EXPERIMENTAL STUDY OF PERVIOUS CONCRETE WITH POLYPROPYLENE FIBER

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Abstract - *Pervious concrete water permeability and compressive strength mainly depend on admixtures, proportion of the materials and aggregate sizes. This paper discusses various combination of pervious concrete with admixture (polypropylene fiber), water cement ratio and different aggregate sizes. Three aggregate sizes 6mm-10mm, 10mm-20mm and 6mm-10mm-20mm sizes are taken. For each aggregate size, W/C ratio of 0.30, 0.35, and 0.40 were used. The objective of this research is to study the effect of polypropylene fiber, variation in aggregate sizes and W/C ratio on pervious concrete. For test of water permeability, we used falling head method. The experimental research has been done to compute void ratio, water permeability, density and compressive strength. If we increase in W/C ratio found in compressive strength pervious concrete. Compressive strength of conventional concrete is greater than pervious concrete. The void ratio that has to be found in range of 25% to 32% of pervious concrete is sufficient. Similarly if we use small size of aggregate, permeability of pervious concrete will decreases. According to investigation it was observed that with using mix (50%) aggregate and 0.30 W/C ratio gives better result for pervious concrete. In this study used of polypropylene fiber gives better result for compressive strength of pervious concrete and does not effect on water permeability of pervious concrete.*

***Key Words*: *Water permeability, void ratio, compressive strength, aggregate sizes, W/C ratio, density, polypropylene fibre*.**

1. INTRODUCTION

Pervious concrete is a unique kind of concrete with high porosity. That reduces the water runoff from particular site and promote to ground water recharge. It is also called as "permeable concrete" or "porous concrete" or "no fines". A highly interconnected void content causes high porosity. Pervious concrete has little aggregate and has sufficient cementitious paste to coat coarse aggregate particles on preserving the interconnectivity of voids which drains quickly. Pervious concrete is used in residential streets, parking areas, pedestrian walkways, areas with light traffic and greenhouses. It is an important application to protect water quality. The proper use of pervious concrete is recognized by the united state environmental protection agency for providing storm water management and pollution control.

1.1 LITERATURE REVIEW

In this study, permeability measurement devise, a falling head apparatus void content for pervious concrete is 18-35% [ACI, 2010; Tennis et al 2004] [1, 2]. This range provides enough strength, while permits for enough hydraulic conductivity. On decreases in aggregate to cement ratio Park and Tia, void ratio was found to increases. The total percentage of voids present by the specimen is defined by void content. As porosity increases permeability increases and compressive strength decreases and vice versa. The content is between 15-25 % and Permeability is found to be between 2-30 mm/s. The typical compressive strength in the range of 2.8 MPa to 28 MPa is common with densities that are in the range of 1600 Kg/m^3 to 2000 Kg/m^3.

1.2 NEED OF STUDY

Pervious concrete doesn't allow storm water to runoff. The porous nature of pervious concrete reduces storm water runoff. On the basis of performance requirements these pervious concrete in designed distinctively manner. That's why for developing this pervious concrete mixture proportion, we have to study different-different parameters with probability of varying aggregate size, w/c ratio with fixed cement content and amount of polypropylene fiber.

2. MATERIALS AND METHODS

2.1 ORDINARY PORTLAND CEMENT (OPC)

We worked with OPC IS 8112:1989 [6] for research and all details about physical properties of ordinary Portland cement (OPC) are given in table no. 1.

Table -1: Physical properties of Ordinary Portland Cement

Properties for 53 grade OPC	Result achieved	Specification in IS 8112:1989
Fineness in m^2/kg	376	Min 225
Initial setting time in minutes	38	Min 30
Final setting time in minutes	257	Max 600
Specific gravity	3.15	3.15

2.2 AGGREGATE

Two sizes 6mm-10mm and 20m of crushed aggregate were used as coarse aggregate in our research as per standard specification is 383:1970 [7] and Evolution of aggregate sizes by sieve test and Details are given in table no. 2.

