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Rainwater Harvestment by Using Pervious Permeable Pavement System

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ABSTRACT: In this project permeable pavements system (PPS) method is considered for rain water harvesting. Pervious concrete is used or No fineness concrete is a conventional concrete that is used in foreign countries for draining of storm water and increasing the ground water level. The permeable (pervious) concrete has generally lower strength when compared to normal conventional concrete. The strength of pervious concrete is mainly depends upon the proportions of which the concrete is made off and the size of aggregate used. In this project i used aggregate size(20mm) and also the various Aggregate Cement ratios with constant water cement content 0.4-0.45 the aggregate/cement ratio of 4:1 gave the highest compressive strength compared to other aggregate/cement ratio of 6:1,8:1 and 10:1.and also conduct analysis on porosity and permeability of pervious concrete pavement for10:1 gives high porosity and permeability Particular emphasis of this method given a detailed design, maintenance and water quality control aspects. The most important target of this method is removal of pollutants like hydrocarbons, heavy metals and nutrients (i.e. nitrogen and phosphorus), total suspended solids; because storm water runoff is a major non-point source of pollutants released into the environment.

KEYWORDS: Rainwater harvesting, Permeable pavement, Storm water Management, Compressive strength, porosity ,Permeability, Water Quality, Pollutants

I. INTRODUCTION

It was very difficult to imagine few decades before that you will require to buy drinking. The use value of water was never undermined, but it's about time that even its exchange value is given due importance. Fresh water today is a scarce resource, and it is being felt the world over. More than 2000 million people would live under conditions of high water stress by the year 2050, according to the UNEP (United Nations Environment Programme), which warns water could prove to be a limiting factor for development in a number of regions in the world.

To date, much attention has been given to the first option and only limited attention has been given to optimising water management systems. Among the various alternative technologies to augment freshwater resources, rainwater harvesting and utilisation is a decentralised, environmentally sound solution, which can avoid many environmental problems often caused in conventional large-scale projects using centralised approaches.

II.RELATED WORK

Natural resources are nowadays increasingly depleting due to rapid urbanization and infrastructure developments. In recent years, due to urbanization in Indian cities, most areas are occupied with buildings and air proof concrete pavements. Rain water does not pass into the underground because of the lack of water permeability and air permeability in concrete pavements. Various strategies are being followed by engineers to protect and restore the world's natural ecosystem. One such strategy is the application of pervious concrete, which is a special type of concrete characterized by high permeability and porosity. Pervious concrete is a mixture of cement, uniform coarse aggregate, a low quantity of fine aggregate (which can be omitted), water and, optionally, admixtures. Appropriate amounts of water and cementitious material are used to make a paste that forms a thin coat around aggregate particles, but leaves free

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space between aggregates. A complete elimination or drastic reduction of fine aggregates creates large and continuous voids. The main important function is its ability to transport large volumes of water through its pores to the underlying strata. Pervious concrete is also known as a no-fines concrete, porous concrete, and permeable concrete. Pervious concrete pavements have become popular as an effective storm water management tool to reduce the volume of storm water runoff and concentration of pollutants. It is used at parking areas, low traffic areas, pedestrian pathway etc., because of its attractive storm water mitigation capabilities, and also in other applications. Apart from this, pervious concrete may be used as a wall concrete in structural applications for lightweight or better thermal insulation, as surface course for parking lots, tennis courts, zoo areas, stalls, etc., and for greenhouse floors to keep the floor free of standing water. Pervious concrete has been increasingly used due to several sustainability-related benefits offered by this material. Pervious concrete includes other environmental benefits such as reduced noise generated by tire-pavement interaction, reduced urban heat-island effect, minimized road splash, improved skid resistance, recharge of ground water table, reduced storm water runoff, limited pollutant penetration into the ground water and preservation of native eco systems

III.MATERIALS

The strength of pervious concrete is dependent on the cement content, water to cement ratio, compaction level, and aggregate gradations. Pervious concrete made with angular aggregate generally requires more paste to produce the specified workability, compared to pervious concrete made with uniformly sized round aggregate. Angular aggregate provides better paste for aggregate bonding. Hence, the locally available granite was selected as coarse aggregate. grade, i.e. the aggregate passing through the 25 mm sieve and retained on the 20 mm sieve, and the aggregate passing through the 12.5 mm sieve and retained on the 9.5 mm sieve, were used in this project. The ordinary grade 53 Portland cement was used in casting the specimens. Potable water available in laboratory with the pH value of no less than 6, conforming to IS 456-2000 requirements, was used for mixing concrete and curing the specimens. Fundamental tests for cement, water and coarse aggregate were conducted and the parameters obtained were incorporated in mix design.

