ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com

International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 5, Special Issue 3, January 2018

EXPERIMENTAL INVESTIGATION ON CHARACTERISTICS OF PERVIOUS CONCRETE

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ABSTRACT

Pervious concrete is a form of lightweight porous concrete, obtained by eliminating the sand from the normal concrete mix. This concrete possesses certain advantages like lower density, cement content, thermal conductivity, low drying shrinkage, no segregation and capillary movement of water. It has better insulating characteristics compared to conventional concrete due to presence of large voids. In the present investigation M20 grade pervious concrete is designed by ACI 522R-10 code. The effect of w/c ratio and aggregate size on the strength property of pervious concrete and replacement of cement by rice husk ash are studied. Falling head permeability test is been used to find permeability of pervious concrete. It is observed from investigation that the compressive strength increases as the water/cement ratio decreases up to optimum w/c ratio and with increase in volume of paste. Coefficient of permeability decreases with increase in the percentage of small aggregate. It is concluded that cement can be effectively replaced by rice husk ash which reduces the cost of pervious concrete.

Keywords— Concrete, conventional, pervious, permeability, strength

I. INTRODUCTION

Pervious concrete is made up of Portland cement, coarse aggregate and water. Pervious concrete has many different names including zero-fines concrete, no-fines concrete and porous concrete. The impervious nature of bitumen and concrete which are used in the construction of pavements, walkways, and open car parks will contribute to the increased water runoff to the drainage system, over-burdening the infrastructure. Pervious concrete is an engineered concrete which has very high permeability to allow the rain water to drain rapidly. With a combination of structural and hydrological designs, pervious concrete can be effectively used for sustainable pavement construction.

Pervious concrete is a special type of concrete with a high porosity that allows water from precipitation and other sources to pass through it, thereby reducing the runoff from a site and recharging ground water levels. The force exerted on the foundation by no-fines concrete is approximately one third of that produced by the same pavement constructed from conventional concrete. The skid resistance of any surface is an important characteristic for the driving safety point of view. The rain affects the traffic security, because there are splash and sprays effects caused by the truck wheel. This fact contributes to the dynamic hydroplaning effect. In recent years many agencies have studied the porous concrete as material to serve a sacrifice layer with increase in skid resistance.

A. Benefits and Applications of Pervious Concrete

Environmental Benefits- Pervious concrete pavements allow the water to recharge the underground water supply and channel water to tree roots. Pervious concrete pavements reduce runoff by storing a large volume of water within the pavement until it seeps into the ground. Most of the pollutants are carried by the first 12 to 25 mm of rain. Since this initial water is contained within the pavement it reduces the quantity of polluted water from reaching the waterways.

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B. Economical Benefits

There is lower installation costs associated with the use of pervious concrete because the need for underground piping and storm drains are eliminated. No major earthworks are required since the pavement does not need to slope to gutters and drains for adequate water control methods. The system does not require the upgrading of existing storm sewer systems, as there is little or no runoff. Pervious concrete pavements are effective than the storm water management system and eliminate the need to purchase additional land for retention basins, as the pavement works as one. This helps developers maximize their profits and utilize the land more efficiently.

II. OBJECTIVES OF PRESENT STUDY

1. To mix design the proportion of pervious concrete by ACI 522-R10 code.
2. To study the properties of pervious concrete design by replacing cement by rice husk ash.
3. To study the effect of w/c ratio on pervious concrete.
4. To evaluate flexural strength of pervious concrete.
5. To evaluate permeability of pervious concrete.
6. To study the effect of aggregate size on compressive and flexural strength of pervious concrete.

III. LITERATURE REVIEW

From the available literature, it was found that there is a limited amount of work done in this field. There is some information relating to pervious concrete in general. The following literatures relate to the properties of no-fines concrete that have already been investigated.

