EFFECT OF SILICA FUME AND SUPER PLASTICIZER ON FRESH AND HARDENED PROPERTIES OF PERVIOUS CONCRETE

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Abstract- Pervious concrete is an environmental friendly building material which is quickly gaining recognition as a green building component. Pervious Concrete is a porous concrete which allows for rain and storm water runoff to percolate through it rather than flooding surrounding areas or storming drains. The present work involves systematic study of fresh and hardened properties of pervious concrete using different size of the aggregates with constant water cement ratio 0.34. The cement aggregates ratio has been taken as 1:4. Different properties such as workability, compressive strength, spilt tensile strength, flexural strength and bond strength of pervious concrete have been studied experimentally by replacing cement with silica fume (6% by weight of cement) and by adding super plasticizer (CICO PLAST SUPER) 0.25% and 0.13%.

Keywords- Concrete, Pervious Concrete, Silica Fume, Super Plasticizer

I. INTRODUCTION

Concrete is the most commonly used building material in the world. It is estimated that the present consumption of concrete in the world is of the order of 10 billion tonnes every year. Concrete is artificial stone made of Portland cement, coarse aggregates and fine aggregates and water. Aggregates are 65% - 80% of the volume of the concrete. Sand, gravel and crushed stone are the primary aggregates used. Sometime admixtures are added to improve the properties of the concrete. Concrete is a versatile material that can easily be mixed to meet a variety of special needs and formed to virtually any shape. [1].

Pervious concrete is an environmental friendly building material which is quickly gaining recognition as a green building component. It acts as a filter to trap and remove pollutants from rain run-off. This allows the sun's heat to evaporate volatiles leaving the remaining solids to be consumed by microbial action. Pervious concrete is concrete made by eliminating most or all the fine aggregates in the concrete mix, which allow interconnected void spaces to be formed in the hardened product. These interconnected void spaces allow the concrete to transmit water at relatively high rates. 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. This creates 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. A simple solution to avoid these problems is to stop constructing pavement with conventional concrete or asphalt and switch to pervious concrete or porous pavement, a material that offers the inherent durability and low life-cycle costs of a typical concrete pavement while retaining storm water runoff and replenishing local watershed systems. Instead of preventing infiltration of water into the soil, pervious pavement assists the process by capturing rainwater in a network of voids and allowing it to percolate into 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. Pervious concrete has very high permeability that drains water quickly. Pervious concrete is lightweight concrete having weight 1600 to 1900 kg/m3. Most of the reported studies on pervious concrete have determined compressive strength, permeability, void content and specific gravity [2-10]. Whereas, the present study includes workability, split tensile strength, flexural strength and bond strength of pervious concrete with variation in size of aggregates.

II. METHODOLOGY

Detailed study of the experimental work on pervious concrete has been discussed in this paper. Different mix proportions by replacing cement with silica fume (6%) and addition of super plasticizers (0.13% and 0.25%) have been used for studying properties of fresh and hardened pervious concrete [11]. 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 [12].

Three different types of the aggregates (4.75 to 10), (10 to 20) and (4.75 to 10)+(10 to 20) have been used with physical properties given in Table 1.

Table 1 Physical properties of coarse aggregate

Property	C.A. (4.75 - 10 mm)	C.A. (10 -20 mm)	C.A. (4.75 - 20 mm)
Bulk density (Loose) kg/m^3	1480	1501	1471
Bulk density (Compacted) kg/m^3	1542	1563	1609
Specific gravity	2.4	2.5	2.8
Fineness Modulus	6.7	6.6	7.1

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 [13]. Three controlled mix proportions were prepared with different size of aggregates and without any admixture. Table 2 shows different mix proportions used in the present study. The ratio of cement to coarse aggregates has been taken as 1:4 and the w/c (0.34) has been kept constant for all the mix proportions.

Ordinary Portland cement of 43 grades conforming to IS: 8112- 1989 was used [14]. The cement was tested as per IS 4031-1968. Locally available crushed angular coarse aggregates have been used in the present study.

Potable water is generally considered satisfactory as per clause no. 5.4 of IS 456-2000 [15]. Tap water available in the laboratory was used for mixing the ingredients of concrete and curing of the specimens.

Table2 Mixproportions

Mix number	Aggregates size(mm)	Silica fume(%)	Super Plasticizers (%)
M 1	4.75 to 10	-	-
M 2	10 to 20	-	-
M 3	(4.75 to 10)+(10 to20)	-	-
M 4	4.75 to 10	6	-
M 5	10 to 20	6	-
M 6	(4.75 to 10)+(10 to 20)	6	-
M 7	4.75 to 10	6	0.25
M 8	10 to 20	6	0.25
M 9	(4.75 to 10)+(10 to 20)	6	0.25
M 10	4.75 to 10	6	0.13
M 11	10 to 20	6	0.13
M 12	(4.75 to 10)+(10 to 20)	6	0.13

Cico plast super is new generation concrete admixture based on modified Sulphonated naphthalene formaldehyde, combining the properties of super plasticisers with high degree of slump retention characteristics, high range water reducer and also acts as water proofers for concrete, conforms to ASTM C-494. Specification: complying with IS:9103-2003, IS:2645-2003 has been used in the present study.

