CALTRANS POLICY AND STANDARDS FOR EVALUATION, DESIGN, AND CONSTRUCTION OF PRECAST CONCRETE PAVEMENT

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ABSTRACT

California Department of Transportation (Caltrans) has been using precast concrete pavement technology for over ten years. The main goal of Caltrans for adopting this technology was to rapidly repair or replace distressed pavements with long-lasting sustainable alternatives. The need for rapid construction and long-performing pavement comes from California's presently highly congested urban highways and the increasing trend of traffic volume in the future. Caltrans recently completed the first phase of implementing precast concrete pavement technology and started the second phase of this initiative. The results of phase one came in the form of selection criteria, design and performance prediction, plans and specifications, alternative or innovative proposals, evaluation of new features, and construction practices of different precast systems that were used in the pilot projects. Based on the conclusions made in phase one, the scope and work plan for the phase two of the implementation process was suggested. A description of these items as well as challenges and lessons-learned in the course of the implementation process is discussed in this paper.

Keywords: Precast, Concrete, Pavement, Panel, Pre-stressed, Post-tensioned

INTRODUCTION

Many parts of California highway system are close to the end of their service life and in need of rehabilitation and/or reconstruction[1]. Closing highways for a long period to maintain or repair them is not feasible due to heavy use and long traffic delays. Accelerated construction is the only viable solution in such cases.

The benefits of precast concrete pavement (PCP) are clear; precast panels could be installed quickly in any weather condition with no need for special materials and could be driven on immediately[2, 3].

The two main categories of precast concrete pavement are precast jointed concrete pavement (PJCP) and precast pre-stressed concrete pavement (PPCP). Pre-tensioning could be used in either of these systems, however, the PPCP method uses post-tensioning to tie the panels together, while load transfer mechanisms such as dowel bars are used to tie panels in PJCP. Within each category, there are sub-systems depending on where the post-tensioning is applied, the direction of pre-tensioning, the type of load transfer between the panels, the way panels are graded, etc. A special sub-category of PJCP, which is used for repair applications, is referred to as individual precast slab replacement (IPSR).). A detailed description, design characteristics, and the proposed application of each precast concrete pavement category are given in the literature.

Caltrans started thinking about using this technology in 2000. The first short pilot project was built on I-10 in 2004[4]. The success of this project prompted Caltrans to start a full scale research program with Heavy Vehicle Simulator (HVS) in 2005[5,6,7,8,9]. The results of this research led to another pilot project on I-15 in 2008[10]. The precast system used in this project was completely different than that of the I-10 project.

In 2010, Caltrans initiated an implementation program through partnership with industry under the Rock Products Committee (RPC)[11]. The goal of this initiative was to prepare standards, including specifications and plans, and guidance for using precast concrete pavement in California. Other pilot projects with different precast systems were considered under this program, among them was I-680, I-5/14, and I-710. To plan the experiment properly, Construction Evaluated Work Plans (CEWP) were prepared for these pilot projects[12]. At the end of construction, the lessons-learned from these projects were documented to develop the standards for precast concrete pavement[10, 13].

Table 1 lists the location, system type, and project phase of all precast concrete pavement projects in California. In general, type selection for these projects has been based on the length of the project, thickness limitations, service life expectancy, resource availability, and cost. At present, there are eight active construction Capital Outlay projects using precast concrete pavement technology with a cost of over $65 million. This is in addition to the rapidly increasing Maintenance projects.

As was mentioned earlier, Caltrans initiated an implementation program by partnership with industry to prepare standards for using precast concrete pavement in California about five years ago. The first phase of this program is already completed and the next phase is about to start. The activities of Phase I and the work plan of Phase II are elaborated in the following sections.

Table 1 Precast Concrete Pavement Projects in California

Location	**System**	**Phase**
I-10 in El Monte, Los Angeles	PPCP	Completed 2004
Research Center in San Bernardino,	Super Slab	2005
I-15 in Ontario, San Bernardino	Super Slab	Completed 2010
I-5/14 in Sylmar, Los Angeles	PPCP	Completed 2010
I-680 in San Ramon, Contra Costa	PPCP & IPSR	Completed 2012
I-710 Los Angeles	PPCP	Construction
I-80 in Dixon, Solano	PPCP	Completed 2014
I-580 Alameda	PPCP & IPSR	Completed 2014
I-5 Los Angeles	PPCP & IPSR	Completed 2014
I-405 Los Angeles	PPCP	Construction
I-210 Los Angeles	PJCP, IPSR	Construction
101 (Section 1) Los Angeles	PJCP, IPSR	Construction
101 (Section 2) Los Angeles	PJCP, IPSR	Construction
I-605 Los Angeles	PJCP, IPSR	Construction
I-15 at Cajon Pass, San Bernardino	PPCP or IPSR	Design
I-710 (Phase II) Los Angeles	PPCP	Design
210, 134, 101, 15 Los Angeles and San Bernardino	IPSR	Maintenance Projects
101 Santa Barbara	IPSR	Construction
I-15/215 San Bernardino	IPSR	Construction
57 Los Angeles	IPSR	Design

PHASE I IMPLEMENTATION

The results of this phase of implementation are briefly discussed below.

SPECIFICATIONS AND PLANS

Caltrans developed draft specifications and construction details for precast concrete pavement including precast pre-stressed concrete pavement (PPCP), precast jointed concrete pavement (PJCP), and individual precast slab replacement (IPSR). PPCP and PJCP are used for lane replacement (long-life performance); IPSR is used for slab replacement (short-term repair). Precast concrete pavement projects were designed, went under construction, and are now operational using these standards.

The draft standards have been revised many times during the life of Phase I implementation based on lessons-learned from pilot projects. In addition, these drafts have been customized for different projects with specific needs or special requirements. Figure 1 shows an example of a construction detail sheet belonging to the PPCP draft standard plans.

The significant characteristics of the specifications and plans are discussed in more detail later in the document.

