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An Experimental Study of Pervious Concrete Pavement

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ABSTRACT
The aim of this project is to check the performance of the pervious concrete pavement. Typically pervious concrete has no fine aggregate and has just enough cementing paste to coat the coarse aggregate particles while preserving the interconnectivity of the voids. The properties of the aggregate are tested. In this project cubes of 150mm x 150mm x 150mmsize are caste with three categories of SET A, SET B, SET C coarse aggregates with same W/C ratio. Testing of cubes at the ages of 7, 14 and 28 days. The corresponding compressive strengths are noted. Pavement slab is designated as per IRC SP62:2004.This project conducted experimental studies on the compressive strength on pervious concrete as it relates to water-cement ratio, aggregate-cement ratio, aggregate size, and compaction.

Key words: Pervious concrete, compressive strength, water-cement ratio

I. INTRODUCTION

Generally normal concrete is its high density. No-fines concrete also known as porous concrete, pervious concrete, zero slump concrete etc. which is partially a solution to high density of concrete is made without fine aggregate in conventional concrete. No-fines concrete dramatically reduces environmental degradation and the negative effects associated with urban sprawl. Pervious concrete is becoming one of the most viable solutions. It helps to prevent run off. The no fines concrete pavement consists of a concrete slab over a clean aggregate sub base, a filter fabric and a permeable sub grade.

The sub grade material is important, as it is required to be permeable to allow the water in the sub base to penetrate the soil. The sub grade material has to contain a set of favourable properties relating to permeability, support and moisture content while the sub base requires a homogeneous materials with set of properties. The permeability of sub grade is important as it dictates the effectiveness of no fines concrete pavement. Prior to the place of no fines concrete pavement the sub grade has to be tested for rate of permeability with a suitable sub grade permeability test. Malhotra, V.M., "***No-Fines Concrete – Its Properties and Applications***", conducted the experiments on pervious concrete applications and Properties such as water cement ratio, aggregate cement ratio, compaction, and curing time. He concluded that the compressive strength of pervious concrete was dependent on the water cement ratio and the aggregate cement ratio.
The objective of the present study is to check the performance of no fines concrete on various sizes of aggregates .

II. MATERIAL AND METHODS

Concrete is the most important material for construction purposes and cement is the most expensive ingredient in it.. Due to the absence of fine aggregate in no fines concrete, there is a high percentage of void space which results in high permeability. The unit weight, drying shrinkage and hydrostatic pressure for no fines concrete is less compared to conventional concrete. Due to the less cement content in no fines concrete, the cost of the overall project reduces. This project cube of 150 mmxl50 mm x 150 mm size are caste with three categories of SET A, SET B, SET C

The cubes are tested and their corresponding Compressive strengths and densities are noted. The objective of trying various ratios and their combinations is to arrive at a mix for M20 grade concrete and design a pavement with the mix.
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1. Cement: concrete mix by volume is taken as 1:4.
2. Ordinary Portland cement of 53 grades
3. Aggregates of sizes SET A, SET B, SET C are taken

SETA (20mm Nominal size aggregates)
SET B (20mm passing and 10mm Retained aggregates)
SET C (10mm passing and 4.75mm retained aggregates)

4. Water/cement ratios are limited to 0.4.
5. Testing of specimens at the ages of 7, 14, 28 days.

PROPERTIES OF PERVIOUS CONCRETE PAVEMENT

1. FRESH PROPERTIES

The plastic pervious concrete mix is stiff compared to traditional concrete. Slumps, when measured, are generally less than ¾ inches (20mm), although slumps as high as2 inches (50mm) have been used. When placed and compacted, the aggregates are tightly adhered to one another and exhibit the characteristic open matrix.

Mixtures are approximately 70% of traditional concrete mixtures. Concrete working time is typically reduced for pervious concrete mixtures. Usually, one hour between mixing and placing is all that is recommended. However, this can be controlled using retarders and hydration stabilizers that extend the working time by as much as 1.5 hours, depending on the dosage.

2. HARDENED PROPERTIES

Density and Porosity

The density of pervious concrete depends on the properties and proportions of the materials used, and on the compaction procedures used in placement. In-place densities on the order of 100 lb./ft^3 to 125lb./ft^3(1600kg/m ^{3} to 2000kg/m^3) are common, which is in the upper range of lightweight concretes. A pavement 5 inches (125mm) of a sustained rainstorm in its voids, which covers the vast majority of rainfall events in the U.S. when placed on a 6 inch(150mm) thick layer of open-graded gravel or crushed rock sub base, the storage capacity increases to as much as 3 inches (75mm)of precipitation.

Permeability:

The flow rate through pervious concrete depends on the materials and placing operations. Typical flow rates for water through pervious concrete are 120 l/m^2/min or 0.2 cm/s to 320 l/m^2/min or 0.54 cm/s with rates of up to 700l/m^2/min. even higher rates have been measured in the laboratory.

Flexural Strength

Flexural strength in pervious concrete generally ranges between about 1Mpa to 3.8 MPa. Many factors influence the flexural strength, particularly degree of compaction, porosity, and the aggregate-to-cement ratio.

