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Precast Airport Lane Analysis of Military Air Base Using ANSYS

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ABSTRACT: This report portrays the innovation of utilizing precast that is pre fabricated panels made up of concrete for fixing and repairing old damaged runways or constructing new lanes of an air base. In critical situations such as war or terrorist attacks, our enemies can attack our airbases, air craft runways or airport lanes to devastate our facilities and totally block our transportation system. Therefore we planned and took efforts in developing such technology where we can construct an airport lane within 3 to 4 hours. The purpose of this literature is to investigate and examine some of existing techniques which can prove to be efficient in the construction and development and thoroughly analyse the use of precast panels for repairs, development and construction of airport lanes. Specific and concomitant objectives of the report include assessment of the state-of-technology plus to recognize accomplishment challenges. Advantages of the precast development and construction are the simplicity, superior quality, speed, enhanced durability, improved safety and all-climate development and construction. In the end precast runway is compared with cast-in-situ r.c.c. runway in ANSYS software for dynamic analysis. With taking advantage of Finite element analysis detailed investigation and research was performed and all results were found out to be positive.

Keyword: Precast Airport, ANSYS, Airport runway, Fast track construction.

I. INTRODUCTION

Precast concrete development strategies have now become most suitable possible options in many applications in the structures like streets, metro rail, flyovers, subways, bridges and some other similar infrastructure projects. The most essential advantages of precast development and construction are the ease of construction, superior quality, high construction speed, enhanced durability, improved safety and all-climate development and construction. Precast components can be cured and casted in controlled conditions at precast manufacturing plant, giving us more prominent command over systems of vibration, appropriate curing and consistency of concrete blend that is mix proportions. Precast items decrease air-entrainment issues that are basic with ordinary concrete and also eliminate twisting and curling effects. Precast components can be made at a casting or fabrication yard far ahead of time of when they will be required, stored, and moved to the building or construction site. The structure can then basically be formed by utilizing the precast components. Time required for the concrete to be cured, which is crucial as far as effective time and long term execution, especially for Portland cement concrete pavement, would never again be a factor. The utilization of precast components disposes or removes of the operational steps and reduces the curing time in a efficient way.

A. PROBLEM STATEMENT AND PROJECT OBJECTIVES

The main objective of this report is to assess the application of precast concrete panels for construction and repair of precast concrete air field pavements. Airport lanes are hotspots as they are most likely to be targeted by enemies in critical situations of war and terrorist attacks. Therefore we planned and took efforts in developing such technology where we can construct an airport lane within 3 to 4 hours. Specific and concomitant objectives of this report include the following:

- Develop an attainable strategy for fast track construction of an Airport Runway and fixing of Portland Cement Concrete panels using precast innovation.
- Investigation and analysis of the performance of existing concrete pavements repaired by precast panel technology.
- Identification of principle challenges for the successful execution of the precast innovation.

- Documentation of the significant discoveries in brief.

The goal of this task was to build up an idea of precast concrete pavement technique- one that meets the fundamentals for fast development and that is practically possible from the viewpoint of structure, development, financial efficiency, and robustness. 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 meet these objectives, the tasks undertaken as a part of this project were as follows:

- Determination of possible ways of construction of airport runways speedily in case of war situations.
- Evaluate potential pavement types for airport runways.
- Identify potential ideas for a precast concrete pavement i.e. interlocking systems
- To check strength analysis and validation of experiment models are done with finite element analysis software ANSYS.
- Perform a Perform a feasibility analysis for the recognized concepts.
- Make suggestions for further examination and future implementation.

II. PROPOSED CONCEPT

The anticipated conception for utilising pre cast concrete panels for construction and repair of runway have evolved from several key facets that are brought about in the feasibility project report. The anticipated design 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 bump cutting or diamond grinding. The proposed concept includes panels as shown in the outline below.

