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Study on Behaviour of Porous Concrete with Silica Fume and GGBS (for Airport Runway Purpose)

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ABSTRACT

Pervious concrete, from the name itself describes its nature as it will make the water pass-through it. It has minute pores in it which allows the water to pass through it. The pervious concrete is the zero slump Concrete with the OPC or PPC cement, Admixute, Coarse aggregate, water. This is also known as no fines & little fines concrete. The Cement and the Water which forms a paste and binds with the Coarse Aggregate producing the pores that allows water to pass through it easily. In this Project the feasibility and the Porous Concrete is tested for its usage in the Airport Runways. In order to Increase the strength of the Concrete the Silica Fume and the GGBS is being added to the Mix. The required concrete strength for the runway pavement to handle the smaller aircrafts is M20 grade. In this phase of the project the minimum required strength is identified and in the next phase the concrete be casted and tested with various Mix Designs and addition of GGBS and Silica Fumes with their strengths

Keywords: Pervious Concrete, Airport Runway, GGBS, Silica Fume, Runway Pavement

1.INTRODUCTION

From the date of invention of the concrete, the affordable material which could take any shape subject to the shape of the mould is none other than the Concrete. A wise man and the irreplaceable science always told that there are 3 factors to start a fire i.e Atmosphere, Temperature and Fuel similarly for the concrete there are three Basic Components along with the water i.e Cement, Fine Aggregate & Coarse Aggregate. Almost 95% of the concrete researches have done either by replacement of either 3 partially or fully but not completely eliminating from the Mix.

During later 1980s, the US Military have tested a new type of concrete called the Pervious Concrete. In this type of concrete the Cement and Coarse Aggregate will be bonding by leaving the Fine Aggregate out of the Mix.

The concrete is a material for Civil Engineer similar to iron for Mechanical Engineer. Compressive Strength is the Main characteristic of the concrete.

The porous concrete is the one in which the fine aggregate is not at all used or used to minimum percentage to make the concrete permeable or porous.

In the UG, I have studied about the behavior of the Pervious Concrete practically and also built a small pavement in the College Garden which is used for the walking and cycling. That brings the objective of this project of using the Pervious Concrete in the Airport Runway Pavements and Taxiways.

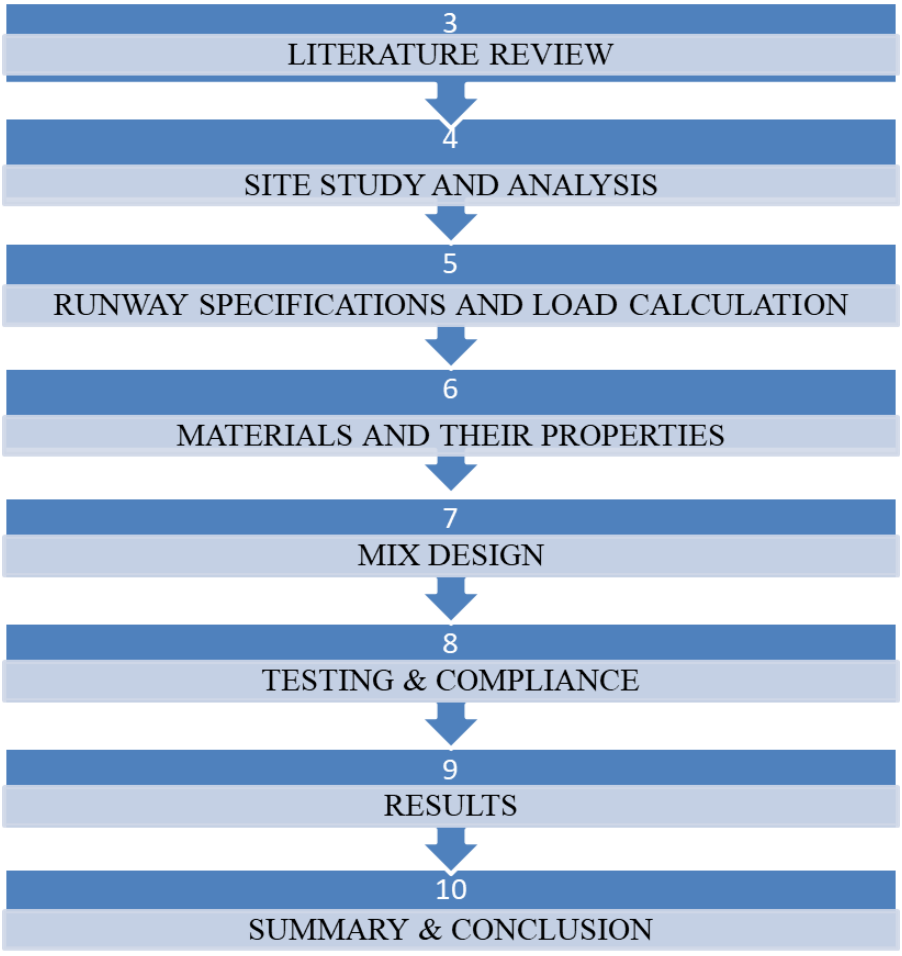
The Airports became a very mandatory thing for all the Tier one to three cities or commercial hubs. In the year 1990, India is having only 57 odd Airports whereas in 2021, there are 153 Airports which handles the passenger movements of more than 70,000 footfalls every day on average.