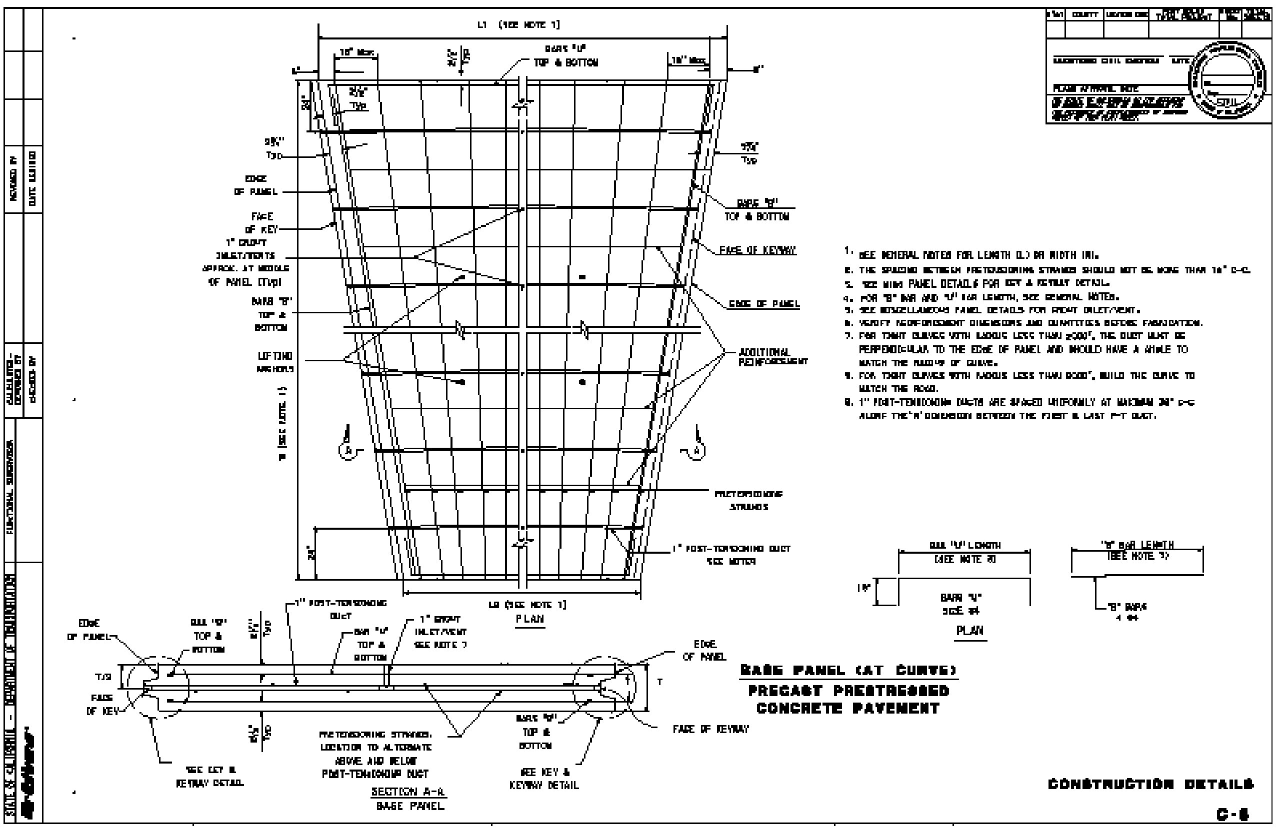


Fig. 1 A sample of Precast Concrete Pavement Construction Detail

DESIGN METHODOLOGY

A key consideration in selecting and justifying the cost of a precast concrete pavement system is its predicted performance and life expectancy. Similar to the other pavement types, not all the PCP systems perform the same way for the same period of time. This explains the need to establish a procedure to predict the PCP service life in order to compare different systems.

While Caltrans has been monitoring and evaluating the constructability and field performance of the PCP projects, it started another study on the PCP design methodology to evaluate this technology from a theoretical point of view. The main focus was to come up with acceptable methods to structurally analyze PJCP and PPCP in order to compare the cost-benefit of these two systems. The other more detailed goals of this study were:

- Evaluate the performance life of the precast concrete pavement strategies
- Incorporate changes and evaluate their impact on the design life
- Allow assessment of alternatives to the original design
- Provide criteria to compare rapid construction alternatives
- Comply with the requirement of the life cycle cost analysis (LCCA)

Through a consultant contract, the design methodology was prepared and finalized in 2012[14]. The completion of this study was almost concurrent with finalizing a national study on the precast concrete pavement technology under SHRP2 program[15]. These documents provided critical information for implementation of the precast concrete pavement strategy and provided a tool to establish design criteria and testing methodology for potential alternatives.

GUIDANCE ON TYPE SELECTION

Precast concrete pavement is used in two main applications; 1) Repair of the existing pavement, and 2) Reconstruction or replacement with new pavement.

The first application is for fixing the damaged portions of an existing roadway. This application, which is commonly called individual slab replacement (ISR) in California, is a corrective maintenance strategy with an expected service life of 5 to 10 years. Although it is called individual slab replacement, the strategy could be used for replacing a limited number of adjacent slabs in one or more lanes. The thickness of the precast panels used for slab replacement is often equal to the thickness of the existing pavement. The base is not replaced for ISR, unless it is found necessary to repair or replace it. Figure 2 shows the general layout and possible configurations of the individual slab replacement with precast panels.

