Study on Characteristics of Pervious Concrete and its Colourful Applications

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Abstract - *Pervious concrete (no-fines concrete) is a concrete containing little or no fine aggregate; it consists of coarse aggregate and cement paste. It seems pervious concrete would be a natural choice for use in structural applications in this age of 'green building'. It consumes less raw material than normal concrete (no sand), it provides superior insulation values when used in walls, and through the direct drainage of rainwater, it helps recharge groundwater in pavement applications. In recent years, however, due to increased awareness of the need for conservation of nonrenewable mineral resources, increased consideration is being given to the use of pervious concrete in most countries. Pervious concrete is generally used for light-duty pavement applications, such as residential streets, parking lots, driveways, sidewalks, channel lining, retaining walls and sound walls. Colouring pigments are also added to create aesthetic appearance. This study discusses the possible mix proportions of pervious concrete, fresh concrete properties such as slump test, compaction factor, void content and hardened concrete properties such as infiltration rate and compressive strength. From the experimental investigation 1:4 mix proportion has desired properties in both fresh and hardened concrete test when compared to mix proportion 1:5 and it is suitable for pavement application.*

Key Words: **Pervious Concrete, Colouring pigments, mix proportion, strength, etc**

1.INTRODUCTION

1.1. GENERAL

Pervious concrete is also named as porous concrete or permeable concrete. In previous concrete, carefully controlled amount of water and cementious materials are used to create a paste that forms a thick coating around aggregate particles. A pervious concrete mixture contains little or no sand which create a substantial void content in it. Using sufficient paste to coat and bind the aggregate particles together creates highly permeable system with interconnected voids which drains quickly.

Pervious concrete is a zero-slump, open-graded material consisting of hydraulic cement, coarse aggregate, admixtures and water. In the absent of fine aggregates, pervious concrete has connected pores size range from 2 to 8 mm, and the void content usually ranges from 15% to 25% with compressive strength of 2.8MPa to 28MPa (however strength of 2.8 to 10 MPa are common).

1.2. MATERIAL PROPERTIES

- Specific gravity of cement -3.07
- Fineness of cement – 9%
- Initial setting time - 32 minutes
- Specific gravity of coarse aggregates (20mm passing and 10mm retained)-2.5
- Water absorption of coarse aggregates – 0.45%
- Colouring pigments – as specified by ASTMc979

2. EXPERIMENTAL INVESTIGATIONS

2.1 TESTS ON FRESH CONCRETE

2.1.1. Slump Test (IS 1199-1999):

To determine the workability of concrete where the nominal maximum size of the aggregate does not exceed 38mm.

2.1.2. Compaction Factor Test (IS 1199-1999):

The compaction factor tests were designed for very low workable concrete. The degree of compaction called as compacting factor is measured by the density ratio. That is, ratio of the density actually achieved in the test to the density of the same concrete fully compacted.

2.1.3. Void Content Test (ASTM C1688) :

The void content is defined as the total percentage of voids present by volume in a specimen. The void content of pervious concrete is calculated using equation.

Void content (%) = $\left[\frac{T-D}{T}\right] \times 100$

where,

$D = (M_c - M_m) / V_m$

M_c = Mass of measure filled with concrete

M_m = Net mass of concrete by subtracting mass of measure

V_m = Volume of measure

$T = M_s/V_s$ (Theoretical Density)

M_s = Total mass of materials batched

V_s = Total absolute volume of materials

2.2. TESTS ON HARDENED CONCRETE

2.2.1. Infiltration Test (ASTM C1701):

This test method covers the determination of the field water infiltration rate of in place pervious concrete. The equation for calculating the rate of infiltration is as given below.

$$I = \frac{K \times M}{D^2 \times T}$$

where,

I = Infiltration rate, (mm/hr)

M = Mass of infiltrated water, (kg)

D = Inside diameter of infiltration ring, (cm)

T = Time required for measured amount of water to infiltrate the concrete

K = Conversion factor 4583666000 (mm^2 × sec)/(kg × hr)

Fig -1: Infiltration test

2.2.2. Density Test (ASTM C1688):

The density of the concrete is the measure of its unit weight.

$$\textbf{Density of concrete} = \frac{\text{Weight of concrete}}{\text{Volume of concrete}}$$

2.2.3. Compressive Strength Test (IS 516-1959):

This test is done to determine the compressive strength of concrete cubes

2.3. MIX DESIGN

The mix proportion can be varied from 1:3 to 1:7 with different w/c ratio. But high ratios of 1:6 and 1:7 are unacceptable due to low compressive strength and 1:3 ratio due to less permeability. So mix proportion of 1:4 and 1:5 has been taken with cement content of 400 kg/m^3 and 0.36w/c.

