Review Paper on Precast Airport Lane Analysis of Military Air Base Using Ansys

Mr. Abhishek Dattatray Gabhane [1] Prof. N. C. Dubey [2]
[1]Dept of Civil Engineering
[2]Assistant Professor, Dept of Civil Engineering
[1, 2]GHRCEM

Abstract- *The use of precast cement concrete pavement units (PCPUs) as surfacing for runways in relation to slabs which have concrete to be saw cut, broken out and replaced with no dowelled, replaceable PCPUs and accept immediate overrunning by any type of aircraft in service. The finite-element analysis of the proposed replaced area shows that a considerable increase in aircraft numbers and loading can be sustained. The limiting design factors are the strengths of the sub base and the subgrade and means of overcoming these limitations are described. The development of this fast-track, rapid, runway repair technique for civilian as well as military airports is encouraged.*

Keywords- Precast Airport, ANSYS, Airport runway, Fast track construction.

I. INTRODUCTION

Precast concrete construction methods have now become feasible alternatives in applications such as buildings, roads, metro rail, flyovers and bridges. The primary benefits of precast construction are the speed, improved durability, improved safety and all-weather construction. Precast elements can be cast and cured in controlled environment at a precast plant, providing greater control over consistency of the concrete mix, procedures of vibration and proper curing. Precast objects reduce or eliminate curling, strength and air-entrainment problems that are common with conventional concrete paving. Precast elements can be cast at a pre-casting yard far in advance of when they will be needed, stockpiled, and transported to the construction site. The structure can then simply be assembled using the precast elements. Time required for the concrete to be cured, which is critical in terms of operational time and long-term performance, particularly for Portland cement concrete pavements, would no longer be a factor. The use of precast elements eliminates the operational step and optimizes the curing time.

A. Construction of Greenfield Runway.

Precast Concrete Pavement technology would particularly offer great advantage in the remote and inaccessible areas of North and North East. The haulage of heavy plant and machinery that is required for the traditional cast-in-place construction methods is very difficult and uneconomical. Moreover, the areas mentioned above offers a very limited number of working corridor due the weather conditions that prevail. Modular panels would make the construction process safer and more efficient as the construction work can be completed in shorter time frame. Using the panels can extend the construction season because prefabrication would purge the need to pour concrete in adverse weather conditions.

Construction of Greenfield runway using the precast construction methods has never been attempted anywhere in our country. No literature is available open source which would state that it has ever been undertaken anywhere in world. In the remote areas and high altitudes where construction of conventional cast in situ pavement appears to be a problem, can be overcome using precast technology and the same will be analyzed in this study.

B. Runway Rehabilitation.

Accomplishment of Air Mission requires ground facilities like runways, taxiways, aprons etc and targeting them would paralyze the Air Force on the ground itself and thus these assets have now become more lucrative leaving the air power most vulnerable at the air base. Thus, rehabilitation of the damaged runways, dispersals and taxiways in a quick time frame becomes extremely important with respect to the recuperative ability of the airbase to ensure the fighting fleet is put back in action in a tactically acceptable time frame. From the point of view of the Defense Forces, with the advent of hardened shelters at almost all the air bases, targeting the aircraft on ground has become difficult.

Repair of concrete pavements using precast concrete panels is considered rapider air methodology which is not being followed in India. Rapid repair techniques for concrete pavements (alternatively known as fast track construction) have become part of common pavement engineering practice, mostly in Highway Engineering. Fast-track repair techniques can reduce operational delays by short ending construction schedules. Applications that can benefit from the use of fast-track repair techniques to restore operational readiness include the replacement of distressed slabs that have become severe enough to affect the safe operation of aircraft and maintenance vehicles using the facilities.

