PERFORMANCE EVALUATION OF PERVIOUS CONCRETE USING SUPPLEMENTARY CEMENTITIOUS MATERIALS

Anjana Shaju[1], Arathy M Nair[2], Chikku Gigi[3], Feba Baby[4]
[1]U.G. Student, Department of Civil Engineering, MITS Ernakulam.
[2,3,4]U.G. Student, Department of Civil Engineering, MITS Ernakulam

Abstract

Pervious concrete is a special type of concrete, which consists of cement, coarse aggregate, water and if required, admixtures and other cementitious materials. As there are no fine aggregates used in the concrete matrix, the void content is more which allows the water to flow through its body. In this research, the strength requirements of pervious concrete is studied by replacing cement by supplementary cementitious materials like quartz powder silica fume and ground granulated blast furnace slag. The effective utilisation of these waste materials helps to reduce the environment pollution to a greater extend. The powders were optimised using particle packing approach which involves the selection of combination using maximum packing density. Using the selected mineral admixture the strength is improved economically.
Keywords: Pervious concrete, cementitious materials, packing density

I. INTRODUCTION

Concrete is a versatile material that can be cast easily and economically to meet a variety of needs and formed to any shape. Rapid urbanization leads to construction of impervious surfaces using cement concrete. A larger amount of rainwater ends up falling on impervious surfaces such as parking lots, driveways, sidewalks, and streets rather than soaking into the soil creating an imbalance in the natural ecosystem and leads to a host of problems including erosion, floods, ground water level depletion and pollution of rivers, lakes and coastal water. Switching to pervious concrete as a solution to avoid these problems is of worldwide concern. Since pervious concrete consists of little or no fines, void content is more. Instead of preventing infiltration of water in to the soil, it assists the process by capturing rain water in to the network of voids and allowing it to percolate in to the underlying soil. Pervious concrete also naturally filters water from rainfall or storm and can reduce pollutant loads entering into streams, ponds and rivers. So in this way it helps in ground water recharge. Thus it eliminates the need for retention ponds and other costly storm water management devices creating an efficient land use method. But the strength and durability of pervious concrete is low as compared to normal concrete, hence its use is limited in high speed roads and roads subjected to heavy loads. As cement industry is one of the most polluted industries due to CO_2 emission and it consumes lots of non-renewable energy, if partial or full replacement of ingredients of cement is preformed, then there is a change in strength and durability, reduction in CO_2 emission and thus we can protect our environment. Quartz powder, silica fume and GGBFS are waste materials from certain industrial process; they are simply dump on outskirts, leads to environmental pollution and land use issues. Some of this are cementitious and pozzolanic. Replacing cement by these materials partially or fully, will leads to sustainable development and good in economic consideration.

II. MATERIALS AND PROPERTIES

Cement, coarse aggregate, water, supplementary cementitious materials and superplasticer were the constituent materials used in pervious concrete. Portland pozzolanic cement, 53 grade was used for casting of the specimen which has a specific gravity of 2.80. Coarse aggregate was crushed granite stones conforming to graded aggregate of nominal size 20 mm with specific gravity 2.74 and water absorption 1%. The supplementary cementitious materials were silica fume, blast furnace slag and quartz powder with specific gravities 2.23, 2.85 and 2.65 respectively.

III. METHODOLOGY

A. OPTIMISATION OF MINERAL AND CHEMICAL ADMIXTURES IN CEMENT

1. Optimization of mineral admixture dosage

The first phase involves the optimization of mineral admixture dosage. Mineral admixtures are proportioned in order to optimize the paste for its best flow properties. Since the packing density of cement mixtures and the flow properties of the corresponding fresh concrete are related, concept of particle packing was used to optimize the mix. Puntke test has been used to maximize the packing density of the paste with various level of replacement by mineral admixtures. Various replacement levels adopted was 5, 10, 15, 20, 25 % replacement of volume of cement by supplementary cementitious materials.

2. Optimizing chemical admixture dosage

The chemical admixture used was PCE. Optimization is being done using the concept of rheology. For this investigation, Mini slump test was used. Mini slump was used to perform the optimization because of the simplicity of the test. For the same reason, this test is a part of various international standards to establish guidelines for flow behaviour. The combination of cement and mineral were used to carry out these experiments. The dosage giving Maximum Slump flow without segregation in Mini Slump test was selected as the optimum dosage.

