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AN EXPERIMENTAL INVESTIGATION OF PERVIOUS CONCRETE WITH USE OF FLY ASH AND SILICA FUME AS ADMIXTURE

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ABSTRACT

In many developed countries, pervious concrete is becoming popular for the construction of pavements, car parks and driveways. For the effective use of pervious concrete, it is necessary to evaluate performance of this new type of concrete. The most important property of pervious concrete is its water permeability as it is measure of perviousness of the said concrete. To achieves high porosity only coarse aggregates may be used but it reduces the compressive strength of pervious concrete. So, different categories of coarse aggregates are taken to achieve the required compressive strength. Different Percentage ratio of (20-10) mm and (10-4.75) mm coarse aggregates has been used to cast pervious concrete. As the ratio of 50%-50% has given optimum permeability it has been selected for further work in pervious concrete.

In this study, fly ash and silica fume has been replaced by cement from 0% to 25% and water permeability as well as compressive strength of pervious concrete has been tested. Results showed that Replacement of Fly ash from 5% to 25% shows decrement in strength from 4% to 28%. And permeability also decreased with increment of fly ash mix up to 30% than normal pervious concrete as well as in silica fume, replacement from 5% to 25% shows that with 5% replacement of cement with silica fume increased strength up to 24% higher than normal pervious concrete. But with further increment of this admixture with replaced to cement showed strength loss of 44% then normal pervious concrete

Keywords: Pervious concrete, porous concrete, fly ash, silica fume.

I. INTRODUCTION

Pervious concrete or no fines concrete is a different type of concrete which has high porosity and generally used in applications that allows water to precipitate and pass directly through which reduces the runoff water from sites. Generally, this type of concrete made of mostly large coarse aggregates and less fine aggregates allows passing water through this concrete and traditionally it is used in parking areas, some residential streets and pedestrian walkways and some light structure conditions. Due to use of large coarse aggregates and cementitious materials, pervious concrete has very high-water permeability and very low compressive strength.

Rough surface texture of this concrete gives traction for vehicles and prevents driving hazards especially beneficial during the most difficult and dangerous of driving conditions, such as in rain and snow. Permeability of pervious concrete gives higher safety against flooding of water on roads and ground areas of building. High porosity helps to remove excessive water from surface of roads and it also increases safety for vehicle drivers especially in slippery and wet conditions. Pervious concrete is durable enough that parking areas properly constructed will last 20-40 years without or less maintenance.

Pervious concrete

- Pervious concrete or no fines concrete is a different type of concrete which has high porosity and generally used in applications that allows water to precipitate and pass directly through which reduces the runoff water from sites.
- Generally, this type of concrete made of mostly large coarse aggregates and less fine aggregates allows passing water through this concrete and traditionally it is used in parking areas, some residential streets and pedestrian walkways and some light structure conditions.
- Due to use of large coarse aggregates and cementitious materials, pervious concrete has very high-water permeability and very low compressive strength.

Pervious concrete ingredients

- Cement - Cement is the binding material. After addition of water it hydrates and binds aggregates and the surrounding surfaces. Generally richer mix (with more cement) gives more strength. Setting time starts almost after 30 minutes and ends after 6 hours. Hence concrete should be laid in its mould before 30 minutes of mixing of water and should not be subjected to any external forces till final setting takes place.
- Coarse Aggregate – Generally coarse aggregate consists of crushed stones. They should be well graded, clean and hard. They give mass to the concrete and prevent shrinkage of cement. In previous concrete, generally 20mm aggregates are used enough to get more water permeability. But if we are taking coarse aggregate size above 20mm than it gives very poor compressive strength.
- Water - Water used for making concrete should be clean. It activates the hydration of cement and forms plastic mass. As it sets completely concrete becomes hard mass. Water gives workability to concrete which means water makes it possible to mix the concrete with ease and place it in final position. But in pervious concrete, water is not needed much as this concrete has very high porosity. Water gives strength enough to make paste to bind the large coarse aggregates and cement.
- Generally pervious concrete is made of course aggregate, water and cement materials but for proper bonding of these materials, admixture is used to increase bonding capacity of this concrete.
- Sometimes less percentage of fine aggregates are also used to get proper mixing of concrete but because of fine contents, pervious concrete gets low water permeability.

II. MINERAL ADMIXTURE

Mineral admixtures are finally divided siliceous materials, which can be added to concrete in relatively large amounts, generally in the range of 15 to 60% by weight of cement. They may be pozzolanic or cementitious or both. Benefits of using mineral admixtures in concrete are improvements in high ultimate strength, resistance to thermal cracking and chemicals, better durability and economy. In this chapter, we are talking about two most commonly used mineral admixtures which are given below:

- Fly ash
- Silica fume

Experimental programme

The aim of this experimental program is to find out the compressive strength and permeability of pervious concrete made using normal content as well as fly ash and silica fume replacement with cement. The basic tests carried out on concrete samples are discussed in this chapter, followed by a brief description about mix design adopted.