II. STATE OF DEVELOPMENT

Chen, Y. S. et. al.[1] The Port Authority of NY and NJ installed two types of precast PCC slabs using the Fort Miller method on a taxi way of La Guardia Airport in September 2002. The first type was a precast PCC slab 304 mm (12in) thick. The second type was a conventionally precast reinforced PCC slab406 mm (16in) thick. All slabs were3.8 m by7.6 m. The entire installation, consisting of grinding the existing AC surface, installation of steel bearing plates, installation of slabs, grouting, diamond grinding (where required), and lighting installation was completed in 36 hours. To date, both types of precast panels are performing well. According to November 2007 email interview with Mr. Ernes to Larrazabal, the Port Authority is satisfied with the performance of the precast slabs. No subsequent report or paper has been compiled.

Farrington et. al.[2] Unreinforced PCC slabs casting place in 1962, sitting on an unbound granular layer were replaced with precast slabs in 2001. All panels were380-mm thick (15 in). One7.6-m x 7.6-m (25-ftx25-ft) panel was replaced with four3.8-mx3.8-m (12.5-ftx 12.5-ft) panels; the two 4.0-mx6.1-m (13-ftx20-ft)contiguous half panels were each replaced with two 2.0-mx3.0-mpanels.The bedding of the precast panels, and their leveling was done by injection of high-density polyurethane material under the panels. The high- density polyurethane also supported the adjacent pavement. Load transfer was restored byplacing6-mm thick, non-corrosive fiber glass reinforced polymeric inserts into narrow saw-cut slots and filling the slots with non-expanding, high-density polymer. The load transfer was not verified by field testing. Lessons learnt:

- Cuts done in advance for measurement purposes may result in slab creep. The cuts should be done half-depth.
- To speed-up the removal of old slabs, it may help to excavate relief trench around the perimeter of the repair area and temporarily fill it with asphalt concrete.
- Technology now exists to allow for expansion in transverse joints using the fiber glass reinforced polymeric inserts.
- If possible, the cause for the pavement failure should be investigated and fixed (e.g., drainage). Two authors of their port, Mr. Rodney Farrington and Mr. Douglas Steiner were contacted in November2007 regarding the performance of the repairs. According to Mr. Steiner, an assessment of field performance is pending.

Bull, J. W. et. al.[3] The paper describes the use of three-dimensional finite element analysis for the design of precast slabs that had been installed in 1990 or 1991 in Charleston International Airport. During each overnight working session, a square section of the existing runway intersection, 7.6mx7.6m, was cut out using concrete saw. The subgrade was dugout to a level of 910 mm below the finished pavement surface and a 300-mm thick layer of granular sub base was placed on the exposed subgrade. The subgrade was compacted to a California bearing ratio (CBR) of 20%, the minimum required for satisfactory performance of precast concrete paving units (PCPUs).The 7.6- m x7.6-m section was filled with four PCPUs 3.8 m x3.9 mx610mm thick. The size of the PCPUs being related to the load capacity of the available crane (225kN). The PCPUs were used as temporary replacements and later replaced on a slab-by-slab basis using high-early-strength quick-setting cement. The authors conclude that the PCPUs did not have to be replaced.

Wade, M. et. al.[4][5][6] This series of three papers describes the results of a project sponsored by the Innovative Pavement Research Foundation. Precast panels are mentioned as a material for the construction of temporary pavements. Also mentioned is the use of high-early-strength rapid-setting concrete material. Most of the discussion in these three papers concerns the management and logistics issues rather than detail design and engineering issues.