Table -1: Mix Proportion

SI No.	Particular	Mix proportion	
		1:4	1:5
1	Cement (kg/m^3)	400	400
2	Coarse Aggregate kg/m^3)	1600	1950
3	Water (litre)	140	140
4	Coloring Pigments	Partial replacement of 10% by weight	

2.4 PROPERTIES OF PERVIOUS CONCRETE

Table-2: Properties of Pervious Concrete

SI No.	Characteristics	Properties
1	Density	1600 N/mm^2- 2000 N/mm^2
2	Void content	16% - 35%
3	Compressive strength	Less than 20 N/mm^2
4	Flexural strength	1 Mpa - 3 Mpa
5	Cement content	270 kg/m^3 - 415 kg/m^3
6	Aggregate content	1190 kg/m^3 - 1480 kg/m^3
7	Aggregate size	Passing 20 mm and retained on 10mm

3. RESULTS

3.1SlumpTest

The graph is plotted for the design mixes along the X-axis and the slump value obtained along the Y-axis. From Chart 1, we can observe that the slump value increases with the increase in the mix proportion.

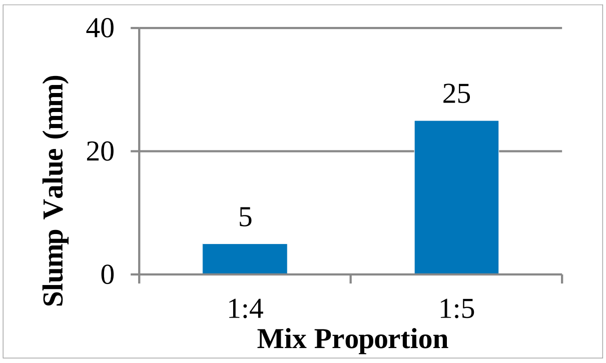

Chart-1: Variation of Slump Test Values

3.2 Compaction Factor Test

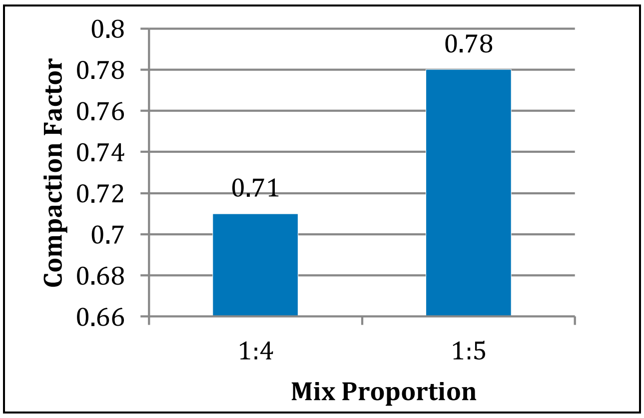

Chart-2: Variation of Compaction Factor Test Values

The graph is plotted for the design mixes along the X-axis and the compaction factor obtained along the Y-axis. From Chart 2, we can observe that the compaction factor increases with the increase in mix proportion.

3.3 Void Content Test

Table -3: Void Content Test

SI No.	Particular	Mix proportion	
		1:4	1:5
1	Cement (kg)	2.54	2.54
2	Coarse aggregate (kg)	10.08	12.348
3	Water (ltr)	0.882	0.882
4	Empty wt.of mould (kg)	8.248	8.766
5	Wt.of mould+concrete (kg)	15.028	15.57
6	Wt. of concrete (kg)	6.780	6.804
7	Theoretical density (kg/m³)	2496.71	2518.49
8	Practical density (kg/m³)	2008.89	2016
9	Void content (%)	19.53	19.95

The graph is plotted for the design mixes along the X-axis and the void content (%) obtained along the Y-axis. The Chart 3, shows that the percentage of voids is within the limit for both the mix proportion. Also the percentage in voids increases with the increase in mix proportion.

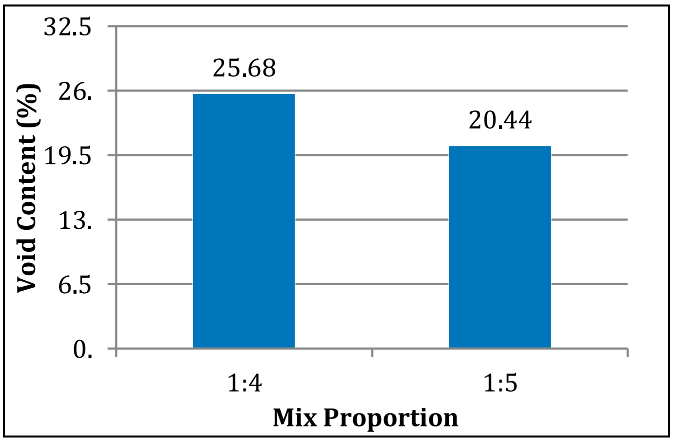

Chart-3: Variation in Void Content Test Values

3.4 Infiltration Test

Single ring infiltration test was carried for to determine the infiltration rate. The results obtained are tabulated in Table 3.

Table-4: Infiltration Rate

SI No.	Particular	Mix proportion	
		1:4	1:5
1	Time to pass 6.3 ltr (sec)	10	6.2
2	Time to pass 10 ltr (sec)	26.11	23.5
3	Conversion factor (K)	4583666000 (mm³×sec)/(kg×hour)	
4	Infiltration rate (mm/hour)	35258	39009.9

The graph is plotted for the design mixes along the X-axis and the infiltration rate along the Y-axis. From Chart 4, we can observe that the rate if infiltration increases with the increase in the mix proportion.