HYSD bars of 12 mm diameter and grade Fe 415 confirming to IS: 2502-1963 have been used in the present study for pull-out test. Various properties of fresh pervious concrete such as workability (slump, compaction factor and flow table) and hardened properties such as compressive strength, split tensile strength [16] , flexural strength and bond strength [17] were determined at 7, 28 and 56 days.

III. RESULTS AND DISCUSSION

In the present work the slump test (figure 1), the compaction factor test (figure 2) and the flow table test (figure 3) were performed to find the workability. Table 3 gives the workability of different concrete mixes in terms of slump, compaction factor and flowability.

T able 3 Workability of various pervious concrete mix proportions

Mix No.	Slump (mm)	C.F.	Flowability (%)
M1	175	0.75	193.4
M2	160	0.73	191.42
M3	150	0.76	192.64
M4	63	0.74	197
M5	60	0.73	190
M6	40	0.83	196
M7	160	0.73	192.01
M8	110	0.67	190.08
M9	127	0.7	191.32
M10	80	0.76	192.68
M11	70	0.73	189.64
M12	60	0.70	190.22

Slump for M4, M5 and M6 has been decreased by 64%, 63% and 73% in comparison to M1, M2 and M3 respectively. The slump of pervious concrete

mix M 7, M8 and M9 decreased by 8%, 31% and 15% respectively w.r.t. M1, M2 and M3 and increased by 60%, 45% and 68% respectively w.r.t. M4, M5 and M6. The slump of concrete M10, M11 and M12 decreased by 54%, 56% and 60% respectively w.r.t. M1, M2 and M3 and increased by 21%, 13% and 4% respectively in comparison to M4, M5 and M6 respectively. Compaction Factor of pervious concrete mix was increased as silica fume is added to the concrete mixes. Compaction Factor of concrete mixes decreased with 0.25% of super plasticizers and again decrease with 0.13% of super plasticizers to concrete mix. Flowability of pervious concrete mix proportions increased with the addition of silica fume. Flowablity of pervious concrete decreased with the addition of 0.25% of super plasticizers and increased with 0.13% of super plasticizers.



Fig. 1 Slump test set up



Fig. 2 Compaction factor test set up



Fig.3 Flow table test set up

The compressive strength of M1, M4, M7 and M10 was more than M3, M6, M9 and M12 and M2, M5, M8 and M11 comparatively because pervious concrete made with small sizes aggregates has high strength in comparison to pervious concrete made with all-in-aggregates and with large size aggregates.

The compressive strength of all the mix proportion with constant water cement ratio 0.34 at 7, 28 and 56 days has been shown in figure 4 and figure 5. The compressive strength of M1 is maximum and minimum at M8. The compressive strength of pervious concrete of M4, M7 and M10 decreased by 25%, 27% and 28% respectively in comparison to M1. The compressive strength of pervious concrete of M5, M8 and M11 decreased by 18%, 17% and 18% respectively w. r. t. M2. The compressive strength of pervious concrete of M6, M9 and M12 decreased by 16%, 21% and 22% respectively with respect to M3. The split tensile strength of all the mix proportions with water cement ratio 0.34 at 7, 28 and 56 days have been shown in fig. 6 and 7.

The split tensile strength of all the mix proportion with constant water cement ratio 0.34 at 7, 28 and 56 days has been shown in figure 6 and figure7. The split tensile strength of M4, M7, M10 decreased by 23%, 26% and 27% respectively with respect to M1. The split tensile strength of M5, M8 and M11 decreased by 16%, 16% and 17% respectively w.r.t. M2. The split tensile strength of M6, M9 and M12 decreased by 17%, 21% and22% respectively in comparison to M3. The split tensile strength was maximum at M 1 and minimum at M 11. The flexural strength of all the mix proportions with water cement ratio 0.34 at 7, 28 and 56 days have been shown in figure 8 and figure 9. Flexural strength of M4, M7 and M10 decreased approximately by 21%, 10% and 8% respectively at 7, 28 and 56 days with respect to M1. Flexural strength of concrete of

M5, M8, M11 decreased approximately by 11%, 3% and 7% respectively at 7, 28 and 56 days with respect to M2. Flexural strength of M6, M9 and M12 decreased approximately 6%, 3% and 3% respectively in comparison to M3. The flexural strength was maximum at M1 and minimum at M5. The flexural strength of pervious concrete is less than that of conventional concrete due to absence of fine aggregates. The bond strength of all the mix proportions with w/c 0.34 at 28 and 56 days has been shown in the figure 10 and figure 11.

