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Suitability of Fly Ash in Replacement of Cement in Pervious Concrete

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Abstract- **With enhanced urban infrastructure growth, the natural available earth surface or the top soil strata has been covered with buildings roads along with footpath parking lots. As a result there is no scope for the precipitation of water to get into the substrata. Hence ground water table in urban areas is depleting at an alarming rate. Pervious concrete when used in such application would allow, the precipitated water to percolate thereby not only reduces the burden on road side drains but also improve the level of ground water table. In the present work porous concrete with fly ash as a blended material is tested for its strength and permeability for assessing the adaptability of fly ash as a substitute material to cement. From the results of considered parameters, it is observed that 20% replacement of cement with fly ash showed better performance compared to pervious concrete without fly ash.**

Keywords- Pervious concrete, fly ash, strength ,permeability.

I. INTRODUCTION

In reviewing technology advances through the centuries it is evident that material development plays a key role. Considerable efforts are still being made in every part of the world to develop the new construction materials.

About 35% to 70% of our construction sites are being covered by paved surfaces. This impervious surface blocks natural water infiltration into the soil, pervious concrete is one such solution for this problem.

1.1 Pervious concrete / Porous concrete is an innovative material which is a mixture of coarse aggregate, cement, water and little to no sand along with chemical admixtures, containing a network of holes or voids, to allow air or water to move through the concrete. This allows water to drain naturally through it and allows replenishment of groundwater where conventional concrete does not. Absence of sand or fine aggregate permit the properly placed pervious concrete to have about 15 to 30% of void space, the pores can range from 2 to 8mm, which permit water to pass through without causing any damage to the matrix of the porous concrete.

1.2 Fly ash consists of fine, powdery particles that are predominantly spherical in shape, either solid or hollow and mostly glassy (amorphous) in nature, having similar physical characteristic with silt. Compared to its physical properties, its chemical properties are more influenced by the type of burned coal and the techniques used for handling and storage. **Class C** and **Class F fly ash** are classified according to the ASTM C 618. Class C contains more lime than class F fly ash. Class C fly ash has both pozzolanic and cementitious properties and is mostly used in the situations where high early strength is important such as prestressed applications. Class F fly ash is considered an ideal pozzolanic material in mass concrete and in high strength mixes and it is recommended to be used in concrete exposed to ground water.

II. OBJECTIVE OF THE PRESENT WORK

The objective of this study is to investigate the effects on the important engineering properties of pervious concrete with the use of fly ash. The physical properties examined include compressive strength, flexural strength, split tensile strength and permeability of pervious concrete.

III. MATERIALS USED AND ITS PROPERTIES

A. Cement: In the present study ordinary Portland cement of grade 43 is used and tests are conducted as per IS-12269:1987.

Sl No.	***Particulars***	***Results***
1	Specific Gravity	2.9
2	Fineness of Cement	6.92%
3	Standard Consistency	32%
4	Initial Setting Time	41 min

Table 1: Properties of cement

B. Fine Aggregate: Fractions passing through 4.75mm sieves and retained on 150µ sieve are used for the present study. Tests are conducted as per IS-650:1996 & IS-2386:1968.

Sl No.	***Particulars***	***Results***
1	Fineness Modulus	4.71%
2	Specific Gravity	2.4
3	Bulk Density	1.63g/cc
4	Void Ratio	78%
5	Zone	II grading

Table 2: Properties of Fine Aggregate

C. Course Aggregate: Crushed Cysts stone with fraction I (16mm passing -12.5mm retained) 70%, fraction II (12.5mm passing -10mm retained) 30% was adopted. Tests are conducted as per IS-2386:1963.

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Sl No.	*Particulars*	*Results*
1	Fineness Modulus	7.39%
2	Specific Gravity	2.65
3	Crushing Value	22.43%
4	Abrasion Value	30.2%
5	Water Absorption	0.1% by weight of aggregate.

Table 3: Properties of Course Aggregate

D. Chemical Admixture: Super plasticizer galemium-B233 has used.

Sl No.	*Particulars*	*Results*
1	Colour	Yellowish
2	Relative Density	1.09±0.01@25^{0}c
3	p^H	7±1
4	Chloride ion content	<0.2%

Table 4: Properties of Chemical Admixture

E. Fly Ash: For the present work Class F fly ash sourced from Raichur Thermal Plant and tests are conducted as per IS-3812:2003

Sl No.	*Particulars*	*Results*
1	Fineness Modulus	298
2	Specific Gravity	2.0
3	Soundness	0.035
4	Particle Retained on 45µm IS sieve	38.5

Table 5: Physical Properties of Fly Ash

SI. No.	*Tests Conducted*	*Obtained Results %*
1.	$(SiO_2) + (Al_2O_3) + (Fe_2O_3)$, % by mass,(Min.)	90.90
2.	(SiO_2), % by mass, (Min.)	58.2
3.	(MgO),% by mass, (Min.)	0.98
4.	Total Sulphur as SO_3, % by mass, (Max.)	0.15
5.	LOI, % by mass, (Max).	0.50

Table 6: Chemical Properties of Fly Ash

IV. METHODOLOGY ADOPTED

1. *Mix design*: In the present work, 1:0.546:4.5 mix design is adopted for M15 grade pervious concrete.

2. *Proportioning:* Weigh Batching is used for the experimental study. The weighed cement is mixed with 0%-30% fly ash and then with weighed FA & CA aggregates. The whole dry sample is mixed thoroughly by hand mixing. Water and super plasticizer in liters is added to the dry sample and mixed well until a uniform homogeneous mix is obtained, the mixing time should not exceed 3-5 minutes.

