Experimental Studies on Pervious Concrete

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Abstract- **In modern day infrastructure, use of impervious surfaces on pavements to rapidly collect and transport rain water runoff is very important. Due to this storm water reachesthe water bodies rapidly, in bigger volume and carries more contaminants than natural conditions. Permeable pavement on parking lots, sidewalks, and driveways provides asolution to this problem. One such material that can be used to produce porous surfaces ispervious concrete. Even though no-fines concrete mix has been used for many years, thereare still many unresolved issues related to its structural performance and issues withreduced filtration capacity over time especially when exposed to real conditions. This paper presents a study describing a project pervious concrete system. The details of the construction technique including details of the material used are described in this paper. On-going tests to monitor the performance of this test slab are also described.**

Index terms- **Pervious concrete, Porous surface, Rain water runoff, No-fines concrete, Permeable pavement**

1. INTRODUCTION

Pavement systems creating about 30-40 per cent of the total urban fabric have converted pervious natural ground into impervious systems, which have created a negative impression on the environment. These impressions can be broadly categorised as variations in hydrological aspect and temperature in the surrounding ambience. About the hydrological aspects, the existing dense pavement system being impervious in nature, increases the quantity of runoff and reduces the infiltration of rainwater into the ground, which may create a flood-like situation in low-lying areas. The runoff, which occurs immediately during rainfall, termed as the first flush, is highly-polluted and requires large treatment facilities before being discharged into natural water bodies. Further, the problems of water logging, hydroplaning and skidding, which affect road users, exist when the pavement is wet. Thus, pervious concrete enables to percolate the storm water into

ground and helps to recharge the ground water table and excess water is stored in underground tank and used for domestic purpose.

Regarding temperature in the surrounding ambience, impervious pavement systems act as a heat storage media that stores heat and releases it back to the atmosphere, increasing results in an increase in the urban temperature by about 2-6°C compared to the surrounding rural areas. This results in thermal discomfort, which increases the consumption of electricity for cooling systems and other energy sources.

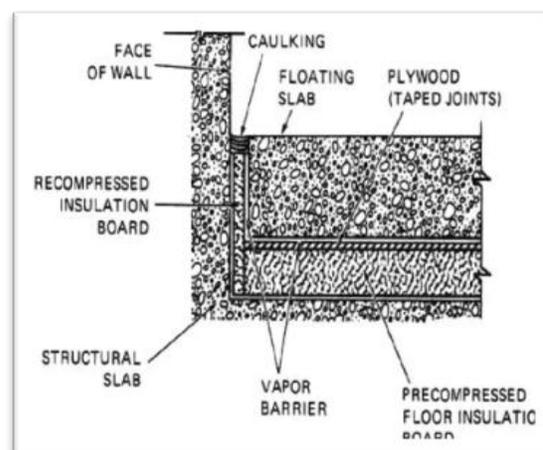The no fine concrete concept is well described in following figure.

Fig 1 Typical Section of Pervious Concrete Pavement

In this work, no-fines concretes with three different mixtures corresponding to low (5-10 MPa), medium (15-20 MPa) and high (25-30 MPa) compressive strengths were manufactured.

2. BACKGROUND

Many related work has been introduced and undertaken by the enthusiasts and researchers as follows-

M.UmaMaguesvari and V.L. Narasimha studied the influence of fine aggregate and coarse aggregate

quantities on the properties of pervious concrete. Materials used are OPC Type I, fine aggregate corresponding to grading II and four sizes of coarse aggregate namely, 4.75mm to 9mm, 9mm to 12.5mm, 12.5mm to 16mm, 16mm to 19.5mm. Mixes were prepared with the water cement ratio of 0.34, cement content of 400kg/m3 and maintaining the aggregate cement ratio as 4.75:1. Fine aggregate was replaced with coarse aggregate in the range of 50 - 100 % by weight. Various mechanical properties of the mixes were evaluated. Coefficient of permeability was determined by using falling head permeability method.

Mr. V. R. Patil, Prof. A. K. Gupta, Prof. D. B. Desai studied that our cities are being covered with building and the air-proof concrete road more and more. In addition, the environment of city is far from natural. Because of the lack of water permeability and air permeability of the common concrete pavement, the rainwater is not filtered underground. Without constant supply of water to the soil, plants are difficult to grow normally. In addition, it is difficult for soil to exchange heat and moisture with air; therefore, the temperature and humidity of the Earth's surface in large cities cannot be adjusted.

