STUDIES ON WATER PERMEABLE CONCRETE BY UTILIZING LOW DENSITY AGGREGATE

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ABSTRACT. This study examines the advantages of using material to increase the infiltration capacity of Permeable concrete and recharge the ground water. Influence of fine aggregate, natural coarse aggregate and low density aggregate quantities on the properties of permeable concrete are discussed here. Materials used are OPC 43 grade cement, 10 mm to 12.5 mm size both natural aggregate and low density aggregate. Experimental work was done with cement content 400kg/m3, water cement ratio of 0.34 and maintaining the aggregate cement ratio as 4:1 to 7.5:1. Concrete specimens were prepared for both Natural aggregate permeable concrete (NAPC) and Low density aggregate permeable concrete (LDAPC). According to water cement ratio and cement content, control mix corresponding to aggregate sizes are proportioned as per IS:10262-2009 by absolute volume method. Natural fine aggregate content in the above mix was selected as one of the study parameter. Fine aggregate was replaced with 0% and 30% by weight of coarse aggregate. Hardened concrete test like compressive strength, flexural strength, split tensile strength test are carried out for both NAPC and LDAPC. Coefficient of permeability was determined by using falling head permeability method. The test result shows that the permeability is extremely increasing by using low density aggregate in place of natural aggregate. For strength characteristics, the result shows LDAPC give the lower compressive strength, flexural strength and split tensile strength than the NAPC which is prepare by natural aggregate.

Keywords: Natural aggregate permeable concrete (NAPC), Low density aggregate permeable concrete (LDAPC), compressive strength, flexural strength, split tensile strength, Coefficient of permeability.

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INTRODUCTION

Rapid urbanization has resulted in an increase of unutilized surface areas. Many places have been covered with impermeable surface like cement concrete. Impermeable surface blocks the percolation of runoff. Large impermeable surfaces commonly lead to multiple negative impacts on stream systems and surface water and it has also major impact on the ground water recharge. If storm water is not properly managed surface runoff can lead to flooding. The drainage system is another problem as it is associated with overloading botheration. In rainy season, managing runoff in urban area are challenges for engineers. For storm water management, one method is used to reduce runoff from urban area by increasing infiltration through the use of permeable pavement. To reduce the negative impact of normal concrete as an impermeable material for water and air on the environment, a new concrete type namely permeable concrete has been developed. In the year 1980s, in Japan, An environmental friendly material was developed called permeable concrete. Permeable concrete is sometimes called as "no-fines" concrete, "it is said to be a hydraulic mixture of cement and single grained small size coarse aggregate, admixtures along with water. Actually, permeable concrete doesn't have any sand and its void content varies between 15 and 35%. To improve compressive strength less quantity of fine aggregate can be used but content of air void will be lessened and permeability efficiency decreases. The major factor is to maintain appropriate volume of paste/mortar in the mix design so as to consider that the aggregate is coated equally, but the excess of paste/mortar does not fill the void space within coarse aggregate.

Research Objective and Scope.

The object of this study is to asses and compares the properties of permeable concrete which is considering two different type of coarse aggregate along with 0 & 30% of fine aggregate. This study aims in enhancing the coefficient of permeability by using low density aggregate.

MATERIALS USED AND PROPERTIES

In present work, OPC 43 grade is used. In concrete mix, sand is used as a natural fine aggregate material which is passing through is 4.75mm sieve. Sand used for present study has specific gravity 2.26 and is conforming to zone-ll. In permeable concrete, course aggregate was used as a primary ingredient. Course aggregate grading used in permeable concrete is typically single sized coursed aggregate

Table 1 Comparison between properties of LDA and Natural Aggregate

PROPERTIES	LDA	NATURAL AGGREGATE
Bulk Density	750-900kg/cum	1450-1750kg/cum
Water Absorption	12%-16%	0.5%-1.5%
Specific Gravity	1.45-1.65	2.50-2.95
Shape	Round	Angular