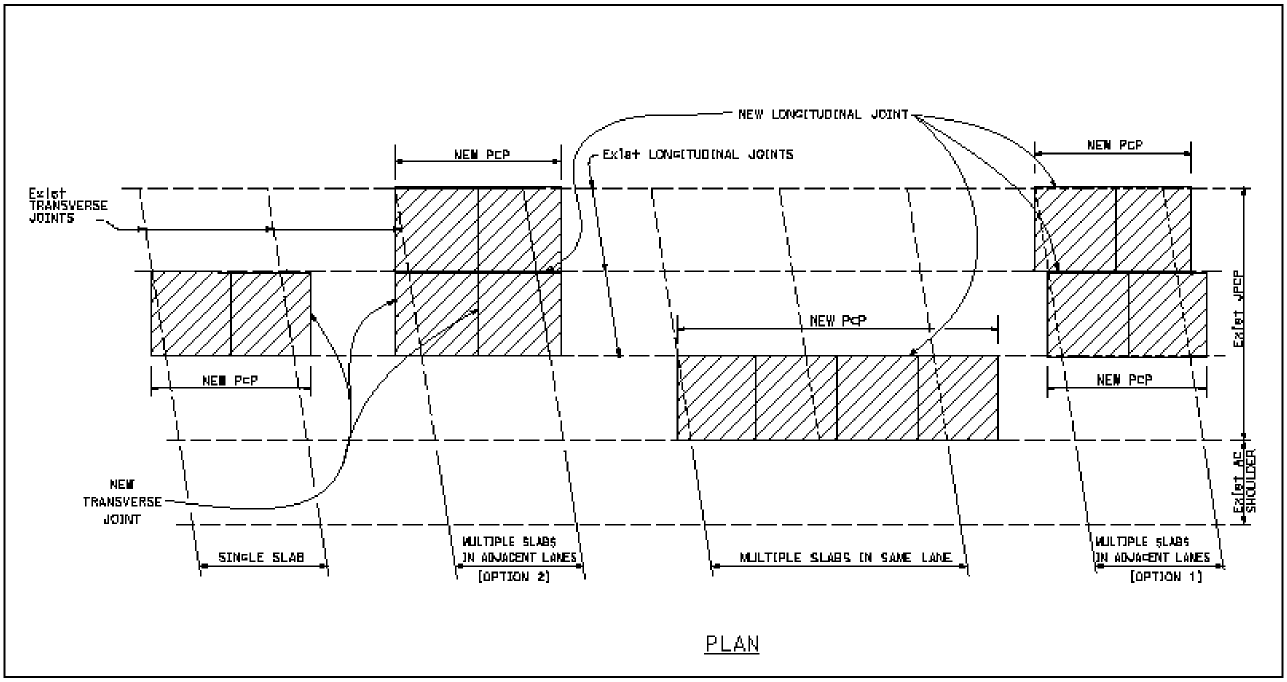


Fig. 2 Individual Slab Replacment With Precast Panels

The second application is for reconstruction or new pavement. This is commonly called lane replacement (LR) in California. The lane replacement is expected to have a service life of over 40 years. The panel thickness is designed to make sure that PCP meets the expected service life, with no need for a major rehabilitation, and in most cases, the base is removed and replaced. The general layout showing different configurations of the lane replacement with precast panels are illustrated in Figure 3.

While the type selection for precast concrete pavement is closely related to its proposed application (individual slab replacement versus lane replacement), the selection of the system depends on other factors such as:

- Type of the road, which is related to the road classification, traffic, access, and expected performance life.
- Traffic management, which is related to the clearance and construction zone requirement for different PCP systems.
- Time constraint, which is related to the production rate of different systems.
- Budget, which is related to the system price tag.

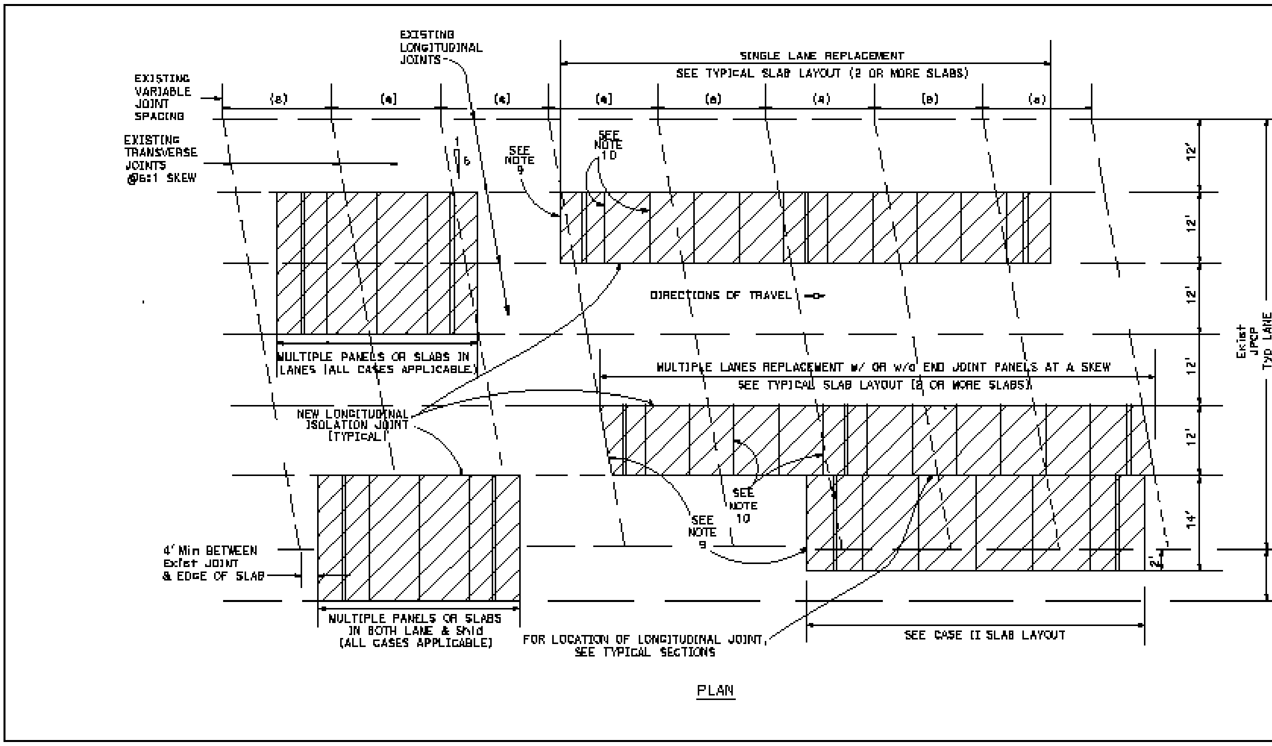


Fig. 3 Lane Replacement With Precast Panels

In order to help the project engineers to make the right choice of a precast concrete pavement system, Caltrans has created guidelines on the type selection. The guidelines consist of data on production rate, work zone requirement, and cost.

TRAINING

An important piece of the implementation process is the training. To disseminate and exchange information on this relatively new technology, a number of presentations, webinars and workshops on this topic have been conducted within the state and nationally to increase the knowledge and provide communication between all stakeholders[16].

