REVIEW ON USE OF PRECAST PANELS FOR THE IMPROVEMENT OF PAVEMENTS

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Abstract - *Currently, precast concrete panels are being increasingly used for rapid construction and repair of various types of pavements. Precast panels with controlled quality have been utilized since 1950, this report reviewed published literature on application of precast element in various forms and systems and found that precast concrete elements have had limited application in flexible pavements, specially to the layered pavement system. The review of application of precast concrete element and past experiences of an analytical study of precast slab system concluded that available analysis and design methodologies can be adopted for the improvement of various other types of pavement. This gathered information may use as a solution to some special issues such as uneven sub-grade settlement, strength reduction due to adverse weather condition and longevity of pavement*.

Key Words: Precast Panel, Flexible Pavement, Deign Method, Precast Technology, Rigid Pavement.

1.INTRODUCTION

The performance of pavements in India until today is not to be ideal. The constructions of flexible or rigid pavement usually don't reach designed service lives, either because of the actual fact that the development doesn't meet specifications or inevitable excessive load (Ackroyd 1985).Technical difficulties such as shortage in asphalt delivery in flexible pavement case, highway obstructions in case of typical rigid pavement (jointed plain concrete pavement, JPCP), inability to satisfy quality specification in case of rigid pavements are usually faced during the construction of the pavements. If rigid pavement deteriorates faster than its design life period, the maintenance or repair would be expensive and hinder highway users. Additionally, the system is not addressed properly (Nurjaman et al. 2017).

Pavement construction has several types; the two broad categories of pavement construction are (i) precast construction and (ii) cast-in-situ construction (Olidis et al. 2010). Cast in place concrete pavements are used for over 20 years and represent an economical solution for the development of rigid pavement which offer adequate support for loads exerted by vehicle(L.P. Priddy, P.G. Bly 2013). Long-term traffic restrictions as a result of intensive and extended lane closures, long curing period needed to achieve sufficient strength and also the inability to put a material in all weather conditions increased pressure on the use of systems with enhanced construction technology (Novak et al. 2017). Such problems would possibly cause delays and consequently increase the cost associated with extended construction time. As a consequence, various precast concrete technology are developed till now and used for the development of technical structures, significantly for the repair and rehabilitation of roads, parking yards and airfield pavements. Precast concrete system are the system that are primarily fabricated or assembled off-site, transported to the project site and placed on a existing foundation (Tayabji, Ye, and Buch 2013).

Prior to recommending the use of precast panels for construction of pavement and repair, a literature review is conducted to study a current system or to aid in developing a alternate system that might be employed in the envisioned environment(Bly et al. 2013).

Precast panels may be casted in an exceedingly controlled manner with less demanding environmental constraints which give better standard concreting practices to be followed. Panels created may be reserved and hold on off-site for later use whenever required. Another prevalence is that the utilization of standard Precast Technology with native materials is also additional economical than victimization the expensive proprietary materials for cast-in-place repairs (Bly et al. 2013). Each of those benefits need further exploration to know the installation time necessities and therefore the cost needed to use this repair technology compared to current expedient and permanent repair strategies already used for various types of pavements (L.P. Priddy et al. 2013).

More than twenty years practice with PCP systems allows assembling enough data on the performance of the systems when applied for new construction and repairs of existing slabs. Panel cracking, joint spalling, panel surface condition, grout condition, joint elevation difference, joint width measurement and quality of ride belong to main attributes which are monitored during a site inspection(Novak et al. 2017). This gathered information will guide for development of methodology for development and analysis of precast panels and its application to various types of pavements.

2. RESEARCH OBJECTIVE

The paper represents the integrated study to know the current state of tradition in world in using precast panels for improvement of various types of pavements. The aim was to acquire a superior knowledge of current best practices for application of precast panel systems. The information was assembled associated to precast concrete panel systems to select a system for improving characteristics of other types of pavements. The paper briefly introduces relevant precast pavements experiences in India and World that were studied to understand the history and challenges in precast panel analysis and design. This paper mainly focuses on the investigation of the feasibility of applying these technologies for layered pavement systems.

3. PRECAST PANEL EXPERIENCES

Precast constructions of concrete elements are used extensively in manufacturing industries. Off-site construction and storage of these element help the user by lessen jobsite congestion, and a controlled construction process results in increased quality and minimized cost. The use of precast concrete panels in conventional road is not a recent innovation; several precast pavement researches have been done over the last 50 to 80 years (Tayabji et al. 2012).

A pre-casted cement concrete element for road pavement, in a roadway served with a previous compaction work, consisting rectangular cement concrete panel prefabricated into a transportable size accepted to the width of a lane, and configured for road pavement by horizontally arranging neighboring panel units along a road bed. Positioning of precast panels generally requires the use of crane which is in turn requires additional experienced operator and equipment on the job site compared with traditional precast concrete placement. As a result, this method was not necessarily useful to emergency or contingency construction efforts where experienced crews or heavy equipment were not available (Olidis et al. 2010).

