCP panels were installed along non-tangent sections with radii ranging from 975 m (3,200 ft) to 6,096 m (20,000-ft). While this is a very large radius, it still necessitates non-rectangular precast panels. After careful surveying of the limits of each panel, precast panels were fabricated in a casting bed with flexible siderails and adjustable bulkheads to

achieve the “pie shaped” precast panels. Although not employed on this project the precaster also had the ability to produce panels with curved (non-tangent) edges.

Conclusion

This paper provides an overview of the largest precast prestressed concrete pavement project ever constructed in the United States. The innovations developed through this project and lessons learned throughout construction have provided a viable solution that can be deployed throughout California and the world. Essential to the success of this project was partnering and constant communication between Caltrans District 4 inspectors and designers, the contractor, and precast supplier. The result was the development of precast pavement systems that will provide a useful solution for future projects of varying applications.

The future of precast pavement at Caltrans is very promising. While precast pavements provide a solid alternative to PCC rehabilitation, it by no means is intended to replace other forms of concrete pavement repair. The use of precast concrete pavement is site specific and must meet the needs of the owner/operator. The I-680 project demonstrates the tremendous benefit precast concrete pavement brings as a longer-life, rapid rehabilitation alternative to current strategies used by Caltrans in an era where agencies are looking to rehabilitate and preserve, rather than continually reconstruct our existing infrastructure.

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