Effect of Different Types of Aggregate on The Mechanical Properties of Pervious Concrete

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Abstract- *This study investigates the influence of aggregate type and size on the Mechanical properties of pervious concrete. Five different concrete mixtures were prepared, including a standard concrete mixture and four different concrete mixtures with varied aggregate type and size (Grit, Red Mandana, Granite, Kota Grey). After successful concrete mixtures, its performance (e.g. compressive strength, permeability) was evaluated via multiple mechanical and physical tests. As for the experimental result for high strength pervious concrete (HSPC), its 28 days compressive strength peaked 22.8 MPa together with a 21.5 mm/s corresponding permeability. The necessity to distinguish compressive strength and total porosity from effective concrete mixture is highlighted and taken intoaccount.*

Keywords- Pervious Concrete (PC), Portland Cement Pervious Concrete (PCPC), lightweight aggregate (LWA)

I. INTRODUCTION

Concrete is the most commonly used building material in the world. It is estimated that the present consumption of concrete in the world is of the order of 10 billion tones every year. Our cities are being covered with building and air- proof concrete road. In addition the environment of city is far from natural. Because of lack of water permeability and the rain water is not filtered underground.

1.1 Pervious concrete

Pervious concrete is a special mixture that create voids and the voids make the product highly porous. The porosity allow rainfall & surface water to percolate through the concrete to a permeable base. It is a mixture of Cementations material, No or little amount of sand, Aggregates, Admixtures, and Water. Pervious concrete is also termed as porous concrete and permeable concrete. Due to porous the strength of concrete is relatively low as compare to normal concrete.

1.2 Alternate material

Concrete is mixture of cement, aggregate, sand and water. Alternate material is a material which is substitute to any of the ingredient in concrete. Here Natural aggregate is replaced by other four different types aggregate. This material generally reduce the cost and or improves one or more technical properties of concrete. In this paper some of the alternate material such as Grit, Red Mandana, Granite, and Kota Grey are referred.

II. LITERATURE REVIEW

Ahmed Ibrahim (2014)[3] presented on the mechanical and hydrological properties of Portland cement pervious concrete. The mixtures used consist of either one or two aggregate sizes. Linear regression relationship graph were developed to establish relationships between density and porosity, compressive strength and permeability, tensile strength and permeability and compressive strength and porosity. The results showed that mechanical properties of pervious concrete such as permeability, porosity, are significantly affected by using either one or two coarse aggregate sizes in all concrete mixtures. Moreover density can be an effective factor for calculating compressive strength, and porosity. In this study, the maximum compressive strength was 6.95 MPa obtained by using one aggregate size of 9.5 mm with 250 kg/m3 cement content. The results showed that PCPC could be produced using one or two aggregate sizes at most

Ammar Yahia (2014)[4] presented New approach to proportion pervious concrete. In this study determine the effects of aggregate size and gradation as well as the paste volume on unit weight, compressive and tensile strength, porosity, and permeability of pervious concrete(PC). Three different coarse aggregate (CA) types with nominal maximum size of 2.5/10 mm (CA-10), 5/ 14 mm (CA-14), and 10/20 mm (CA-20) were used. They conclude that the fine fraction of particles lower than D10 in the coarse aggregate can considerably influence the mechanical properties and hydraulic conductivity of pervious concrete. The failure mode

of pervious concrete is mainly affected by the paste volume. For paste volume ranging between 30% and 40% of PV/IPV, the failure occurs at the interface between cement and aggregate.

K.C'osic (2015)[5] reviewed Influence of aggregate type and size on properties of pervious concrete. In this study investigates the influence of aggregate type and size on the properties of pervious concrete. Five different concrete mixtures were prepared, including a standard dense concrete mixture and four pervious concrete mixtures with varied aggregate types (dolomite or steel slag) and differingproportions of 4–8 mm to 8–16 mm aggregate fractions (30:60 or 60:30). They conclude that A higher total porosity is obtained in pervious concrete with dolomite aggregate compared to previous concrete with steel slag aggregate. A higher proportion of coarse fraction in mixtures results in a higher value of overall porosity. Second thing is that connected porosity as a main parameter for the estimation of pervious concrete efficiency is influenced more by the aggregate type than its size.

Prof. Dr K.B. Parikh, M.A.Shaikh, Adil A.Haji (2016) [6] reviewed different literatures related to pervious concrete and effects of mineral admixtures. They studied various aspects of the pervious concrete using mineral admixtures along with the basic behaviour, advantages, limitations, effects & mechanical properties. They concluded that replacement of fly ash with cement up to 40% gives increment in compressive strength of concrete. Use of fine aggregate up to limit from 5% to 10% can give enough structural strength in pervious concrete. But further increment of sand reduces strength properties of pervious concrete. Use of silica fume gives earlier high strength but with higher replacement of cement with this material reduces strength.

Nicholas A. Brake (2016)[7] presented The Flexural strength and fracture size effects of pervious concrete. In this paper a low strength/low unit weight and high-strength/high unit weight pervious concrete mix is studied using notched three point bend specimens to ascertain strength and fracture size effects using beam depths ranging from 100 to 200 mm. They conclude that two variables studied here (size and unit weight), the unit weight was shown to be the most significant predictor of flexural strength, tensile strength, and initial and total fracture energy.If the unit weight or void content is not controlled, its effects on strength need to be accounted for using regression analysis in order to identify size effects.