Table 2 Physical properties of coarse aggregate (CA)

Sr. no.	Properties for CA	Coarse aggregate
1	Specific gravity	2.97
2	Unit weight (kg/m^3)	1591

Figure 1 Sieve Analysis

2.3 POLYPROPYLENE FIBER

Use 12mm polypropylene fiber @ 100 gms/bag of cement of 50 kgs, in 1:4 cement aggregate ratio. Details are given in table no. 3.

Table 3 Physical properties of polypropylene fiber

Properties	Polypropylene fiber
Specific gravity	0.90-0.91 gm/cm^3

3. MIX PROPORTION

For adequate workability, void ratio strength and Permeability, pervious concrete mixture the proportion take as : cement content was 375 kg/m^3, aggregate content was 1500kg/m^3, aggregate ratio 1:4, aggregate sizes 6mm-10mm-20mm, W/C ratio 0.30,0.35,0.40, polypropylene fiber was 2.54 gm/ mould size (150 X 150 X 150 mm^3).

4.0 EXPERIMENTAL PROGARAM

4.1 PREPARATION OF SPECIMEN

For pervious concrete specimens 150 X 150 X 150 mm^3 moulds were used. The specimens cast were demoulded after 24 hours and kept in normal curing for 7 and 28 days.

Table 4 Pervious concrete mix proportions for different size of aggregate

Mix name	Aggregate sizes	W/C ratio	Cement content	Aggregate content	PF content
Mix1	10-20mm	0.3	375 kg/m^3	1500 kg/m^3	2.54 gm
Mix2	10-20mm	0.35	375 kg/m^3	1500 kg/m^3	2.54 gm
Mix3	10-20mm	0.4	375 kg/m^3	1500 kg/m^3	2.54 gm
Mix4	6-10mm	0.3	375 kg/m^3	1500 kg/m^3	2.54 gm
Mix5	6-10mm	0.35	375 kg/m^3	1500 kg/m^3	2.54 gm
Mix6	6-10mm	0.4	375 kg/m^3	1500 kg/m^3	2.54 gm
Mix7	6-10-20mm are equal %	0.3	375 kg/m^3	1500 kg/m^3	2.54 gm
Mix8	6-10-20mm are equal %	0.35	375 kg/m^3	1500 kg/m^3	2.54 gm
Mix9	6-10-20mm are equal %	0.4	375 kg/m^3	1500 kg/m^3	2.54 gm

4.2 COMPRESSIVE STRENGTH TEST

Universal testing machine (UTM) used for determine the compressive strength of pervious concrete. The test procedures given in IS 516-1959 [8].

Figure 2 Cube test of Pervious concrete

4.3 PERMEABILITY TEST

For the measurement of the permeability of pervious concrete, apparatus was suggested by ACI 522R [1]. for determining water permeability, falling head method was used. Below Figure shows diagram of permeability setup.

The initial water head taken 300mm. Pervious concrete cylinder of size 150X150 mm² was casted in the PVC pipe. Permeability of pervious concrete evaluated for 28 days. Formula used for permeability is

$k = \{(A_1 l / A_2 t) \log(h_2/h_1)\}$

Where k = water permeability

h_1 = initial water head (300mm)

h_2 = final water head (1mm)

l = length of specimen (150mm)

A_1 = cross-sectional area of specimen (150mm)

A_2 = cross-sectional area of tube (150mm)

t = time (15.185 s)

k = [{(150 X 150)/ (150 X 15.185)} log (1/300)] = 24.47 mm/s

Figure 3 Falling head apparatus and Base of concrete fill pipe

4.4 VOID RATIO

The void content was evaluated based on ASTM C1688 [5]. The void content is defined as total percentage of voids available by volume in specimen. The void content of the pervious concrete is determined by using equation.