Peshkin, D.G et. al.[7] The high-early-strength, rapid-setting cement used for Charleston (South Carolina) International Airport had been typically used only for small patch sand repairs before the project. Thus, it was necessary to thoroughly investigate the material properties before using it for full slab replacements. Challenges to using the proprietary cement included a relatively narrow blend of mix variables that would produce satisfactory strength, workability, and setting time. Also, chemical reactions between the cement and locally available aggregates and water could be unpredictable, and mix properties needed to be verified in the laboratory. Based on laboratory testing, a mix design was developed that resulted in 3.5 MPa flexural strength (± 50 psi)at 5 hours. One problem that had been previously noted by the manufacturer was a very high degree of bond to steel, which prevented dowels from working normally. Therefore, the designers eliminated the load transfer devices. Eliminating the dowel bars also decreased construction time. The temporary, precast slabs included in the project were constructed on site using the proprietary cement PCC, allowing the batching and transporting issues to be worked out in advance of paving. During construction, the field PCC consistently achieved 3.5 MPa flexural strength5 hours after batching, with7-dayflexural strengthexceeding6.9MPa. The proprietary cement PCC was batched in conventional batch plant offsite and placed using traditional procedures. Special attention was paid to adequate vibration of the PCC and to the use of evaporation retardants to avoid loss of moisture. The Savannah–Hilton Head International Airport intersection reconstruction was completed using similar proprietary cement for its repair material.

Lane, B. et. al.[8] The installation, carried out in November 2004, encompassed three methods: Michigan method, Fort Miller Super-Slab Intermittent Method, and Fort Miller Super-Slab Continuous Method. In the Michigan method,2-m long by full-lane-width concrete slabs were fabricated offsite with three dowel bars per wheel pathcast300 mm apart into the slabs. The deteriorated pavement section was removed and slots were then cut into the existing pavement to accommodate the dowel bars. A cementation flow able fill leveling material was placed on the base prior to setting the precast slab. Once the slab was set, the exposed dowel bars were grouted in their slots to connect the precast slab to the adjacent PCC pavement. In the Fort Miller Intermittent Method, instead of dowels, the precast slabs had slots to accommodate the dowels. Four dowel bars—per one-wheel track at 300-mm spacing— were installed into the adjacent concrete. The precast slabs were installed on a thin layer of crusher screenings. The dowel bars were grouted through ports in the precast slab and bedding grout was injected through interconnected ports and channels in the bottom of the slab.

Hossain, S. et. al.[9] This project evaluated the use of precast concrete patches (12ftx6 ftx8.5 in) for repairing jointed concrete pavement .Six patches were placed: three had dowels cast into them during fabrication(Michigan method),and three had dowels inserted in place (typical dowel bar retrofit).Precast slabs were thinner than the original pavement. Leveling was done by flow able fill, designed to be2 in thick. Due to poor workmanship, the results were not impressive. The average load transfer efficiency per slab ranged from 13 to 70 percent.

De Witt, G.L et. al.[10] Colorado DOT has been using precast concrete panels as a means to speed repair of concrete pavements on high-traffic highways since 2000. Best results were obtained with 8 in thick panels. The largest precast panels were 12 ft widex15 ft long, 10in thick. Widths of joints should not exceed½in for longitudinal joints and 5/8in for transverse joints. The CDOT process is using injection of polyurethane via the URETEK process to level the panels. The leveling/under sealing was also applied to adjacent slabs. The load transfer and longitudinal tie-in are accomplished by fiber glass joint ties. The ties do not allow for the movement of transverse joints; transverse joints are filled with a polymer–aggregate mix. The panels are reinforced with a top and bottom rebar mash.

Buch, N. et. al. [11][12][13] MIDOT started experimenting with using precast concrete panels (PCCP)for repairs in the 1970s. In October 2001 and in summer 2002, 21PCCPs were installed by MIDOT, along I-94BL (Benton Harbor) andI-196(South Haven). The panels were6ft long, 12 ft wide and 10 in thick. The perimeter steel (#5bars) was included to protect the precast panels from developing stress cracks during the handling and transportation operations. Three dowel bars (1½ in in diameter) were cast into the precast panel in each wheel path to ensure load transfer across the joint. The steel mesh was included at the panel mid depth to resist cracking due to contraction and expansion of the panels. Slots for dowels were saw-cut, jack hammered, and sandblasted. Bedding for the panel was flow able fill. Panels were placed with a front-end loader.

