Design of pervious concrete for recharging ground water table

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Abstract – *Pervious concrete is a zero slump, open graded, has cement, water, coarse aggregates as basic materials, pervious concrete may contain little fines or no fine aggregates, sometimes it is referred as "no fines". Pervious concrete is considered as good replacement to traditional impervious hard concrete, as it has high porosity, permeability and also eco-friendly. Permeable concrete because of its insufficient structural strength, various mix designs (without fines and with fines) were attempted to know its mechanical strength.*

This study gives the interrelation between compressive strength and permeability. The strength is inversely proportional to the permeability, a series of experiments have been conducted for developing mix design of pervious concrete. This study discusses various combination like without fines and with fines with aggregate size of 19 mm to 4.75mm and water content of 0.3% and by varying the fines from 5%, 10%, 15%, 20% .mechanical properties of various mixes were evaluated. The model was developed and fabricated to evaluate the permeability of the specimen. The falling head method was used for finding the coefficient of permeability of pervious concrete. The typical compressive strength of pervious concrete lies between 9.18 MPa to 14.06 MPa The permeability ranges from 5.9% to 12.7 %. Good pervious concrete has the void ratio between 15% -20%. Compressive strength of pervious concrete is less than that of conventional concrete. And permeability of pervious concrete reduces with small size aggregates. This study indicates that strength and permeability varies with shape, angularity number, paste content, size, and water/cement ratio. These are considered as important parameter while developing pervious concrete. The main aim of project is to recharge the groundwater table by adopting the pervious concrete for different application.

***Key Words*: Pervious concrete, Hydraulic conductivity, Compressive strength, Void ratio, Ground water recharge.**

1. INTRODUCTION

In an undeveloped, forest site, storm water runoff are less because of the processes of infiltration into surfaces, evaporation from surfaces, and transpiration from vegetation. Very little storm water i.e., less than 1%, leaves the site in the form of runoff.

However as a site are developed, increases in impervious surface due to roads, rooftops, sidewalks, and parking areas cause major changes in the capacity of the site to handle storm water. More water runs off the site about 20-30% and less water is infiltrated, evaporated or transpired. In addition to the increased volume of runoff, it is the speed with which it travels that causes concern. To solve this problem pervious concrete was introduced.

Pervious concrete is concrete which has continuous pores which are purposely incorporated into pervious concrete. As it is entirely differ from the conventional concrete. Porous concrete as plenty of application used in sidewalks, shoulders, parking lots etc, because of its various environmental benefits, pervious concrete is considered as the one of sustainable facilities and infrastructure. So that it is considered as the best remedial measure for storm water management and one of key element of sustainable development by US Environmental Protection Agency(EPA). Pervious concrete provides a rigid structural surface to serve the required structural function as well as allow the water comes on it through the rain or other sources to percolate through the join groundwater table. This is suitable method for reducing the runoff from impervious surface and helps in recharging of groundwater table and storm water management is achieved using pervious concrete.

1.1 Materials:

1. **Cement:**

Ordinary Portland cement, 53 grade conforming to Confirm IS requirement as per IS 12269-2013.OPC was used for casting all the specimens. The type of cement used is important to ensure compatibility of chemical and mineral admixtures.

Table -1: Basic test values of cement

Tests	Value
Normal consistency	32 %
Initial setting time	45 min
Final setting time	600 min
Soundness	3.50 mm
Specific gravity	3.15
Fineness	6.5%

2. **Coarse aggregates and fine aggregates:**

Locally available crushed granite stones conforming to the IS: 2386 (Part III) – 1963. Aggregate of size 19 mm to 4.75mm as prescribed by the ACI -211, Appendix -6, A6.2 were used. The size not more than 20mm is used. In addition to this aggregate type, also has great influence on concrete dimensional stability.

Manufactured sand is used in 5%, 10%, 15%, and 20% by total aggregate weight.