Shrinkage

Drying shrinkage of pervious concrete develops sooner, but is much less than conventional concrete. Roughly 50% to 80% of shrinkage occurs in the first 10 days, compared to 20%to30% in the same period for conventional concrete.

Abrasion Resistance

Most pervious concrete pavements will have a few loose aggregates on the surface in the early loosely bound to the surface initially, and popped out because of traffic loading. After the first few weeks, the rate of surface raveling is reduced considerably and the pavement surface becomes much more stable. Proper compaction and curing techniques reduce the occurrence of surface raveling.

compression test : As per IS: 516– 1959
The cubical mould of size 15cm x 15cm x 15cm is taken. Cement: concrete mix by volume is taken as 1:4.The concrete is poured in the mould. These specimens are tested by compression testing machine after 7, 14 and 28days of curing. Load is applied gradually at the rate of 140kg/cm^2 .Load at the failure divided by area of specimen gives the compressive strength.

SETA **SET B** **SET C**

III. RESULT AND DISCUSSION

The figure 1, 2 and 3 represents the average compressive strength of cubes with W/C ratio 0.4 for SETA, SETB and SETC.The results are consolidated and average values of the three samples are calculated to obtain the design for M20 grade pervious fines concrete.

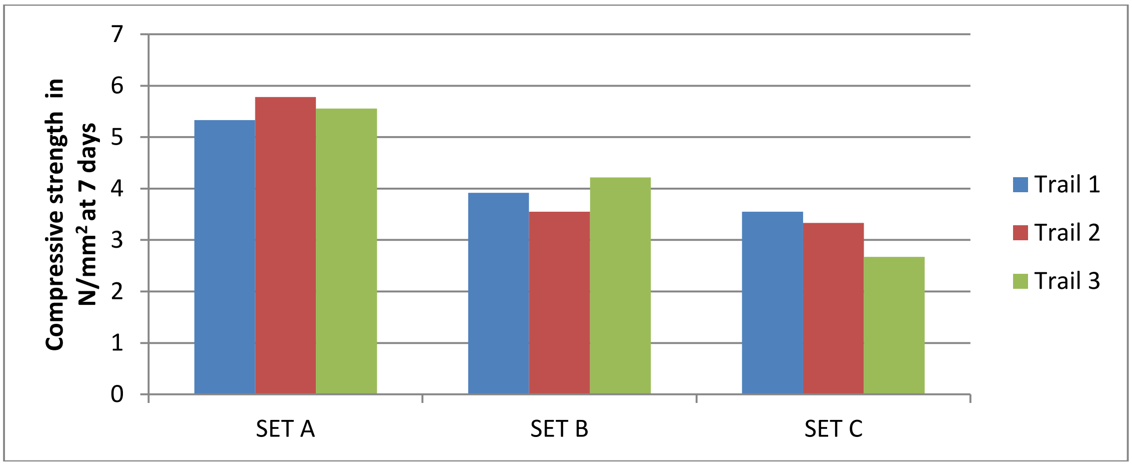

Fig.1.Compression test of cubes for 7 days

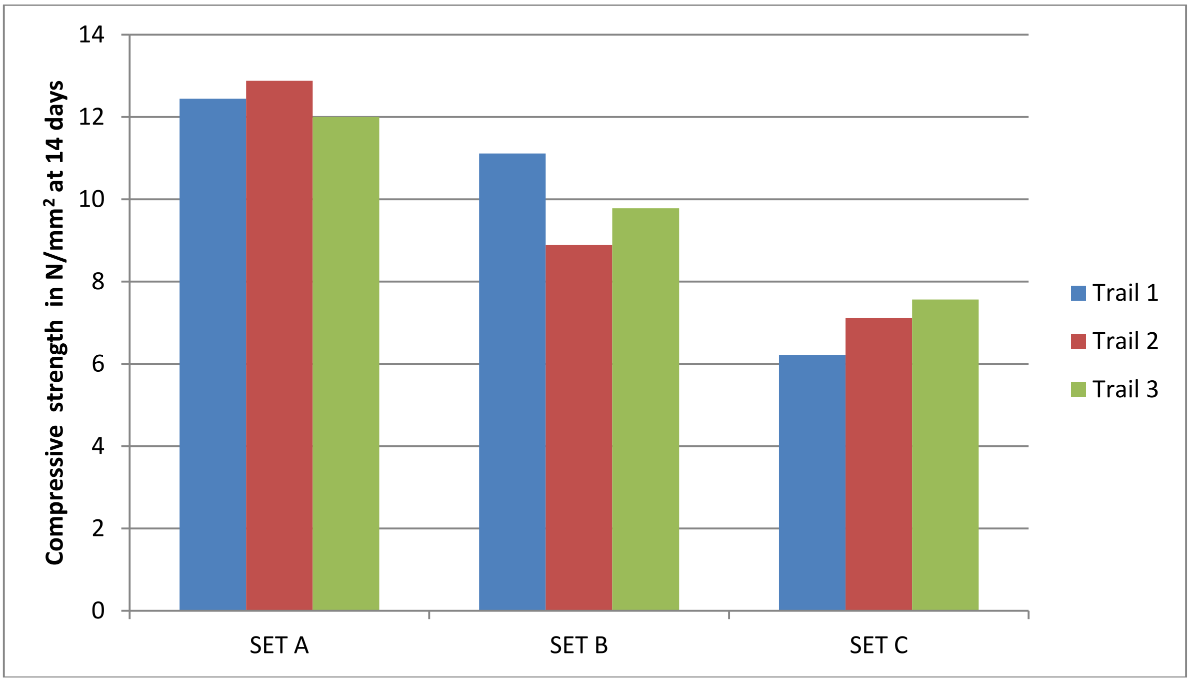

Fig.2.Compression test of cubes for 14 days

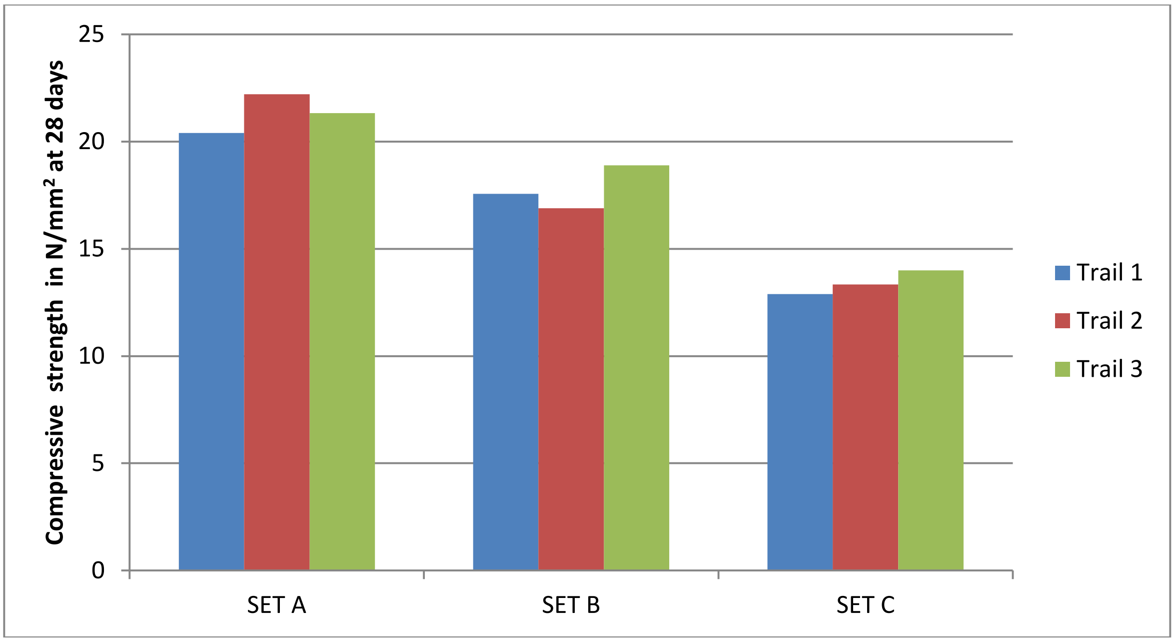

Fig.3.Compression test of cubes for 28 days

IV. CONCLUSION

Based on the study, the following specific and general conclusion can be drawn.

1. M20 grade no fines concrete with a density of about 21 KN/m^3 can be obtained by the following mix proportions.