Gopala Ratnam et. al.[14] the project involved the placement of 1000-ftlong and 38-ft wide pavement consisting of 10-ft widex38-ft long panel's onI-57near Sikeston, Missouri. It was open to traffic in January2006.Thepanels' were pre-stressed along the long dimension and post tensioned longitudinally to form 11 or 12 panel units. The post-tensioning was done at joint panels. Joint panels had expansion joints to allow for thermal movement. There were also anchor panels containing full-depth holes to accommodate dowel bars, which were driven into the subgrade to provide anchorage.(Eight anchors were installed on each corner of two joint panels.)Shear keys were cast into the sides of the panels to help with load transfer and to align the panels during placement and post-tensioning. Once panels were in place, post-tensioning strands were fed through the ducts (cast in to the panels) and stressed at the joint panels. Diamond grinding was done to improve smoothness. No performance at a were reported.

Merritt, D.K. [15] The following projects were completed:

- 2002: Federal Highway Administration (FHWA)Pilot Project in Georgetown, TX 2004: FHWA Demonstration Project in El Monte, California
- 2006: FHWA Demonstration Project in Sikeston, Missouri 2006: FHWA Demonstration Project in

Sheldon, Iowa Additional FHWA Demonstration Projects underway.

Benefits of prestressed concrete:

- Ability to span voids/unsound support layers
- Reduces/eliminates slab cracking (maintenance)
- Reduced number of joints (maintenance/smoothness)
- Reduced Slab Thickness (8 in vs.12 in)results in material saving. Allows for replacement of pavement in-kind.

Merritt, D.K et. al.[16] [17] The first report describing in detail all aspects of the Georgetown precast pavement project including, design, panel fabrication, construction, and post-construction monitoring.

Chang, L-M et. al.[18] A literature review of Precast Prestressed Concrete Pavement (PPCP) construction (as used in Texas and California), and Fort Miller Super-Slab method. The Michigan method and the URETEK methods were not reviewed.

Brabston et. al.[19] Various methods of rapid repair of bomb craters on runways using precast concrete slabs as structural elements are discussed. Primary focus was on optimum utilization of the concrete slabs when placed on debris backfill and on compacted select material backfill. Three primary repair concepts were studied: placement of slabs flush with the surrounding pavement and interlocked at the edges with concrete grout (Flush Slab Method); placement of slabs slightly below the surrounding pavement and surfaced with a 2-in thick concrete caps created flush with the old pavement (Submerged Slab Method); and placement of the slab flush with the old pavement without a load transfer mechanism (German Method).

Chang, L-M et. al.[20] The authors review a precast prestressed concrete panel (PPCP) installation by Texas DOT project (PPCP demonstration project in Georgetown, Texas, on the frontage road of I-35) and by Caltrans project (a part ofI-10HOV(High Occupancy Vehicle widening project). In addition, Fort Miller Super-Slab method was reviewed in generic terms. The paper provides general outline of factors and considerations involved in PPCP and rapid repairs to PCC pavements.

