Precast Concrete For Grid Rapid Runway Construction

Mr. Nilesh Balu Bhagwat [1], Prof. P. A. Nikam [2]
[1]Dept of Civil Engineering
[2]Assistant Professor, Dept of Civil Engineering
[1, 2] S.N.D College of Engineering & Research Center, Babhulgaon, Yeola-423401

Abstract- *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 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 non-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, and Airport..

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. PROBLEM STATEMENT AND PROJECT OBJECTIVES

The objective of this report is to assess the application of precast concrete panels for construction and repair of precast concrete air field pavements. Specific and concomitant objectives of their port include the following:

- Develop a feasible method for expediting construction of an Greenfield Runway and repair of Portland Cement Concrete pavements through the use of precast technology.
- Assessment of the performance of existing repairs of concrete pavement using precast panels.
- Identification of main challenges for the successful implementation of the precast technology.
- Documentation of the major findings.

The goal of this project, therefore, was to develop a concept for a precast concrete pavement — one that meets the requirements for expedited construction and that is feasible from the standpoint of design, construction, economics, and durability. The proposed concept should have a design life of 30 or more years to make it comparable to conventional cast-in-place pavements currently being constructed. To meets these objectives, the tasks undertaken as a part of this project were as follows:

1) Determine the current state-of-the-art technology through a thorough review of available literature and through meetings with professionals in the precast and concrete paving industries.
2) Evaluate potential pavement types.
3) Identify possible concepts for a precast concrete pavement.

4) Perform a feasibility analysis for the identified concepts.
5) Make recommendations for further investigation and future implementation.
6) Make recommendations for performance monitoring of future test pavements.

II. PROPOSED CONCEPT

The proposed concept for utilising precast concrete panels for construction and repair of runway have evolved from several key facets that are brought about in the feasibility project report. The proposed concept for a precast concrete pavement focuses on the use of full-depth precast panels. It is believed that a smooth enough riding surface can be obtained with proper alignment of individual panels and with occasional diamond grinding or bump cutting. The proposed concept consists of panels as shown in the figure below**.**

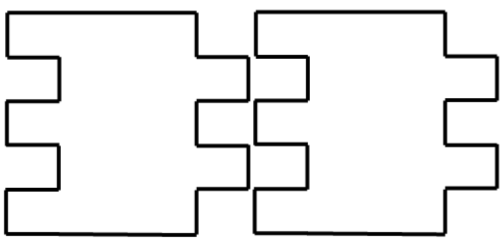


Fig 1.Proposed concept of precast slab

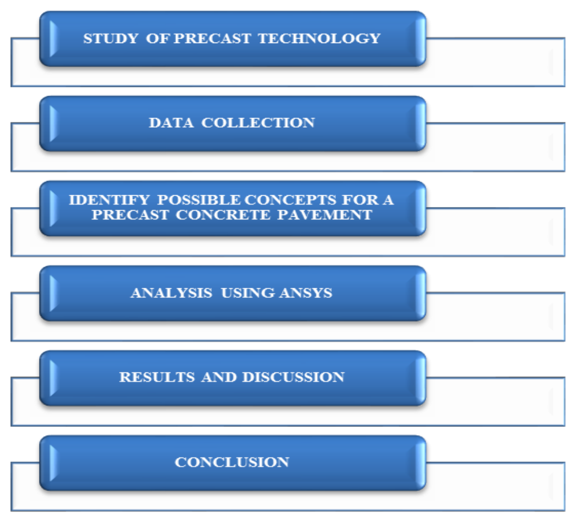
The details of this concept will be discussed over the course of this chapter. The discussion includes a description of the panels that will be used, joint details, panel assembly process and base preparation.

A. PRECAST CONCRETE PANELS

Proper alignment of the individual precast concrete panels is essential for providing a smooth riding surface. The most effective method for ensuring proper alignment appears to be one that uses continuous keyed edges cast which are locked with the adjacent panels. According to this arrangement, a male key will be cast into one side and a female keyed edge into the opposite side of the panel. These keys will interlock the panels together, such that there is a tight fit and exact vertical alignment between adjacent panels. All of the panels will be of the same length to simplify the casting and assembly processes. The panel width will depend on the panel type and on the limitations of the fabrication and handling equipment. A panel width of two metre will probably be the maximum width owing to the transportation limitations.