Presentations are given at design academies for project engineers responsible for developing project specifications and plans. Other field related presentations are also given to construction staff responsible for inspection and contract administration of the construction jobs.

WORK PLAN

Another outcome of Phase I was a roadmap to help further the implementation process. Before discussing the general features of the precast concrete pavement standards delivered in Phase I and the lessons-learned during this phase, the work plan for the upcoming Phase II is briefly discussed below.

PHASE II IMPLEMENTATION

There is a need to monitor and evaluate the "pilot" projects to continue improving the draft standards based upon the lessons-learned. Also, there is a need for additional guidance and training on the precast concrete pavement technology, internally and externally, in order to assure the quality of the overall system installation. To promote the use of this strategy and encourage innovation, data for the life cycle cost analysis needs to be gathered and implementation procedures for new and/or alternative systems improved.

The main purpose of Phase II is to improve the quality of the precast concrete pavement projects by improving precast pavement standards, advancing field handling and installation practices, providing guidance and training, and streamlining contract administration.

The following activities will be performed in Phase II:

- Monitor and evaluate existing precast concrete pavement projects,
- Revise the draft standards and guides based on lessons-learned,
- Develop inspection/installation manual for quality assurance program,
- Address contractor's qualification topic, e.g., need for mandatory pre-bid meetings,
- Develop a training program, including just in time training (JITT),
- Collect performance and cost data.

The expected outcome of this work will be the following deliverables:

- Revised standard plans and specifications,
- Performance, production and cost data for existing projects,
- Inspection/installation manual for different precast concrete pavement systems,
- Training program (classroom or on-line) for designers, inspectors and contractors,
- Specific recommendations for improving the quality of the projects, including contractor qualification.

This new phase of the precast concrete pavement implementation is expected to officially start in mid 2015.

GENERAL FEATURES OF THE PCP DRAFT STANDARDS

The following are some of the main features of the draft specifications and plans for the precast concrete pavement created by Caltrans:

FLEXIBILITY AND ALTERNATIVE DESIGN OPTION

In order to promote innovation, improve efficiency, and increase production, Caltrans has provided flexibility in the specifications for the contractors to adjust the project requirements based on their operations. This is done by communicating the performance criteria and design framework for the elements and features of the precast systems in the specifications. A section of the precast jointed concrete pavement specification discussing the subject of alternative system is given in Figure 4.

The flexibility provided to the contractors has resulted in different innovations and construction methods for the PCP projects. Some of these alternative designs and processes experienced so far are as follows:

- Design with post-tensioning anchors at the end of the panels instead of on the top
- Design with smaller number of ducts and different configurations of transverse joints
- Design with 2-way pre-tensioned panels
- Layout with double-grooved longitudinal joints (in lieu of casting panels monolithically)
- Grading material (cement treated) and leveling devices (adjusting bolts)
- Material for filling access block-outs and dowel bar slots (polyester concrete, grout, and compressed Styrofoam for temporary cover)
- Load transfer methods
- Arrangement of reinforcing steel at thin panel edge or thick crown

"40-8.01C(2) Alternative System

PJCP specifications and plans are provided as the basic design. You may submit a request to use an alternative system. Shop drawing must demonstrate compliance with the following requirements for the alternative system:

1. Precast Prestressed Concrete Pavement (PPCP); must follow PPCP specifications. Get approval from Concrete Pavement Office for panel thickness. There will be no additional compensation for change in roadway excavation or change in thicknesses of other pavement layers as a result.
2. Load transfer between panels must be provided by dowel bars. Install bars using one of the following methods (dowel bar retrofitting is not acceptable):
   - 2.1. Underslab slots
   - 2.2. Narrow top-of-panel slots
   - 2.3. Side holes for sliding dowels
   - 2.4. Other proposed methods may be considered provided that approval is obtained from Concrete Pavement Office.
3. Precast panels with no pretensioning must have:
   - 3.1. Reinforcement
   - 3.2. Maximum dimension (width or length) equal to or less than 15 feet
   - 3.3. Thickness is designed to withstand transportation and installation loads. Obtain approval from Concrete Pavement Office for your proposed thickness.
4. Panels with a width or length greater than 15 feet must be pretensioned in the transverse or longitudinal direction, respectively. Panels may be pretensioned in both directions.
5. At locations of superelevation transition for curves with radii smaller than 2000', either:
   - 5.1. Use proprietary warped or folded panels
   - 5.2. Use cast-in-place concrete pavement (if allowed by engineer)
6. Drop-in panels (if used) must be reinforced or pre-tensioned and at least 8 feet long.
7. Panels must be adjusted to the proper grade and elevation using one of the following methods, or any other approved method that provides acceptable results:
   - 7.1. Shimming - no metal shims allowed
   - 7.2. Treated bedding layer - must be less that o.15 foot thick and used when there is no risk of erosion
   - 7.3. Leveling bolts
   - 7.4. Leveling brackets
   - 7.5. Leveling beams

   For leveling devices, the space between under the panel and top of base must be less than or equal to 0.5".
8. When truck lanes are not cast together (monolithic), the panel edge must be supported or the longitudinal joint must have a system to prevent relative vertical displacement of panels. This may be accomplished with:
   - 8.1. Additional reinforcement at the longitudinal edges
   - 8.2. Key and keyway
   - 8.3. Dual keyway with shear key
   - 8.4. Tie bar retrofit

   Obtain approval from Concrete Pavement Office for use of additional reinforcement or other proposed methods.
9. You may use synthetic fibers in concrete mix, provided that fibers do not adversely impact panel surface final finishing and grindings. Obtain approval from Concrete Pavement Office for use of fibers.

Fig. 4 Part of Draft Specification on Alternative Design Topic

There are other practices that are under investigation as the result of the flexibility of the specifications. One of such studies is the alternative panel geometry at transitions of road superelevation before and after a horizontal curve. It is anticipated that the flexibility of the specifications would potentially lead to a lower bid price through market driven competition between different designs.

SYSTEM APPROVAL

While Caltrans encourages innovation and use of advanced systems, it is responsible to make sure that tax payer's money is cost-effectively used in projects with minimum risk to the public's safety and with better-performing results. To balance these two factors, the specifications for the precast concrete pavement require that any new idea or system to be approved before its use in a project.