Void content (%) = {(T - D)/T} X 100

Where, $D = (M_c - M_m)/V_m$ (Density)

Vs = Total absolute volume of materials

V_m = Volume of measure

M_m = Net mass of concrete by subtracting mass of measure

M_c = Mass of measure filled with concrete

T = Ms/Vs (Theoretical density)

Ms = Total mass of material batched

***SAMPLE CALCULATION**

For making 3 cubes by using 375 kg/m³ cement content with 0.30 W/C ratio and following are requirements.

Cement = 3.81 kg
Aggregate = 16.8 kg
Water = 1.143 kg

Polypropylene fiber = 0.00762 kg

This sample calculation includes 6-10mm size of aggregate. The values are average of 3 cubes.

$M_c - M_m$ = 5.279 kg
V_m = 0.15m X 0.15m X 0.15m = 0.003375 m³
D = 5.279/0.003375 = 1565 kg/m³
T = (3.81+ 16.8 + 1.143 + 0.00762)/[{ 3.81/(3.15*1000) } + { 16.8/(2.71*1000) } + { 1.143/(1*1000) } + { 0.00762/(0.90*1000) }]

T = 2542 kg/m³
Void content (%) = {(2542 - 1565)/2542 }* 100 = 38.5 %.

4.5 DENSITY

The density was determined by ratio of weight of cube to volume of cubes.

D = (weight of cube/volume of cube)

5 RESULT AND DISCUSSIONS

The pervious concrete with polypropylene fiber at the age of 7 days for void content, compressive strength and density for combination of different aggregate size respectively, the experimental result shows table 5. The pervious concrete at the age of 28 days for water permeability, void content, compressive strength and density for combination of different aggregate size respectively, the experimental result shows table 6.

Table 5 The experimental result for pervious concrete with polypropylene fiber at the age of 7 days

Cement (kg/m³)	Aggregate	W/C ratio	Compressive strength (MPa)	Void content (%)	density (kg/m³)
375	10-20mm	0.30	9.10	32.38	1710.23
375	10-20mm	0.35	9.25	28.73	1777.18
375	10-20mm	0.4	9.96	25.27	1837.92
375	6-10mm	0.30	9.30	38.84	1546.96
375	6-10mm	0.35	10.43	33.31	1662.81
375	6-10mm	0.40	12.27	30.41	1718.22
375	6-10-20mm	0.30	10.05	38.92	1544.88
375	6-10-20mm	0.35	12.32	35.10	1618.37
375	6-10-20mm	0.40	12.84	30.75	1703.11

Table 6 The experimental result for pervious concrete with polypropylene fiber at the age of 28 day

Cement (kg/m³)	Aggregate	W/C ratio	Compressive strength (MPa)	Void content (%)	Density (kg/m³)	permeability (mm/s)
375	10-20mm	0.30	9.78	30.82	1749.93	24.47
375	10-20mm	0.35	10.94	27.49	1808.89	22.56
375	10-20mm	0.40	10.97	24.10	1866.96	21.71
375	6-10mm	0.30	9.89	31.54	1731.56	19.74
375	6-10mm	0.35	14.29	29.05	1769.19	18.61
375	6-10mm	0.40	16.14	26.43	1809.48	17.90
375	6-10-20mm are equal %	0.30	10.57	36.58	1604.14	18.33
375	6-10-20mm are equal %	0.35	12.69	32.90	1673.18	16.95
375	6-10-20mm are equal %	0.40	15.42	29.55	1732.74	15.89

5.1 EFFECT OF W/C RATIO ON COMPRESSIVE STRENGTH OF PERVIOUS CONCRETE (28 DAYS)

The compressive strength increases with increase in water cement ratio as shown figure 2. By using 0.40 W/C ratio and aggregate size used mix in grading, we got maximum compressive strength (16.14 MPa) showing in figure 2. The compressive strengths of pervious concrete with polypropylene fiber mixes are given in table no.4 and table no.5.