Characteristic of materials

1) CEMENT: -

Cement is a fine gray powder, it is mixed with water and materials such as sand, gravel, and crushed stone to make concrete. The cement and water form a paste that binds the other materials together as the concrete hardens. The ordinary cement contains two basic ingredients namely argillaceous and calcareous. In argillaceous materials clay predominates and in calcareous materials calcium carbonate predominates. Basic composition of cement is shown In Table 4.1

- Ordinary Portland cement available in local market (Ultra Tech Cement) has been used in this study.
- Care has been taken to see that the procurement made from a single batch and is stored in airtight containers to prevent it is being affected by atmospheric, monsoon moisture and humidity.
- The grade of cement was 53. Summary of the various tests conducted on cement are as under given below in Table 4.2.
- Standard consistency of cement paste is defined as that consistency with permits vicate plunger to penetrate a point to 5 -7 mm from the bottom of the vicat mould. In this test standard consistency is also called normal consistency.
- In this test, 300gm of cement has been taken and placed in enameled tray and then 30% of water by weight of cement mixed with cement after that, vicat mould filled with paste completely and put it under the rod bearing plunger. Fig. shows vicat apparatus for consistency test.

- Then plunger released quickly and allowing sinking into the paste. Depth of penetration at 35 mm achieved with addition of 33% of water mixed with cement which is called normal consistency of cement.
- For initial setting time, water added in cement and needle gently lowered and brought it in contact with test block surface and quickly released. After sometime paste started losing its plasticity and the time when water added to the cement and the needle penetrated the test block at depth of 33mm was 42 min which is called initial setting time.
- And paste attained hardness such that needle didn't pierce through 0.5 mm of paste at 270 min which is called final setting time of cement.

Table 4.2 Physical Properties of cement

Sr.No.	Characteristics	Value Obtained	Standard
1	Normal Consistency	33%	-
2	Initial Setting Time	42 min	Not be less than 30 min.
3	Final Setting Time	270 min	Not be greater than 600 min.

2) FINE AGGREGATES:

The sand for the experimental programmed is locally procured and conformed to Indian Standard Specifications IS: 383-1970. The sand is first sieved through 4.75 mm sieve to remove any particles greater than 4.75 mm and then was washed to remove the dust. Properties of the fine aggregate for the experimental work are tabulated in Table 4.3. The aggregates were sieved through a set of sieves to obtain sieve analysis and the same is presented in Table 4.4.

- 500gm of fine aggregate taken and placed it into the pycnometer. Distilled water fully poured into pycnometer. After that water drained and only saturated and surface dry sample weighted as A.
- Than pycnometer with mix of distilled water and fine aggregate sample weighted as B.
- After that pycnometer filled with only distilled water was calculated as C. Than sample was oven dried at temperature of 110° for 24Hrs. after that weight of sample D was calculated.
  - Specific Gravity = D / (A – (B – C))
  - Water absorption = 100(A – D) / D

Table 4.3 Physical properties of fine aggregates

Sr.No.	**Characteristics**	**Value**
1	Specific Gravity	2.56
2	Bulk Density	1.45Kg/lit
3	Water absorption	1.0%
4	Grading Zone	Zone II

Fineness Modulus = 3.24

- 2000gm of fine aggregate was taken for sieve analysis from 4.75mm sieve to 150µm sieve. Sieves mounted one over the other in order of size with larger sieve on top as shown in fig. 4.1.
- After that sieves were shaken manually and so that particles should passed through the sieves.
- Given table shows percentage passing through the sieves as well as percentage retained on different sizes of sieves

3) Coarse Aggregate:

The material which is retained on IS Sieve no.4.75 is termed as a coarse aggregate. The crushed stone is generally used as a coarse aggregate. The nature of work decides the maximum size of the coarse aggregate. In this work, 20mm crushed stones are used as coarse aggregates. for better bonding between cementitious paste and coarse aggregates, 20mm and 10mm aggregates are used. The aggregate was washed to remove the dust and dirt to surface dry condition. The aggregate was tested as per IS: 383-1970. The results of various test conducted on coarse aggregate are given in Table 4.5 and Table 4.6 Shows the physical properties and sieve analysis results.

Table 4.6 Sieve analysis of coarse aggregates

Sr.No.	Sieve	Cumulative %Retained	% Passing
1	20mm	1	99
2	12.5mm	55.85	44.15
3	10mm	23.81	76.19
4	5.6mm	6.36	93.64
5	4.7mm	100	0

Mix design

There is no specific method is available for pervious concrete mix design. So in this work we are taking approximate mix proportions with reference of ACI 522 Report on Pervious concrete and with reference of Ambuja foundation [34].

Following data which we are taking as concrete mix design

- Design data for Pervious concrete:

(a) Maximum Size of aggregate 20 mm
(b) Specific gravity of C.A. 2.88mm
(c) Specific gravity of F. A 2.65mm

- From reference, below data is taken:
- We are using higher mix design for pervious concrete so:
  1. W/C ratio: 0.40
  2. A/C ratio: 4.0
  3. Fine aggregate is 5% of total aggregate
- With use of different trial mixes, the mix proportion becomes for 1m3:

Table 4.7 mix design

Water (liter)	Cement (kg)	Coarse Aggregate (kg)	Fine Agg (Kg)
169.0	380.0	1520.0	77.0(5%)
	1	4	0.20

❖ With use of above mix design, the experimental work will be carried out with replacement of fly ash and silica fume with cement. The percentage of replacement is 0%, 5%, 10%, 15%, 20%, 25%.