In present study 12.5mm-10mm size analysed. Low density aggregate is used in permeable concrete to enhance the permeability. Low density aggregate is manufactured from fly ash. The different properties of natural coarse aggregate and low density aggregate are presented in table 1

EXPERIMENTAL PROGRAM

Mix Proportion

In this experimental work, material used were OPC 43, natural fine aggregate, and course aggregate. Experimental work chosen with cement content 400kg/m3, water cement ratio of 0.34 and maintaining the aggregate cement ratio as 4:1 to 7.5:1. Based on an earlier study(C.Lian &Y.Zhuge,2010).According to water cement ratio and cement content, three control mixes corresponding to three aggregate sizes are proportioned as per IS:10262-2009 by absolute volume method. Concrete specimens were prepared for both Natural aggregate permeable concrete (NAPC) and Low density aggregate permeable concrete (LDAPC). Natural fine aggregate content in the above mix was selected as one of the study parameter. Fine aggregate was replaced with 0% and 30% by weight of coarse aggregate.

Table 2 Designation of the NAPC mixes

PERCENTAGE OF FINE AGGREGATE	CONTROL MIX	30	0
NAPC	NAFC	NAF30	NAF0
LDAPC	LDAFC	LDAF30	LDAF0

Table 3 Mix proportion of NAPC & material quantity (kg/m^3)

NAME OF THE MIX	MIX RATIO	FINE AGGREGATE	COARSE AGGREGATE
NAF0	1:0:4.836	0	1934.4
NAF30,	1:0.412:4.42	164.8	1768
NAFC,	1:1.376:3.46	550.4	1384

Table 4 Mix proportion of LDAPC & material quantity (kg/m^3)

NAME OF THE MIX	MIX RATIO	FINE AGGREGATE	COARSE AGGREGATE
LDAF0	1: 0:3.406	0	1362.4
LDAF30	1: 0.412: 2.995	164.8	1198
LDAFC	1:1.376:2.03	550.4	812

SAMPLE PREPARATION

Sieving

The preparation of permeable concrete sample is different than normal concrete. In permeable concrete, uniform grade or single size aggregate are used. In this experiment, both natural course aggregate and low density aggregate were sieved and separated that is 12.5mm-10mm by using standard sieves**.**

Figure 1   12.5 mm-10mm Size of aggregate both NA and LDA

Washing

The natural course aggregate and low density aggregate contained high amount of dust and other impurities .It may affect the binding properties of permeable concrete. Before the mixing, washing is a necessary procedure. The aggregate surface coating affects development of bond between aggregate and cement paste, which is play an important role in permeable concrete with providing satisfactory strength. Hence before mixing course aggregate was thoroughly washed in tap water and dried in oven for one day to remove the silt or crusher dust. In case of LDA, it was required to be soaked in water before mixing. Due to voids presents in LDA, it absorbs the water while mixing. So before concrete mixing, LDA is soaked in water for 30 minutes. After 30 minutes all the aggregate were strained out and used in surface saturated condition.

MIXING, CASTING AND CURING

To prepare permeable concrete mix, mixer machine are used with capacity is 40 lit. To protect against any loss of material, an initial batter batch was prepared in the mixture with the same proportions as the design mix. weight and placed the material in concrete mix such as OPC43, natural fine aggregate, natural course aggregate, and low density aggregate and it was mixed for 1 minute or until the aggregate was fully coated by a thin layer of dry cement. After cement was coated in all aggregate, water was added to the mixture. The entire mixture was mixed for three minutes. Then mixture was revived for consistency by taking a handful of pervious concrete mix and creating ball. If the aggregate separated and it did not make a ball shape then the mixture was considered too dry. If the ball had a lot of paste running from the aggregate and stitching to the gloves, then the mixture was considered too wet. After mixing, concrete mix gives a glossy colour. Steel moulds are used to cast the specimen for testing. Permeable concrete mixture was put in the steel mould and concrete surfaces were levelled with steel rod. Steel rod diameter was 16mm. Steel rod was rolled over the specimen to level the concrete sample. It was required to fog water over the concrete sample, if concrete sample are dry while casting. Then all the specimen was covered with polythene sheet in such way that air should not enter into the concrete specimen. The concrete sample with NA is remoulded after 24 hours and concrete sample prepared with LDA are remoulded after 48 hours. Thereafter, the specimens were cured under tap water for 28 days. The water was free from silt, clay sand and any other fine material.