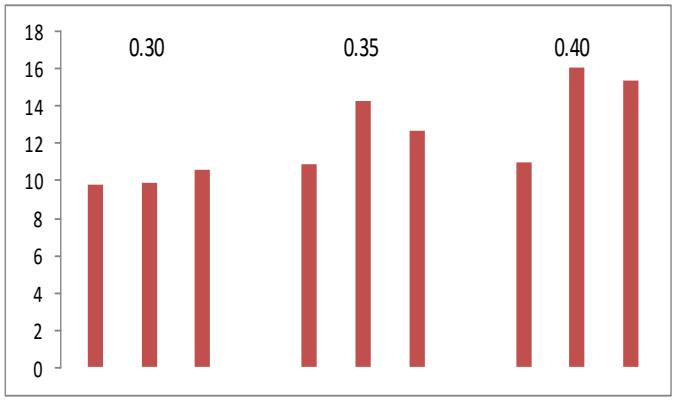
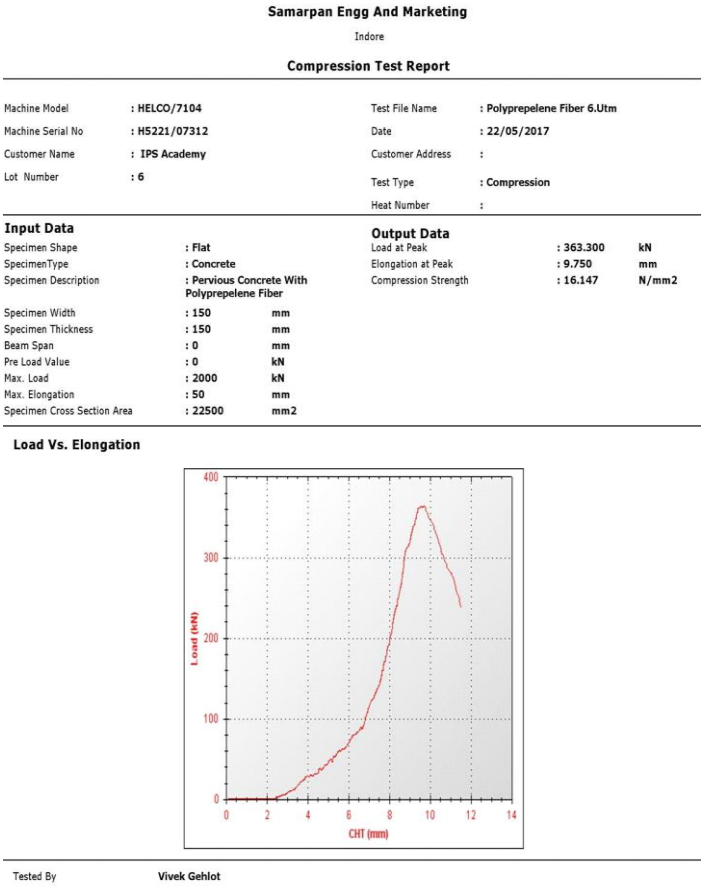


Figure 2 Effect of W/C ratio on compressive strength

Image 1 Maximum compressive strength test report



5.2 EFFECT OF W/C RATIO ON VOID CONTENT OF PERVIOUS CONCRETE (28 DAYS)

The void ratio on pervious concrete with polypropylene fiber discussed in figure 3. We can see void content of pervious concrete reduces with increase in W/C ratio. The void content is large size air void. Figure 3 signify that the aggregate size gives more void ratio (36.58 %). By grading of aggregate and compressive method the void ratio of pervious concrete has been influenced.

5.3 EFFECT OF W/C RATIO ON DENSITY OF PERVIOUS CONCRETE (28 DAYS)

Density of the pervious concrete with polypropylene fiber was achieved in practical investigation ranges from 1600-1900 kg/m³. The maximum density values of pervious concrete with polypropylene fiber achieved that is 0.40 W/C ratio shows figure 4. This investigation shows density of pervious concrete increases with increase in W/C ratio. Density of pervious concrete with polypropylene fiber depends on W/C ratio.