- **Concrete cubes** with different coarse aggregate contents & without any addition of admixtures with 10% additional variation is made out to find compressive strength normal pervious concrete:
- Below are results of compressive strength achieved at age of 7 days and 28 days:

Table 4.8 Normal pervious concrete trial mix

Cube	Cement (kg)	% C.A(20mm)+ Grit(10mm)	C.A(20mm)+ Grit(10mm)(Kg)	F.A (Kg)	Water (Lit)
6	10	70+30	25.2+10.8	2	4.1
6	10	60+40	21.6+14.4	2	4.1
6	10	50+50	18+18	2	4.1

Table 4.9 trial mix 7 days results

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Trial mixes(C.A.)	days	weight(kg)	Average compressive strength(N/mm²)
20mm(70%)+ 10mm 30%	7	6.8	16.4
20mm(60%)+ 10mm 40%	7	6.9	19.2
20mm(50%)+ 10mm 50%	7	7.1	22.1

Table 4.10 trial mix 28 days results

Trial Mixes(C.A)	days	Weight (Kg)	Average Compressive Strength (N/mm²)
20mm(70%)+ 10mm 30%	28	6.9	21.3
20mm(60%)+ 10mm 40%	28	7.1	24.5
20mm(50%)+ 10mm 50%	28	7.3	27.3

- Now, **Concrete cylinders** is made out without any addition of admixtures in concrete with 10% additional variation to find out the permeability in given concrete:

Table 4.11 Normal pervious concrete trial mix for permeability

Cylinders	Cement(kg)	%C.A(20mm)+ Grit(10mm)	C.A(20mm)+ Grit(10mm)(kg)	F.A.(kg)	Water(lit)
3	6.3	70+30	17.90+7.7	1.3	2.9
3	6.3	60+40	15.36	10.25	2.9
3	6.3	50+50	12.8+12.8	1.3	2.9

- Given below is result of water permeability achieved at age of 28 days:

Table 4.12 trial mix results of permeability

Trial Mixes (C.A)	Days	Average Permeability(mm/sec)
20mm (70%) +10mm (30%)	28	27.6
20mm (60%) +10mm (40%)	28	25.8
20mm (50%) +10mm (50%)	28	23.5

Note: Based on CIP-38, National ready mixed concrete association (NRMCA) for normal pervious concrete, compressive strength ranges between 2.8 to 28 MPa. Normal Pervious concrete with 50% coarse aggregate (20 mm) and 50% Grit (10 mm) gives acceptable strength as well as permeability of this mix is also acceptable. So, trial mix of 50% coarse aggregate (20 mm) + 50% Grit (10 mm) is taken for further work.

- After achieving normal pervious concrete, 36 cubes with addition of fly ash as well as silica fume & also combination of fly ash and silica fume in pervious concrete made with given mixes in pervious concrete:

Table 4.13 Normal pervious concrete with fly ash mix

Cubes (no.)	% of Fly Ash content	Fly ash (kg)	Cement(kg)	C.A. (kg) {20mm+10mm}	F.A. (kg)	Water(lit.)
6	0	0	10	18+18	2	4.100
6	5	0.5	9.5	18+18	2	4.100
6	10	1	9	18+18	2	4.100
6	15	1.5	8.5	18+18	2	4.100
6	20	2	8	18+18	2	4.100
6	25	2.5	7.5	18+18	2	4.100

Table 4.14 Normal pervious concrete with silica fume mix

Cubes (no.)	% of silica fume content	Silicafume (kg)	Cement (kg)	C.A. (kg) {20mm+10mm}	F.A. (kg)	Water (lit.)
6	0	0	10	18+18	2	4.100
6	5	0.5	9.5	18+18	2	4.100
6	10	1	9	18+18	2	4.100
6	15	1.5	8.5	18+18	2	4.100
6	20	2	8	18+18	2	4.100
6	25	2.5	7.5	18+18	2	4.100

Table 4.15 Normal pervious concrete with (fly ash+ silica fume) mix

Cubes (no.)	%(flyash+silica fume)	Fly ash+ silica fume (kg)	Cement (kg)	C.A. (kg) {20mm+10mm}	F.A. (kg)	Water (lit.)
6	0+0	0+0	10	18+18	2	4.100
6	2.5+2.5	0.250+0.250	9.5	18+18	2	4.100
6	5+5	0.500+0.500	9	18+18	2	4.100
6	7.5+7.5	0.750+0.750	8.5	18+18	2	4.100
6	10+10	1.0+1.0	8	18+18	2	4.100
6	12.5+12.5	1.250+1.250	7.5	18+18	2	4.100

- Concrete cylinders are made out to find water permeability of pervious concrete and effects of admixtures on permeability of given concrete:

Table 4.16 Concrete cylinders with fly ash mix

Cylinders (no.)	% fly ash content	Fly ash (kg)	Cement (kg)	C.A. (kg) 20mm+10mm	F.A. (kg)	Water (liter)
3	0	0.0	6.300	12.8+12.8	1.300	2.900
3	5	0.315	5.985	12.8+12.8	1.300	2.900

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3	10	0.630	5.670	12.8+12.8	1.300	2.900
3	15	0.945	5.355	12.8+12.8	1.300	2.900
3	20	1.260	5.040	12.8+12.8	1.300	2.900
3	25	1.575	4.725	12.8+12.8	1.300	2.900

Table 4.17 Concrete cylinders with silica fume mix

Cylinders (no.)	% silica Fume	Silica Fume(kg)	Cement (kg)	C.A. (kg) 20mm+10mm	F.A. (kg)	Water (liter)
3	0	0.0	6.300	12.8+12.8	1.300	2.900
3	5	0.315	5.985	12.8+12.8	1.300	2.900
3	10	0.630	5.670	12.8+12.8	1.300	2.900
3	15	0.945	5.355	12.8+12.8	1.300	2.900
3	20	1.260	5.040	12.8+12.8	1.300	2.900
3	25	1.575	4.725	12.8+12.8	1.300	2.900

Table 4.18 Concrete cylinders with combination of fly ash and silica fume mix

Cylinders (no.)	% of Fly ash + silica Fume content	Fly ash+ Silica fume (kg)	Cemen (Kg)	C.A. (kg) 20mm+10mm	F.A. (kg)	Water (litre)
3	0	0.0	6.300	12.8+12.8	1.300	2.900
3	2.5+2.5	0.315	5.985	12.8+12.8	1.300	2.900
3	5+5	0.630	5.670	12.8+12.8	1.300	2.900
3	7.5+7.5	0.945	5.355	12.8+12.8	1.300	2.900
3	10+10	1.260	5.040	12.8+12.8	1.300	2.900
3	12.5+12.5	1.575	4.725	12.8+12.8	1.300	2.900

- Testing of cubes and cylinders will be done for compressive strength and water permeability tests respectively.