Abadjieva et al explored on properties of no-fines concrete. This study used the total bond proportions extending from 6:1 to 10:1. The most noteworthy quality was acquired with a total bond proportion of 7:1 and the quality diminished with an expanding total concrete proportion. It was watched that the pliable and flexural qualities of no-fines cement were impressively lower than those acquired from ordinary cement. Single estimated totals in pervious solid frame extensive interconnected voids conveyed all through the assortment of the cement. The pervious structure of this kind of cement is in charge of the lower thickness of pervious solid in correlation with the common cement. The thickness of the examined cement differs between 1780 to1890 kg/m^3, which is around 22 percent lower than the thickness of ordinary weight concrete. **Nader Ghafoori et al. [4]** have done research facility examination on compacted no-fines concrete for clearing materials. A research center examination was done to focus the viability of no-fines solid as a clearing material. The curing sorts were explored to figure out whether there was any distinction in the middle of wet and fixed curing. There was just a unimportant contrast in quality between the diverse curing systems. It was clear from the test outcomes that the quality improvement of no-fines cement was not subordinate upon the curing conditions. The thickness of compacted pervious solid examples changed from 1570 to 1938 kg/m^3. It was watched that the thickness enhanced with the increment in compaction vitality. It was noticed that with fitting proportioning and compaction exertion a compressive quality of 20.7 N/mm^2 was got. Low water bond proportion and the densification procedure utilized for pervious solid examples are to a great extent in charge of these respectable qualities. **Tennis [5]** examined on pervious solid asphalt. In customary cementing, Portland concretes and mixed bonds may be utilized as a part of pervious cement. Likewise, supplementary cementitious materials, for example, fly cinder; silica smoke and ground granulated impact heater slag may be utilized. Total reviewing utilized as a part of pervious solid are ordinarily either single-sized coarse total or evaluating somewhere around 19 and 9.5 mm. Adjusted and pounded totals, both ordinary and lightweight, have been utilized to make pervious cement. **Richard Meininger [6]** studied on no-fines pervious concrete for clearing. It was found that, when a little measure of sand was added to the blend, the compressive quality of the concrete was expanded from 10.3 MPa to 17.2 MPa. The sand included was somewhere around 10 and 20 percent of the total by weight. The expanded fines filled a percentage of the voids, decreasing the air content from 26 to 17 percent. A decline in the voids causes the cement to bond all the more adequately, consequently expanding the compressive quality. With more than 30 percent sand the cement began to show the properties of traditional cement and did not have adequate voids essential for water stream. The compressive quality of no 67 total with total bond proportion 4 it was watched that compressive quality increments with expansion in water concrete proportion. It was likewise watched that with total bond proportion 6, compressive quality expanded up to water concrete proportion 0.36. **Rita Moura Fortes [2]** investigated

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permeable solid properties for asphalt range in research facility. It was observed that bond quality between materials is crucial for the execution of the meager permeable solid overlay making itself along these lines a made structure out of asphalt. Permeable solid material is prescribed for the utilization of low movement asphalts conditions, stopping, urban regions, because of the perspective of natural contemplations it allows the water invasions. It was found that compressive quality to the 28 days of age was over 20 MPa related a coefficient of penetrability of the 10-3cm/s. The quality increments however the reductions of the penetrability don't prompt its utilization as a seepage layer. The static quality shear was around 50% of the compressive quality of permeable cement. **Norbert Delatte [8]** Concentrated on the manageability advantages of pervious solid asphalt. Portland Cement Pervious Cement (PCPC) is an essential apparatus for tempest water administration and offer significant natural advantages. In hotter atmospheres, PCPC asphalts can help moderate warmth island impacts. A legitimate PCPC blend must be produced, and it must be put, compacted and cured accurately. At the point when appropriately indicated, planned, introduced and kept up, PCPC asphalts give a significant arrangement of natural administrations by coordinating green foundation frameworks in the outline of supportable scenes. [3] proposed a principle in which another NN yield input control law was created for an under incited quad rotor UAV which uses the regular limitations of the under incited framework to create virtual control contributions to ensure the UAV tracks a craved direction. Utilizing the versatile back venturing method, every one of the six DOF are effectively followed utilizing just four control inputs while within the sight of un demonstrated flow and limited unsettling influences. Elements and speed vectors were thought to be inaccessible, along these lines a NN eyewitness was intended to recoup the limitless states. At that point, a novel NN virtual control structure which permitted the craved translational speeds to be controlled utilizing the pitch and the move of the UAV. At long last, a NN was used in the figuring of the real control inputs for the UAV dynamic framework. Utilizing Lyapunov systems, it was demonstrated that the estimation blunders of each NN, the spectator, Virtual controller, and the position, introduction, and speed following mistakes were all SGUUB while unwinding the partition Principle.

IV. PROPERTIES OF MATERIALS

Most of the cement complying with Indian Standards is suitable for making Pervious Concrete. The choice of the type of cement and its content depends on strength and permeability requirements of the mix. In the present study Ordinary Portland cement of ACC 43 grade conforming to IS 8112-1989 (27) is used. Results of preliminary tests on cement are presented in Table 1.