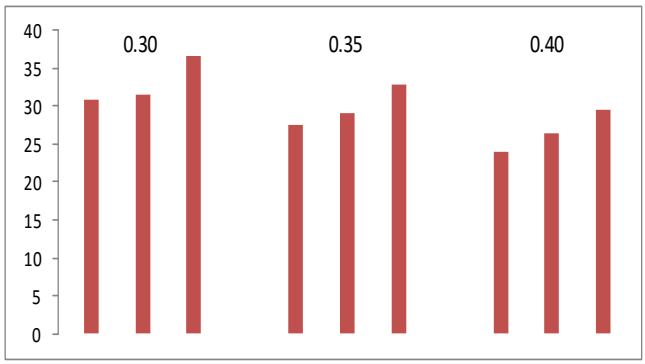


Figure 3 W/C ratios on void content

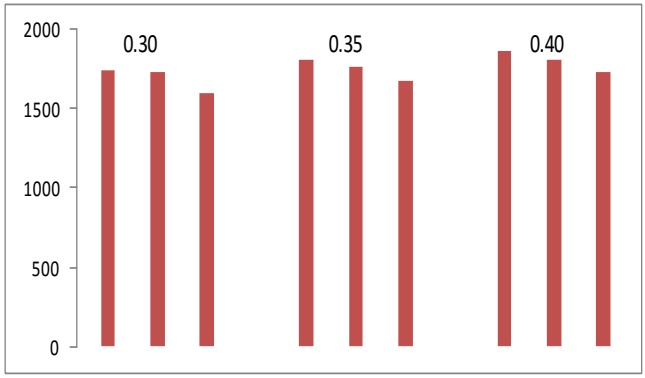


Figure 4W/C ratio on density

5.4 EFFECT OF W/C RATIO ON PERMEABILITY FOR PERVIOUS CONCRETE (28 DAYS)

In Table 6 the water permeability under 300 mm water head has been summaries. The W/C ratio is increased and water permeability decreased for the pervious concrete shown in Figure 5. Higher values of water permeability have been given by 20 mm to 10mm aggregate size was observed. Water permeability found in range of 15.89 mm/s to 24.47 mm/s. for structure influence water permeability of pervious concrete that also affected by grading and compaction. On adding polypropylene fiber causes increase water permeability.

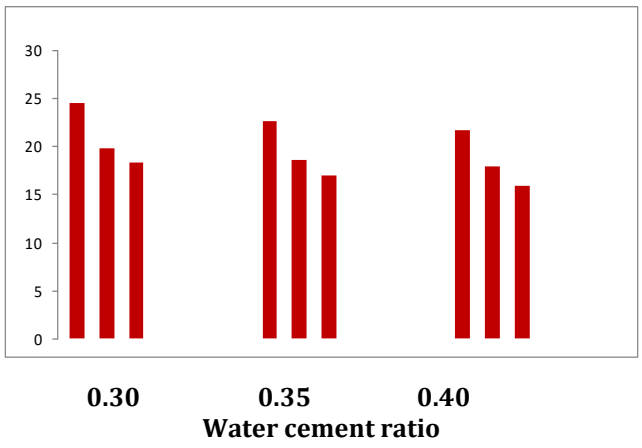


Figure 5 Effect of W/C ratio on water permeability

6. CONCLUSIONS

Based on the experimental investigation on pervious concrete following conclusions has been drawn.

- With using 0.30 W/C ratio and mix (50%) aggregates for pervious concrete gives better result. Mix void content 36.58 % was found.
- Increase in compressive strength of pervious concrete leading by increased density that was observed.
- Another conclusion is that compressive strength of pervious concrete reduced by larger size of aggregate. Better compressive strength given by mixing of smaller and bigger size of aggregate instead of single size of aggregate. Gape was filled by smaller aggregate into the bigger aggregate in pervious concrete and may cause the increase in pervious strength.
- Polypropylene fiber increases strength of compressive strength and water permeability of pervious concrete.

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