III. COMPRESSIVE STRENGTH TEST

- Based on Is: 516-1959, For cube tests two types of specimen's size of 15 cm X 15 cm X 15 cm or 10cm X 10 cm x 10 cm cubes based on the size of aggregates are used. We used 15 cm X 15 cm X 15 cm cube moulds to check out the compressive strength of pervious concrete.
- For pervious concrete, moulds are poured but with low compaction on layers of concrete so the voids shouldn't be closed as our purpose of concrete is porous concrete.

Fig. 4.3 Compressive strength testing machine

- The test specimens are stored in air for 24hours and after, the specimens are removed from the moulds and cured in clear fresh water until taken out prior to test after 7days or 28 days.
- After curing period, Specimen are removed from water and cleaned the bearing surface of cubes. Then it is applied in compressive testing machine.
- Calculation of compressive strength:

$$= \frac{\text{LOAD}}{\text{AREA}}\left(\frac{\text{N}}{\text{mm}^2}\right)$$

IV. WATER PERMEABILITY TEST

- For water permeability measurement, there is no specific measurement is available. With reference of ACI 522, it is done by using of falling head permeability test.
- Figure shows the apparatus of falling head permeameter setup. Using this approach, the sample is enclosed in a latex membrane to avoid the water flowing along the sides of the specimen. Water is added to the

graduated cylinder to fill the specimen cell and the draining pipe. The specimen is preconditioned by allowing water to drain out through the pipe until the level in the graduated cylinder is the same as the top of the drain pipe.

- With use of this method, water was allowed to flow through the specimen by opening the bottom valve. It stopped when level became same of in drainage pipe to the graduated standing pipe above concrete specimen.

Fig. 4.3 water permeameter

- For the calculation of permeability, Darcy's equation is considered as a measurement of coefficient of permeability. Permeability coefficient (k) is calculated according to given equation:

$$\mathbf{K} = \left(\frac{aL}{At}\right) \times \mathbf{ln}\left(\frac{h_0}{h_1}\right)$$

where,
k = coefficient of Permeability
a = cross section of the graduated standing pipe above the sample (mm²)
L = length of the sample (mm)
A = cross section of sample (mm²)
t = time for head drop from h_1 to h_0 in sec

V. RESULTS & DISCUSSION

- For compressive strength measurement, 30 cubes with fly ash mix and 30 cubes with silica fume mix of standard size are made of 15cm mould size and then tested on CTM.
- Cylinders and cubes of pervious concrete made with fly ash as a replacement material with cement content casted results are collected as given below:

Table 5.1 fly ash mix results of permeability

cement (%)	Fly ash(%)	days	Average Permeability (mm/sec)
100	0	28	23.5
95	5	28	22.3
90	10	28	20.6
85	15	28	18.7
80	20	28	17.4
75	25	28	16.3

Table 5.2 fly ash mix results of 7 days compressive strength

cement (%)	Fly ash(%)	weight(kg)	days	compressive strength(N/mm²)
100	0	7.1	7	22.1
95	5	7.3	7	21.4
90	10	7.2	7	19.8
85	15	7.4	7	18.7
80	20	7.3	7	17.3
75	25	7.2	7	16.6

Table 5.3 fly ash mix results of compressive strength at 28 days

cement (%)	Fly ash(%)	weight(kg)	days	compressive strength (N/mm²)
100	0	7.3	28	27.3
95	5	7.4	28	26.1
90	10	7.3	28	24.8

85	15	7.5	28	22.7
80	20	7.4	28	20.3
75	25	7.3	28	19.4

Table 5.4 silica fume mix results of Permeability

cement (%)	Silica fume(%)	days	Average Permeability (mm/sec)
100	0	28	23.50
95	5	28	14.18
90	10	28	12.65
85	15	28	12.15
80	20	28	11.82
75	25	28	11.67

Table 5.5 silica fume mix results of compressive strength at 7 days

cement (%)	Silica fume (%)	weight(kg)	days	Compressive strength (N/mm²)
100	0	7.1	7	22.1
95	5	7.2	7	27.3
90	10	7.1	7	21.6
85	15	7.1	7	18.1
80	20	7.3	7	16.4
75	25	7.2	7	13.2

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Table 5.6 silica fume mix results of compressive strength at 28 days

cement (%)	Silica fume (%)	weight(kg)	days	compressive strength (N/mm²)
100	0	7.3	28	27.3
95	5	7.4	28	33.6
90	10	7.2	28	22.4
85	15	7.3	28	19.5
80	20	7.4	28	17.6
75	25	7.3	28	15.3

➢ Based on results, graphs are shown below that shows the relation between replacement with different percentages and permeability & compressive strength with various mixes of admixtures:

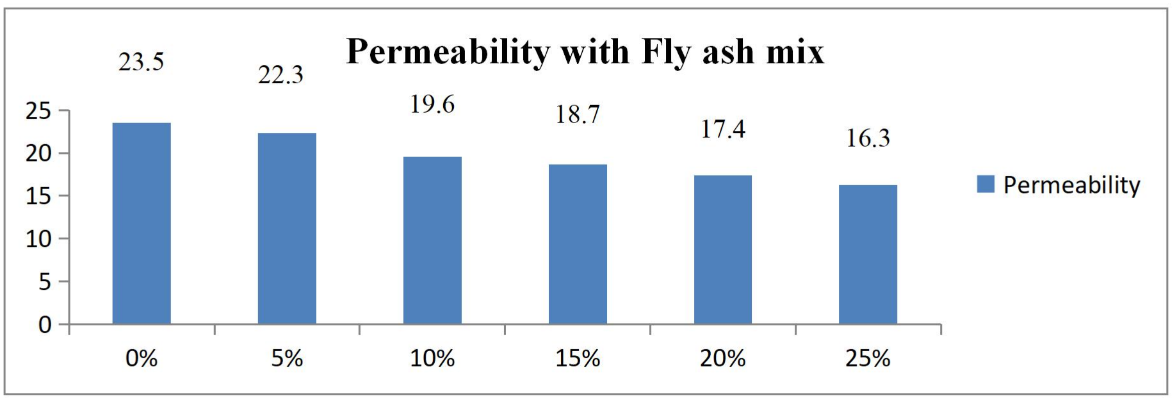

Fig 5.1 % Fly ash mix v/s Permeability (mm/sec)

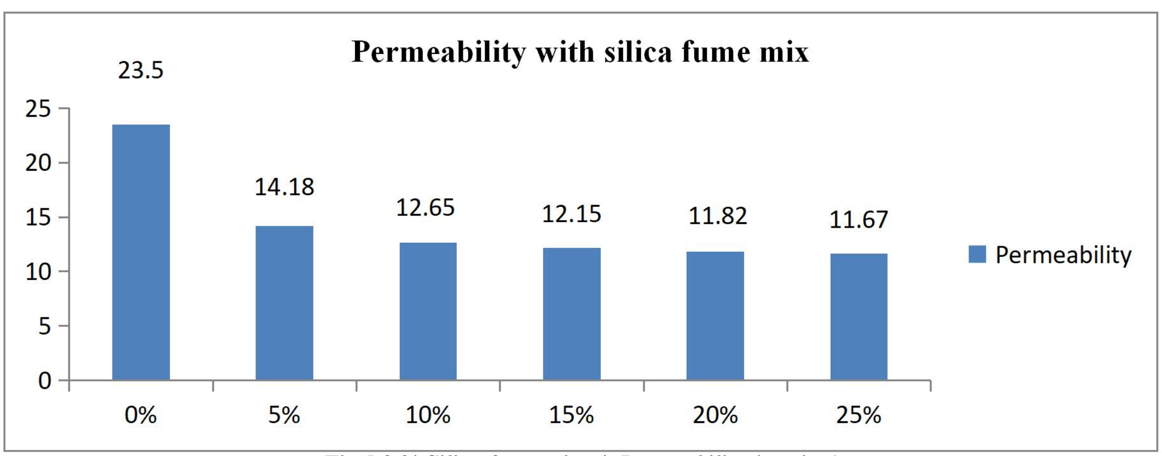

Fig 5.2 % Silica fume mix v/s Permeability (mm/sec)

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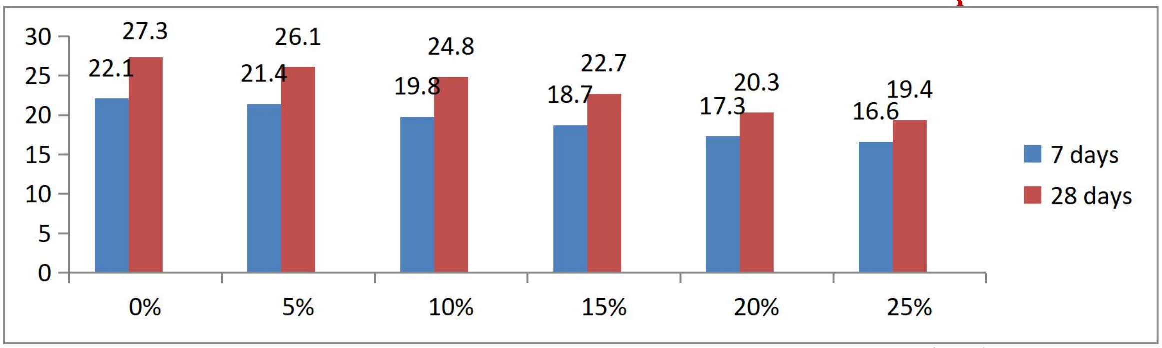

Fig 5.3 % Fly ash mix v/s Compressive strength at 7 days and28 days graph (MPa)