The approval could be based on the valid supporting documents presented by the contractor, or in lieu of such material, by evaluation testing. Supporting documents are comprised of formal monitoring and evaluation of the past experience in a similar application. Anecdotal data is not accepted as proof of system adequacy, and limited performance history is not considered as a guarantee for a long term service life.

The steps required to review and approve a proposed alternative system is provided in the general section of Caltrans's Standard Specifications under value engineering change proposals (VECP)[17]. The precast concrete pavement specifications have additional requirements pertaining to this strategy.

The process requirement for the alternative system approval in the specifications consists of two parts. In the first part, the system designer shall prepare and submit specification, fabrication drawings, and installation procedures. The second part of the approval process will consist of construction and evaluation of a trial installation. Final approval for use as an approved system will be given once the specification, fabrication drawings and installation procedures have been completed, the trial panels have been installed in accordance with the approved process, and Caltrans has determined the trial installation is successful.

The specification language on alternative system approval outlines a generic process for all the components of a precast concrete pavement system. The specific requirements for submittal and evaluation, including the performance criteria, depend entirely on the function and characteristics of the proposed new feature. This is discussed in more detail below.

EVALUATION OF NEW FEATURES

Caltrans has developed a process to evaluate new components and features proposed to be used in precast concrete pavement projects. The key element of this process is performance data. Before an element or method is used in a state project delivery job, it should be proven that the element or method meets the minimum service expectation.

Caltrans encourages that evaluation review and approval for an alternative design is done before a project is awarded. Obtaining the approval before a bid helps the contractor to submit a more realistic price based on its design choice without the risk of the design being rejected after the contract award. This also helps to avoid any additional cost and delays in the project delivery. Otherwise, the contractor is responsible for any delay due to performing Caltrans's evaluation process and obtaining approval for the proposed alternative system.

The general steps to assess a proposed new feature are as follows:

- Specification Submittal – the information pertaining to the new feature needs to be submitted to Caltrans. This information includes, but is not limited to, description of the new feature, its intended application, materials, drawings, construction method, etc.

- Preliminary Review – Caltrans performs a preliminary review within 10 business days, and if acceptable, requires performance and constructability data consistent with the proposed application.
- Performance Data – the contractor submits performance data for approval. The performance data could be in the form of design analytical/numerical assessment, experimental testing such as HVS, or past construction experience. For the former, a formal report containing monitoring and evaluation activities of the feature consistent with expected performance life needs to be provided. Performance data must prove that the feature meets the defined performance criteria specific to that application.
- Material – information in the form of test results should be provided to show that the materials used as an alternative meet the specified minimum requirement. This includes the durability of material to maintain its performance characteristics within the defined service life. Also, information should be provided to indicate that there is a quality control plan in place to assure consistency of the materials used in production.
- Constructibility – the contractor provides information on the constructability aspects of the proposed feature. As an option, a field visit may be arranged to demonstrate the construction of the alternative feature. The constructibility should demonstrate that a competent technician is able to build or install it without any undue difficulty.
- Final Review – Caltrans reviews performance data, materials, and constructability considerations within 20 business days. The final review would contain any potential issues or shortcoming about the feature. If there are any questions, they would be communicated to the vendor for response. The time for responding to any question is not considered in the 20 business day time frame.
- Approval – If the result of the final review is acceptable, the new feature is approved for use in the projects.
- Further Evaluation – If the result of the final review indicates that there is not adequate data to support approval of the alternative feature in a project, Caltrans will work with the vendor to prepare a plan for evaluation. The plan will identify the data that needs to be developed to facilitate the approval.

A more specific version of this general process has been developed for the evaluation of load transfer systems for PJCP[18]. Figure 5 shows the falling weight deflectometer (FWD) testing for the evaluation of a proposed load transfer system based on this process.

Fig. 5 Evaluation of Load Transfer Efficiency Using FWD for a Proposed New System

GENERIC VERSUS PATENTED FEATURES

Caltrans encourages innovation and values partnership as is mentioned in its vision statement. It also respects the intellectual property laws and regulations. However, Caltrans does not accept short cuts to eliminate the evaluation and assessment process for new and patented features.

While Caltrans generally avoids including any patented precast concrete pavement features in the contract documents, it does not prevent the contractors from using approved patented products. However, to facilitate contract administration, the specification reminds the contractors about their responsibility for applicable royalties, should they choose to use patented components in a precast concrete pavement project.

The specifications also include language indicating that any new proposed idea or process developed in conjunction with Caltrans and allowed on a job will become the property of Caltrans and no patent could be filed for that idea or process.

CONSTRUCTION DETAILS AND SHOP DRAWINGS

Construction details and shop drawings are significant parts of a contract document. In order to reduce the support cost of the delivery projects, the construction details only need to provide required information without going into the details. Providing unnecessary information such as size and elevation of each and every panel has shown to take a lot of resources and significantly increase Caltrans's liability.

On the other hand, shop drawings communicate the intent of the contractor with all the details required to build the job. As a result of the flexibility offered in the contract specifications and plans, the shop drawings become an important element communicating any proposed changes to the original materials and design.

The shop drawings for a proposed alternative system must include all the information and details needed to construct the system. Since shop drawings need Caltrans's approval before the start of a job, as was mentioned earlier, it is imperative for the contractor to secure consensus for a revised material or design before proposing it as an alternative in the contract.