IV. MIX PROPORTION

It is important to select suitable concrete ingredients and determine their relative proportions, so as to achieve, as economically as possible, an appropriate concrete of adequate strength, porosity and permeability. Material properties of pervious concrete depend on both materials and placement technique. The coarse aggregate content was varied to achieve the proper thickness of paste surrounding the aggregate by trial and error, based on mix proportion of no-fines concrete. A total of ten sets of mixes were designed in a standard manner, As an illustration, A3C1S1 stands for specimen made of concrete mix with Aggregate 4 parts and Cement 1 part, while S1 stands for the aggregate size passing through the 25mm sieve, and retained on the 20mm sieve. Similarly, 6:1 ratio, 8:1 ratio, 10:1 ratio. If the mixture is too wet or over compacted, it will not exhibit the pervious concrete properties and penetration capacity. Hence, a constant water to cement ratio of 0.4-0.45 was considered in the mix proportion for all four sets of mixes

Mix	Aggregate Size	Aggregate to cement ratio	Cement [kg/m ³]	Coarse aggregate [kg/m ³]
A4C1	20mm	4:1	5kg	20kg
A6C1	20mm	6:1	4kg	21kg
A8C1	20mm	8:1	3kg	21.6kg
A10C1	20mm	10:1	2.7kg	22.08kg

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V. SAMPLE PREPARATION

Pervious concrete is prepared by mixing water, cement and coarse aggregate. A total of 12 cube specimens, were prepared to conduct the test. The mixing was done using pan mixer. The coarse aggregate was first mixed with one fourth of the total mixing water. The cement was then added and blended with coarse aggregate, and the remaining water was poured into the mixing pan until a homogeneous mixture was obtained. Concrete was poured in moulds and manually compacted using a tamping rod. During compaction, twenty five blows were uniformly distributed on the surface of concrete for each layer. All specimens were remoulded after 24 hours and cured in water from the time of remoulding until the time of testing. All pervious concrete specimens used in the tests were prepared according to the ASTM C192 guidelines, "Standard Practice for Making and Curing Concrete test Specimens in the Laboratory".

VI. COMPRESSIVE STRENGTH

Compressive strength is a very important parameter for deciding on the concrete quality and performance. The compressive strength test was conducted according to ASTM C 39. Cube specimens measuring 150 mm x 150 mm x 150 mm were prepared for each mix and tested. The compressive strength was reported based on the average of three cube specimens tested.

VII. POROSITY

Porosity is the ratio of volume of voids to the total volume of specimens. The total porosity was measured using the water displacement method based on the Archimedes' principle of buoyance, which states that the buoyancy force is equal to the weight of fluid displaced. The total porosity includes both closed and open pores and can be measured using the buoyancy float apparatus. The dry mass, submerged mass, and total volume, must be known to calculate the porosity value.

Bulk Volume

displacement method

Weight of water displaced $W_{wtr} = W_{sat} - W_{wet}$

Bulk volume $V_b = W_{wtr}/r_{wtr}$

Pore Volume

fluid saturation method

Weight of water in pore space $W_{wtr} = W_{sat} - W_{dry}$

pore volume $V_p = W_{wtr}/r_{wtr}$

$\text{porosity} = V_p/V_b \times 100\%$

- p - Total porosity of pervious concrete [%]
- W_{dry} - Weight of a pervious concrete sample air-dried for 24 hours [kg]
- W_{sat} - Weight of a pervious concrete sample Saturation in water [kg]
- W_{wet} - Weight of a pervious concrete sample submerged in water [kg]
- $W_{r_{wtr}}$ - Density of water [kg/mm^3]

VIII. PERMEABILITY

The test setup was designed based on the constant head permeability method and the permeability testing was conducted as shown in Figure . One of the most important features of pervious concrete is its ability to allow percolation of water through the matrix. The percolation rate of pervious concrete is directly related to the air void content. The Polyvinylchloride (PVC) pipe was placed on the pervious concrete specimen and was properly sealed with

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the contact surface of the specimen in order to avoid leakage. The permeability test was carried out when the quantity of water allowed to flow into the specimen through the PVC pipe was such that the constant head of water could be maintained at the desired water head in the inlet pipe. The water flow rate can be controlled by means of a valve. The flow rate of water can be determined by measuring the volume of water collected in the water tank over time for a particular head of water. The coefficient of permeability k in mm/sec can be expressed as,

$$K = QL / Aht$$

where:

k - permeability [mm/s]

Q - total volume of water [mm³]

L - specimen length [mm]

A - cross sectional area of specimens [mm²]

h - water head [mm]

t - time [s].