Darshan S. Shah, Prof. Jayesh Kumar Pitroda, Prof.J.J. Bhavsar studied Pervious concrete and concluded that it is a relatively new concept for rural road pavement, with increase into the problems in rural areas related to the low ground water level, agricultural problem. Pervious concrete has introduced in rural road as a road pavement material. Pervious concrete as a paving material has seen renewed interest due to its ability to allow water to flow through itself to recharge groundwater level and minimize storm water runoff. This introduction to pervious concrete pavements reviews its applications and engineering properties, including Environmental benefits, structural properties, and durability. In rural area cost consideration is the primary factor which must be kept in mind. So that in rural areas costly storm water management practices is not applicable. Pervious concrete pavement is unique and effective means to meet growing environmental demands. By capturing rainwater and allowing it to seep into the ground. This pavement technology creates more efficient land use by eliminating the need for retention ponds, swell, and other costly storm water management devices.

3. EXPERIMENTAL WORK

This study consists of pervious concrete. Six concrete cubes of size 150 mm x 150 mm x 150mm samples are taken from each mix design. M 40 mix design is chosen for the test. Four design mix is done as plain, 0.5% rubber crumb, 1 % rubber crumb, 1.5% rubber &2.0% crumb by the weight.

3.1 Properties of Materials used in this Investigation

3.1.1 Cement

3.1.1 Aggregates Ordinary Portland cement of 53 Grade (Ultratech) is used throughout this work. The properties of cement used are given in Table 1.

Table 1 Properties of Cement

Name of the Test	Experimental Results	Standard values
Specific Gravity of Cement	3.15	Not Specified
Consistency	32.40	Not Specified
Initial Setting Time	150 minutes	Shall not be less than 30 minutes
Final Setting Time	550 minutes	Shall not be more than 600 minutes
Fineness of Cement	280kg/m^2	Shall not be less than 225 m^2/kg
Soundness of Cement	0.8 mm	Shall not be more than 10mm

3.1.2 Course Aggregate

Normal Coarse Aggregates of Angular shape is used. Coarse Aggregates is kept to a narrow Gradation. Two types of aggregates used. of size passing through 20 mm are sieve and retained on 12.5 mm IS sieve.2nd set of aggregates passing through 12.5 mm IS sieve and retained on 4.75mm IS sieve.

Table 2 Properties of Course Aggregate

Test conducted	Result		Standard values
	Aggregate size		Aggregate size
	20 mm	12.5 mm	20 mm
Specific Gravity	2.8	2.65	2.4 to 2.7
Water Absorption	0.87%	3.05%	Not more than 3%
Crushing value	17	21	Not more than 30%
Flakiness Index	20	25	Not more than 40%

3.1.3 Water

Water sample collected DYPCET College Campus (Kolhapur, Maharashtra) is used throughout this work. The properties of water used in given in Table 3

Table 3 Properties of Water

Name of the Test	Experimental Result	Standard values as per IS 456-2000
Chloride	250 mg/l	RCC max. 500 mg/l
Sulphate	160 mg/l	PCC max. 2000 mg
pH Value	7.8 mg/l	Shall not be less than 6
Inorganic Solids	794 mg/l	Max. 3000 mg/l
Suspended Matte	24 mg/l	Max. 2000 mg/l
organic solids	66 mg/l	Max. 400 mg/l

4. MIX DESIGN

The following mixture proportioning approach can be used to quickly arrive at pervious concrete mixture proportions that would help attain void content of freshly mixed pervious concrete when measured in accordance with ASTM C1688 similar to the target value.

Determine the dry-rodded unit weight of the aggregate and calculate the void content.

Estimate the approximate percentage and volume of paste needed. The volume of paste (Vp) is then estimated as follows:

Vp (%) = Aggregate Void Content (%) + CI (%) - Vvoid (%)

Where CI = compaction index and

Vvoid = design void content of the pervious concrete mix.

The value of CI can be varied based on the anticipated consolidation to be used in the field. For greater consolidation effort a compaction index value of 1 to 2% may be more reasonable. For lighter level of consolidation, a value of 7 to 8% can be used. NRMCA used a value of 5% to get similar values between measured fresh pervious concrete void content (ASTM C1688) and design void content. Using a smaller value for CI (%) will reduce the paste volume.

4.1 Mix proportion A:-

Table 4 Assumptions for mix design

Aggregate void content (%)	47%
Compaction Index (%)	5%
Volume of void	20%

Above table shows the assumption done initially to start with mix design.