Figure 2 Concrete Mixing & Specimen samples level with steel rod

Figure 3 After casting immediately covered the moulds with polythene sheet

TESTING SPECIMEN

Harden strength test

Hardened concrete test like compressive strength(150mm×150mm×150mm), flexural strength(100mm×100mm×500mm), split tensile strength(100mm×200mm) test are carried out for both NAPC and LDAPC. After the specimens were demoulded and Cured in water for 24°C until testing. The strength value was reported as the average of three samples.

Permeability test

Permeability of pervious mixes was determined by using falling head permeability method Specimen of size 100mm×200mm length were casted and tested after 28 days of curing. Permeability measurement are based on the theory of Darcy's law and the assumption of laminar flow within the pervious concrete using falling head permeability test adopted from soil mechanics. The detailed procedures to set up the falling head parameter can be found in the literature S.Hesami et al.(2014). In falling head test parameter, later surface of the specimens are covered and water applied on the upper surface of the specimens. The amount of water passing from certain height with in a specific time is measured. Average permeability coefficient is calculated according to Darcy's law equation .The average result of the tests on three cylindrical specimens are note down. A picture of the falling head parameter set up which is used to measure the permeability of permeable concrete is shown in fig.4

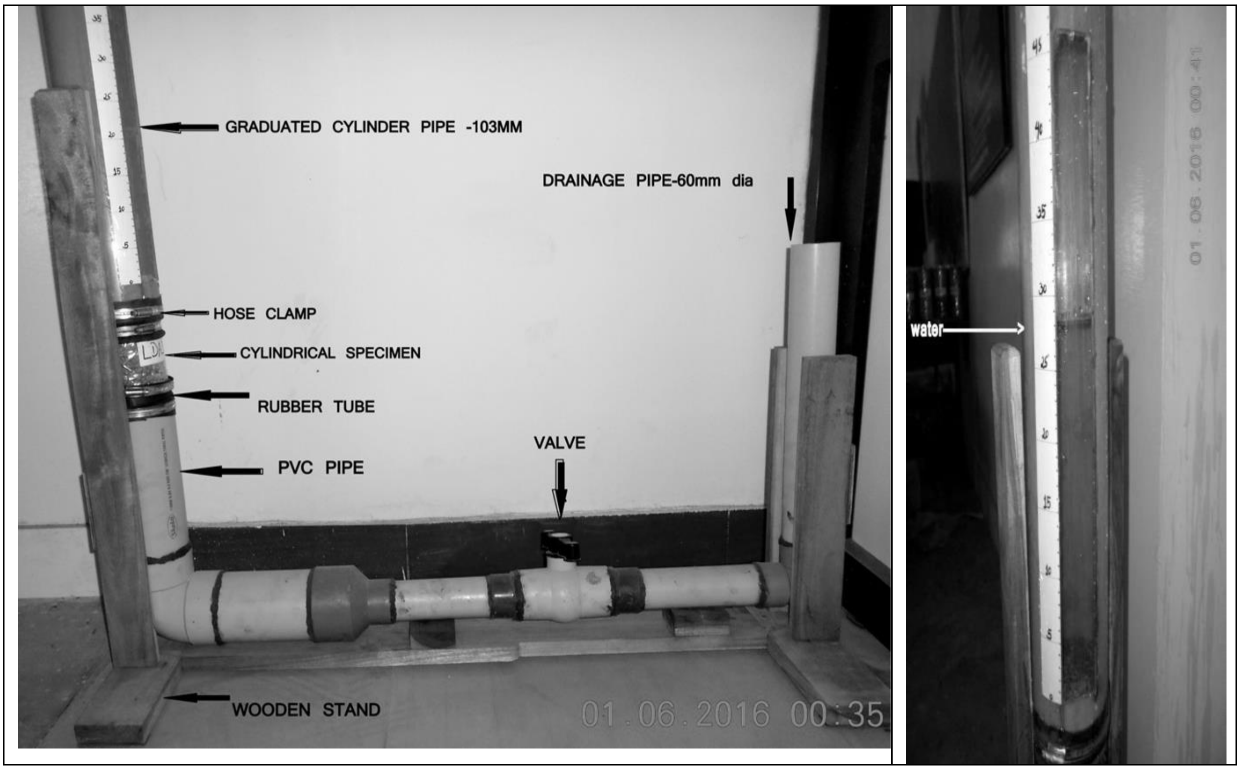

Figure 4 Falling head parameter set up

Finally the average coefficient of permeability was determined by using the eqation

$$k = \frac{al}{At} ln\left(\frac{\mathrm{h1}}{\mathrm{h2}}\right)$$

Where

K=coefficient of permeable, cm/sec
a=cross sectional area of the pipe in cm^2
L=length of the sample, cm

A=cross section area of the sample specimen cm^2
t=Time for water to drop from h_1 to h_2(sec)
h_1=initial water level (cm)
h_2=final water level (cm)

RESULT AND DISCUSSION.

Strength Characteristics

Fig 5, Table 5, 6 and 7 shows the compressive strength, flexural strength and split tensile strength after 28 days of curing periods. The specimens with single selected size of aggregate followed the same trend. .It is observed than increasing the % of fine aggregate increase the compressive strength and by decreasing the size of aggregate compressive strength increases. This is due to the increase in contact area, which increased, as the aggregate size is reduced. Similar trend was observed for the flexural strength and split tensile strength as shown in Fig 6 and 7

Table 5 Comparison of compressive strength between NAPC and LDAPC

% FA	NA		LDA	
	Mix proportion	Compressive strength (MPa)	Mix proportion	Compressive strength (MPa)
0%	NAF0	9.62	LDAF0	9.26
30%	NAF30	17	LDAF30	14.95

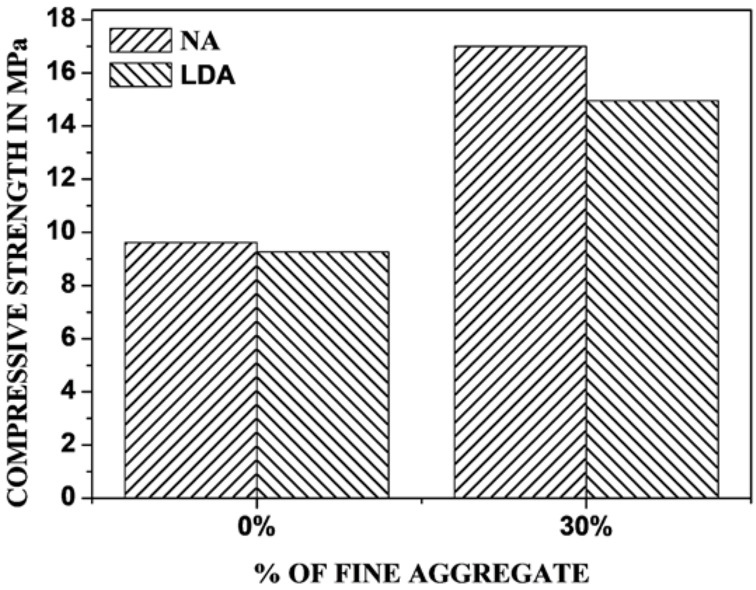

Figure 5 Comparison of compressive strength between NAPC and LDAPC

Table 6 Comparison of flexural strength NAPC and LDAPC.