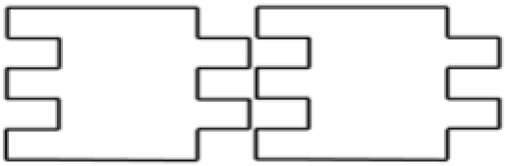

Fig 1.Proposed concept of precast slab

The particulars of this concept will be discussed briefly. The discussion includes a description of the panels that will be used, joint details, assembly process of panels and preparation of base and sub base.

A. PRECAST CONCRETE SLABS OR PANELS

Appropriate alignment of the individual precast concrete panel slabs is crucial for providing a smooth riding surface. The most valuable method for ensuring appropriate alignment seems to be the one that uses continuous keyed edges cast which are locked with the adjacent panels. In accordance with this arrangement, a male key will be cast into one side and a female keyed edge into the other opposite side of the panel. These keys will interconnect and lock the panels together, such that there is a tight fit and exact vertical alignment amid adjoining panels. All of the panels will be of the equal length to make simpler the casting and assembly processes. The width of panel will depend upon the panel type and on the restrictions of the manufacture 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

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A. MATERIALS PROPERTIES.

Sr. No.	Material	Property	Value
1	Structural steel	Yield stress f_{sy} (MPa)	265
		Ultimate strength f_{su} (MPa)	410
		Young's modulus Es(MPa)	205x10^{3}
		Poisson's ratio µ	0.3
		Ultimate tensile strain e_t	0.25
2	Reinforcing bar	Yield stress f_{sy} (MPa)	250
		Ultimate strength f_{su} (MPa)	350
		Young's modulus Es (MPa)	200x10^{3}
		Poisson's ratio µ	0.3
		Ultimate tensile strain e_t	0.25
3	Concrete	Compressive strength f_{sc}(MPa)	42.5
		Tensile strength f_{sy} (MPa)	3.553
		Young's modulus E_c (MPa)	32920
		Poisson's ratio µ	0.15
		Ultimate compressive strain e_s	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)	200x10^{3}
		Poisson's ratio µ	0.15
		Ultimate strain e	0.045

IV. DESIGN CONSIDERATIONS

There are several design considerations to look at so as to develop a precast concrete pavement that improves performance throughout its design life. Such factors can make huge impact on construction time and durability of a precast pavement. The main factor for good performance of pavement throughout its design life is durability of pavement which should be greater than the durability of pavements constructed conventionally in recent time. The critical factor for fast construction of precast is constructability. All the requirements for fast construction should be fulfilled by the methods of construction. Factors affecting the design of precast pavement and design variables used to characterize the design factors are briefly described in Further Section. These factors will primarily influence the durability of the pavement 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. Sub grade restraint and joint movement are also critical factors for precast concrete pavements to be considered. 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 due to wheel load

The continual repetition of wheel loads tends to develop fatigue in 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:

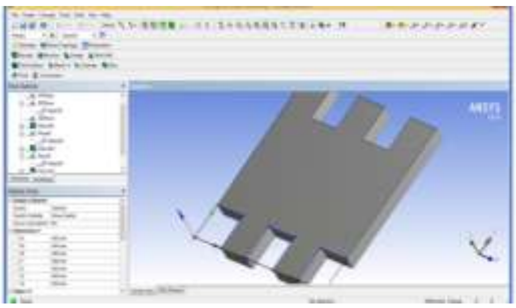

Fig 3 Modeling in ANSYS

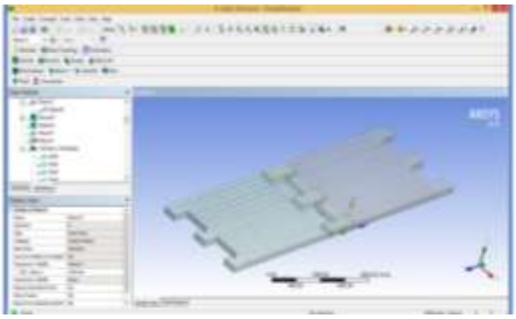

Fig 4 Reinforcment details section in ANSYS

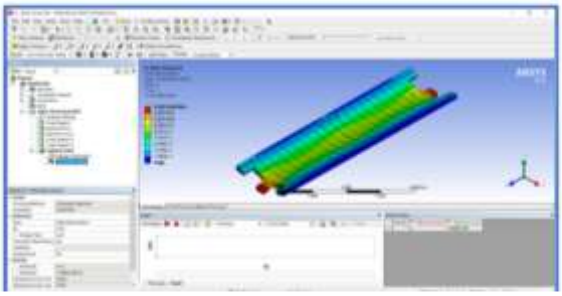

Fig 5 Stresses In ANSYS

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

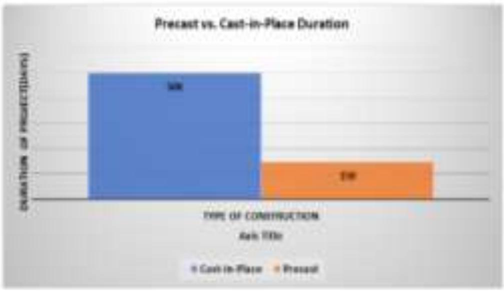

Fig 6: Duration of Construction for Precast vs. Cast-in-Place

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

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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

	Cast In situ Concrete slab panels	Precast Concrete slab panels
Quantity of Concrete (in m^2)	Rs 63135	Rs 63135
Unit Cost (in Rs/m^2)	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

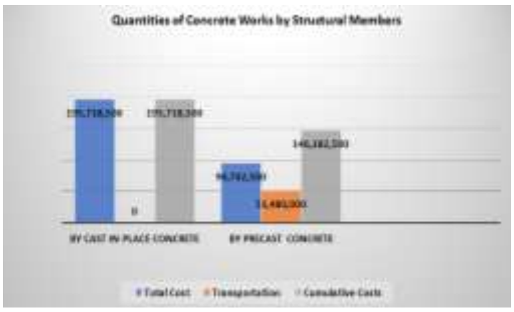

Fig 7 : Quantities of Concrete Works by Structural Members

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.

Following are the Results comparing RCC Runway And Precast Runway

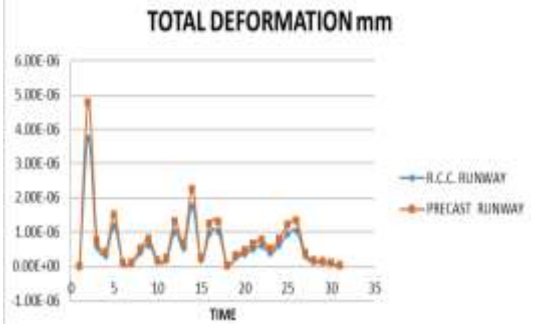

Fig. 8: Total Deformations Mm

Above graph in fig 8, shows results of total deformation for the RCC and precast runway. From the above graph we can conclude, total deformation for the precast runway is less than RCC runway by 10-20%.

Fig. 9, Shear stress Mpa

Above graph in fig 9, shows results of Shear stress for the RCC Runway and precast runway. From the above graph we can conclude, Shear stress for the precast runway is less than RCC runway by 15-20%

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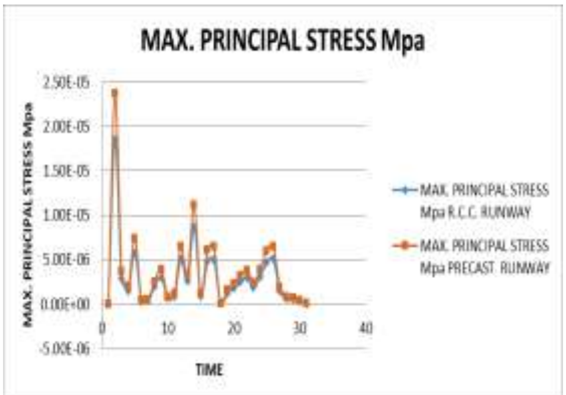


