Technical Considerations of Precast Concrete Pavement

Ashutosh Singh, Prof. D. S. Ray
PG Student, HOD
Department of Civil Engineering
BBDU, Lucknow, India

Abstract:
This Paper aims at the study on technical consideration of jointed precast concrete pavement (JPrCP) system and cost comparison between cast in place concrete pavement system and precast concrete pavement system. Prefabricated concrete pavements use prefabricated concrete panels for rapid construction of concrete footpaths and rehabilitation of concrete and asphalt pavements. The precast concrete pavement can also be used for reconstruction or as an overlay. Precast concrete pavement applications include the isolation repair, intersection and ramp rehabilitation, urban road rehabilitation, and long term rehabilitation of pavement sections. The precast concrete pavement system is fabricated or collected on site, taken to the project site, and installed on a laid foundation (existing pavement or regarded foundation). Prior to opening traffic, system components require minimal field treatment or time to gain strength. Using PCP technology can significantly reduce the traffic impact of road repair and reconstruction projects, especially on heavy travel routes. Technology is applicable to both small sections, which are meant to be used in the construction of corridor-wide sidewalk rehabilitation/reconstruction along with enabling flexibility in construction phase.

I. INTRODUCTION

The use of PCP technology can significantly reduce traffic impacts of roadway repair and reconstruction projects, particularly on heavily traveled routes. The technology is applicable to both small segments, enabling flexibility in construction phasing, as well as for use in corridor-wide pavement rehabilitation/reconstruction. Build PCP systems in order to achieve the five key features of successful sidewalks, as follows:

- Constructability – Techniques and tools are available to ensure acceptable production rate for establishment of PCP system.
- Concrete durability – Plant Fabrication of Precast Panel results in excellent concrete strength and stability.
- Load transfer at joints – Reliable and economical techniques are available to provide effective weight transfer on transverse joints in both joint and prestressed PCP systems.
- Panel support – The technology to provide adequate and equal support is available and improving is ongoing.
- Efficiency – The panels are thinner than standard cast-in-place concrete and are due to prolonged prestressing and/or strengthening of elements in PCS systems.

Pavement design procedures that are specific to PCP have not yet been developed; therefore, the design of JPrCP is currently based on the available procedure for Cast-in-Place (CIP) concrete pavement system.

II. KEY OF THE PROPOSED EXPERIMENT

Jointed precast concrete pavements are similar to cast-in-place jointed concrete pavements. Once installed, jointed precast concrete pavements behave similarly to cast-in-place jointed concrete pavements. Some specific differences that influence the performance of the jointed precast concrete pavements are as follows:

- The panels are installed flat. Consequently, they do not exhibit construction-related curling or warping.
- The panels contain steel reinforcement. Therefore, any service cracking that develops over time due to traffic loading can be kept tidy.
- The panel transverse joint faces are smooth (cast surfaces); Therefore, total interlock cannot be calculated for load transfers on these joints.

In order to understand the structural requirements for PCP, it is necessary to understand the loading that under a solid pavement can be done. Pavements are designed on the basis of truck traffic. Without truck traffic, the pavements will only show the content related to the crisis. For new concrete pavement systems, the following loading related items need to be considered:

Design Traffic. Most new concrete sidewalks are now designed for at least 40 years of initial service life. Suppose a roadway takes 50,000 vehicles per day in one direction and 20 percent of trucks account for vehicles. Without accounting traffic growth, the design lane will carry more than 100,000 trucks in 40 years. When such a precast pavement system is used for such applications, then the precocity pavement components need to be designed to accommodate high levels of traffic loading. The
stress and deflection in the concrete slab resulting from traffic loading is accounted for in traditional mechanical-based design processes, such as the new AASHTO mechanics-empirical pavement design guide (MEPDG).

2. Load Transfer at Joints. When fully effective, there will be 90 to 95 percent load load effectiveness (LTE) as a doweled transverse joint construction. Over time, LTE will be reduced as a result of traffic loading. For conventional joint concrete footpaths, an LTE range of approximately 65 to 70 percent is considered, on which some load transfer restoration treatments may be required to be provided. The load carried (transferred) by a dowel bar at a joint may range from about 1,360 kg with the axle load positioned about 2 feet (0.6 m) away from the lane edge. On the primary highway system, more than 100,000 loads of these loads are expected to be carried by Dowell bars, most truck drives with lane edge.