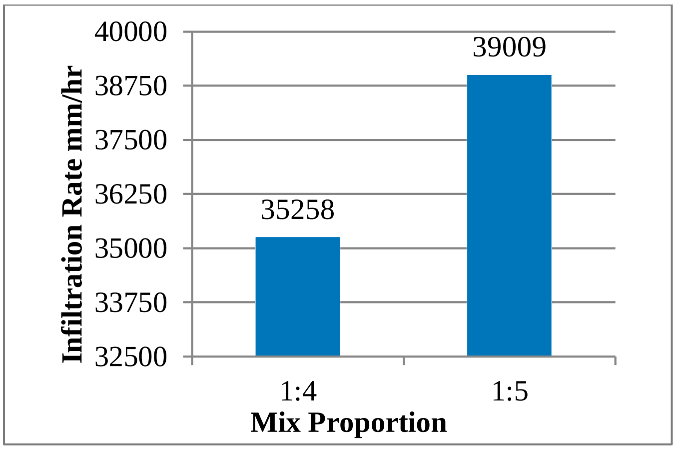

Chart-4: Variation in Infiltration Rate Values

3.5 DENSITY TEST

The density test was conducted on the dry concrete specimen. The test results are shown in the Table 4.

Table-5: Density Test

SI No.	Particular	Mix proportion	
		1:4	1:5
1	Weight of concrete cube (kg)	7.413	7.064
2	Volume of concrete cube (m^3)	(0.15^3)	
3	Density (kg/m^3)	2196.44	2093.03

The graph showing the density variation has been plotted. The mix ratio plotted along X-axis and density plotted along Y-axis has been shown in Chart 5.

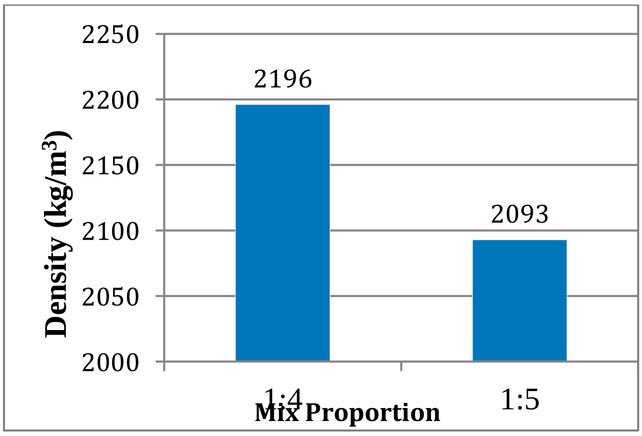

Chart-5: Variation of Density Test Values

3.5 COMPRESSIVE STRENGTH TEST

The graph is plotted for the design mixes along the X-axis and the compressive strength obtained along the Y-axis. Chart 6, shows the strength of the two mixes proportion sample on 7 days and 28 days. Where the mix proportion 1:4 shows the higher strength then the mix proportion of 1:5

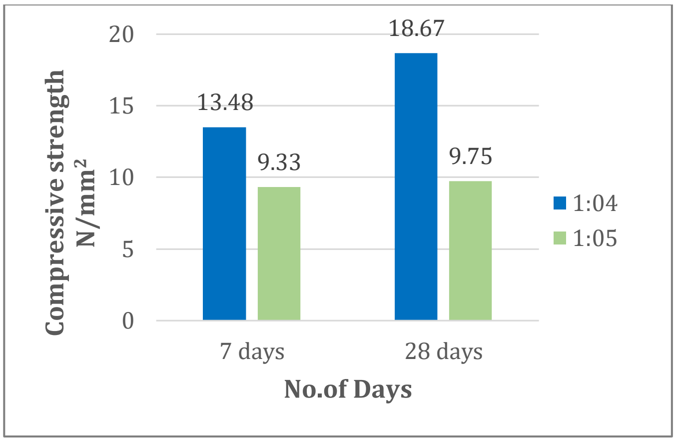

Chart-6: Variation of Compressive Strength Test Values

4. CONCLUSIONS

- From the test results it was observed that, the aggregate size of 12.5mm to 20mm size of aggregate is preferred.
- The compressive strength of the pervious concrete decreases with increase in the cement/aggregate ratio. Among the two mix proportions, the cement/aggregate ratio of 1:4 gives better results than the other proportions.
- **Therefore, it was concluded that the cement/aggregate ratio of 1:4 with aggregate size of passing 20mm and retained on 10mm is best suitable for the design of pervious concrete with increased permeable capacity.**
- Manual compaction with tamping rod is preferred if necessary.
- The mechanical vibration shouldn't be provided since it leads to slurry settlement.
- Larger the aggregate size lower the strength and vice-versa.
- Density increased leads to the increase in compressive strength of pervious concrete.

- Although the compressive strength achieved are relatively less than the conventional concrete, the strength is suitable for the light traffic.

Fig-2: Pervious Concrete Cubes

Fig-3: Water passing through Pervious Concrete

Fig-4: Colored Pervious Concrete

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