As per the experts opinion, all the Airports shall have a Main Runway which handles the Main Traffic and a secondary runway to handle the Private Jet Operations and Charter Operations. Those secondary runway doesn't always need to be matching the Main runway Specifications as the Load will be very much lesser than the Main Runway. Hence, the Pervious Concrete could be used in this type of runways.

The project will be focusing on studying the behaviour of the Pervious Concrete used in the Airport Runway pavements which is being designed to handle the small jets and Bombardier type aircrafts.

2.METHODOLOGY

This with the procedures such as study and Analysis of site, Collection of soil parameters, Traffic Control Options and Design of Structural Components as shown in Figure . The explanations of flow chart are mentioned below.



III. LITERATURE REVIEW

3.1 INTRODUCTION

This chapter deals with the literature that were collected and studied for the project. So many articles have been collected which are grouped under sub headings. The Abstract & Main points of the articles are described in paragraphs.

3.2, MATERIALS

3.2.1 POROUS CONCRETE

Ms. Rita et al, (2006) have examined and published that Porous concrete or pervious concrete consists of no-fines, open-graded Portland concrete mixture usually with 15–25% voids, which enables water to be drained quickly. The authors have identified that the as a material the Porous Concrete is generally used in the low traffic zones like the Parking Bays, Pedestrian Walks, walking trails etc. Although, it is noted that layer of pervious concrete over a base of normal concrete base will of result in the reduction of hydroplaning and tyre spray. The most important properties are i) Noise Reduction ii) Drainage iii) Skid Resistance iv) Strength and Stiffness v) Service Life etc. This paper reports about the aggregate selection and the grading to achieve the porosity of Max. 25% and Min 15%. Also, the adequate amount of cement has to be present inorder to bind the aggregates. This study concludes that the Porous Concrete could be used as the wearing course in the Runways.

3.2.2 SILICA FUME

Mr.Prakash, et al (2018) in their paper studied about the Silica Fume usage in the Porous Concrete. In this study it is known that the Porous concrete should have 30% void conente. The size of the aggregate to be used should be small. The addition of silica fume & fly ash was assigned as 5%-5%, 10%-10%, and 15%-15% by volume of cement and the mechanical properties like compressive strength, flexural strength and split tensile strength were evaluated.

Mr.GoranAdil, et al (2020), have concluded that the Anecdotal evidence has suggested that silica fume is beneficial for improving pervious concrete strength and durability. The Cement paste is the deciding factor in the Pervious concrete i) Performance ii) Workablity iii) Compacts etc. and admixture will represent field-placed pervious concrete were used to provide baseline behavior. Porous Concrete created with fixed compaction energy, changes in workability are reflected in the Porosity and performance.

In the result the paper concludes that the 5% addition of silica fume will give the possibly better performance.

3.2.3 GROUND GRANULATED BLAST FURNACE SLAG

Mr.AnandBabu, et al (2018) through the investigation have concluded that Pervious concrete is a light weight concrete containing voids in the range of 14 to 31%. The usage of pervious concretes has been in- creased due to its merits on pollution control and environmental considerations. The pervious concretes are also used to reduce the storm water runoff and recharges the underground water table. Eventhough the pervious concrete has lot of merits, it also has consider- able demerits related to strength issues. In order to achieve the strength high cement content mixes may be incorporated which is not a viable solution. In this paper, geopolymer technology has been used to develop pervious concrete.

Geopolymer pervious concrete is produced using GGBS as raw material and sodium hydroxide and sodium silicate as activator solution. Five mixes have been developed with varying GGBS content of 450 to 490 kg/m3 at 10 kg/m3 intervals.

The ratio of cement aggregate is maintained at 1:3 for all the mix and the water cement ratio is kept constant at 0.3. The compressive strength revealed that strength of around 20 MPa was attained for all the mix and similarly the compressive strength increased with increase in the GGBS content. There was not significant changes in the permeability property since the aggregate cement ratio is maintained.

Mr.VenkateswarRao et al (2016) thin their extensive paper which has the objective to study the role of silica fume and GGBS on concrete strength characteristics of a high-strength test program has been accomplished. Concrete with different design mix were casted and tested with cement replacement of 0% to 40% of GGBS with active silica fume 0% to 15% . To find the optimal replacement GGBS with Silica Fume in M60 grade concrete with maintaining water cement ratio of 0.32 .