% FA	NA		LDA	
	Mix proportion	Flexural strength (MPa)	Mix proportion	Flexural strength (MPa)
0%	NAF0	2.9	LDAF0	2.6
30%	NAF30	3.86	LDAF30	3.6

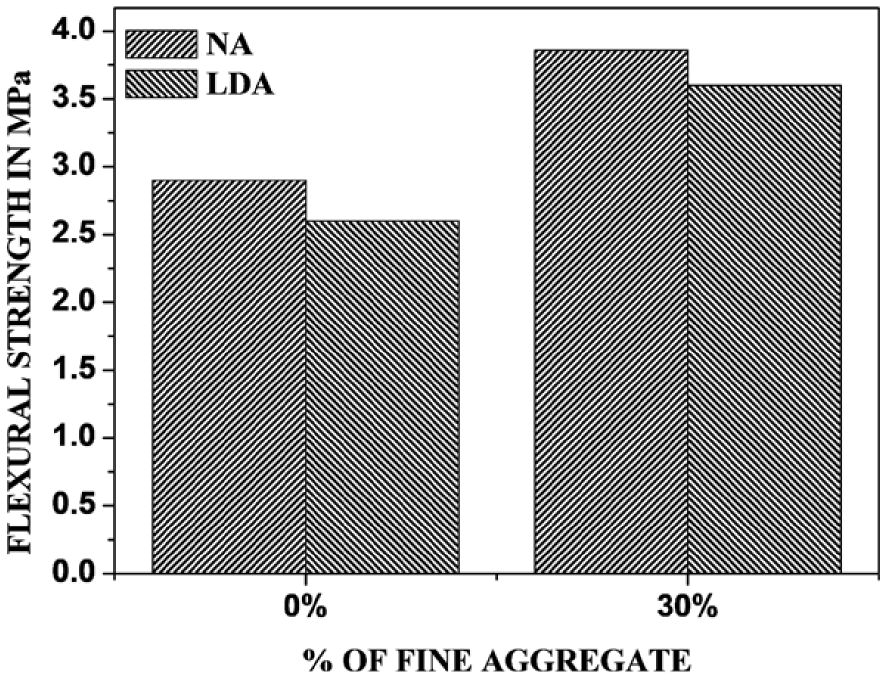

Figure 6 Comparison of flexural strength NAPC and LDAPC.

Table 7 Comparison of split tensile strength between NAPC and LDAPC

% FA	NA		LDA	
	Mix proportion	Split tensile strength (Mpa)	Mix proportion	Split tensile strength (Mpa)
0%	NAF0	1.28	LDAF0	1.00
30%	NAF30	2.16	LDAF30	1.539

The compression of two different permeable concrete which is made with natural aggregate and low-density aggregate with replacement at 0 & 30% of fine aggregate**.** The compressive, flexural & split tensile strength is increases with replacement of fine aggregate in both NAPC and LDAPC. The compressive, flexural & split tensile strength in NAPC is higher than the LDAPC at both percentage of fine aggregate. Due to circular shape of low density aggregate, it decreases the contact area. NAPC gives the higher compressive, flexural & split tensile strength at 30% replacement of fine aggregate.

