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Experimental Study on Mechanical Properties of Pervious Concrete by Using Silica Fume and Super Plasticizers

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ABSTRACT

Concrete is a widely used structural material consisting essentially of a binder and a mineral filler. . Pervious concrete is a type of concrete that has a low water-cement ratio and contains none or very little amount of sand. Pervious concrete has low installation costs. In addition, it filters the storm water thus reducing the number of pollutants entering the rivers and ponds. Pervious concrete also improves the growth of trees. In the present study the behavior of pervious concrete has been studied experimentally. Various mix proportions were prepared by replacing cement with silica fume (6% by the weight of cement), by adding super plasticizers (0.13% & 0.25%) and varying size of aggregates. The water-cement ratio was kept constant 0.34. Different properties of pervious concrete e.g. workability, compressive strength, split tensile strength, flexural strength test at 7, 28 & 56 days and bond strength tests at 28 & 56 days have been studied experimentally. Experimental results showed that strength of pervious concrete decreased with the addition of silica fume (6%) and super plasticizers (0.13% & 0.25%). The mix proportions with aggregates size (4.75 mm to 10 mm) gives higher strength when compared to mixes with aggregates size (10 mm to 20 mm) and (4.75 mm to 20 mm) respectively.

KEYWORDS: *Cement, Granite powder, Crushed Tiles. concrete, Pervious concrete, compressive strength, Split tensile strength, Flexural strength, Bond strength..*

I. INTRODUCTION

Concrete is the most common used building material in the world. It is estimated that the present consumption in the world is 10 billion tones every year, A large amount of rain water ends up falling on impervious surface such as parking lots, driveways rather than soaking into the soil. This creates an imbalance in the natural ecosystem and leads to a host of problems including erosion, floods, ground water level depletion and Pollution Rivers, lakes and coastal water. A simple solution to avoid these problems is to stop constructing pavement conventional concrete or asphalt and switch to pervious concrete or porous pavement, a material that offers the inherent durability and low-cycle costs of a typical concrete pavement. While retaining storm water runoff and replenishing local watershed systems. The present work involves systematic study of fresh and hardened properties of pervious concrete using different sizes of coarse aggregate with low water cement ratio 0.38. The cement aggregate ratio has taken as 1:4.Different proportions has been taken by replacing cement with silica fume by 6% of it's weight and different percentage of super plasticizers has been added with a different percentage of 0.25% and 0.13%.

II. EXPERIMENTAL PROGAMME

2.1 General

Pervious concrete is a mixture of coarse aggregate, cement, water and little to no sand. A typical pervious concrete pavement has a 15-25% void structure. Table 3.1 shows the typical material proportions of pervious concrete. Detailed study of the experimental work on pervious concrete has been discussed in this chapter. Different mix proportions by replacing cement with silica fume (6%) and addition of super plasticizers (0.13% &0.25%) have been used for studying properties of fresh and hardened pervious concrete. A concrete mix with cement, coarse aggregates ratio 1:4 and water cement ratio of 0.34 has been taken as control mix in the present study.

2.2 Batch Specifications

Four batches of 150 mm x 150 mm x150 mm cubes, 150 mm x300 mm cylinders, 450 mmx100 mm x 100 mm beams and 150 mmx300 mm cylinders with 12mm diameter bars were prepared. Three controlled mix proportions were prepared with different size of aggregates and without any admixture. Table 2.1 shows different mix proportions used in the present study. The ratio of cement to coarse aggregates has been taken as 1:4 & the w/c (0.34) has been kept constant for all the mix proportions.

Table 2.1 Mix Proportions

Mix NO.	Aggregate Size in mm	Silica Fume %	Super Plasticizers %
M1	4.75 TO 10	-	-
M2	10 TO 20	-	-
M3	(4.75 TO 10)+(10 TO 20)	-	-
M4	4.75 TO 10	-	-
M5	10 TO 20	6	-
M6	(4.75 TO 10)+(10 TO 20)	6	-
M7	4.75 TO 10	6	0.25
M8	10 TO 20	6	0.25
M9	(4.75 TO 10)+(10 TO 20)	6	0.25
M10	4.75 TO 10	6	0.13
M11	10 TO 20	6	0.13
M12	(4.75 TO 10)+(10 TO 20)	6	0.13

2.3 Cement

Ordinary Portland cement of 43 grades conforming to IS: 8112-1989 was used. The cement was tested as per IS 4031-1968. Table 3.4 shows the physical properties of cement.

Table 2.2 Physical Properties of Cement

S.No	Property	Observed value
1	Fineness %	5
2	Initial setting time	158 min
3	Final setting time	208 min
4	Specific Gravity	3.11

2.4 Coarse aggregate

Locally available crushed angular coarse aggregates have been used in the present study.