Cement: Course aggregate 1: 4
Course aggregate 20 mm nominal size aggregate
Water to cement ratio 0.45
Water: Potable water

2. Assuming a uniform distribution of material and density of normal concrete to be 24 KN/m3, it can be observed that there is a reduction of 12.5% in the density of no-fines concrete. Hence there would also be an increase in the water absorption of this concrete by 12.5 %.
3. Determination of the water absorption of the no-fines concrete by conventional method was very difficult as water was not being retained. Hence, it has to be determined by finding immersed weight of the Concrete in water.
4. The mix proportions for no-fines concrete depends predominantly on the final application. In building applications, the aggregate-cement ratio used is leaner, usually ranging from 6:1 to 10:1 where strengths ranging from 5 MPa to 15 MPa are obtained. This leaner mix ensures that the void ratio is high and prevents capillary transport of water. However, in pavement applications the concrete strength is more critical and aggregate-cement mixes as low as 4:1 has to be used. This lower ratio ensures an adequate amount of bonding between the aggregate and cement to withstand the higher loads.
5. Flexural strength of pervious concrete ranges between 1.5and 3.5 MPa.
6. The general range for water-cement ratio is between 0.38 and 0.52 (Neville 1997). From

Study it was observed that 0.45 w/c ratio is ideal for No fines concrete.

No-fines concrete has properties capable of being used in road pavement applications. In spite of having low Compressive strength, it still has favorable properties that can be utilized in road pavement applications. The mix proportions and water content are critical when obtaining a sufficient bond between the aggregate particles.

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