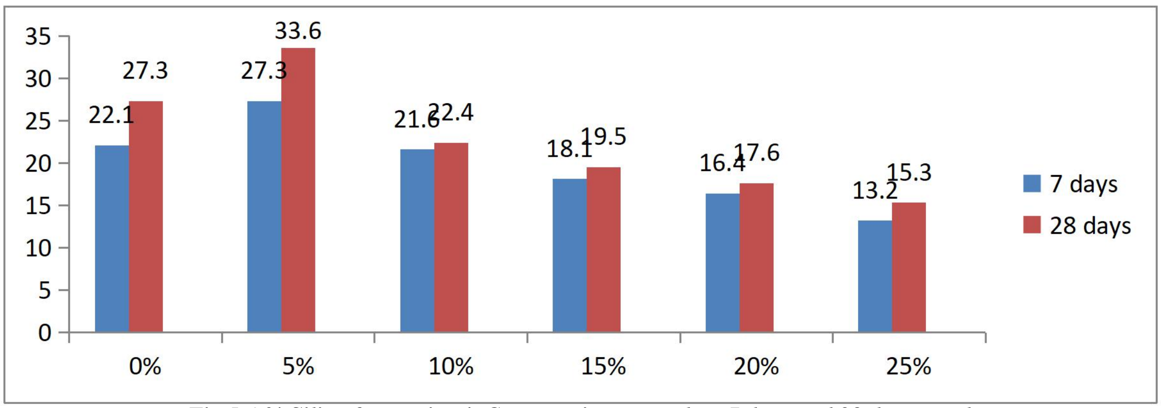

Fig 5.4 % Silica fume mix v/s Compressive strength at 7 days and 28 days graph

- Comparison graphs of permeability and compressive strength of fly ash and silica fume replacement with cement in pervious concrete are given below:

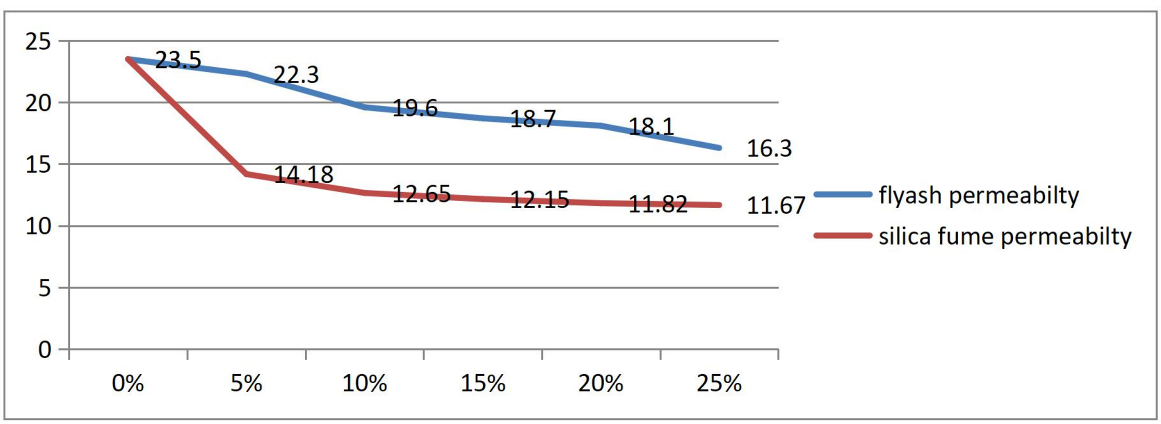

Fig 5.5 comparison graph of Permeability (mm/sec)

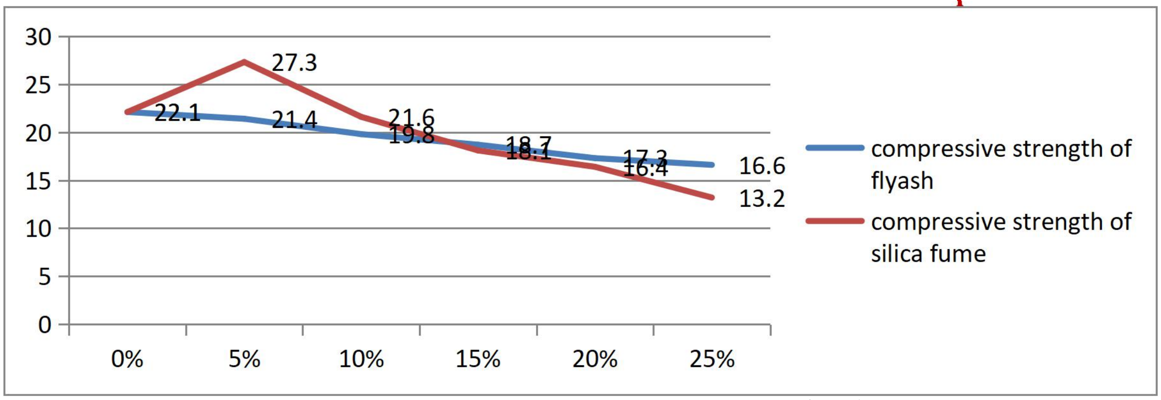

Fig 5.6 comparison graph of compressive strength (MPa)

- Fig. 5.5 and Fig. 5.6 show that, after certain limit both of the admixtures loss strength as well as reduce permeability of pervious concrete. But fly ash gives lesser reducing value of permeability than silica fume.
- Based on above results, it shows that 5% replacement in fly ash decrease permeability 5% then normal pervious concrete and also 5% replacement of silica fume shows 24% higher strength than normal pervious concrete. So, it may possible that combination of these both admixtures replaced upto 5% with cement can give acceptable permeability as well as compressive strength. So, different combination of fly ash and silica fume has been made out for further work which is shown in below table.