Table -2: Basic test values of course aggregates

Tests	Value
Specific gravity	2.70
Water Absorption	1%
Dry rodded density	1524 kg/m^3
Angular number	12.36
Impact test	5.96

Table -3: Basic test values of fine aggregates

Tests	Value
Specific gravity	2.52
Water Absorption	1.5%

3. **GGBS (Ground Granulated Blast Furnace Slag):**

GGBS is one of the supplementary cementious material the solid waste produced from iron manufacturing industries. It is common type of mineral admixture used nowadays.

4. **Chemical admixture:**

Main aim using chemical admixture is to reduce water content.

The chemical admixture used was PC-Based Plasticizers named Chyrso Plast Delta D780

5. **Water:**

Casting and curing is done with the help of portable water conforming to the IS 10500(2012).

2. Experimental methodology:

2.1Mix design:

PERVIOUS CONCRETE MIXTURE PROPORTIONING

As per ACI 211.3R-02

(GUIDE FOR SELECTING PROPORTIONS FOR NO-SLUMP CONCRETE)

SL NO:	MIX MATERIALS		Density Kg/m^3
1.	Cementations Content		
	a. Cement		182
	b. GGBS		182
2.	Total Aggregate Content		
	CA Content		1524
	FA Content	0%	-
		5%	30.48
		10%	152.4
		15%	228.6
		20%	304.80
3.	Water Content (% by wt of cementations content)		97.947
4.	P.C Plasticizers (% by wt of cementations content)		1.0883

Pervious concretes designed and proportioned in the laboratory were cast into 150 x 150 x 150 mm size cubes for the determination of cube compressive strength under compression testing machine. Circular specimens of size 100 mm diameter x 200 mm long were used for the determination of hydraulic conductivity (permeability) of pervious concretes. Cube/cylindrical specimens are used for finding total void percentage.

2.2 Fresh state of concrete

2.2.1 Density of concrete

2.3 Harden state of concrete

2.3.1 Total percentage of voids:

The total percentage of voids in the casted specimen were found by Park and Tia (Park, 2004)[1]. The relationship for total void ratio is as follows:

$$V_r = [1-((W_1-W_2)/\rho_w * V)] \times 100$$

Where,

V_r = Total Void ratio (%)

W_1-= weight specimen in water

W_2= oven dry weight of specimen

V = volume of specimen

ρ_w = density of water

2.3.2 Hydraulic conductivity (permeability):

As it has been stated that the pervious concrete has a large interconnected pore network, and hence the conventional method used for evaluating hydraulic conductivity of normal concrete is not applicable. Therefore to evaluate or to estimate the hydraulic conductivity of pervious concrete, a falling head permeability test apparatus has been fabricated at R&D Centre, Karnataka Ready Con Mix, a unit of KRC Group, Bengaluru as shown in Fig. The way by which the water gets percolated through pervious concrete when poured from top is shown in Fig

k= (aL÷ At) LN (h1/h2)

Where:

k=coefficient of permeability, mm/s;

a=cross sectional area of the standpipe, mm^2;

L=length of Sample, mm;

A=cross sectional area of specimen, mm^2;

t=time in seconds from h1 to h2;

h1=initial water level in mm,

h2=finial water level in mm.

2.3.3 Compressive strength:

Compressive strength test were conducted in accordance with IS 516 (1959). Cubes of specimen of size 150 mm x 150 mm x 150 mm were prepared for each mix. After 24 hours the specimens were demoulded and cured in water for 24ºC until testing. The strength value was reported as the average of three samples at 7 days and 28 days.