IX. EXPERIMENTAL RESULTS

MIX	Compressive strength [N/mm ²]			Porosity [%]	Permeability [mm/s]
	7days	14days	28days		
A4C1	11.7	12.17	16.6	27.06	15.64
A6C1	4.19	5.39	6.09	28.2	16.08
A8C1	3.23	4.52	5.2	31.9	16.69
A10C1	3.2	3.6	3.85	35.19	17.04

X. GRAPH

COMPRESSIVE STRENGTH TEST

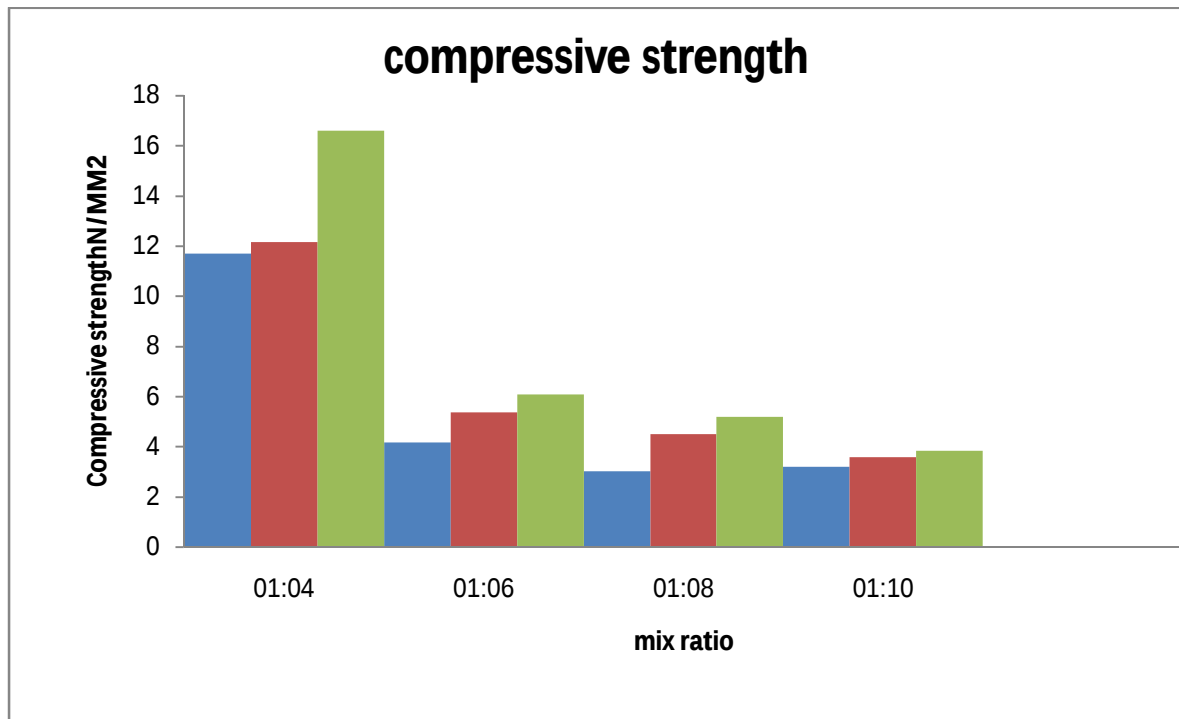
The test was conducted as per **IS 516-1959**. In Universal Testing Machine (UTM). The cubes of standard size 150 mm x 150mm x 150mm were used to find the compressive Strength. The concrete cube was tested after the period of 7, 14 & 28 days of curing. The bearing surfaces of the resting machine shall be wiped clean and any loose sand or other material removed from the surfaces of the specimen. In the case of cubes, the specimen shall be placed in the opposite sides of the cubes as cast, that is not to the top and bottom. The axis of the specimen shall be carefully aligned with the centre of thrust of the spherically seated platen No parking shall be used between the faces of the test specimen. The movable portion shall be rotated gently by hand so that uniform seating may be obtained. The load shall be applied without shock and Increased continuously at a rate of approximately 140 kg/cm² until the resistance of the specimen to the Increasing load breaks specimen shall then be recorded and the appearance of the concrete and any unusual features In the type of failures shall be noted.