3.1 State-of-Art of Application of Precast Technology

Highway departments are constantly searching for the techniques to repair damaged pavement rapidly and in ways which will keep the performance of roadways is improving in popularity is precast concrete pavement systems. This system has adopted as one of its Highways by US Federal Highway administration (FHWA) for life programs (S. Tayabji1et al. 2011). Also, the use of precast panel technology is an alternative rehabilitation method to the application of cast in place slabs for full-time depth repairing of concrete highways and airfield pavements. Full depth repairing of concrete pavements is a rehabilitation method which involves the removal of an entire existing slab, the installation of devices for load transfer and the replacement of PCC material (Grant C. Luckenbill et al. 2009). The following part summarizes early and current application of precast panels in India and other countries for the improvement of various pavements.

3.1.1 Precast pre-stressed concrete pavement (PPCP) system:

PPCP is the work of a development of conventional materials associated with cost effective fabrication and Transportation system to manufacture a product that enhances the performance and implementation of current pavement rehabilitation systems. PPCP applies a pre compressive force to reduce amounts and Strength of Materials which use a more economical design. Prestress system is having the advantage to span the voids that produce below the pavement due to many factors. These voids produce stressed localized areas which ultimately reduce the life of the pavement due to repetitive wheel loading. This results in increasing the prestressing force Hipster panel to act like a thicker pavement. Another essential advantage of pre-stressed pavement is the ability to manage the quality of product. PPCP is also very useful in reducing serviceability problems like cracking and load transfer. Cracks may spell and fault and thus water will penetrate the base which will create voids under the pavement and results in freeze-thaw damage. It results in degradation of the pavement and creates load transfer problems. The pre-compression forces in precast pre-stressed system help to keep the cracks from opening up wide enough to avoid above mentionedproblems. The shear friction provided by the pre-compression in the precast pre-stressed pavement, serves optimal load transfer through joints and cracks (Grant C. Luckenbillm et al. 2009)

3.1.2 **Kwik slab system**:

The Kwik slab system is a new precast panel repair system that is developed and marketed in Hawaii and Singapore. The system depends on the installation of precast panels that are attached by using steel couplers which are precast in one or more panel ends (Olidis et al. 2010). The Kwik slab with Kwik joint couplers instantly interlocks precast concrete panels for two way rebar continuity through entire pavement slab. Kwik slabs are then lifted on site, interlocked and leveled using plastic leveling shims. Ready mix grout is pumped up through holes within the slab and distributed across the channels cast on the underneath of Kwik slab. Grout channels on the bottom of Kwik slab produce continuity within the grout bed and facilitate to produce full bearing of the slab on the sub-grade. Due to the monolithic action of the Kwik slabs, this system is advantageous in maintaining two-way rebar continuity of pavements(www.kwiklab.com 2011).

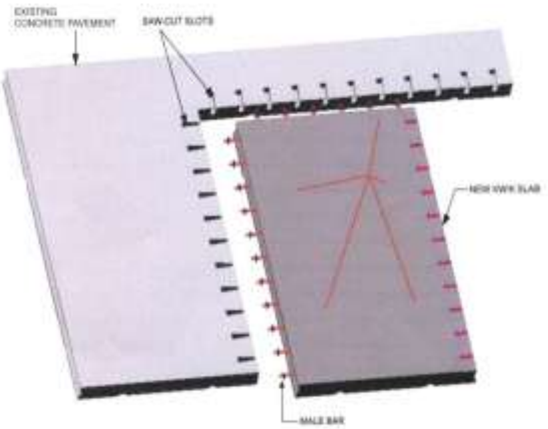

Figure-1. Kwik slab and existing concrete pavement connection detail (www.kwiklab.com 2011)

Figure.2 Grouting within Kwik slab panels (www.kwiklab.com 2011)

3.1.3 **Michigan method:**

This method focuses on ultimate wheel load transfer using dowel rods under the wheel path. The 21 precast panels were installed along two interstates in 2003 which called Michigan method (Olidis et al. 2010). The panels with three bars were casted into the precast panel wheel paths to maintain load transfer across the joints. Dowel bars that casted into the panels are attached to the surrounding pavement by using dowel slots. After the dowel slots get prepared, the panels were lowered, leveled into a place and then dowel bars were grouted with Rapid-setting grout. In the last step of this process, the joints were sealed. The distress surveys and falling weight deflectometer

(FWD) test were conducted to determine the repair effectiveness of the panels. The test results showed that the average joint LTE ranges between 61% to 70% and the deflection ratios are less than 2 which is acceptable. This process is also known as injection method. As the multiple panels are fabricated at the same time, this leads to the uniformity of construction. This is the most common method adopted for precast panel repair in the United States (Novak et al. 2017).