B. FLEXURAL STRENGTH TEST

The test was conducted in flexural testing machine and was carried out in beams of size 50cm X 10cm X 10cm. The concrete was gushed into the mould and compacted. After 28 days of curing, load was applied to the specimen by two point loading in the flexural testing apparatus. Load was applied until the specimen fails.

C. SPLITTING TENSILE STRENGTH TEST

After 28 days of curing, the specimen was taken out and sides were wiped for the test. Aligned the specimen and load was applied continuously without shock at a rate of approximately 14-21 kg/cm^2/minute.

D. COMPRESSIVE STRENGTH TEST

For compression test, cylindrical moulds of diameter 150mm and height 300mm are used. After the cylinder has been casted, it was kept for 28 days of curing. Placed the specimen vertically on the platform of the compression testing machine. Load was applied gradually without shock and continuously at the rate of 315 kN /min till the specimen fails. The maximum load was recorded.

IV. RESULTS AND DISCUSSIONS

A. OPTIMIZATION OF MINERAL ADMIXTURE

Cement was replaced by supplementary cementitious materials and packing density of various combinations were determined.

1. Optimization of quartz powder

Initially the packing density was increased till 15% replacement. This could be attributed to the fact that the supplementary cementitious materials filling up the voids between the cement particles. Maximum packing density (55.40) was obtained at 15 % replacement of cement by quartz powder.Subsequently the packing density gradually decreased due to the loosening effect imparted by the powder.

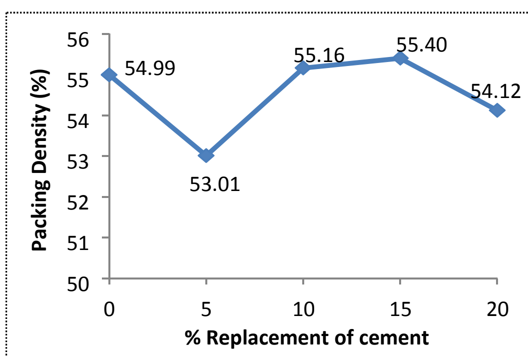

Fig. 3.1 Optimization Curve For Quartz Powder

2. Optimization of Silica fume

Maximum packing density (56.49) was obtained at 15 % replacement of cement by both quartz powder and silica fume. Subsequently the packing density gradually decreased due to the loosening effect imparted by the powder.

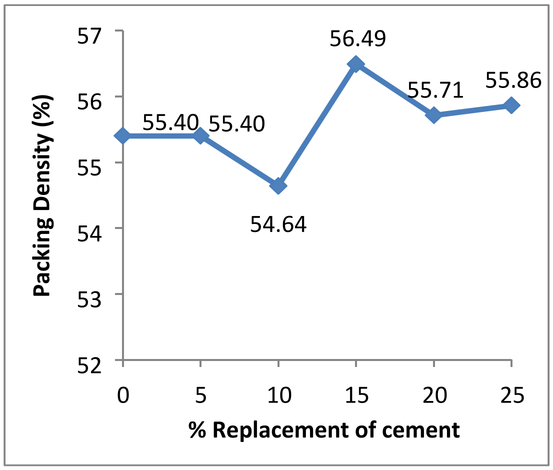

Fig. 3.2 OptimizationCurve for Silica Fume

3. Optimization of GGBFS

The packing density was increased till 15% replacement of cement by the each of quartz powder, silica fume and GGBFS. This could be attributed to the fact that those supplementary cementitious materials filling up the voids between the cement particles. Subsequently the packing density gradually decreased due to the loosening effect imparted by the powder.

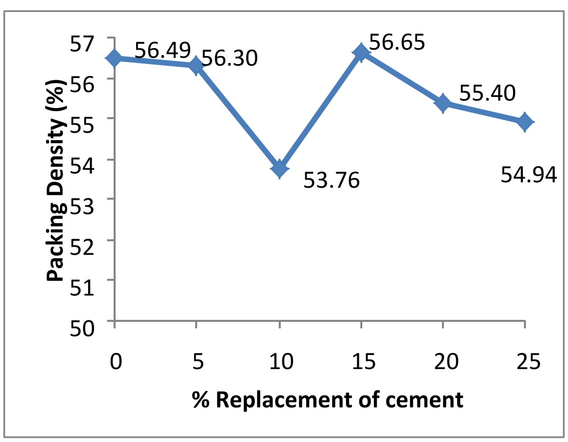

Fig. 3.3 OptimizationCurve forGGBFS

B. OPTIMIZATION OF CHEMICAL ADMIXTURE

A graph was plotted between mini slump flow and varying dosage of chemical admixture. The optimum dosage was obtained as 0.38 with, since it results in maximum flow without bleeding.