3. Temperature Related Curling. Temperature change curling with depth in the concrete panel inspires patience. These stresses vary widely throughout the daytime temperature and as a function of day-to-day solid temperature distribution and can be very high and are responsible for traditional mechanical-based design processes, such as AASHTO MEPDG. As discussed previously, specific design procedures have not been developed for PCP systems. The development of credible pavement design processes requires the sound understanding of the design of the concept of concepts based on the behavior of the pavement and the performance of the field. As discussed, the traditional interconstruction / installation method is a traditional built-in cast-in-place between JCP and PCP systems. Once the PCP system is installed, the system's behavior should not be significantly different than a cast-in-place concrete pavement system. Some differences do exist and are listed below:

1. Less slab warping in the precast panels, if properly done in the plant.
2. Less variability in concrete strength for precast panels.
4. A smoother bottom surface for PCP systems
5. JPrCP panels have smooth vertical faces on transverse joints and as a result of the installation process these joints can have a difference of up to 0.5 inches. Therefore, overall interlocking does not develop on these joints.

III. METHODOLOGY

FOR PRECAST CONCRETE PAVEMENT

Concrete requirements
Concrete requirements should be similar to those places which are specified by the highway agency for concrete footpaths in place. However, because the precast concrete pavement is used for highways with high traffic volumes, where lane closures are at a premium, concrete stability is of great importance. Concrete should not fail due to material related distresses or poor quality construction. Fabricator can optimize overall size and grading to obtain an economical and durable concrete mix, which is practical for the construction of panels. An added advantage of using precast concrete panels is that the strength of commonly received concrete is more than concrete used for the concrete in-place concrete pavement.

Panel reinforcement:
A double mat of epoxy-coated reinforcement is usually used for concrete panels to reduce cracking due to lifting and transportation. The amount of reinforcement is usually around 0.20% of the cross-sectional area in both directions, depending on the dimensions of the panel. Reinforcement is not necessary for pavement performance unless the panels are designed as reinforced concrete pavements. Some agencies require heavy reinforcement if the installed panels are subject to traffic before the completion of the installed sub-panel. One advantage of panel reinforcement is that if the panel develops cracking for a long time due to traffic loading, cracks can be expected to be tightened without affecting the serviceability of the pavement.

Figure 1. Panel size 4×3.5

Production rates
The panel installation rate is one of the most important factors in considering precast concrete pavement. Panel Installation rate determines productivity and lane closure requirements. The installation of the panel includes all activities that are organized during closing a given lane, as listed below:

- Milling of a stable base may be required according to the design requirements, including the existing pavement removal, one part or base material.
- The dowel bars are drilled and grouted for repair applications (based on system design).
- Base preparation involves having a new base and bed material to get about the existing base or to get a proper base grade. The base is compacted if granular or kept and ends if cementitious (Rapid-Setting Lean Concrete Base). Bed material can be granular, can be fast flushing or polyurethane foam material.
- The panel-base interface treatment, typically polyethylene fabric or geotextile membrane, is placed.
- Panel is placed.
To stop a given lane, there is a temporary transition to the existing pavement at the end of the installation of the precast concrete pavement.

**DESIGN CRITERIA FOR JOINTED PCP SYSTEMS**

For continuous jointed PCP systems, the following long-term failure manifestations can result:

1. **Structural distress:**
   a. Slab cracking.
   b. Joint faulting.
   c. Joint spalling.

2. **Functional distress:**
   a. Poor ride quality (smoothness).
   b. Poor surface texture (in terms of surface friction and tire-pavement noise).

The design criteria recommended for CIP JCPs for long-life service are considered applicable to the jointed PCPs. However, because the individual panels of the precast pavement are reinforced, any cracks in the panels will be held tightly closed and would not be expected to deteriorate and affect ride quality. As a result, the criteria for cracking can be relaxed. The design criteria recommended by FUGRO for jointed PCPs for long-life service is given in Table

<table>
<thead>
<tr>
<th>Distress</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Structural Distress</strong></td>
<td></td>
</tr>
<tr>
<td>Cracked Slabs, % (based on Caltrans recommendations)</td>
<td>10% (Note 1)</td>
</tr>
<tr>
<td>Faulting, in.</td>
<td>0.10</td>
</tr>
<tr>
<td>Spalling (length, severity)</td>
<td>Minimal</td>
</tr>
<tr>
<td>Materials Related Distress</td>
<td>None</td>
</tr>
<tr>
<td><strong>Functional Distress</strong></td>
<td></td>
</tr>
<tr>
<td>Smoothness (IRI), in./mile</td>
<td>160</td>
</tr>
<tr>
<td>Surface Texture - Friction</td>
<td>Long lasting, FN &gt; 35</td>
</tr>
<tr>
<td>Surface Texture - Noise</td>
<td>No criteria available, but surface should produce accepted level of pavement-tire noise</td>
</tr>
</tbody>
</table>

**Panel support condition**

The new construction of the pavement is important for long-term performance. Proper siting of the panels is important on the basis. Under the panels, support should be as well as strong (strong). For most precast concrete pavement applications, the following support alternatives may need to be considered:

**Existing base**

- A granular base may be reworked, graded, and compacted. The panel is placed on the compacted granular base.