Figure-3. Installation of panels by Michigan method (Olidis et al. 2010)

3.1.4 **Roman Road system:**

The Roman Road system was introduced in 2009 by the Roman stone construction company for intermittent repairs as shown in the fig. 4. In this system dowel bars are not embedded in the panels, but are installed using the dowel bar retrofit (DBR) technique after the panels are placed. The slots for dowel placement are cut in the existing concrete as well as in the panel after the panels are set in final position. The unique feature of this system is the use of polyurethane foam material as a bedding material. The panel is cast about 1 inch (25 mm) place in thickness than the existing pavement. The panel is placed in the prepared hole after removal of the deteriorated portion of the existing pavement and the panel sits about an inch below the final elevation. The polyurethane material is then injected under the panel, raising the panel to the desired elevation and providing uniform seating of the panel over the existing base. The system is two times better than other system because it doubles the life of the road ways as the polyurethane polymer material completely stabilized the base and provides a stronger, longer lasting repair (Ashtiani et al. 2010).

Figure-4. Roman road system
(Ashtiani et al. 2010)

3.1.5 **Uretek method:**

The Uretek method is a patented precast concrete panel repair method adopted for a single or multiple repairs. The Uretek method consists of injection of polyurethane foam across portholes in the precast panel to give bearing support to the panel and for lifting the panel to the desired grade. After the precast concrete panels are placed, the fiber glass ties are installed. These ties are grouted into slots that extend to precast panel from existing slab. This system is recommended to use only for small area in order to avoid the damages regarding bonding system (Novak et al. 2017).

Figure-5. Uretek Fiberglass Tie Installation Process
(Olidis et al. 2010)

3.1.6 **Fort Miller super slab system:**

The Fort Miller super slab system is a proprietary precast concrete pavement Technology adopted all over the world for both intermittent and continuous pavement rehabilitation as shown in the fig. 5. This paving system consist of precast concrete panels of various sizes placed directly on a graded and compacted bedding material or placed over a graded existing granular base which provides a uniform slab support. The load transfer and the intersection between adjacent precast panel and the existing pavement was ensured by a particular load transfer system that consists of dowel bars placed into prepared slots in existing base and grouted. This particular precast concrete panel Technology allows production of non planar panels with varying cross slopes. This system provides a superior finished pavement and reduces inspection time and cost and repair cost (Olidis et al. 2010).

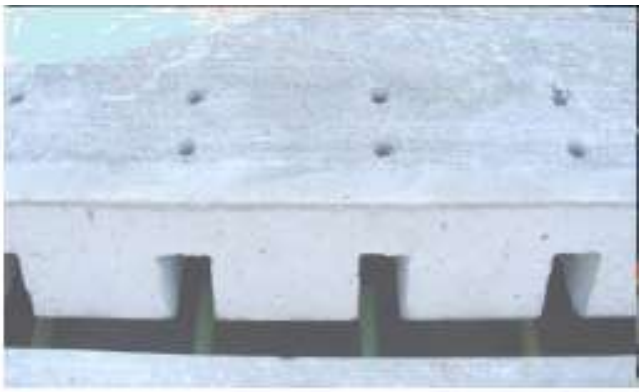

Figure-6. Interlock systems between adjacent elements
(Olidis et al. 2010)

3.1.7. **Hexagonal shaped PCP system:**

The first PCP system was developed in Soviet Union for the construction of airfields pavement. It was constructed using panels having a hexagonal shaped made of plain concrete without reinforcement. Depending on the aircraft weight for which the airfield pavement was designed, the length and thickness of the precast panels varies from 1.2 m to 1.5 m and from 100m to 220 mm, respectively. The system often faced the problems with spalling and rocking as the construction of panels was done without using reinforcement(Novak et al. 2017).

Figure-7. Precast unreinforced hexagonal concrete slabs
(Novak et al. 2017)

3.1.7 **PAG system:**
A standard slab system for airfield pavement was introduced in the Soviet Union called PAG system. The system consists of a longitudinally pre-stressed panel with reinforcement mesh and two layers of 12 mm reinforcement bars at top and bottom. The size of prestressed panels varies, but mainly they were 6 m in length, 2 m in width and 140 mm in

thickness. Due to the panel size and the reinforcement used, they showed excellent load carrying capacity. Two lifting loops exposed on the other side of panels enabled to control with the panels and place them into a right position. Mostly this panels were installed on sand base has providing such material helped in improving working conditions, uniform support, low coefficient of friction, better drainage and it was also cost efficient and widely available at that time (Novak et al. 2017).

Figure-8. PAG precast airfield slab

(Novak et al. 2017)

4. CONCLUSIONS

This paper has demonstrated the following conclusions after the full study:

1) On basis of evaluation of different types of pavements, Pre-cast concrete panels were determined to be the most practical type of pavement to apply for pavement construction. Precast panel effectively reduces thickness of the pavement and improves the durability of the pavement, which is particularly important for handling operations.
2) The feasibility analysis for design concluded that a precast pavement can be designed to improve the design life of pavements, with a significant savings in pavement thickness.
3) The feasibility analysis for economics and durability revealed the economic advantages of a precast pavement, such as reduced user costs, as well as advantages in terms of durability.
4) Other major advantages of precast panels are increased slab lengths (fewer joints), material savings (less concrete and reinforcement), and increase in durability.
5) Repair of concrete pavements using precast panels is a feasible fast track alternative rehabilitation method to cast-in-place repairs of highway and airfield pavements. Repairs using precast panels can also provide an alternative emergency repair method with good long-term performance.

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