III. CONCLUSION

This paper focuses only on the literature review of previously published studies. The findings of this paper is the first type was a precast PCC slab 304 mm (12in) thick. The second type was a conventionally precast reinforced PCC slab406 mm (16in) thick. Farrington et. al. [2] Unreinforced PCC slabs casting place in 1962, sitting on an unbound granular layer were replaced with precast slabs in 2001. Cuts done in advance for measurement purposes may result in slab creep. If possible, the cause for the pavement failure should be investigated and fixed (e.g., drainage). During each overnight working session, a square section of the existing runway intersection, 7.6mx7.6m, was cut out using concrete saw. The size of the PCPUs being related to the load capacity of the available crane (225kN). et. al.[4][5][6] This series of three papers describes the results of a project sponsored by the Innovative Pavement Research Foundation. Precast panels are mentioned as a material for the construction of temporary pavements. Peshkin, D.G et. al.[7] The high-early-strength, rapid-setting cement used for Charleston (South Carolina) International Airport had been typically used only for small patch sand repairs before the project. Thus, it was necessary to thoroughly investigate the material properties before using it for full slab replacements. In the Fort Miller Intermittent Method, instead of dowels, the precast slabs had slots to accommodate the dowels. Four dowel bars—per one-wheel track at 300-mm spacing— were installed into the adjacent concrete. Leveling was done by flow able fill, designed to be2 in thick. The average load transfer efficiency per slab ranged from 13 to 70 percent. Widths of joints should not exceed½in for longitudinal joints and 5/8in for transverse joints. The CDOT process is using injection of polyurethane via the URETEK process to level the panels. Buch, N. et. al. [11][12][13] MIDOT started experimenting with using precast concrete panels (PCCP)for repairs in the 1970s. Joint panels had expansion joints to allow for thermal movement. Once panels were in place, post-tensioning strands were fed through the ducts (cast in to the panels) and stressed at the joint panels. Merritt, D.K. [15] The following projects were completed Reduced Slab Thickness (8 in vs.12 in) results in material saving. Chang, L-M et. al. [18] A literature review of Precast Prestressed Concrete Pavement (PPCP) construction (as used in Texas and California), and Fort Miller Super-Slab method. The Michigan method and the URETEK methods were not reviewed. Brabston et. al. [19] Various methods of rapid repair of bomb craters on runways using precast concrete slabs as structural elements are discussed. Primary focus was on optimum utilization of the concrete slabs when placed on debris backfill and on compacted select material backfill. In addition, Fort Miller Super-Slab method was reviewed in generic terms. The paper provides general outline of factors and considerations involved in PPCP and rapid repairs to PCC pavements.

REFERENCES

[1] Chen, Y. S., Murrell, S.D., and Larrazabal,E.,Precast Concrete(PC)Pavement Tests on TaxiwayD–D at Laguardia Airport, Airfield Pavements 2003, pp. 447–483.

[2] Farrington, R.,Rovesti,W.C., Steiner, D., Switzer, W.J., Overnight Concrete Pavement Replacement Using a Precast Panel and Expanding Polymer Positioning Technique— Washington Dulles International Airport Case Study, Airfield Pavements, 2003, pp. 13–28.

[3] Bull, J. W., and Woodford, C.H., *Design of Precast Concrete Pavement Units for Rapid Maintenance of Runways*, Computers &Structures, Vol. 64, No. 14, pp. 857–861, 1997.

[4] Bruinsma,J.E,Peshkin, D.G., Wade, M.J.,Delatte, N.J., Accelerated Practices for Airfield Concrete Pavement Construction: Lessons Learned from the Planning Phase ,Paper 07-3407. TRB 2007 Annual Meeting CD-ROM.

[5] Peshkin, D.G., Wade, M.J.,Bruinsma,J.E.,Delatte,N.J.Accelerated Practices for Airfield Concrete Pavement Construction: Lessons Learned from the Design Phase, PaperNo07-3396, TRB 2007 Annual Meeting CD-ROM.

[6] Wade, M.J.,Bruinsma,J.E.,Peshkin, D.G.,Delatte,N.J.,Accelerated Practices for Airfield Concrete Pavement Construction: Lessons Learned from the Construction Phase ,Paper No 07- 3400. TRB 2007 Annual Meeting CD-ROM.

[7] Peshkin, D.G., Bruinsma, J.E, Wade, M.J.,Delatte, N.J., AcceleratedPractices for Airfield Concrete Pavement Construction—Volume I: Planning Guide, ReportIPRF-01-G-002-02-3, Innovative Pavement ResearchFoundation, Airport Concrete Pavement Technology Program, Programs Management Office, 5420Old Orchard Road, Skokie,IL60077, April 2006.