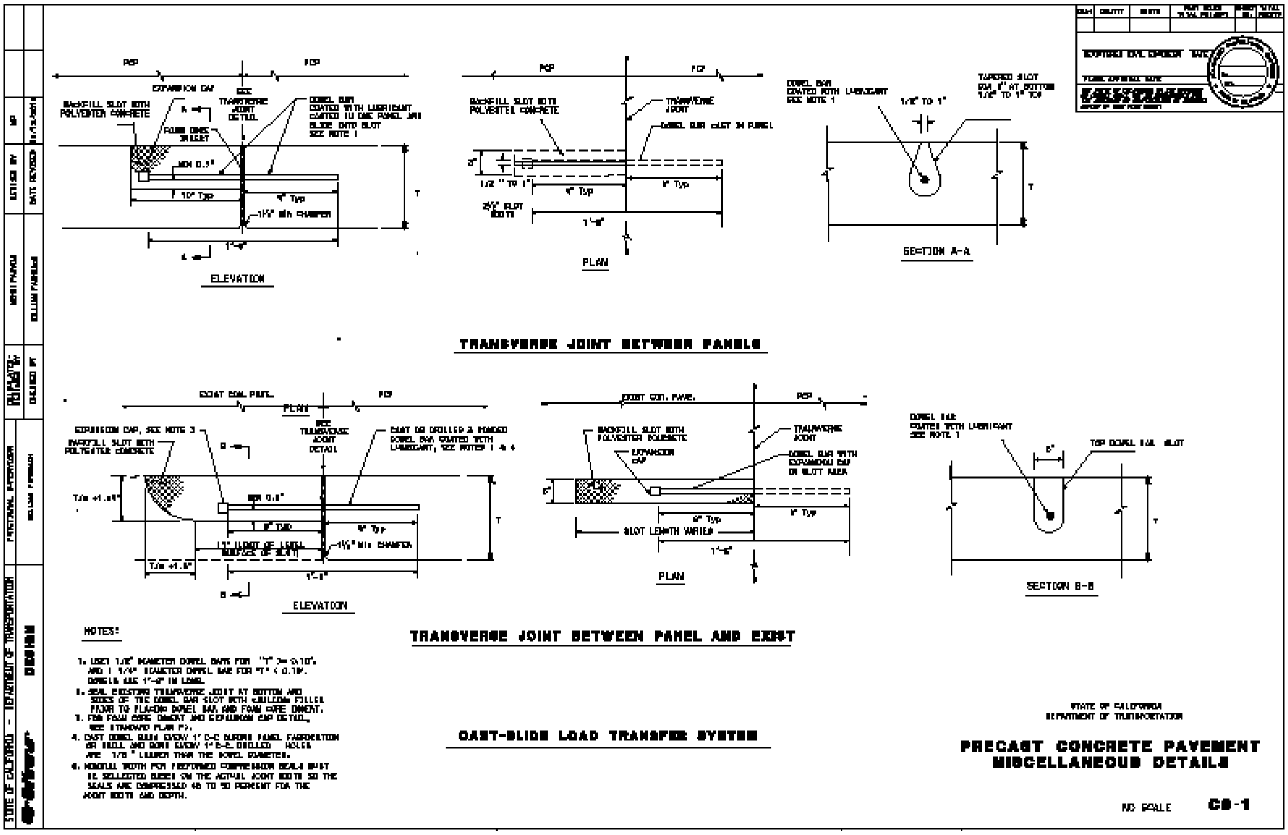
SPECIFIC FEATURES OF THE PCP DRAFT STANDARDS

In addition to the general features of the draft standards that were discussed above, some of the specific features of the standards that are the key to the performance of the precast concrete pavement are as follows:

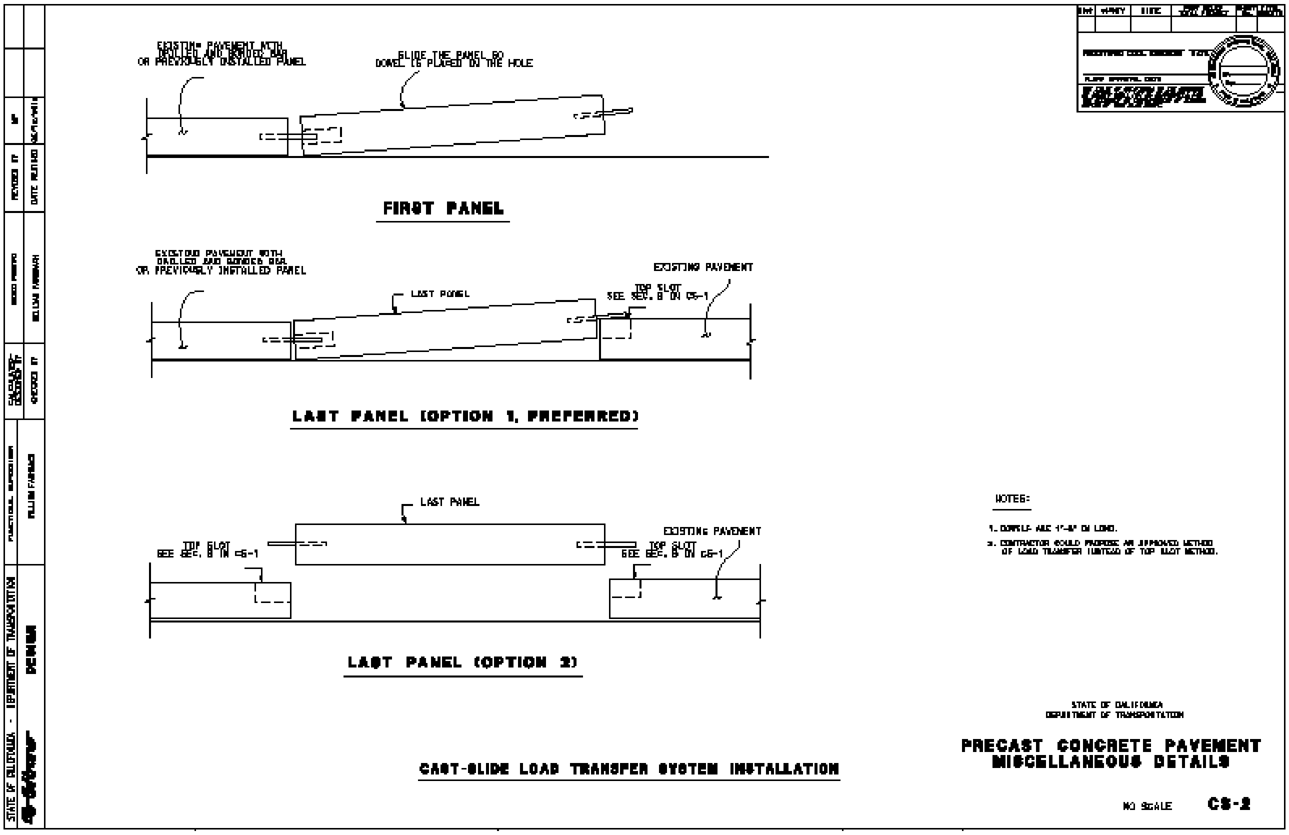
LOAD TRANSFER BETWEEN PANELS

Load can transfer from one panel to another by a key/keyway system (in PPCP), or by using shear elements such as dowel bars (in PJCP). For load transfer with dowel bars, different configurations are suggested and used, some of which are top slot, bottom slot, sliding bar, and cast-slide method.