III. CRITICAL REMARKS

- Pervious concrete has high porosity which leads to higher permeability in pervious concrete.But other hand, higher porosity decrease the amount of compressive strength of pervious concrete than conventional concrete.
- Use of fine sand at limit from 5% to 10% can give enough strength in pervious concrete. But further increment of sand can reduce permeability of pervious concrete which is main parameter of this concrete.
- The compressive strength of pervious concrete is in between 2.8 to 28 MPa. But with use of different types of aggregates, strength can increase in range of 12 to 14%.
- Research needs to be done with use of higher gradation of coarse aggregates in pervious concrete.

IV. RESEARCH OBJECTIVE

- The Aim of this study is to investigate the best Relationship between Permeability and compressive strength of the Pervious Concrete.
- To find the effectiveness of different types of aggregate in pervious concrete.
- The parameters under study are :
  - Compressive strength of pervious concrete.
  - Permeability of Pervious concrete

V. EXPERIMENTAL WORK

5.1 Materials:

5.1.1 Cement

Ordinary Portland cement available in local market (Ultratech Cement) has been used in this study corresponding to IS-8112. The specific gravity of cement is 3.15.

5.1.2 Fine aggregate

- Sand: In addition natural river sand is used as find aggregate. As per IS: 2386 (Part III)-1963, the bulk specific gravity in oven dry condition and water absorption of the sand are 2.6 and 1% respectively.
- Grit: Crushed stones of maximum size 10 mm are used as coarse aggregate. As per IS: 2386 (Part III)-1963 [8], the bulk specific gravity in oven dry condition and water absorption of the coarse aggregate are 2.66 and 1.2% respectively.

5.1.3 Course aggregate

- Natural aggregate: Natural aggregates consist of crushed stone. Sand and gravel are among the most abundant natural resources.
- Red Mandana: This sandstone also known as Wine Red or Bhilwara-Red has quartz grains cemented together by secondary silica & calcite. In strength, this aggregates' radioactive background is usually very low and they are light weight than other aggregates.
- White Marble: Marble is a metamorphic rock composed of recrystallized carbonate minerals, most commonly calcite or dolomite.
- Kota Grey: Kota Stone is a variety of limestone quarried at Kota district, Rajasthan, India. Kota stone industry generates both solid waste and stone slurry.

5.1.4 Water

Fresh water is used in this study. It react with cement to produce desired properties of concrete.

5.2 Characteristic of materials:

As per IS:2386 (P-3)1963 and IS:2386(P-4)1963 the results are obtained as shown in table below.

Table : 1 Physical properties of aggregate (20mm)

Sr. No.	Test Parameter	Result (Natural Aggregate 20mm)	Result (Natural Aggregate 10mm)	Result (Red Mandana 20mm)	Result (White Marble 20mm)	Result (Kota grey 20mm)
1	Specific Gravity	2.78	2.62	1.82	2.70	3.01
2	Water Absorption	0.72	0.80	1.20	0.78	0.68
3	Impact Value (%)	12.10	-	18.06	14.28	8.87
4	Crushing Value (%)	14.00	-	19.60	17.10	9.90
5	Abrasion Value (%)	15.10	-	21.98	20.22	10.28

5.3 Mix design

Pervious Concrete mix design

There is no specific IS guidelines for pervious concrete Mix Design. Therefore in this study we are taking approximate mix proportions with reference of ACI 522[10] Report on Pervious concrete. Following data which we are taking as concrete mix design,
For Higher W/C ratio 0.40 and fixed A/C ratio 4:1 and fine aggregate is 5% of total aggregate.

Table 2 Mix design of M20 Pervious Concrete reference by ACI 522 [10] Report on pervious concrete

Mix Design for	Water (Litre)	Cement (kg)	C.A. (kg)	F.A. (kg)
1m3	**169.0**	**380.0**	**1520.0**	**77.0 (5%)**
1 cube (150mm*150mm*150mm)	0.870	1.28	4	0.20

VI. TEST AND RESULT DISCUSION

6.1 Compressive strength test

The test was carried out in accordance with BS1881108: 1983 and ACI 522R-10. For cube test specimens of size of 15 cm X 15 cm X 15 cm were used. 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 permeable concrete. Concrete cubes with different types of coarse aggregate contents with 10% additional variation is made out to find the compressive strength of pervious concrete. Based on the load value the compressive strength of the concrete specimen calculated as follows, Compressive strength=ultimate load/contact area of the cube.