The bond strength of pervious concrete M4, M7 and M10 decreased by approximately 50%, 17% and 7% respectively in comparison to M1. The bond strength of pervious concrete M5, M8 and M11 decreased approximately 50%, 15 % and 7% respectively in comparison to M2 at 28 and 56 days. The bond strength of concrete M6, M9 and M12 decreased approximately 44% and 9% and increased approximately 24% respectively at 28 and 56 days w. r. t. M3.

It has been observed from experimental results that the mechanical properties of pervious concrete increased by using small size aggregates (4.75 mm to 10 mm) in comparison to large size (10 mm to 20 mm) and all-in aggregates (4.75 mm to 10 mm and 10 mm to 20 mm). The pervious concrete has low strength as compared to conventional concrete. That's why this type of concrete is used in low volume pavements, residential road and driveways, sidewalk and pathways, parking lot, tennis court, low water crossing, patios, slope stabilization, artificial reef, well lining, tree grate in sidewalk, hydraulic structure, swimming pool decks , noise barriers, walls (including load bearing) and pavement edge drains.

CONCLUSIONS

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.



Fig. 4 Compressive strength of cube test set up

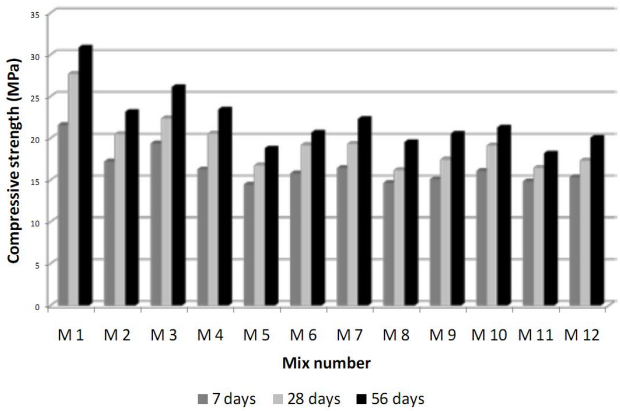

Fig. 5 Compressive strength of various pervious concrete mix proportions at different age



Fig. 6 Split tensile strength of cylinder

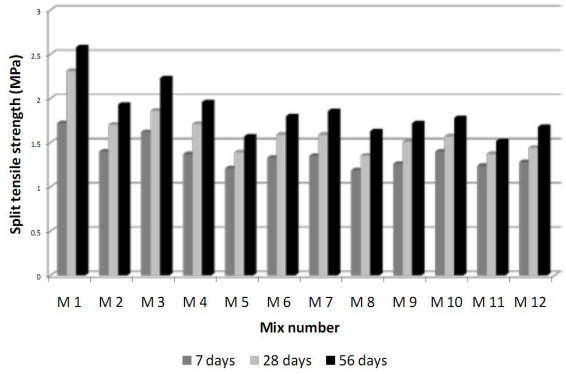

Fig. 7 Split tensile strength of various pervious concrete mix proportions at different age



Fig. 8 Flexural strength set up

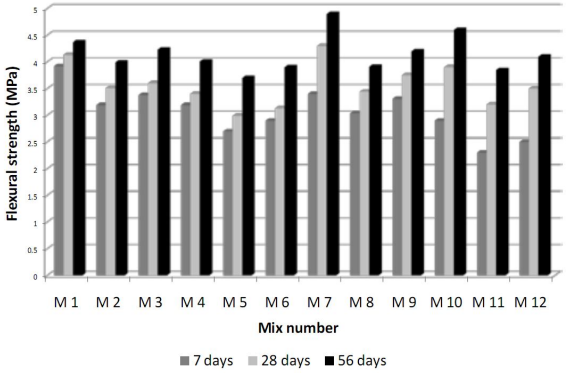

Fig. 9 Flexural strength of various pervious concrete mix proportions at different age



Fig. 10 Pull-out test set up

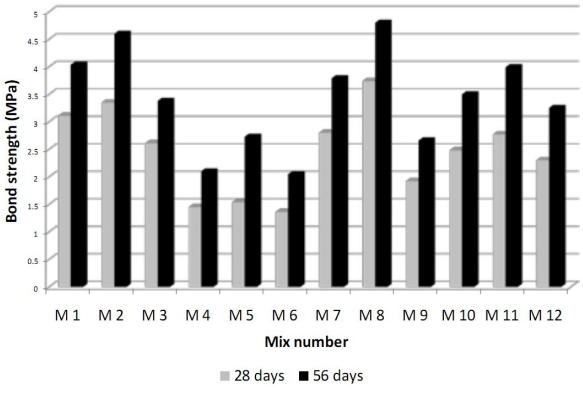

Fig. 11 Bond strength of various pervious concrete mix proportions at different age

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