Table 5.7 combination of fly ash & silica fume mix for compressive strength

Cubes (no.)	% of fly ash + silica fume content	Fly ash+ silica fume (kg)	Cement (kg)	C.A.(kg) {20mm+10mm}	F.A.(kg)	Water (lit.)
6	1+4	0.100+0.400	9.5	18+18	2	4.100
6	2+3	0.200+0.300	9.5	18+18	2	4.100
6	2.5+2.5	0.250+0.250	9.5	18+18	2	4.100
6	3+2	0.300+0.200	9.5	18+18	2	4.100
6	4+1	0.400+0.100	9.5	18+18	2	4.100

Table 5.8 fly ash & silica fume mix for permeability

Cylinders (no.)	% Fly ash + Silica fume content	Fly ash+ Silica fume (kg)	Cement (Kg)	C.A. (kg) 20mm+10mm	F.A. (kg)	Water(liter)
3	1+4	0.063+0.252	5.985	12.8+12.8	1.300	2.900
3	2+3	0.126+0.189	5.985	12.8+12.8	1.300	2.900
3	2.5+2.5	0.157+0.157	5.985	12.8+12.8	1.300	2.900
3	3+2	0.189+0.126	5.985	12.8+12.8	1.300	2.900

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3	4+1	0.252+0.063	5.985	12.8+12.8	1.300	2.900

Table 5.9 fly ash & silica fume mix results of water permeability at 28 days

cement (%)	Fly ash (%) + silica fume (%)	days	Average Permeability(mm/sec)
100	0	28	23.50
95	1+4	28	17.18
95	2+3	28	17.53
95	2.5+2.5	28	18.01
95	3+2	28	18.88
95	4+1	28	19.78

Table 5.10 fly ash & silica fume mix results of compressive strength at 7 days

Cement (%)	Fly ash (%)+ silica fume (%)	weight(kg)	days	compressive strength (N/mm²)
100	0	7.1	7	22.1
95	1+4	7.2	7	26.3
95	2+3	7.1	7	24.9
95	2.5+2.5	7.1	7	24.1
95	3+2	7.0	7	22.8
95	4+1	7.1	7	22.1

Table 5.11 fly ash & silica fume mix results of compressive strength at 28 days

Cement (%)	Fly ash (%) +Silica Fume (%)	weight(kg)	days	compressive strength(N/mm²)
100	0	7.3	28	27.3

95	**1+4**	**7.4**	**28**	**32.4**
95	**2+3**	**7.3**	**28**	**32.1**
95	**2.5+2.5**	**7.3**	**28**	**31.5**
95	**3+2**	**7.4**	**28**	**29.14**
95	**4+1**	**7.3**	**28**	**28.89**

- Based on results, graphs are shown below that shows the relation between replacement with different percentages and permeability & compressive strength with various combination mixes of fly ash & silica fume:

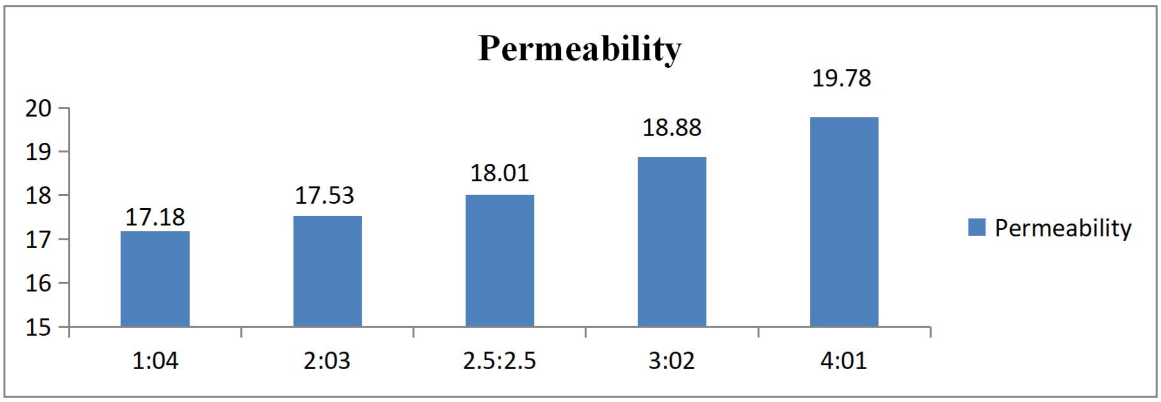

Fig 5.7 % (Fly ash: silica fume) mix v/s Permeability (mm/sec)

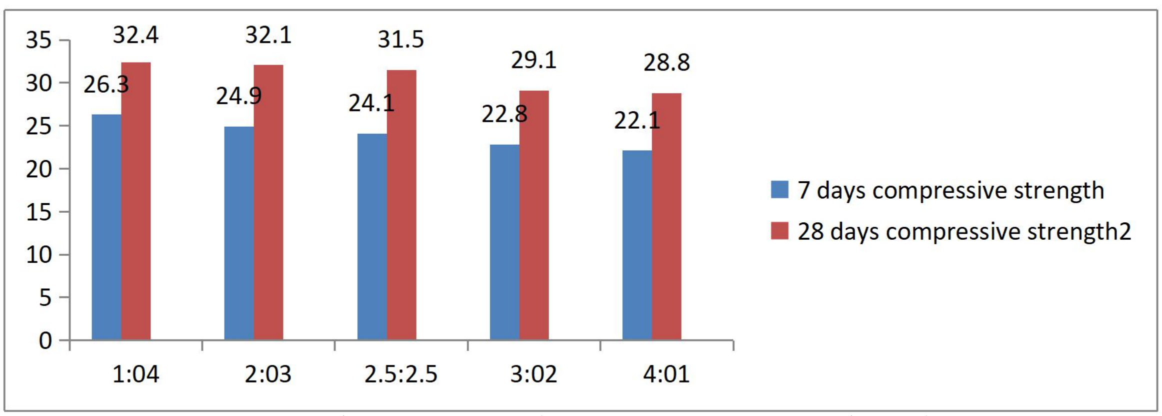

Fig 5.8 % (Fly ash: silica fume) mix v/s compressive strength (N/mm2)