III. METHODOLOGY

The experience of the researchers and a comprehensive literature review were used to generate ideas and preliminary concepts prior to the first expert panel meeting. These ideas, along with input from the first expert panel, led to the development of the proposed concept. A strategy evaluation was used to further select a pavement type and possible cross section strategies for the proposed concept. The feasibility of the proposed concept was then evaluated with respect to design, construction, economics, and durability, based on design considerations



A. MATERIALS PROPERTIES.

Ser.No.	Material	Property	Value
1	Structural steel	Yield stress f_{sy}(MPa)	265
		Ultimate strength f_{su}(MPa)	410
		Young's modulus E_s(MPa)	205×10^3
		Poisson's ratio μ	0.3
		Ultimate tensile strain ϵ_t	0.25
2	Reinforcing bar	Yield stress f_{sy}(MPa)	250
		Ultimate strength f_{su} (MPa)	350

		Young's modulus Es(MPa)	200×10^3
		Poisson's ratio μ	0.3
		Ultimate tensile strain e_t	0.25
3	Concrete	Compressive strength f_{cu}(MPa)	42.5
		Tensile strength f_{cy}(MPa)	3.553
		Young's modulus E_c(MPa)	32920
		Poisson's ratio μ	0.15
		Ultimate compressive strain e_x	0.045
4	Stud shear connector	Spacing (mm)	110
		Number of rows	2
		Numbers of connectors	68
		Yield stress f_{sy}(MPa)	435
		Ultimate strength f_{su} (MPa)	565
		Young's modulus E_s(MPa)	200×10^3
		Poisson's ratio μ	0.15
		Ultimate strain ε	0.045

IV. DESIGN CONSIDERATIONS

There are several design considerations that must be accounted for in order to develop a precast concrete pavement that maximizes performance during its design life. These factors affect both the durability and constructability of a precast pavement. Durability is critical for ensuring a high-performance pavement that has a design life equivalent to, if not longer than, that of conventional pavements currently being constructed. Constructability is a critical factor, as expedited construction is the main reason for using precast pavement. The methods used for construction must meet these expedited construction requirements. Section 5.2 presents factors affecting the design of a precast pavement. These factors will primarily influence the durability of the pavement. In Section 5.3, design variables used to characterize the design factors are discussed. These variables will primarily influence the constructability of the pavement and will differ for each job.

A. FACTORS AFFECTING DESIGN

Factors affecting the design of a precast pavement include design considerations, such as load repetition effects, temperature effects, and site geometry that must be accounted for in any pavement design. To be considered also are those factors that are critical for precast concrete pavements, such as sub grade restraint and joint movement. All of these factors should be taken into account, together, in the design of a precast pavement to ensure that the pavement will meet the durability requirements of a high-performance concrete pavement.

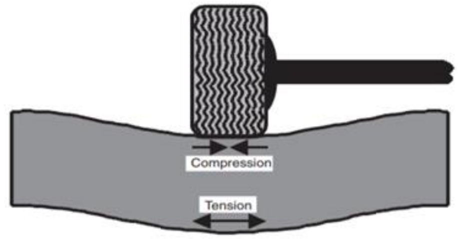


Fig 2. Slab stresses generated from wheel load application

The continual repetition of wheel loads tends to fatigue concrete pavements over time. Several factors, including the foundation strength and magnitude and number of wheel loads, will dictate the effects of these factors. However, these effects are fairly well understood for conventional concrete pavements, making it possible to design a pavement for a specified life based on given conditions. To determine wheel load repetition effects, the magnitude and occurrence of various traffic loadings are converted to the total number of passes of the equivalent standard axle loading, which are generally obtained from the International Civil Aviation Organization (ICAO) manual of Air force. For the purpose of this study Aircraft class C-130(Maximum Take Off Weight-79,378 Kg) is taken into consideration for 100 number of passes.

V. CONCLUSION

A. THE PRE-CAST SLAB MODEL

Although precast pavement construction will have many advantages over conventional pavement construction, such as speed of construction, increased durability, and reduction in user costs, in order for a precast concrete pavement to truly be a feasible alternative to conventional concrete pavement it must have a design life at least equivalent to that of conventional pavement. Incorporated in this equivalent design is elastic design for fatigue loading, and elastic design for environmental stresses and wheel loads.

After thorough discussions with the experts on the subject and keeping in view the practicality and ease of construction in mind, a particular design for the pre-cast panels was thought of and the same was modelled in ANSYS software. The panels were joined in the software itself and the reinforcement detailing was done. The model which gave the satisfactory results after application of load was selected for construction. The loads were applied keeping in view the Aircraft Class C-130 which has a load of almost 800 kN and an Aircraft Classification Number of 39. The model is shown below:

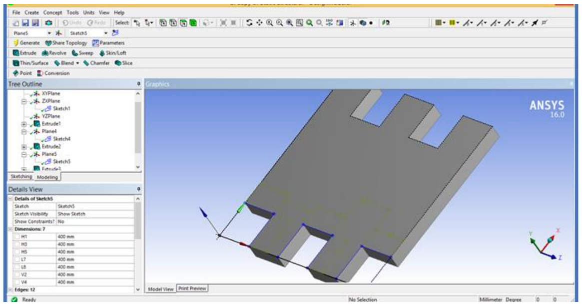


Fig 3 Modeling in ANSYS

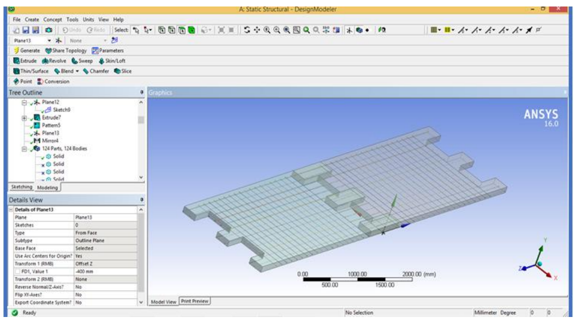


Fig 4 Reinforcment details section in ANSYS

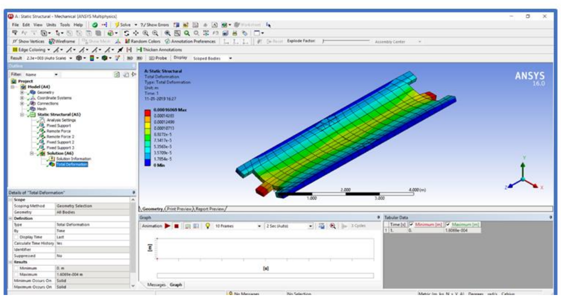


Fig 5 Stresses In ANSYS

B. ECONOMY COMPARISON

The comparison between the conventional cast in place pavements and the cost of one precast panel that was cast during the study has been drawn to arrive at the cost analysis.

Table 1: Duration of Concrete Precast vs. Cast-in-Place

Type of Construction	Cast-In-Place	Precast
Duration of Project(Days)	500	150

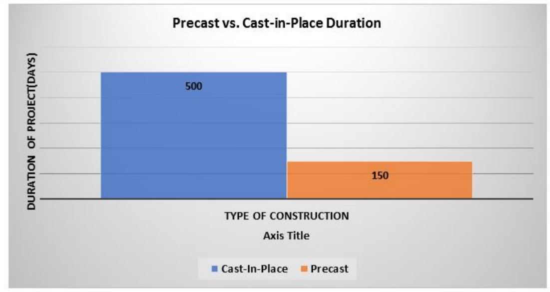


Fig 6: Duration of Construction Concrete Precast vs. Cast-in-Place

As this particular study has been done keeping in view C-130 class of aircraft, The Manual of Military Traffic Management Command Transportation Engineering Agency Titled C-130 Transportability of Army Vehicles published in June 2001 states that C-130 requires a runway length of 5000x90 feet that is 1524x24.3 m. For the purpose of economy calculation, lets consider the runway of equal dimensions as that of PTT. 18000 (Catering for 10% Extra) number of Pre-Cast Panels will be required for the construction of similar area of runway.The cost for casting of these many slabs is calculated to be approximately Rs9,47,02,500. Considering that the pre-casting yard is located at Guwahati and the slabs have to transported to Tawang which is approximately 520 km away, the transportation cost for 12 tonnes of load (10 Panels) in one truck will be around Rs5,14,80,000.

Table 2 Quantities of Concrete Works by Structural Members

	By Cast In Place Concrete	By Precast Concrete	
Quantity of Concrete (in m^3)	Rs 63135	Rs 63135	
Unit Cost (in Rs/m^3)	Rs 3100	Rs 1500	
Total Cost	Rs 19,57,18500	Rs 9,47,02,500	
Transportation	-	Rs 5,14,80,000	18000 (No of Panels) x 520 (Km) x 5.50 (Rs/Km)
Cumulative Costs	Rs 19,57,18500	Rs 14,61,82,500	

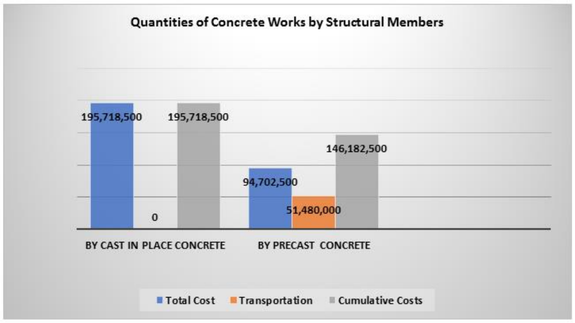


Fig 7 : Quantities of Concrete Works by Structural Members

The overall cost of the work will be less than the conventional cast in place method. It is pertinent to mention that all the calculations for the rates for the precast panels have been done keeping all the prevailing rates and even the quantities on a higher side. Once the methodology and use of the materials is further streamlined and the size and weight of the panels is reduced, cost will further be reduced.

C. CONCLUSION

The study reveals that the Precast Panels are 25.3% cheaper than cast in place panels but still there are some conditions which we have to take care of while using precast, those are quantity of construction, Distance of site from manufacturing unit, Type of building etc. Construction professionals prefer the use of precast concrete construction mainly because of low life cycle cost, reduction of on-site waste, speed of construction and quality of work done. Precast Construction Methodology has been found to be very effective and efficient as compared with Conventional Construction of Large Construction Projects. It is effective in terms of time, labour requirement, superior quality, better performance and finish, material requirement, it eliminates shuttering, desired shape and accurate finish etc.It is convenient to establish precast yard and to erect the precast elements at site which speeds up the process and contributes towards mitigating delays in large construction projects. As, this method requires huge initial investment, it is only suitable economically for Large Size Construction Projects.

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.