Table 2.2 Physical Properties of Coarse aggregate (4.75 mm to 10 mm)

S.No	Property	Observed value
1	Specific Gravity	2.38
2	Fineness modulus	6.7
3	Bulk Density(Loose), kg/m^3	1480
4	Bulk Density(Compacted), kg/m^3	1542

Table 2.3 Physical Properties of Coarse aggregate (10 mm to 20 mm)

S.No	Property	Observed value
1	Specific Gravity	2.545
2	Fineness modulus	6.57
3	Bulk Density(Loose), kg/m^3	1501
4	Bulk Density(Compacted), kg/m^3	1563

Table 2.4 Physical Properties of Coarse aggregate (4.75 mm to 20 mm)

S.No	Property	Observed value
1	Specific Gravity	2.8
2	Fineness modulus	7.1
3	Bulk Density(Loose), kg/m^3	1471
4	Bulk Density(Compacted), kg/m^3	1609

2.5 Water

The water to be used for casting should be free from organic matter. Potable water is generally considered satisfactory as per clause no. 5.4 of IS 456-2000. Tap water available in the laboratory was used for mixing the ingredients of concrete and curing of the specimens.

2.6 Super Plasticizers

Cico plast super is used for producing extremely flowable concrete, pumped concrete, pre-stressed and denser concrete as well as in industrial / commercial flooring and floor toppings.

2.7 Silica Fume

Table 2.5 Physical Properties of Silica fume

S.No	Property	Observed value
1	Fineness %	Below 45 microns
2	Specific Gravity	2.17
3	Colour	Light Grey
4	Moisture Content	0.1 to 3%

2.8 Steel Reinforcement

12 mm diameter HYSD bars of grade Fe 415 confirming to IS: 2502-1963 has been used in the present study for pull-out test.

2.9 Casting of Specimens

Silica fume was used to replace cement in the mix as 6% by the weight of cement. The mixing of ingredients was done manually. Workability was measured by slump test, compaction factor test and flow table test. The test specimens 150 mmx 150 mm x150 mm cubes for the compressive strength, 150 mm x300 mm cylinders for split tensile and 450 mm x100 mm x100 mm beams for flexure strength and 150 mmx 300 mm cylinders with 12mm diameter steel bar embedded upto 200mm from top for bond strength were prepared. The specimens were cast according to IS: 516-1959. The specimens were tested at the age of 7, 28 and 56 days. The aggregates used were in saturated, surface-dry condition. The test procedures were followed as per relevant Indian standard specifications. The batching was done by weight.

2.10 Workability

A number of different methods are available for measuring the workability of fresh concrete, but none of them is wholly satisfactory. Each test measures only a particular aspect of it and there is really no method which measures the workability of concrete in its totality. However, by checking and controlling the uniformity of the workability it is easier to ensure a uniform quality of concrete and hence uniform strength for a particular job. In the present work, following test were performed to find the workability.

Fig 1 Slump test

2.11 Compressive strength test

The specimens were tested at the age of 7, 28 and 56 days. The cubes were tested on the universal testing machine after drying at room temperature according to IS 516-1959. The load was applied continuously without impacts and uniformly @140N/cm²/minute. Load was continued until the specimen failed and maximum load carried by the specimen was recorded. The compressive strength was obtained by considering the average of three specimens at each age.

Fig 2 Compressive test

2.12 Split tensile test

The split tensile strength is well known indirect tensile test used for determining the tensile strength of concrete. The tests were conducted at the age of 7, 28 and 56 days in CTM as shown in the fig.3.

Fig 3 Split Tensile Strength test

2.13 Flexural Strength test

The specimens were tested at the age of 7, 28 and 56 days in Universal Testing Machine (UTM).

Fig 4 Flexural Strength test

III. RESULTS AND GRAPHS

3.1 Workability

Table 3.1 Slump values in mm

Mix Number	Slump in mm
M1	175
M2	160
M3	150
M4	63
M5	60
M6	40
M7	160
M8	110
M9	127
M10	80
M11	70
M12	60

3.2 Compressive Strength test

Table 3.2 Compressive Strength in Mpa

	7 DYAS	28 DAYS	56 DAYS
M1	21.59	27.7	30.9
M2	17.23	20.5	23.2
M3	19.42	22.37	26.15
M4	16.29	25.56	23.48
M5	14.48	16.76	18.82
M6	15.81	19.19	20.7
M7	16.45	19.33	22.33
M8	14.67	16.19	19.56
M9	15.11	17.44	20.6
M10	16.11	19.14	21.33
M11	14.85	16.46	18.22
M12	15.37	17.33	20.1