Table no 1: Physical properties of cement

Sl no	Properties	Chart result
1	Specific gravity	3.14
2	Fineness	2.0%
3	Normal consistency	33%
4	Initial setting time	70min
5	Final setting time	195min
6	Compressive strength	
7	7 days	27.43Mpa
8	28 days	44.15Mpa

Table 2: Properties of coarse aggregate.

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Sl no	Properties	Results
1	Shape of coarse aggregate	Angular
2	Water absorption	0.5%
3	Specific gravity of 12 mm size aggregate	2.71
4	Specific gravity of 8 mm size aggregate	2.71
5	Dry density of 12mm size aggregate	1625.16 kg/m^3
6	Dry density of 8mm size aggregate	1585.43 kg/m^3
7	Dry density of combined aggregates(50:50)	1602 kg/m^3

V. EXPERIMENTAL INVESTIGATION

A. Test Methods

1] Workability test- Slump Cone Test.
2] Compression Test- Cube specimens of size 150 x 150 x 150 mm.
3] Permeability Test- For finding out the rate of flow of water through the pervious concrete, both constant head permeability test and falling head permeability tests are conducted.
4] Flexural Test- Flexural strength test was conducted on beams of dimension 150 x 150 x 700 mm. The test procedure includes placing beam on a hydraulic operated loading machine and symmetrical two point load.

B. Casting of Concrete Permeability cylinders

Cylinder Moulds of 100mm diameter and 127mm height were used for casting the permeability specimens.

Curing-The cubes and beams were remoulded after 24 hours of casting and kept for curing tank which is maintained at laboratory temperature. Curing age is 7 and 28 days including casting day.

Mix design

In the present study, American Concrete Institute reported by ACI Committee 522R-10 design code is utilized for design of M20 grade concrete.

C. Proportioning procedure

A procedure for producing initial trial batches for pervious concrete is shown below. The b/b_0 method applies absolute volume concepts. The b/b_0 method for designing a pervious concrete mixture can be broken up into a series of eight steps.

1. Determine aggregate weight.
2. Adjust to Saturated Surface Dry weight (SSD).
3. Determine paste volume.
4. Determine cement content.
5. Determine water content.
6. Determine solid volume.
7. Check void content.
8. Iterative trial batching.

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Table 3: Proportion for the mix 1:4.22

Cement	634.33 lb	287.72 kg
Water	222.01 lb	100.7 litre
Aggregate	2676.51 lb	1214.04 kg
Density	130.84 lb/ft^3	2095.95 kg/m^3

D. Compressive strength at 7 and 28 days

The cubes of size 150 x 150 x 150 mm were casted to determine the compressive strength of pervious concrete. Compressive strength of pervious concrete at 7 and 28 day of curing for different proportion, water cement ratio, void content are plotted graphically.

E. Flexural strength at 28 days

Moulds of size 100 x100 x 500 mm were casted to determine the flexural strength of pervious concrete. Flexural strength of pervious concrete at 28 days of curing for different proportion, water cement ratio, and void content are presented graphically.

F. Compressive strength at 7 and 28 days

The cube sizes of 150 x 150 x 150 mm were casted to determine the compressive strength of pervious concrete where cement was replaced by RHA. Compressive strength of pervious concrete at 7 and 28 days of curing for proportion 1:4.41, water cement ratio 0.35, and void content 15% are plotted graphically.

The results of slump cone test, compressive strength, flexural strength, and permeability of pervious concrete are discussed below.

Table 4: Slump values for different mix proportions

SL NO	Mix proportion	Slump (mm)
1	1:7.56	29
2	1:7.03	27
3	1:6.30	30
4	1:5.86	27
5	1:4.54	35
6	1:4.22	30