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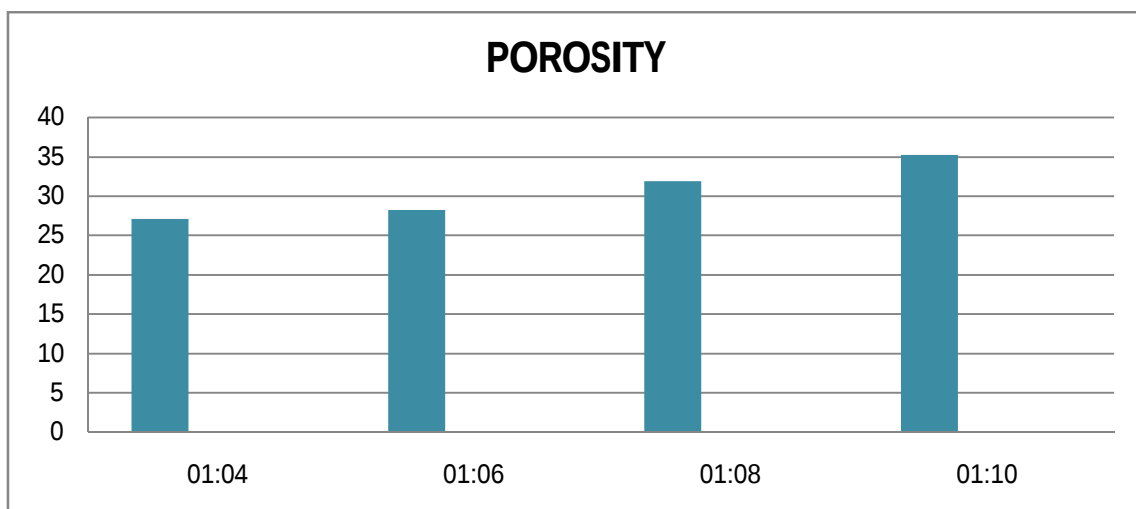
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POROSITY TEST

Porosity ranges from 27.06 % to 35.19 % for the 20mm type aggregate with different aggregate to cement ratio 4:1 to 10:1, as shown in Figure . It can be seen that porosity ranges from 27% to 35% in most mixes, which falls within the acceptable limit of 15 % to 30% for pervious concrete



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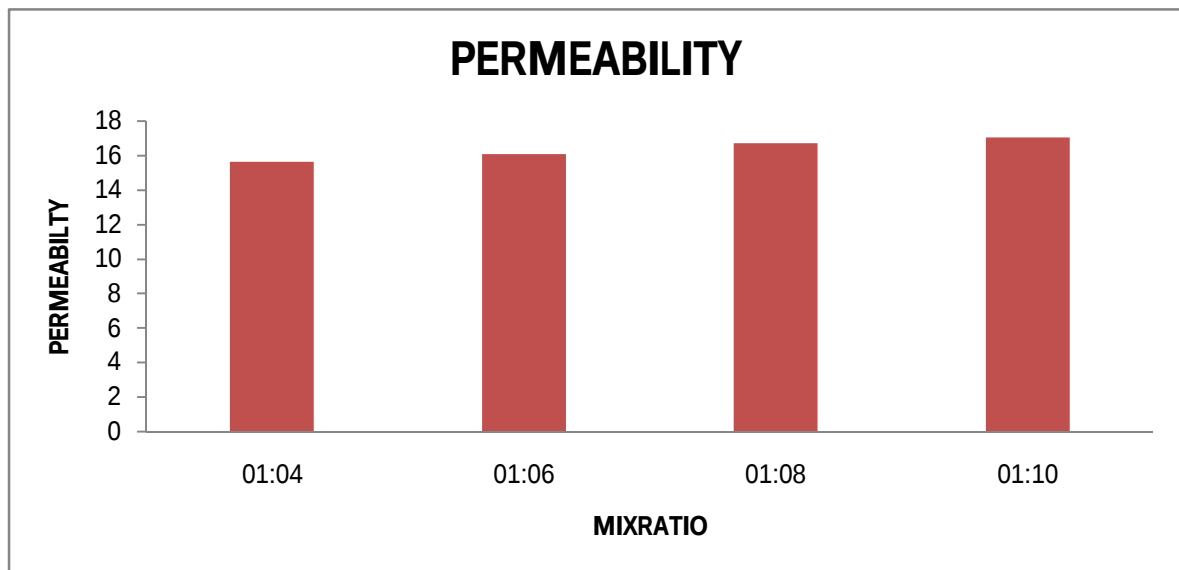
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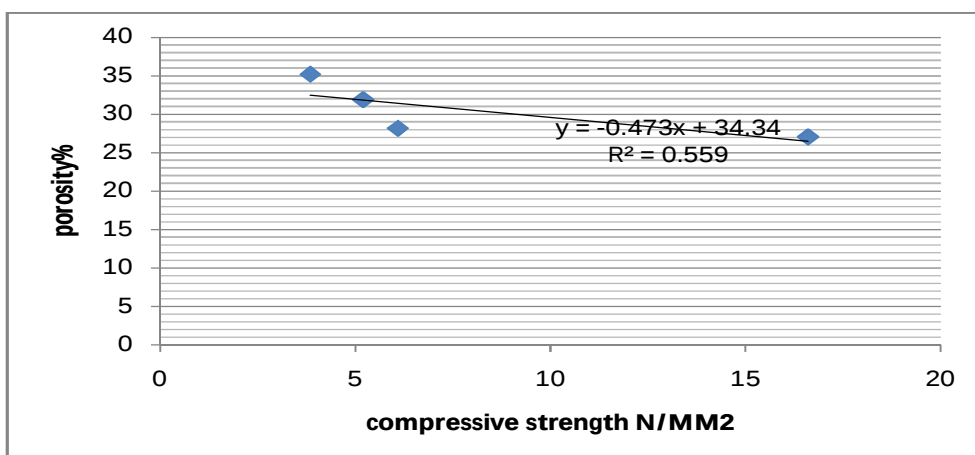
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PERMEABILITY TEST