Hence, Vp (%) = Aggregate Void Content (%) + CI (%) - Vvoid (%)

1. Vp (%) = 47% + 5% - 20%
Hence, Vp = 32%

4.1.1 Calculate the volume of paste
Vp in m^3 per cubic meter of pervious concrete:
$Vp = Vp$(%) Hence $Vp = 0.32 m^3$ Select the w/c ratio for the paste. Recommended values are in the range of 0.25 to 0.36. Hence w/c ratio assumed = 0.25

4.1.2 Calculation of Absolute Volume of Cement (Vc)
$Vc = Vp / (1+ (w/C \times RDc))$
Where: RDc is the specific gravity of cement
Hence $Vc = 0.32 / (1+(0.25 \times 3.15)) = 0.179 \ m^3 = 563.85 \ kg/m^3$

4.1.3. Determination of volume of water (Vw)
$Vw = Vp - Vc$
$Vw = 0.32 - 0.179 = 0.141 \ m^3 = 141 \ kg/m^3$
4.1.4 Calculate the volume of SSD aggregate.
$Vagg = 0.48 \ m^3 = 1392 \ kg/m^3$

Table 5 Proportion of Materials

Material	Quantity	For one Cube
Cement	563.85 Kg	1.98 kg
Aggregate	1392 kg	4.87kg
Water	141 litres	0.5litres
Admixture	1.5 %	1.5 %

4.1.5 Void Ratio
Void ratio is the ratio between total volumes minus solid volume divided by total volume of concrete. The formula for calculating the percentage of voids is given below, Percentage of Vvoids = (V total - V solid) X 100 / V total

4.1.6 Compressive Strength
Total numbers of 21 cubes specimens were casted and tested. The concrete mixes of different proportion M1, M2, M3, M4, M5, M6, and M7. Were tested to compression strength as per Indian standards figure 6 shows the compressive strength while conducting test in compression testing machine.

5. RESULTS

Table 6 Mix Proportions for Different Mixes

Mix	Void %	Cement in kg	Course Aggregate(Kg)		Water
			12.5 mm	20 mm	
M 1	20	441.09	1183.2	295.8	150
M2	25	365.04	1183.2	295.8	125
M3	30	286.65	1183.2	295.8	99
M4	35	211.05	1183.2	295.8	73

Above table 6 shows mix proportions for different mixes.

5.1 Permeability Test Result

Table 7 shows various permeability test results for different void ratios.

Table 7 Permeability Test Results

Mix	Void Ratio %	Permeability for 0.1 $sq.m.$(ml/min)
M1	20	350
M 2	25	390
M 3	30	427
M 4	35	516

5.2 Compression Test Results

Table 8 Compressive strength Results

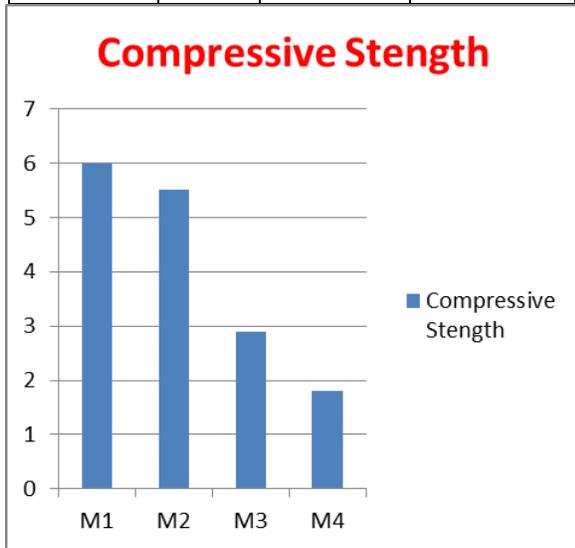| Mix	Void %	Compressive Strength N/mm²	
		(7 Days)	(28 Days)
M 1	20	6	11.6
M2	25	5.5	9.8
M3	30	2.9	5.4
M4	35	1.8	4.88

Figure 8 Comparison of compressive strength for different mixes

6. CONCLUSIONS

The following are the conclusions and recommendations made by this study. According to the Experimental results, it has been observed that,

1. If the voids ratio increases, compressive strength & flexural strength values are reduced.
2. The compressive strength of pervious concrete with 12mm size aggregates are more compare to 20mm size aggregates.
3. Compared to conventional mix, large quantity of admixtures (AlgiTech) are required for Pervious concrete.
4. The mix M4 gives 83.24% more Compressive Strength, 72.53 % more Flexural strength 34.11% less Void ratio Compared to the Mix M1.
5. The mix M1 gives 51.78% more voids ratio (Maximum), 45.42% less Compressive Strength and 42.42% less Flexural strength compared to the mix M4.

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