VI. RESULTS AND DISCUSSION

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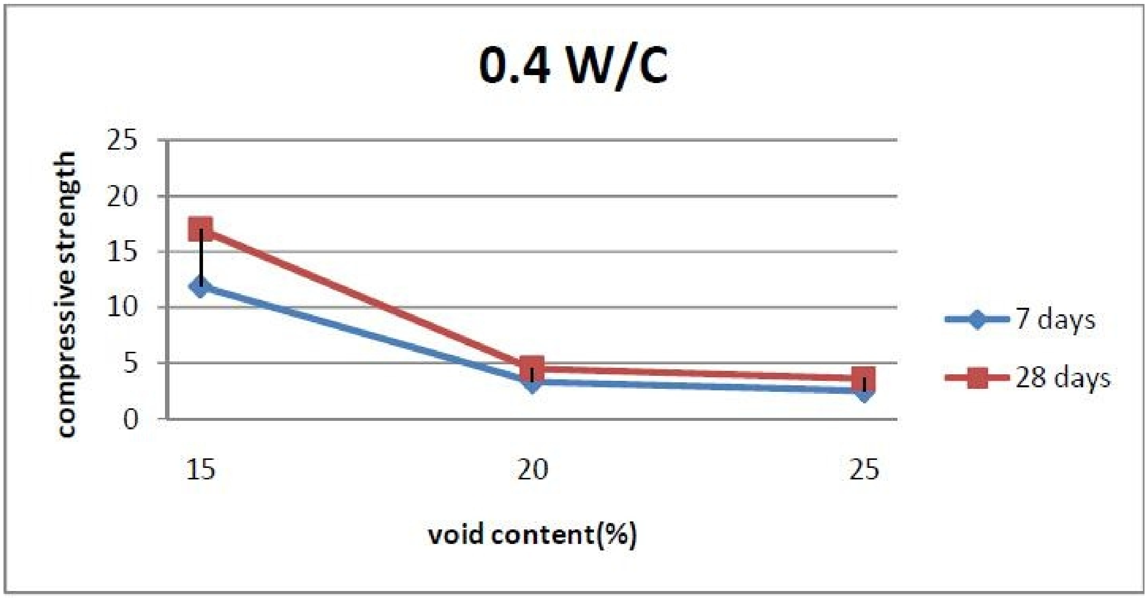