Permeability test is an important test required for determining the permeability or draining capacity of pervious concrete, which is the core idea of the project. From the testing values it is found that the values of permeability are relatively higher for 10:1 ratio



REALATIONSHIP BETWEEN COMPRESSIVE STRENGTH AND POROSITY



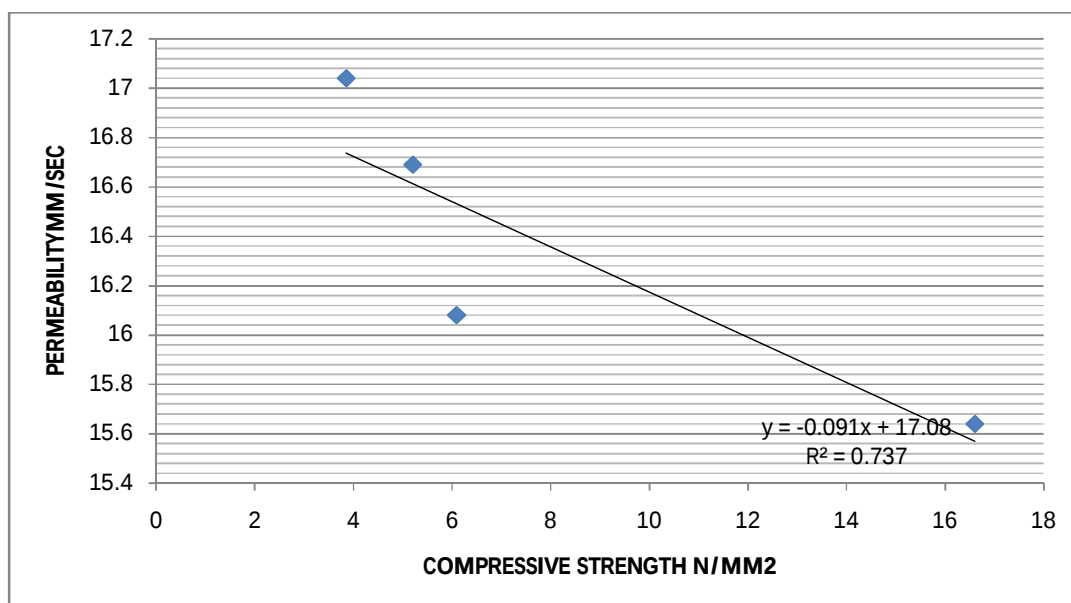
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REALATIONSHIP BETWEEN COMPRESSIVE STRENGTH AND PERMEABILITY



XI. CONCLUSION

Rain water harvesting can be done by this method best as compared to other methods because pollutants removal, no storage problem, storm water management and also economical and Compressive strength high for 4:1 ratio 16.6N/mm² porosity and permeability high for 10:1 ratio 35.19% and 17.04mm/sec. Based on experimental results, it can be concluded that, when runoff collection is of primary concern and strength is not a governing issue, the use of pervious concrete can be regarded as a suitable and sustainable choice in various storm water management applications. And applicable in fire land area and pedestrian area.

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