3.3 Split Tensile Strength test

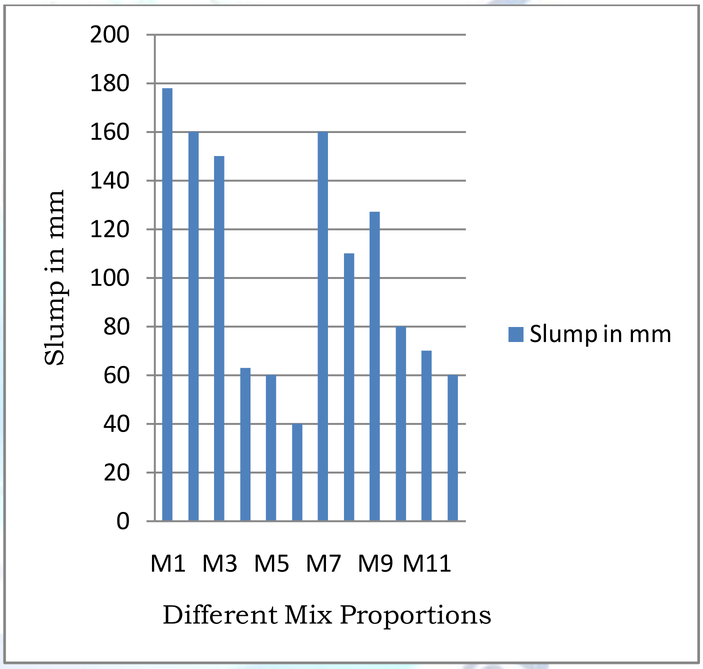
Table 3.3 Split Tensile Strength in Mpa

	7 DYAS	28 DAYS	56 DAYS
M1	1.72	2.31	2.58
M2	1.4	1.7	1.93
M3	1.62	1.86	2.23
M4	1.37	1.71	1.96
M5	1.21	1.39	1.57
M6	1.33	1.59	1.8
M7	1.35	1.59	1.86
M8	1.19	1.35	1.63
M9	1.26	1.51	1.72
M10	1.4	1.57	1.78
M11	1.24	1.37	1.52
M12	1.28	1.44	1.68

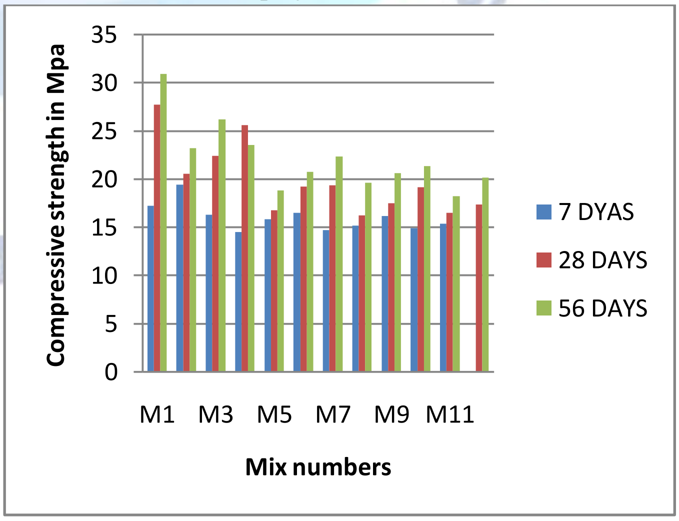
3.4 Flexural Strength test

Table 3.4 flexural Strength in Mpa

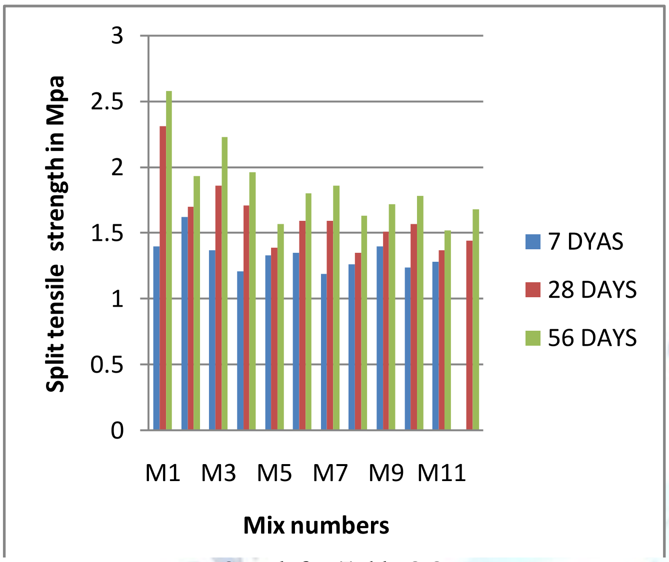
	7 DYAS	28 DAYS	56 DAYS
M1	3.92	4.13	4.37
M2	3.19	3.51	3.99
M3	3.38	3.6	4.23
M4	3.19	3.4	4.01
M5	2.7	2.99	3.7
M6	2.9	3.13	3.9
M7	3.4	4.3	4.9
M8	3.04	3.44	3.91
M9	3.31	3.75	4.2
M10	2.9	3.9	4.6
M11	2.3	3.2	3.85
M12	2.5	3.5	4.1