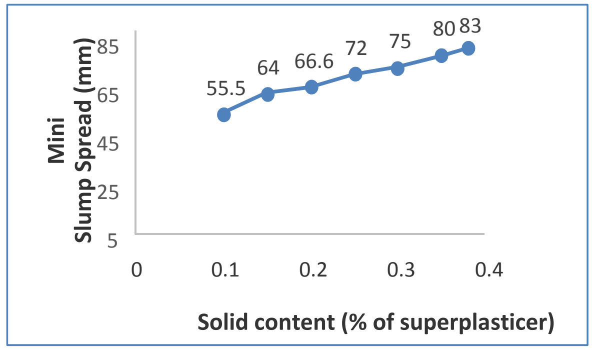

Fig. 3.4 Optimization Curve for Chemical Admixture

C. COMPRESSIVE STRENGTH

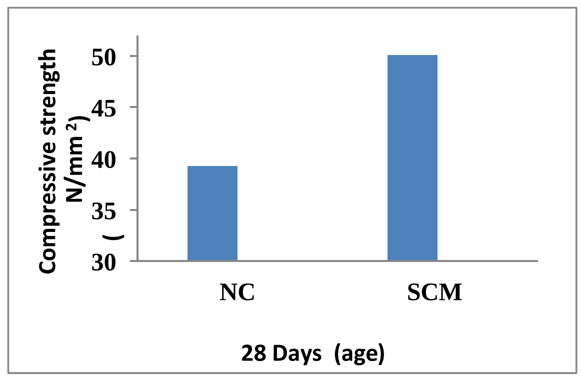

Fig. 3.5 Variation of Compressive Strength

D. FLEXURAL STRENGTH

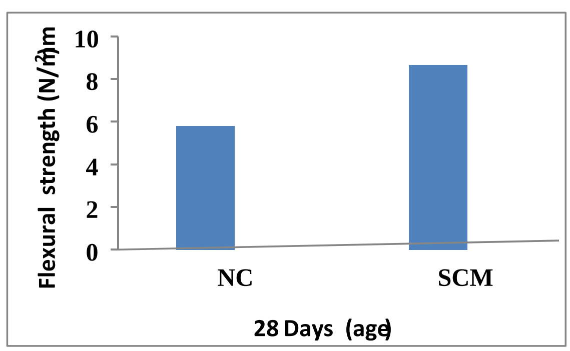

Fig. 3.6 Variation of Flexural Strength

E. SPLITTING TENSILE STRENGTH

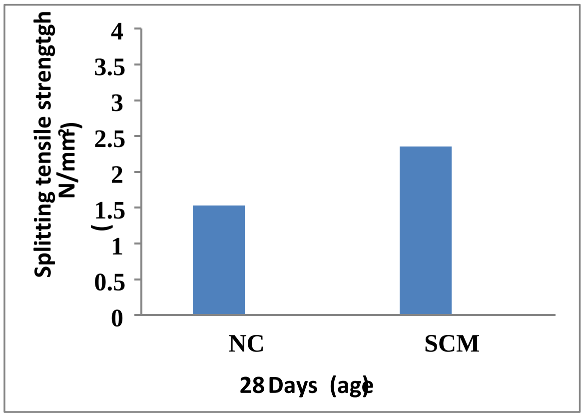

Fig. 3.7 Variation of Splitting Tensile Strength

V. CONCLUSIONS

The conclusions drawn from the present study are;

1. The compressive strength results of concrete mixes revealed that concrete with 15 % of each supplementary cementitious material (SCM) has 27% increment in compressive strength than control mixture at 28 days. This is due to the enhancement of pozzolanic activity with passage of time.
2. The flexural strength and splitting tensile strength of SCM concrete was more than control concrete due to enhanced calcium silicate hydrate (C-S-H) formation.
3. The cement can successfully be replaced by 15% by volume of quartz powder, silica fume and GGBFS.
4. The above replacement results in improved hardened properties of concrete.

VI. REFERENCES

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