3.3 AIRPORT PAVEMENT LOAD

Krzysztof Blacha, et al (2020) identified that contact area of the wheel and the runway is the main safety measure in the airport operations.

The pressure range from 200 to 800 kPa is where the tires tested. The Wheel load on the runway is max. 4.0 kN. It is evident through the tested that there is influence of the tyre pressure value and the pressure on contract area

IV MATERIALS & METHODS

4.1 COMPONENTS AND SPECIFICATION OF RUNWAY

In most of the Airports the Runway belongs to the Rigid Type Pavement and the another type of least used type is Flexible Pavement.

In all the Runways there are three Basic Layers to be laid as mentioned they are:

Subgrade – In Situ Soil

Sub-Base – Moderate Strength Inexpensive Natural Material

Base/ Surface – Asphalt, Bituminous Concrete, PCC etc

All the runways are graded as PCN: Pavement Classification Number which is a five part code associated to any section of the Airport Pavements

The Sample PCN Number is 27/F/A/W/T

The First Digit is the PCN Numerical Value which represents the load carrying capacity of the pavement

First Letter indicated the Rigidity of the pavement R for Rigid and F for Flexible pavements.

Second Letter expresses the strength of the underneath subgrade section. A represents the High to D represents ultralow

Third Letter is the indicator for the Maximum tyre pressure that the pavement can support.

W – No pressure Limit

X – 1.5 Mpa

Y- 1.0 Mpa

Z – 0.5 Mpa

The Fourth Letter describes how the PCN numerical value was determined

T Indicates technical evaluation & U Indicates usage

4.2 APPROXIMATE CONCRETE STRENGTH CALCULATION

The Minimum Strength required for the Pervious Concrete to be used in the Airport Runways could be identified by using the total load of the Aircraft.

Let us take the Total Load of the Bombardier Aircraft

Total Weight of the Aircraft	= 40,000 Kg (Full Capacity)
No. of Wheels in the Aircraft	= 06 Wheels (4 Rear & 2 Front)
Weight on Each Wheels	= 6,666 Kg Per Wheel
Weight in kN	= 65.37 kN
Tyre Contact Area	= (2 Inch x 6.25Inch) = 12.50
Load per sq Inch	= 5.2296 ~ 5.3 kN/sq. inch
Load in PSI	= 1191.48
F.O.S	= 2 (As per AAI)
Max Load of Pavement	= 2382 PSI ~ 2500 PSI
Required Concrete Strength	= More than 2500 PSI
Min. Grade of Concrete	= M20

Hence, as per the Theoretical Calculation the Min. Strength of Concrete Required is said to be 20 MPa.

4.3 SITE STUDY AND ANALYSIS

In this project we will be testing the pervious concrete for the Airport Runways. Hence, we could take the Chennai International Airport runway 2 for our Design consideration.

The Runway 2 is mainly used to accommodate the small airplanes and the Private Charter planes. The Runway 2 has the capacity to handle the Airplanes having Gross weight less than 40000 Kg. Currently the Runway 2 is having the asphalt concrete with the concrete thickness of 350 mm in the top layer.

As per the details received available in the internet, it was understood that the total length of the runway is 2,925 meters i.e 2.92 K.M. The runway is of PCN 68/F/A/W/T which could handle the Aircrafts of Bombardier Dash series and Small jet planes.

The CBR value of the subgrade soil in the site is observed as 82. Since taking the samples for testing in the sensitive area is very much difficult, the data is gathered from Internet and the nearby residential area.

Further Site Study will be done in the second phase of the Project through an IPT or Internship in AAI on availability of permission from the Govt. Authorities

5. DICUSSION

The first phase of the Project wholly comprises of the Theoretical Studies and the Literature Reviews. During this study we could identify that the Minimum Compressive Strength required for the Airport Runway Pavement to handle the small Aircrafts. On the other had as per the literature reviews the Nominal Compressive strength of Porous Concrete with Mix Design as same as normal concrete by eliminating the fine aggregate gives 12 Mpa.

Similarly, in the other studies of Normal Concrete, the addition of the GGBS increases the compressive strength of the Concrete.

In this phase of the project the following salient points were considered before arriving the conclusion

Theoretical Load on Pavement Calculation

Pervious Concrete Properties

Effect of Silica Fume in the Normal Concrete

Effect of GGBS in the Normal Concrete

Efficiency when GGBS and Silica Fume when added together

All the above-mentioned parameters are compared theoretically, and the conclusion is arrived but it has to be tested practically which will be done in the Second phase of the Project

CONCLUSION

Based on the theoretical study it is very likely to conclude that the Pervious Concrete could be used in the Runway Pavements.

After undergoing literature review on various topics, it is possible to conclude that the pervious concrete with various admixtures could be experimented in the Airport Runway.

The GGBS and the Silica Fume both when used in the PCC is said to increase the Compressive strength by 10 % to 20% but their actual mix proportions have to be identified experimentally.

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