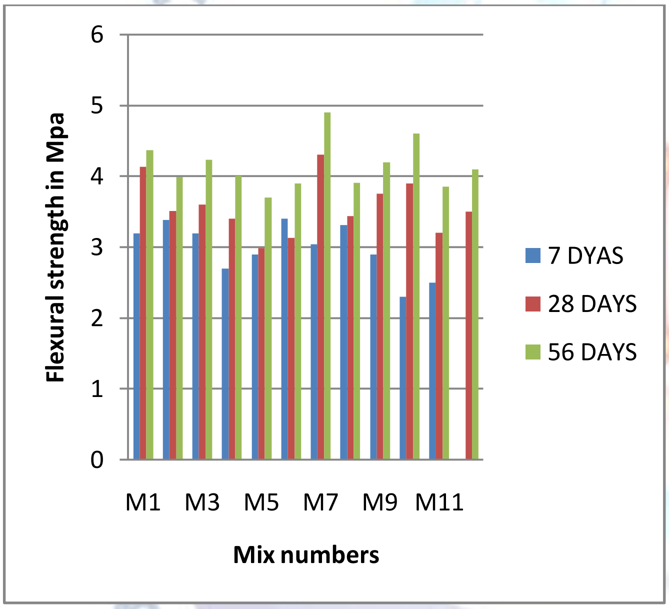
Graph for Table 3.1



Graph for Table 3.2



Graph for Table 3.3



Graph for Table 3.4

IV. CONCLUSION

1) Slump of Pervious Concrete Mix Proportions Decreased With the Addition of Silica Fume

2) Slump of pervious concrete mix proportions increased with addition of 0.25% of super plasticizers and again decreased with addition of 0.13% of super plasticizers.

3) The compressive strength of pervious concrete decreased by 25% with the addition of silica fume for small size aggregates (4.75 mm to 10 mm). The compressive strength of pervious concrete decreased by 27% and 28% with the addition of super plasticizers 0.25% and 0.13% respectively.

4) The compressive strength of pervious concrete decreased by 18% with addition of silica fume and also decreased 17% and 18% with the addition of super plasticizers 0.25% and 0.13% respectively for large size (10 mm to 20 mm) aggregates.

5) The compressive strength of pervious concrete decreased by 16% with addition of silica fume and also decreased by 21% and 22% with the addition of super plasticizers 0.25% and 0.13% respectively for all-in (4.75 mm to 20 mm) aggregates.

6) The split tensile strength of pervious concrete decreased by 23% with addition of silica fume and also decreased by 26% and 27% with the addition of super plasticizers 0.25% and 0.13% respectively for small size (4.75mm to 10mm) aggregates.

7) The split tensile strength of pervious concrete decreased by 16% with addition of silica fume and also decreased 16% and 17% with the addition of super plasticizers 0.25% and 0.13% respectively for large size (10mm to 20mm) aggregates.

8) The split tensile strength of pervious concrete decreased by 17% with addition of silica fume and also decreased 21% and 22% with the addition of super plasticizers 0.25% and 0.13% respectively for all-in (4.75 mm to 20 mm) aggregates.

9) The flexural strength of pervious concrete decreased by 21% with addition of silica fume and also decreased 10% and 8% with the addition of super plasticizers 0.25% and 0.13% respectively for small size (4.75mm to 10mm) aggregates.

10) The flexural strength of pervious concrete decreased by 11% with addition of silica fume and also decreased 3% and 7% with the addition of super plasticizers 0.25% and 0.13% respectively for large size (10mm to 20mm) aggregates.

11) The flexural strength of pervious concrete decreased by 6% with addition of silica fume and also decreased 3% and 3% with the addition of super plasticizers 0.25% and 0.13% respectively for all-in (4.75 mm to 20 mm) aggregates.

The aggregates size 4.75mm to 10mm has more compressive strength as compared to (4.75 mm to 20 mm) and 10 mm to 20 mm aggregates size.
12) The split tensile strength of aggregates size 4.75mm to 10mm has more strength than (4.75 mm to 20 mm) and (10 mm to 20 mm) aggregates size of various pervious concrete mix proportions.

13) The aggregates size 10mm to 20mm has low flexural strength than that of (4.75mm to 20mm) and (4.75mm to 10mm) aggregates size pervious concrete mix proportions.

14) The M4 and M7 can be used at places where moderate compressive strength is required e.g. pathways. These can also be used as sound absorbing walls in classrooms, auditorium etc. This can also be used at railway platforms. This will help in reducing water accumulation on railway tracks.

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