Compressive strength N/mm^2 =

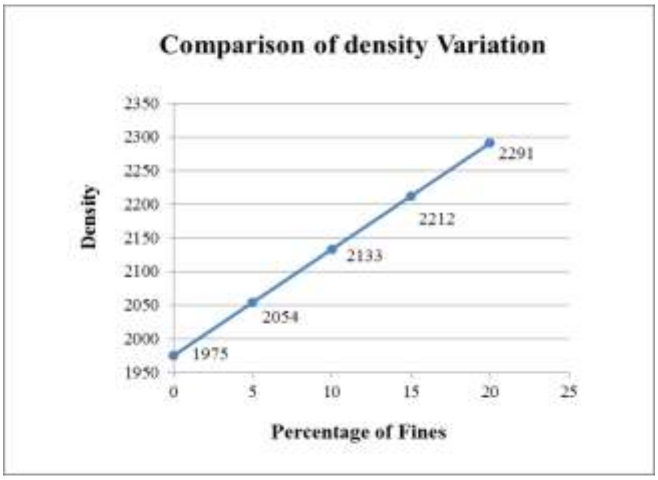
$$\frac{\text{load applied (N)}}{\text{area of the specimen (mm2)}}$$

3. Result and Discussion:

3.1 FRESH PROPERTIES TEST RESULTS

3.1.1 Comparison of density with respect to the different percentage of fines at the fresh state given by table

Percentage of Fines	Density(Kg/m^3)
0	1975
5	2054
10	2133
15	2212
20	2291

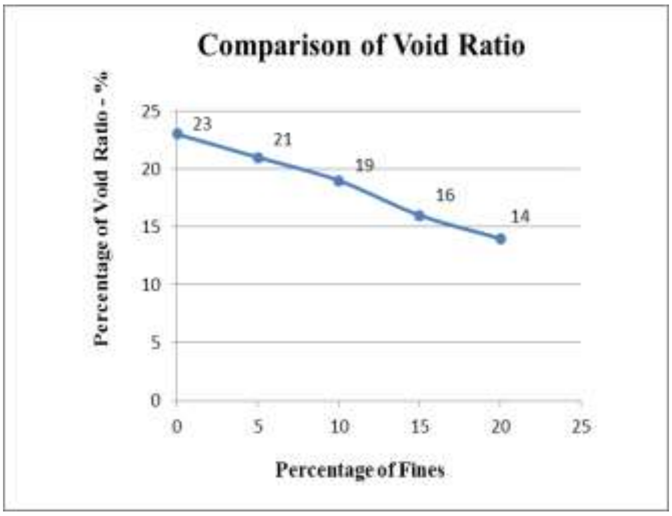


Graph 1: Comparison of variation of Density with different dosage of fines

3.2 HARDEN PROPERTIES TEST RESULTS

3.2.1 Comparison of void ratio with respect to the different percentage of fines given by table

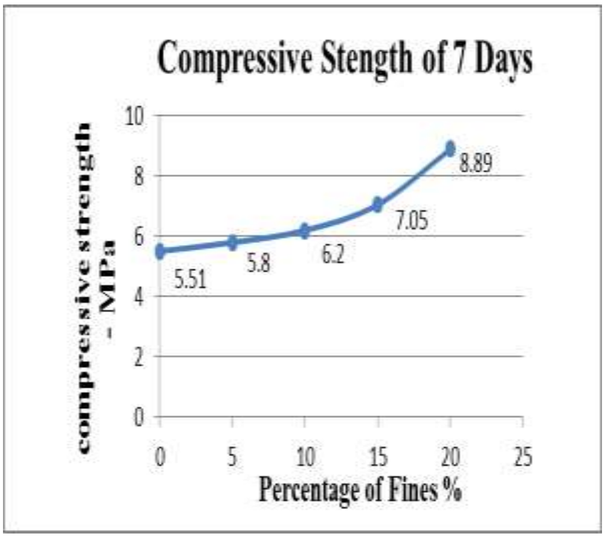
Percentage of	Percentage of Void
0	23
5	21
10	19
15	16
20	14