Graph 1: Relationship between void content v/s compressive strength

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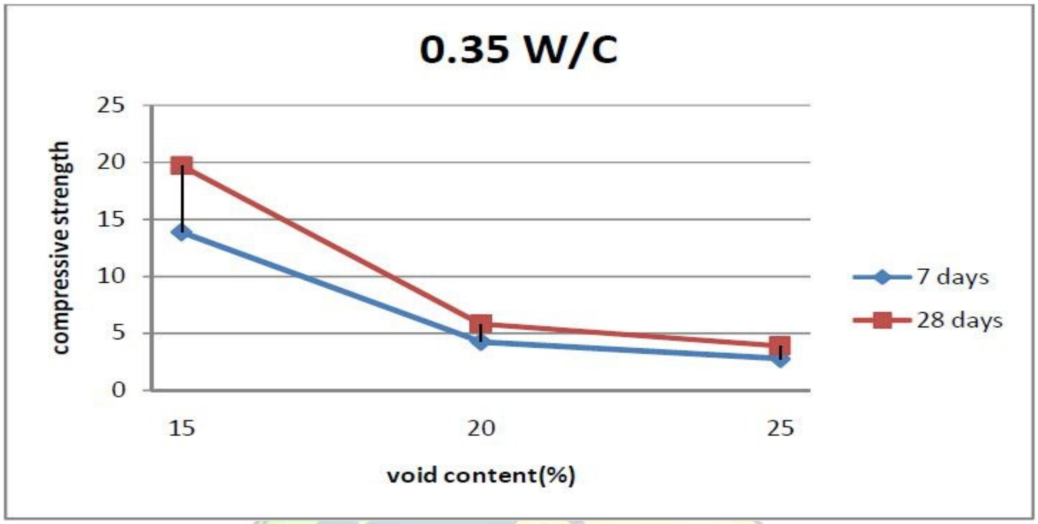
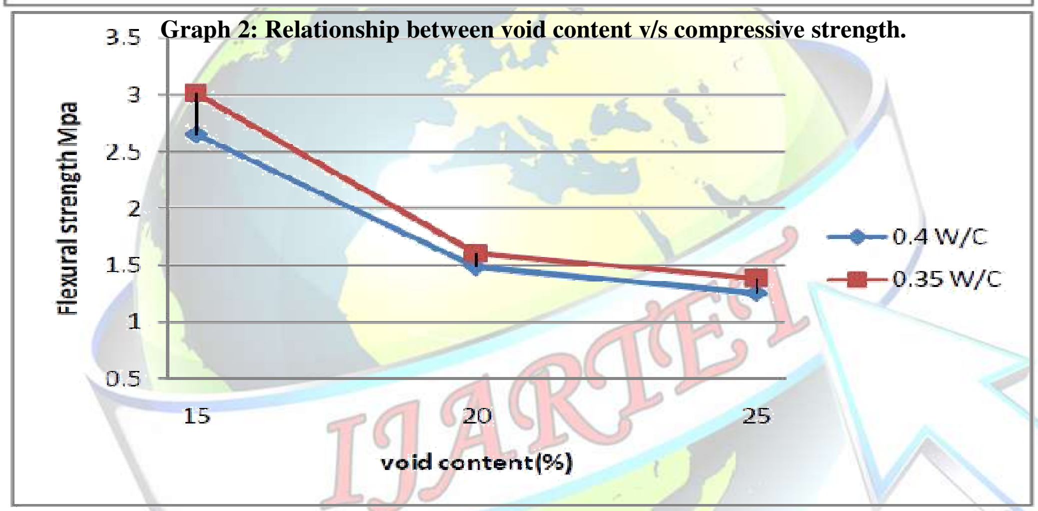
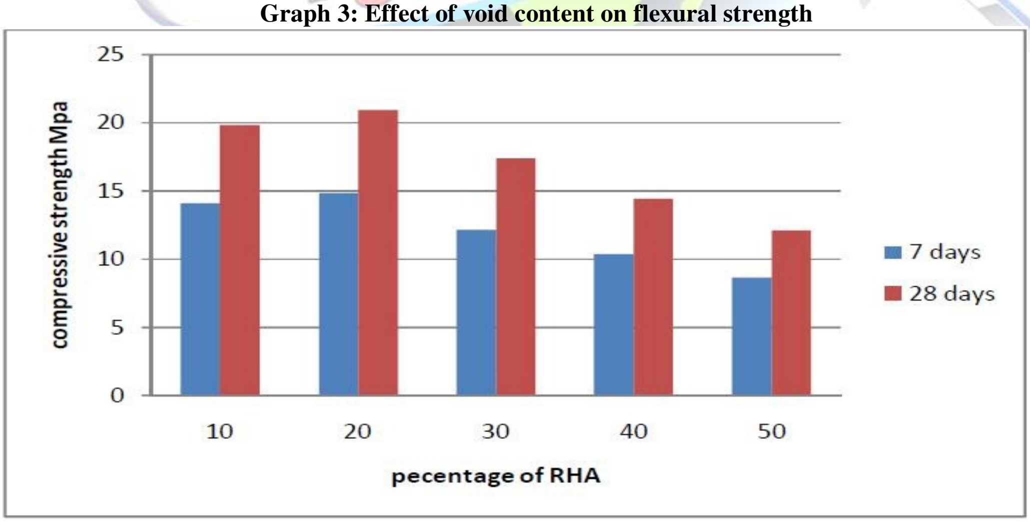


Graph 2: Relationship between void content v/s compressive strength.



Graph 3: Effect of void content on flexural strength



Graph 4: Relationship between percentages of RHA v/s compressive strength.

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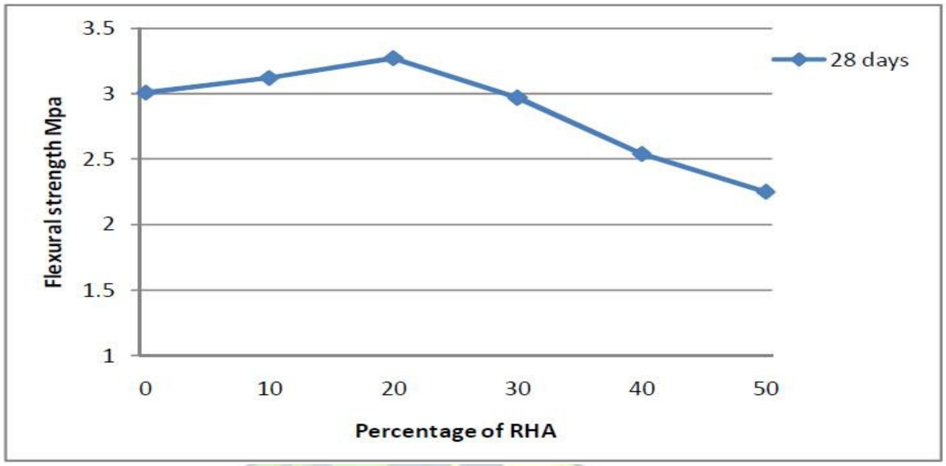