- A granular base can be worked again, sorted, classified, and compacted; Extra bed material is used to differentiate the necessary base grade. The bedding material may be the following:
  - A thin layer of finely graded granular material or sand
  - Fast-setting flow able cementitious grout or flowable fill
  - Polyurethane foam material, applied after the panel is placed or set in position (for repair application, a foam thickness of up to 1 in. (25 mm) may be used)

- If the slab is not damaged in the removal of the existing slab, then it can be used. To set the panel, a thin layer of fine graded granular material or sand can be used to provide a level surface.

- To adjust the thickness of the panel, the stable base can be safely squeezed. To provide a level surface to set up the panel, granular graded granular material or a thin layer of sand is used.

**Panel structural design**

The design of the precast concrete pavement is based on the sensation, which is not quite different from the same cast-in-place concrete pavement once established, traffic loading and its overall behavior under environmental loading. Thus, a combined precast concrete pavement is expected to treat the cast-in-place joint concrete pavement similarly, and expect a precast, cast-in-post from prestressed concrete footpath, to behave like a tense concrete pavement. Is performed. Concrete pavement is usually designed, manufactured and rehabilitated to provide long life performance. The definition for long-life concrete pavements, generally used in the United States, is as follows:

- There will be 40 or more years of service life in the original concrete.
- The pavement will not exhibit premature failures or distress related to the material.
- The ability of cracking, malfunction and chewing will be less in the sidewalk than the concrete footpaths of traditional 20 years of life.
- The sidewalk will maintain a desirable ride and surface texture with the perfect intervention for ride and texture, combined residence, and minor repairs.

**IV. RESULT:**

**RATE COMPARISON BETWEEN PRECAST PAVEMENT AND CAST IN PLACE CONCRETE PAVEMENT:**

**DATA ASSUMPTION**

ANALYSIS PERIOD = 40 YEAR

MAINTENANCE COST = 20 %
<table>
<thead>
<tr>
<th>SR NO</th>
<th>PRECAST CONCRETE PAVEMENT</th>
<th>CAST IN PLACE PAVEMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>COST OF PAVEMENT PER KM FOR 40 YR</td>
<td>3,39,52,500</td>
</tr>
<tr>
<td>2.</td>
<td>20% MAINTENANCE COST (2,03,09,520) BEFORE 20 YR</td>
<td>NULL</td>
</tr>
<tr>
<td>3.</td>
<td>20% MAINTENANCE COST (2,03,09,520) BEFORE 40 YR</td>
<td>7,190,500</td>
</tr>
<tr>
<td></td>
<td>TOTAL COST</td>
<td>4,31,43,000</td>
</tr>
</tbody>
</table>

V. CONCLUSION

As the use and adoption of PCP technology continues to grow, the job FHWA has played in the innovation's advancement and the advantages and expenses of PCP establishments have turned out to be clear. As far as the dispersion of R&T, the assessment group found that FHWA and SHRP2 productions, subsidizing, and programming added to the advancement and utilization of PCP in a variety of settings. FHWA exercises have given direction to various States that have utilized the office's materials. Like other solid techniques, PCP costs differ dependent on various variables, including venture measure and geographic area. Expenses for PCP or CIP cement can fluctuate fundamentally inside each State, let alone around the nation. In view of this cost variety, the various application types and PCP frameworks being used, and the presence of choices, for example, high-early-quality solid, it is hard to definitely extrapolate the expense of PCP contrasted with regular prepared blended cement. To do as such, the assessment group talked with routine clients of the innovation and assessed a few explicit undertakings. All in all, societal expenses for PCP are not as much as expenses for CIP and conventional solid arrangements. This cost distinction is especially evident when contrasting PCP with high-early-quality solid, which is comparable as far as establishment times and expenses; be that as it may, PCP performs better and is increasingly sturdy after some time. Generally speaking, we observed FHWA's endeavors to be to a great extent fruitful and contributory to the improvement and reception of PCP innovation. FHWA has directed starting exploration and models and has helped the utilization of the innovation. In its proceeded with endeavors, FHWA has encouraged and received beginning use in a few States. PCP is a successful and productive approach to lead roadway upkeep, fixes, and reproduction. Advantages most surpass costs in high volume regions or exceptional roadway segments that would prompt critical alternate routes whenever shut for significant lots of time.

VI. REFERENCE


[7]. Y. Jung, T. J. Freeman, and D. G. Zollinger. Guidelines for Routine Maintenance of Concrete Pavement. Research Report 5821-1, Texas Transportation Institute, Texas A&M University, July 2016

[8]. Tayabji, S., Ye, D., and Buch, N., (2012), Precast Concrete Pavement Technology, SHRP 2 Report S2-R05-RR-1, Transportation Research Board of the National Academies, Washington, D.C.