Fig. 10: Maximum Principal Stress

Above graph in fig 10, shows results of Maximum Principal Stress for the RCC and precast runway. From the above graph we can conclude that Maximum Principal Stress for the precast runway is less than RCC runway by 15-25%

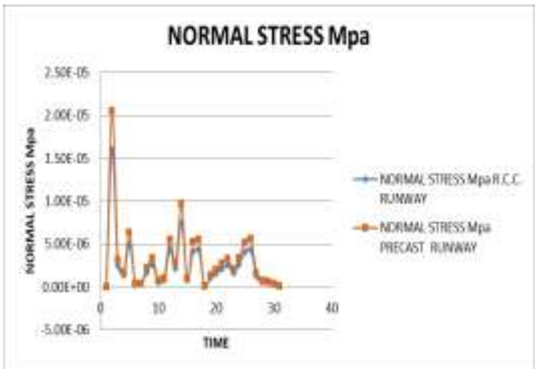
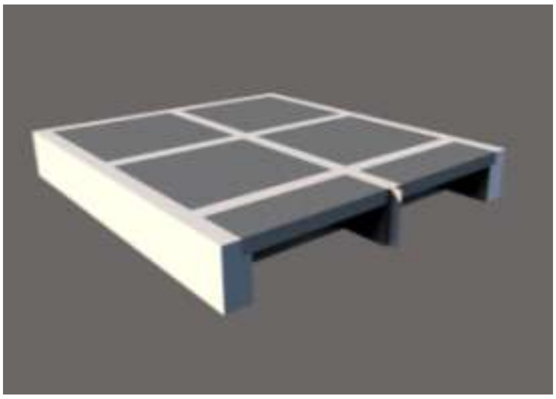


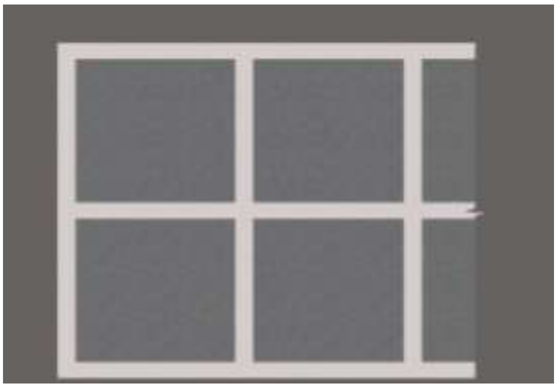
Fig. 11, Normal Stress Mpa

Above graph in fig.11, shows results of Normal Stress for the RCC and precast runway. We can conclude that Normal Stress for the precast runway is less than RCC runway by 10-15%

Following are the Conventional R.C.C. Runway Models



Model No 1 RCC RUNWAY (3D view)



Model No 1 RCC RUNWAY(PLAN)

C. CONCLUSION

This project has demonstrated that the construction of a Greenfield Precast Pavement runway is feasible and provides numerous benefits. This report also validates that the repairs of damaged runway section can also be done successfully as per the design suggested in this report. The proposed concept for precast concrete pavement was presented. The concept consists of placing the precast panels on a fully compacted soil layer. The panels have continuous keyed edges for interlocking to aid with alignment of the panels during assembly and load transfer. Design considerations for a precast concrete pavement were discussed. The design considerations include factors affecting the design, such as aircraft loads, load repetitions, sub grade restraint and joint movement, as well as design variables, such as foundation strength and pavement thickness.

various materials that were used for the construction were discussed along with the tests that are required to be conducted to arrive at the design mix.

We presented a feasibility analysis for design and construction of the slabs. A precast concrete pavement was designed using Ansys software which was 150 mm Thick and 2x2 mtr in L x B dimension.

Various pavement evaluation techniques were discussed. The results of the PCN evaluation of the constructed panels were also presented in this chapter. It was established that the pre-cast panels that were constructed during the course of study can be utilised for construction of runways and rapid repairs of runways.

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