3. *Trial mix*: The main objective of the trial mixes were to determine the percentage of fly ash required to achieve a suitable workability for pervious concrete and also to determine the optimum proportion which give better strength and permeability results.

4. *Final mix*: Based on the results of trial mix or batches the proportions which is resulted in higher compressive strength value with good workability is selected for the final mix, to find 28th day compressive strength and other strength properties.

5. *Curing:* After 24 hrs of moulding, concrete specimens are removed from the moulds and kept for curing in water bath for 7 days & 28 days as per standard procedure.

6. *Tests:* The specimens are tested for compression, split tension, flexural bending and permeability as per Indian Standard Specifications.

V. RESULTS AND DISCUSSION

A. Workability of Pervious Concrete: Slump test is used to get the required workability of pervious concrete as per Indian standard specifications. The pervious concrete samples momentarily held the shape of the slump cone before collapsing for producing slump of 50mm by replacing cement by different percentages of fly ash with & without super plasticizer. The test results obtained are shown in table 7 & 8.

Trial Mix No.	*Cement Content (%)*	*Fly Ash Content (%)*	*W/C ratio*	*Slump (mm)*	*Average Compressive strength (N/mm^2)*
M0	100	0	0.32	50	10.4
M1	90	10	0.34	50	9.59
M2	80	20	0.36	55	10.42
M3	70	30	0.38	55	7.53

Table 7: 7th day average strength values without super plasticizer

Trial Mix No.	*Cement Content (%)*	*Fly Ash Content (%)*	*W/C ratio*	*SUPER PLASTICISER (%)*	*Slump (mm)*	*Average Compressive strength (N/mm^2)*
M0	100	0	0.30	0.3	45	10.4
M1	90	10	0.32	0.4	50	9.89
M2	80	20	0.34	0.5	55	10.13
M3	70	30	0.36	0.5	45	8.01

Table 8: 7th day average strength values with super plasticizer

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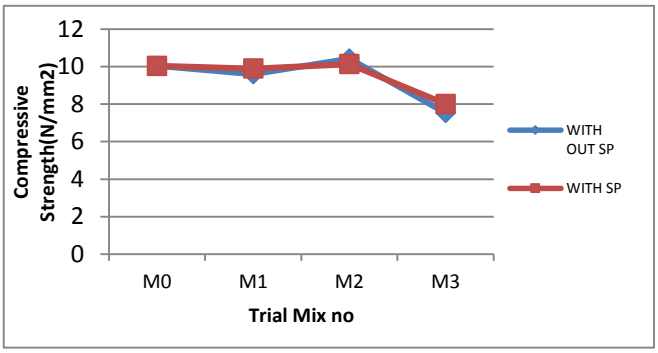

Graph: 7th day average compressive strength with & without super plasticizer

- ✓ As observed from the table 7 and 8, specimen with 20% replacement are showing strength higher than the strength of controlled concrete in compression.
- ✓ The specimen without super plasticizer is slightly higher than specimen with super plasticizer for 20% replacement.
- ✓ Specimen with 10% & 30% replacements are showing less strength than compared to controlled specimen.
- ✓ Hence, we adopted 1:0.546:4.5, 0.36 with 20% replacement of cement with fly ash as final mix for 28th day compressive strength and other engineering properties of pervious concrete.

B. *28TH DAY STRENGTH CHARACTERISTICS OF PERVIOUS CONCRETE*

The basic tests were conducted as per the Indian standards for adopted concrete mix to study the behavior of the pervious concrete. The specimens used for this test are 150X150X150 mm cubes, 150 mm dia with 300 mm length cylinders & prism of cross-section 100mm x 100mm x 500mm with a span of 300mm for compressive strength test, split tensile strength test & Flexure strength test respectively.

1. *Compressive Strength Results*

Specimen	W/C ratio	% of fly ash	Average Compressive strength (N/mm^2)
M1	0.36	0%	17.10
M3		20%	18.08

Table 9: Compression Test Results

2. *Split Tensile Strength Test Results*

Specimen	W/C ratio	% of fly ash	Average Flexural strength (N/mm^2)
M1	0.36	0%	1.51
M3		20%	1.64

Table 10: Split Tensile Test Results

3. *Flexure Strength Test Results*

Specimen	W/C ratio	% of fly ash	Average Flexural strength (N/mm^2)
M1	0.36	0%	2.81
M3		20%	2.91

Table 11: Flexure Test Results

- ✓ From the above results it is observed that the pervious concrete with 20% replacement of cement by fly ash shows higher strength in all tests compared to pervious concrete without fly ash.

4. *Permeability Test*

The constant head permeability test method has been adopted; the time required for the flow of 1000 ml of water through the cylindrical mould was noted. Table below shows time and coefficient of permeability for the different specimens.

Specimen	% of fly ash	Time (sec)	Co-efficient of Permeability (K) (cm/sec)
1	0%	166	$1.06X10^{-3}$
2		135	$1.09\ X10^{-3}$
3	20%	115	$1.16\ X10^{-3}$
4		119	$1.12\ X10^{-3}$

Table 12: Permeability Test Results

- ✓ The co-efficient of permeability in the range of $1.11x10^{-3}$ is permissible as per IS Code 3085.

VI. CONCLUSION

Based on the analysis of results following conclusion are drawn

1. The compressive strength of concrete with 20% replacement results in increased strength compared to the pervious concrete without fly ash.
2. By the use of cementicious material fly ash, the usage of cement can be reduced which will reduce the cost of concrete to certain extent.
3. As the pervious concrete with 20% replacement of fly ash gives slight increase in compressive strength, hence this material can be used for road pavement at the places of low volume of traffic road, parking lots, play grounds etc which helps in recharging underground water table.

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