- Comparison graphs of permeability and compressive strength of combination of fly ash & silica fume mix replacement with cement in pervious concrete are given below:

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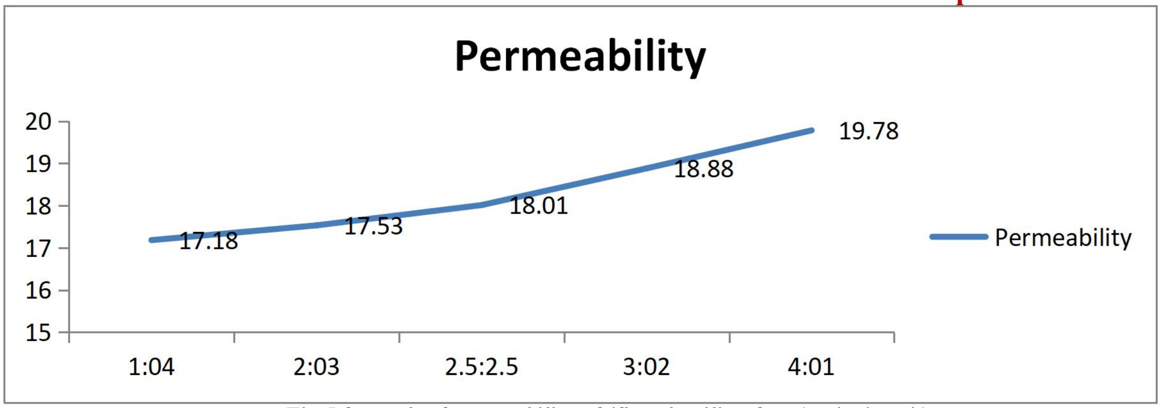

Fig 5.9 graph of permeability of (fly ash: silica fume) mix (mm/s)

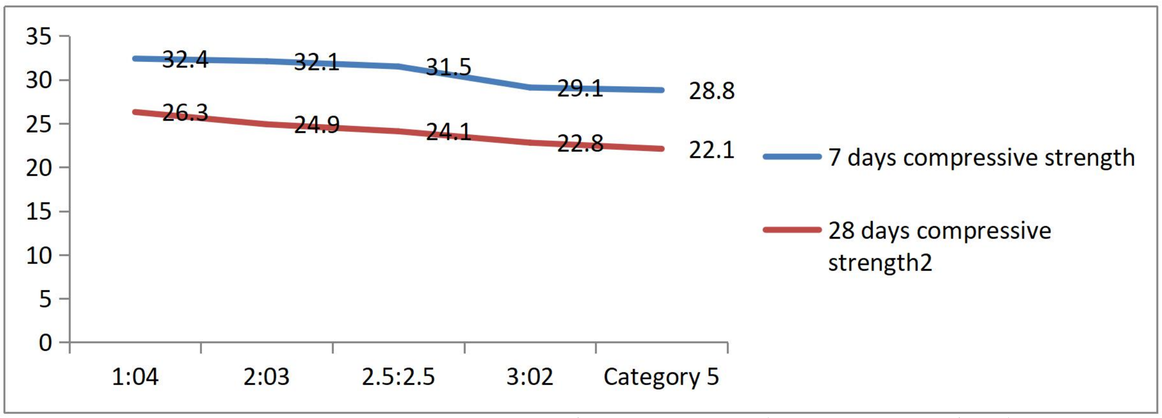

Fig 5.10 graph of compressive strength of (fly ash: silica fume) mix replacement (MPa)

VI. CONCLUSION

Replacement of Fly ash from 5% to 25% shows decrement in strength from 4% to 28% & permeability is also decreased with increment of fly ash mix up to 30% than normal pervious concrete but with 5% replacement of fly ash shows only 5% decrement in permeability and so still it is acceptable for pervious concrete.

With silica fume replacement in pervious concrete, it shows that with 5% replacement of cement gives strength up to 24% higher than normal pervious concrete. But with increment of this admixture with replaced to cement shows strength loss of 44% then normal pervious concrete.
Based on above results, we found out that if we use fly ash at range of 0% to 5% as a replacement material with cement content in pervious concrete it gives better performance with permeability as it is main parameter of pervious concrete.

On other hand, silica fume is much expensive than fly ash and also at a limit of 5%, it gives better compressive strength but permeability of pervious concrete gradually decreases with use of this admixture.

Based on above results, combination of 5% of (fly ash: silica fume) mix has been taken. Different percentage ratios such as, 1: 4, 2: 3, 2.5: 2.5, 3: 2 & 4: 1 have been taken.

Ratio 1: 4 shows deduction in permeability up to 26% but as well as compressive strength of this ratio increases up to 15%. Ratio 2:3 shows permeability of pervious concrete decreased up to 25% but compressive strength increases up to 14% than normal pervious concrete. Ratio of 2.5: 2.5 gives decrement in permeability of 23% and compressive strength gets higher up to 13%. 3: 2 ratio gives compressive strength increment of 6% than normal concrete as fly ash is more than silica fume content. Among all ratios, 4:1 ratio has permeability decrement of 19% which is less than other combination mix and also compressive strength increases 5% than normal pervious concrete.

VII. FUTURE SCOPE OF WORK

- Flexural strength should be checked.
- Effect of different mineral admixtures can be used.
- Effect of air enteraining agents should be checked in pervious concrete.