Figure 6 illustrates the details and installation sequence of a newly developed non-patented load transfer system, referred to as cast-slide method. In this system, dowels are casted in one panel at fabrication, and are slid into another panel during installation. The "tear drop" shape of the slot helps to confine the fill material, allow delayed filling (after opening to traffic) due to the small opening on the top, and is easily converted to a top slot.



a) Details of Panel Connection



b) Installation Method

Fig. 6 Details of a Non-patented Innovative Method for Load Transfer

BASE GRADING AND PANEL LEVELING

To conform to the existing pavement for road rehabilitation or widening, or meet the profile grade (transverse and longitudinal) for a new pavement, panels need to be graded. This can be done by either grading the base and installing the panels on the graded base, or by directly grading the panels by means of adjusting devices.

When grading the base, random voids under the panels are filled with grout through the grout ports or holes. In the past, bedding layers of fine aggregate have been used to help facilitate grading the base. However, the use of bedding layers (both untreated and treated with cement) has shown to be problematic when there is erosion potential under the panels.

On the other hand, grading the panels directly requires systematically leaving a space between the bottom of a panel and the base. This space is also grouted after installation; however, the volume of the grout to fill the gap between the panel and the base would be much more than the previous method above.

While grading panels with leveling devices has been frequently used for IPSR and PJCP projects, it has not yet been used for a PPCP project.

BOND BREAKER

Similar to the other concrete pavement structures, bond breakers are supposed to eliminate the bonding between the panels and the base in the precast concrete pavements. While a bond breaker system such as a polyethylene sheet is needed to allow panel movement for PPCP system, there seems to be no need to install a bond breaker for a PJCP or IPSR system. Precast panels, unlike cast-in-place concrete pavement, would not bond to the base. It is anticipated that future PJCP and IPSR specifications would eliminate the present use of a polyethylene sheet under the panels. Figure 7 shows the present application of a bond breaker for a PJCP project.

Fig. 7 Use of a Polyethylene Sheet under the Panels for a PJCP Job

GROUT CONFINEMENT

Although polyethylene sheets are not required as bond breakers, they have been used to confine the under slab grout and prevent this expensive material from escaping under the existing pavement. While this sheet works efficiently as a grout confinement tool, its use has created a concern for long-term performance of PJCP. This is due to the fact that the sheet does not allow bonding of the grout to the base. With a smooth surface at the bottom of the panels, experience has shown that grout does not bond to the panel either (although bonding stress requirement is included in the specification). As a result, the under slab grout would stay as a separated thin layer, which is prone to breaking and pulverization under dynamic traffic loads. Figure 8 confirms the anticipated separation of the grout from a panel in a recent test project.

Fig. 8 Seperation of Grout from Panel and Base

A lesser concern in using polyethylene sheets is the potential of its folding and wrinkles, which prevent the grout from distributing uniformly under a panel.

FILLING DOWEL SLOTS AND ACCESS BLOCK-OUTS

The installation of precast concrete pavement requires that either the access block-outs for a PPCP or dowel slots for a PJCP be filled with a backfill material. There are a number of materials that have been tested for this application. Some of them did not meet the structural, consolidation, or durability requirements. Regardless of the material type, the method of application is critical in the performance of the backfill material. This is something that needs more investigation to assure an acceptable quality for the filled areas. Figure 9 shows a method of filling dowel slots that has the potential of causing segregation of the fill material.

Fig. 9 Segregation of the Fill Material during Dowel Slot Backfill

TRANSVERSE AND LONGITUDINAL JOINTS

Transverse and longitudinal joints between precast panels and between panels and the existing pavement need to meet the safety considerations and design requirements. A challenge in fabrication and installation of the panels is to make sure that the joint widths are within a reasonable tolerance. Clear instructions are provided in the plans to help the contractor modify its operation to install joints that meet the acceptable criteria.

Figure 10 illustrates three acceptable joint configurations that could result in a panel installation activity. As the figure shows, joints ¼" and smaller do not need to be sealed. However, any joint wider than ¾" (up to 1- ½") needs to be retrofitted. Joints equal or larger than 1- ½" are not acceptable.

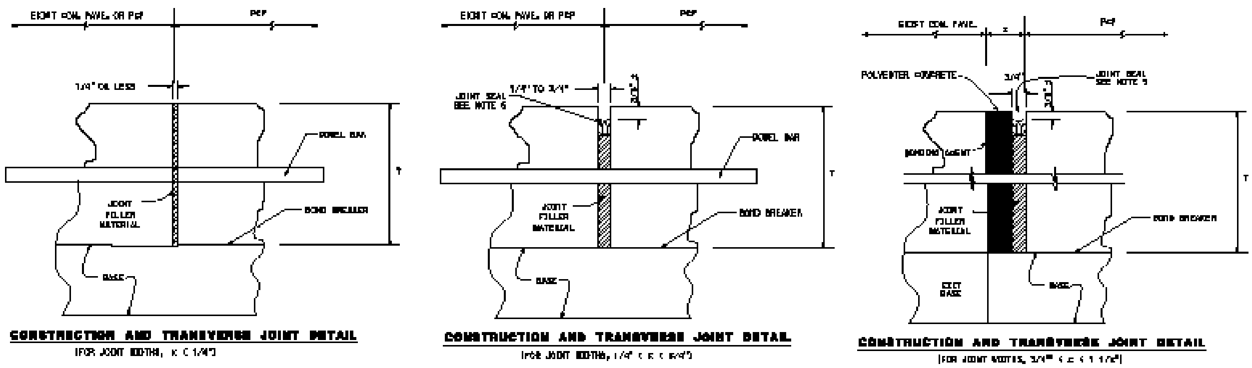


Fig. 10 Types of Acceptable Joint Configurations

LESSONS-LEARNED

The precast concrete pavement “pilot” projects have helped Caltrans to gain experience and knowledge in all stages of this strategy from planning and programming through project study, design, bidding, construction and maintenance. This knowledge has been used to revise the draft standards on an ongoing basis in Phase I, and create the scope and work plan for Phase II of the implementation efforts.