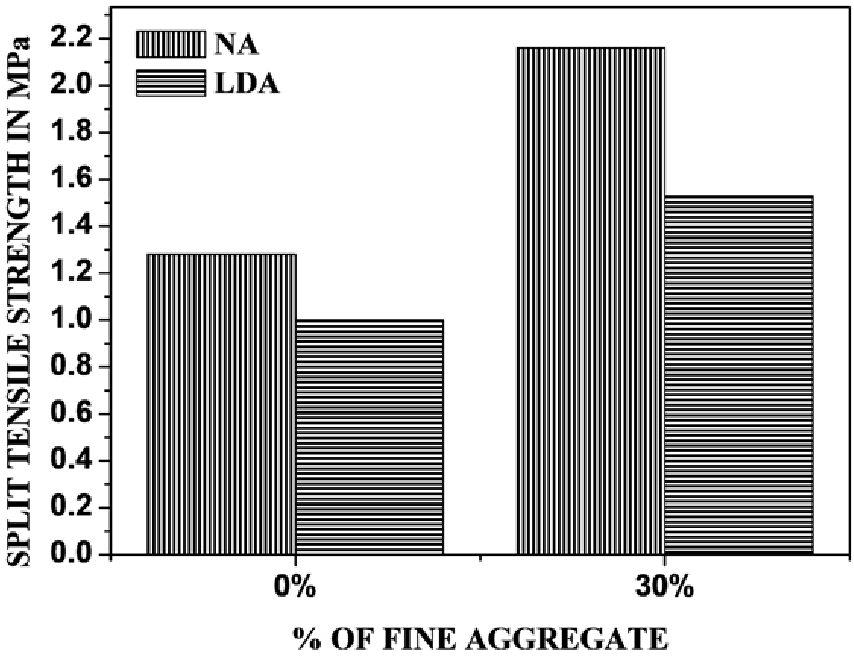

Figure 7 Comparison of split tensile strength NAPC and LDAPC.

Coefficient of Permeability test.

Table 8 represents the permeability result for partial replacement of sand with natural course aggregate and low density aggregate. It is observed that increasing the % of fine aggregate, decrease the permeability and by decreasing the size of aggregate permeability also decrease.

Table 8 Comparison of coefficient of permeability (cm/s) between NAPC and LDAPC

% FA	NA		LDA	
	Mix proportion	Permeability	Mix proportion	permeability
0%	NAF0	1.086	LDAF0	2.12
30%	NAF30	0.812	LDAF30	1.25

It observed that the permeable concrete prepare with LDAPC gives the higher permeability than the Natural aggregate permeable concrete. LDAPC with 0% of fine aggregate gives the highest permeability in above experiment. From figure 8 it showing clearly with increasing the percentage of fine aggregate the permeable coefficient are decreasing.

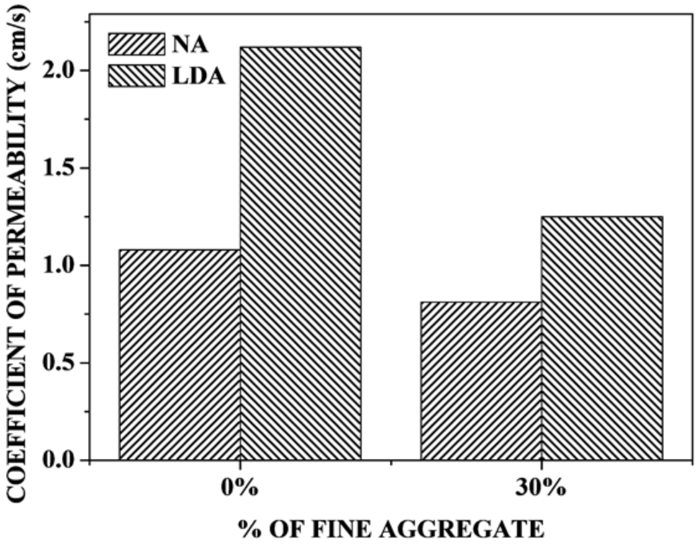

Figure 8 Comparison of permeability coefficient between NAPC and LDAPC.

CONCLUSION

The low density aggregate can be used as coarse aggregate for making permeable concrete. The LDAPC gives lower compressive strength, flexural strength and split tensile strength than the NAPC which is prepare by natural aggregate. The specimen with NAPC & 30% fine aggregate gives the highest compressive, flexural & split tensile strength of 17 MPa, 3.86 MPa & 2.16 MPa . The LDAPC concrete mix gives highest coefficient of permeability 2.12 cm/sec at 0% of the fine aggregate. A conclusion can be drawn that low density aggregate gives lower strength than natural aggregate. The deviation of strength is too much. From result it shows that the permeability is extremely increasing by using low density aggregate in place of natural aggregate

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