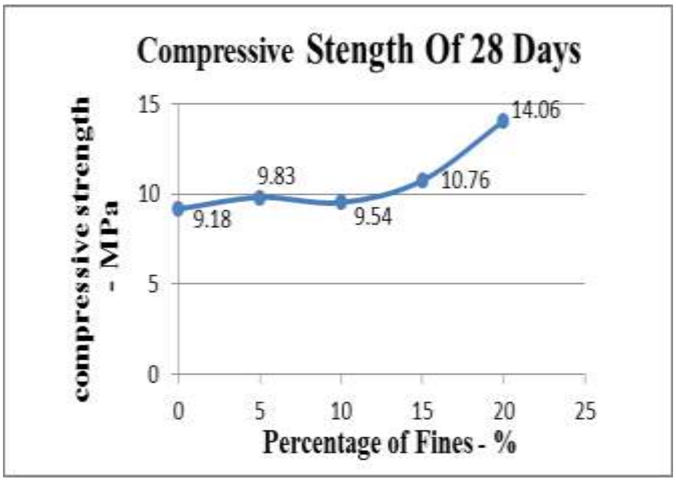
Graph 2: Comparison of variation of voids ratio with different dosage of fines

3.2.2 Comparison of compressive strength with respect to the different percentage of fines given by table

Percentage of Fines	Compressive Strength(Mpa)	
	7 Days	28 Days
0	5.51	9.18
5	5.80	9.83
10	6.20	9.54
15	7.05	10.76
20	8.89	14.06



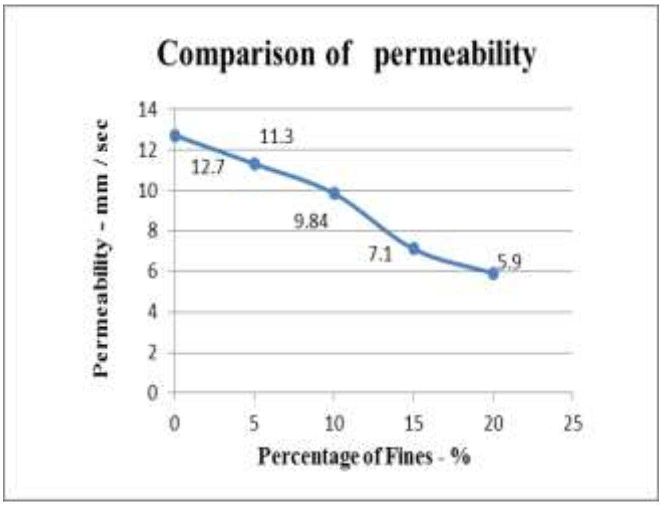
Graph 3: Comparison of variation of 7 Days Compressive Strength with different dosage of fines



Graph 4: Comparison of variation of 28 Days Compressive Strength with different dosage of fines

3.2.3 Comparison of permeability with respect to the different percentage of fines given by table

Percentage Of Fines	Permeability	
	mm / sec	mm / min
0	12.70	762
5	11.30	678
10	9.84	590.4
15	7.10	426
20	5.90	354



Graph 5: Comparison of variation of Permeability with different dosage of fines

4. CONCLUSIONS

1. The percentage decreases in compressive strength in pervious concrete is 50% to 75% compared with conventional concrete.
2. The percentage of void ratio is increased to 4% in pervious concrete as compared with conventional concrete. So that permeability is high.
3. Density is reduced by 30% compared to conventional concrete.
4. Larger the aggregate size of coarse aggregates, larger is the void ratio.
5. Cube compressive strength drops as size of the aggregates increases.
6. Addition of sand improves the mechanical strength but decreases permeability.
7. Permeability increases as the aggregate size increases.
8. Dose of chemical admixture is necessary to reduce the water cement ratio.
9. All the lower as well as higher value of water cement ratio than the optimum value, the compressive strength of the mix is typically lower.
10. Permeability of porous concrete varies with respect to water cement ratio, shape and size of aggregates.
11. A correlation with different percentage of fines was found for the pervious concrete properties, i.e., unit weight, compression strength, void ratio and hydraulic conductivity.
12. When the void ratio percentage is between 15% - 25%, good pervious concrete with relatively high strength but low void ratio.

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