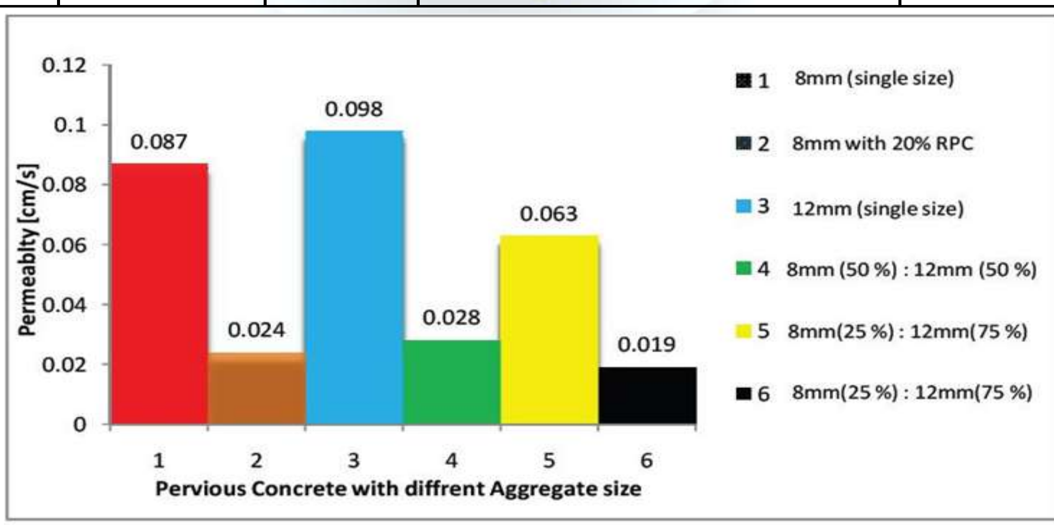
Graph 5: Relationship between percentage of RHA v/s flexural strength.

Permeability of pervious concrete

Permeability was evaluated by varying aggregate sizes and 20% cement replacement by RHA the results are presented in the table 5.

Table 5: Permeability results for different size aggregate

Sl no	Proportion	w/c ratio	Aggregate size	Permeability (Cm/sec)
1	1:4.22	0.35	8 (single size)	0.087
2	1:4.22	0.35	8 (single size) with 20% cement replacement	0.024
3	1:4.22	0.35	12 (single size)	0.098
4	1:4.22	0.35	8 (50 %) : 12 (50 %) combined size	0.028
5	1:4.22	0.35	8 (25 %) : 12(75 %) combined size	0.063
6	1:4.22	0.35	8 (75 %) : 12 (25 %) combined size	0.019



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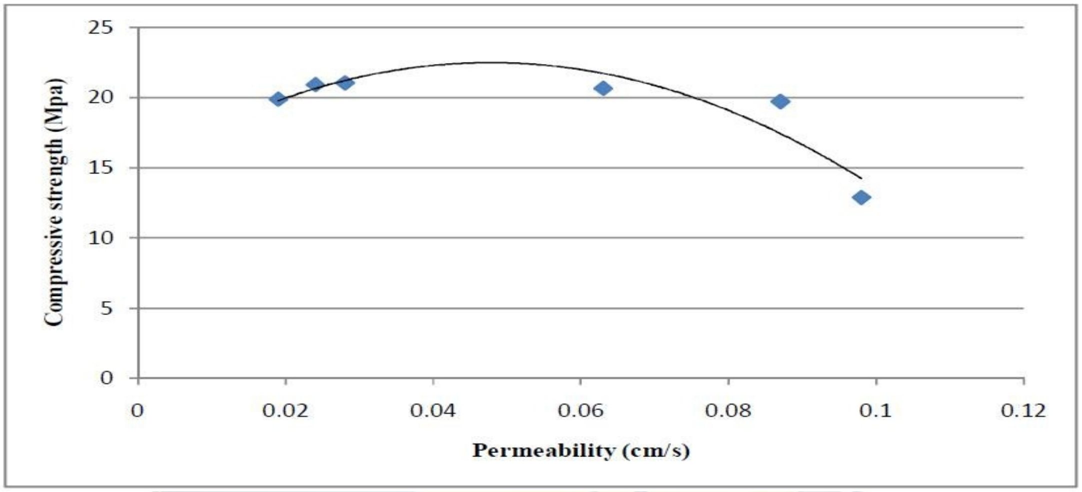

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