Fig 1 : showing testing of compressive strength

Table 3Results of compressive strength at 7 days :

Aggregate	days	Weight (kg)	Average compressive strength(N/mm²)
Normal Aggregate (20mm)	7	7.1	15.4
Grit (10 mm)	7	6.3	13.7
Red Mandanaa (20mm)	7	5.8	12.8
White Marble (20mm)	7	6.9	15.0
Kota Grey (20mm)	7	8.2	17.7

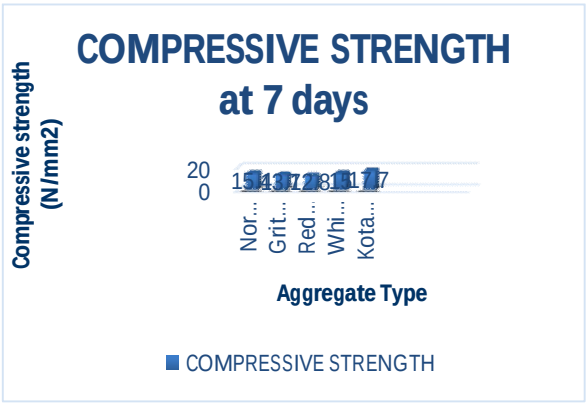

Fig.2 : Graph of compressive strength at 7 days

Table 4: Results of compressive strength at 28 days :

Aggregate	days	Weight (kg)	Average compressive strength(N/mm²)
Normal Aggregate (20mm)	28	7.5	20.2
Grit (10 mm)	28	6.8	22.5
Red Mandanaa (20mm)	28	6.1	18.3
White Marble (20mm)	28	7.2	21.7
Kota Grey (20mm)	28	8.8	24.8

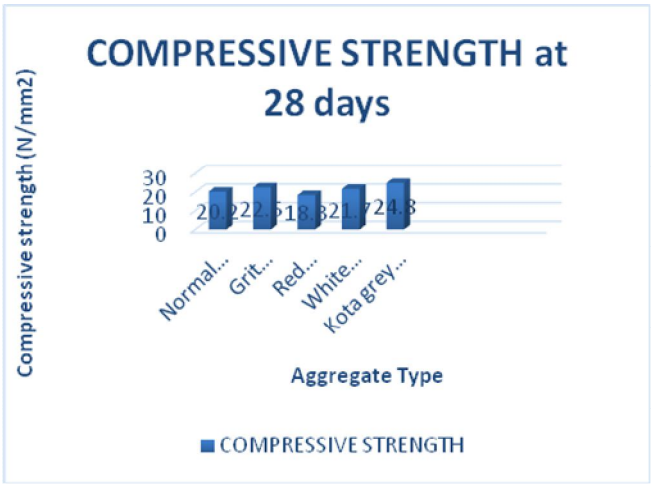

Fig.3 : Graph of compressive strength at 28 days

6.2 Permeability test

Reference of ACI 522, is taken by using of falling head permeability test to find out permeability of pervious concrete. Figure shows the apparatus of falling head permeameter setup.

Fig 4 : Falling head 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:

K= (aL)(lnh0) (At)(h1)

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 h0 to h1 in sec

Now, Concrete cylinders is made out with 10% additional variation to find out the permeability in pervious concrete.

Table 5 :Results of Permeability test at 7 days and 28 days

Aggregate	At 7 days Average Permeability (mm/sec)	At 28 days Average Permeability (mm/sec)
Normal Aggregate (20mm)	20.2	20.1
Grit (10 mm)	18.2	16.8
Red Mandanaa (20mm)	26.5	26.0
White Marble (20mm)	21.3	20.9
Kota Grey (20mm)	23.7	21.5

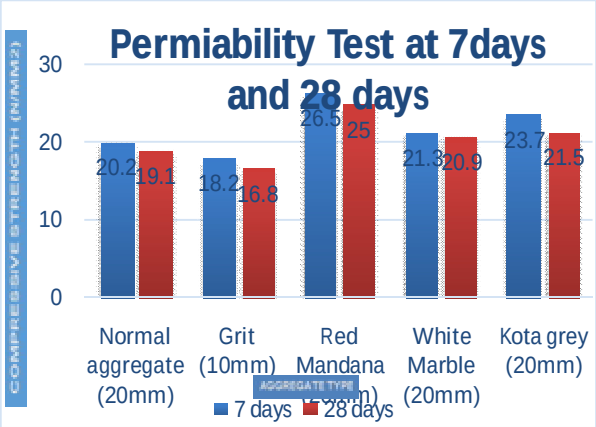

Fig.5 : Graph of permiability test at 7 & 28 days

VII. CONCLUSION

The influence of aggregate type and size on the mechanical properties of PC was investigated in this paper.

- Normally pervious concrete can be achieved from cement, coarse aggregate and water as suggested by ACI 522.
- Pervious concrete has correlations between compressive strength, permeability, and void content and with the use of alternate material such as, Grit, Red Mandana, Granite, Kota Grey etc. up to certain limit it is possible to get higher strength and permeability compared to conventional concrete.
- A higher compressive strength is obtained in Kota grey PC compared to Natural aggregate PC.
- A lower compressive strength is obtained in Red Mandana PC due to its lower density it could be used for application in insulating material.
- A higher Porosity but lower strength is achieved in Grit PC compare to Natural PC.

VIII. FUTURE SCOPE

- Effect of air enteraining agents should be checked in pervious concrete.
- Effect of different admixtures can be used.
- Effect of geo-grid as a sub base of pervious concrete.

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