[8] Lane, B., Kazmierowski, T., Short Term Performance of Innovative Precast Concrete Slab Repairs on Highway 427, Toronto, Proceedings,2007 Annual Conferenceof the Transportation Association of Canada, Saskatoon, Saskatchewan. Also presented as Use of Innovative Pre-Cast Concrete Slab Repair Technology in Canada Proceedings, 8thInternational Conference on Concrete Pavements, Colorado Springs, Colorado,14–18 August 2005,

[9] Hossain, S.,Ozyildirim, C., and Tate, T.R., Evaluation of Precast Patches on U.S. 60 Near the New Kent and James City County Line, Report VTRC 06-R22,VirginiaTransportation Research Council, 530 Edgemont Road, Charlottesville, VA 22903,March2006.

[10] DeWitt,G.L., PrecastConcrete Paving Panels: The Colorado Departmentof Transportation Region4 Experience, 2000 to 2006,Report No. CDOT-DTD-R-2006-8,NTIS, Springfield, VA 22161, August 2006.

[11] Buch, N., Barnhart, V., and Kowli, R., Precast Concrete Slabs as Full-Depth Repairs: Michigan Experience, Transportation Research Record No. 1823. Transportation Research Board, Washington, D.C., 2003, pp. 55-63.

[12] Buch, N., Vongchusiri,K., Meeker, B.,Kaenvit, B., Command, M., and Ardani, A., *Accelerated Repair of Jointed Concrete Pavements (JCP)Using Precast Concrete Panels— Colorado Experience*, Proceedings, 8thInternationalConference on Concrete Pavements, Colorado Springs, Colorado, 14–18 August 2005.

[13] Buch, N., Precast Concrete Panel Systems for Full-Depth Pavement Repairs: Field Trials, Federal Highway Administration Report, FHWA-HIF-07-019, NTIS, Springfield, Virginia 22161,February2007.

[14] Gopalaratnam, V. S., Donahue, J., Davies, B.,Hall, L., Dailey, C., Precast Panels for Rapid Full-Depth PavementRepairs, Structures 2006.

[15] Merritt, D.K., and Tyson, D.S.S, PrecastPrestressed Concrete Pavement: A Long-Life Approach for Rapid Repair and Rehabilitation,Presentation at theInternational Conference on Long-Life Concrete Pavements, October 2006.

[16] Merritt,D.K.,Stahl, K., Tyson, S.S., and McCullough, B.F, Expedited Construction Using PrecastPrestressed Concrete Pavement in California, Proceedings, 8thInternational Conference on Concrete Pavements, Colorado Springs, Co., 14–18 August 2005. Also, Morian, D.A., GraftonR.J.,Construction of the PrecastPrestressed Pavement Installation onI-10 in El Monte, California,Proceedings,8thInternational Conference on Concrete Pavements, Colorado Springs, Colorado, 14–18 August 2005.

[17] Merritt, D.K., B.Frank McCullough, B.F., and Burns, N.H., Construction and Preliminary Monitoring of the Georgetown, Texas, PrecastPrestressed Concrete Pavement, Report FHWA/TX-03-1517-01-IMP-1, NTIS, Springfield, Virginia 22161,December 2002

[18] Chang, L-M., Chen, Y-T., Sustainable Precast Concrete Pavement, Paper No 07-0592, TRB 2007 Annual Meeting CD-ROM.

[19] Brabston, W.N., Bomb Damage Repair. Precast Slab Design, Accession Number: ADA141687, US Army Engineer Waterways Experimental Station, Vicksburg, MS, Defense Technical Information Center.

[20] Chang, L-M., Chen Y-T, Sustainable Precast Concrete Pavement, TRB2007 Annual Meeting CD-ROM. This is a précis of a larger port by Chang ,L.M.,Chen Y-T, and Lee S., Using Precast Concrete Panels for Pavement Construction in Indiana, Report FHWA/IN/JTRP-2003/26, NTIS, Springfield, VA 22161, June 2004.