Some of the design and construction revisions examined during this learning process in Phase I were briefly discussed above. The results of these examinations will be confirmed after the first deliverable of Phase II, namely monitoring and evaluation of in-service precast concrete pavements, and made available. The details on the success and failure stories, including solutions to advance this technology are the subject of an upcoming article.

CONCLUSIONS

Caltrans has completed its first phase of the precast concrete pavement technology implementation in California. Based on the results of this phase, it is Caltrans's intent to continue the implementation process and advance the application of this strategy. The early indications of the in-service PCP performance data are favorable; however, formal evaluation is the scope of the next phase.

As the result of the lessons-learned, some of the general topics that are included in Phase II of the implementation are as followed:

Performance Evaluation – An important piece of the implementation process is monitoring and evaluating existing projects. A comprehensive evaluation and testing program is needed to properly assess all the factors pertaining to the behavior of the precast concrete pavement. This includes defining failure modes and establishing values for performance factors of each precast concrete pavement system.

Training – It has been noticed that the quality of a precast concrete pavement job is directly related to the familiarity of the contractor's crew and Caltrans inspectors with this technology. As such, emphasis has been placed on training both the industry personnel and Caltrans's staff. This includes a proposed mandatory pre-bidding workshop, and expanding the existing just in time training (JITT) before the fabrication and installation activities commence.

Contract Document Clarification – As a relatively new technology, the specifications and plans for the precast concrete pavement contracts are prone to misinterpretation. The requirements and the expected quality of the job need to be clearly communicated in the contract documents. This is particularly important when flexibility is provided for a contractor to propose alternative methods. Criteria for approval of the shop drawings and acceptance of the work, including limits for tolerances, need to be understood by all parties involved in the construction process.

FUTURE ACTIVITIES

As was discussed under the topic of Phase II implementation, the plan is to improve the quality of the precast concrete pavement projects by monitoring past projects for constructability, and evaluating their performance. The lessons-learned would be used to revise and improve the draft specifications and plans. Eventually, the goal is to prepare standard specifications and plans to cover all approved precast concrete pavement materials, components, or systems. Creating guidelines and offering training would also be a significant part of the work plan for the future.

REFERENCES

1. Office of Planning and Programming, "State of the Pavement Report", California Department of Transportation, 2013.
2. Tayabji, Shiraz, and Katie Hall, "Precast Concrete Panels for Repair and Rehabilitation of Jointed Concrete Pavements (FHWA-IF-09-003)", Federal Highway Administration, Washington, DC, 2008.
3. Merritt, David, and Shiraz Tayabji, "Precast Prestressed Concrete Pavement for Reconstruction and Rehabilitation of Existing Pavements (FHWA-IF-09-008)", Federal Highway Administration, Washington, DC, 2009.
4. David K. Merritt, B. Frank McCullough, Ned H. Burns, Robert Otto Rasmussen, "Construction of the California Precast Concrete Pavement Demonstration Project", Publication No. FHWA-IF-06-010, Federal Highway Administration, Washington, DC, 2004.
5. Partnered Pavement Research Program, "HVS Test Plan: Super-Slab Reconstruction of Rigid Pavement Sections", Test plan prepared for the California Department of Transportation (Caltrans) by University of California Pavement Research Center, Dynatest Consulting Inc., and CSIR South Africa, 2005.
6. Kohler, E., Du Plessis, L., and Theyse, H., "Construction and Preliminary HVS Tests of Pre-Cast Concrete Pavement Slabs", Research report prepared for the California Department of Transportation (Caltrans) by the University of California Pavement Research Center (UCPRC-RR-2006-10), 2007.
7. Theyse, H., Du Plessis, L., and Kohler, E., "Interim Assessment of Expected Structural Life of Pre-Cast Concrete Pavement Slabs with HVS Testing", Technical memorandum prepared for the California Department of Transportation (Caltrans) by the University of California Pavement Research Center (UCPRC-TM-2006 04), 2007.
8. Kohler, E., "Comparison of Precast and Cast-in-Place Concrete Pavements Under Heavy Vehicle Simulator Loads", Research report prepared for the California Department of Transportation (Caltrans) by the University of California Pavement Research Center (UCPRC-RR-2008-03), 2008.

9. Kohler, E., "Precast Concrete Pavement Testing with Heavy Vehicle Simulator Loading: Summary Report", Research report prepared for the California Department of Transportation (Caltrans) by the University of California Pavement Research Center (UCPRC-RR-2008-03), 2008.
10. Den Hartog, Jonathan, "I-15 Precast Pavement Installation", Construction Report, California Department of Transportation, Sacramento, California, 2011.
11. Parvini, Mehdi, "Precast Concrete Pavement Scoping Document", Prepared for Rock Products Committee, Precast Concrete Pavement Sub-task Group, California Department of Transportation, Sacramento, California, 2010.
12. Stahl, Kirsten, "Construction Evaluated Work Plan. I5/14 Project", California Department of Transportation, Sacramento, California, 2008.
13. Mishra, Tinu, and Bobby Petska, "I-680 Precast Pavement", California Department of Transportation, Sacramento, California, 2012.
14. Fugro Consultants, Inc., "Proposed Process for Design of Precast Concrete Pavements", Task Order No. 56A0315-003, Report Prepared for: California Department of Transportation, Sacramento, California, 2012 (Revised 2013).
15. Tayabji, Shiraz, Ye, D., and Neeraj, B., "Precast Concrete Pavement Technology, Project R05 – Modular Pavement Technology", Prepared for The Strategic Highway Research Program 2, Transportation Research Board of The National Academies, Washington, DC, 2013.
16. Parvini, Mehdi, "Planning, Project Selection & Design of Precast Concrete Pavement, TRB Webinar, 2014.
17. "Standard Specifications", California Department of Transportation, 2010.
18. Parvini, Mehdi, "Proposed Protocol for Evaluation of Load Transfer Systems for Jointed Precast Concrete Pavements", California Department of Transportation, 2015.