An Experimental Study on Application of Pervious Concrete in Effective Rainwater Harvesting System

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***Abstract*--- India is a subtropical country, which receives good amount of rain each year. Due to sudden and massive urbanization, the availability and supply of water for domestic purpose has introduced new challenges in urban water supply. Rainwater harvesting is a sustainable and reliable approach to manage the water in urban areas. In the recent years, rainwater harvesting is as statutory mandate during construction approval. Pervious concrete is a application oriented special concrete product, which has been effectively used to manage the surface run off in the shoulder, parking lane and other highway applications. In the present experimental study, efforts are made to use the pervious concrete as filtration medium for rainwater harvesting. The mechanical properties and permeability of pervious concrete are studied. A filtration medium model has prepared to study the permeability.**

***Keywords*---- Rainwater harvesting, previous concrete, integrated rainwater management, special concrete application.**

I. INTRODUCTION

Water is essential for life and plays a major role in creating earth's climate. Rainwater is the major source of sweet water. 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. Rain Water Harvesting, is an age-old system of collection of rainwater for future use. As per the Rainwater Harvesting and Conservation manual of CPWD (Central Public Works Department), rainwater harvesting is the activity of direct collection of rainwater for the purpose of direct use and recharge of ground water. However, systematic collection and recharging of ground water, is a recent development and is gaining importance as one of the most feasible and easy to implement remedy to restore the hydrological imbalance and prevent the water crisis.

Pervious concrete is a mixture of gravel or stone, cement, water and little or no sand, which creates an open cell structure that allows water and air to pass through it. According to EPA (Environmental Protection Agency's) storm water runoff can send as much as 90% of pollutant such as oil and other hydrocarbon. The ability of pervious concrete to allow water to flow through itself recharges ground water and minimizes the extent of pollution and storm water runoff. Pervious concrete is used to allow storm water to infiltrate through the pavement and reduce or eliminate the need for additional control structures, such as retention ponds.

II. LITRATURE SURVEY

The recent work carried out in better understanding of rain water harvesting concept, the modification of rainwater harvesting technology and use of sustainable materials in rainwater harvesting are critically review to judge the proper usage of pervious concrete in harvesting the rain water.

[6] conducted a study of unconfined aquifer response in terms of rise in water level due to precipitation. Cross correlation of rise in water level and precipitation is established. [2]have reviewed the impact assessment of RWH on ground water quality at Indore and Dewas, India. The impact assessment of roof top improve the quality and quantity of Ground Water. [3] investigated the hydrologic performance of permeable concrete paving stone installations of various ages. The primary objective of the studies was to determine the relationship, if any, between infiltration capacity and the age of a permeable concrete paver installation for various land uses and maintenance practices.

[2] carried out an experimental study on possibility of using the pervious concrete in to collect the storm water. The compressive strength and the permeability of the pervious concrete in studied and concluded that pervious concrete will be an ideal contribution to increase the usage of storm water in recharging of ground water, and sustainable land management. [1] conducted a laboratory experiment to study the improvement in the strength properties of pervious concrete through the incorporation of latex polymer. The study focused on the balance between permeability and strength properties of polymer-modified pervious concrete (PMPC). In addition to latex, natural sand and fiber were included to enhance the strength properties of pervious concrete. The test results indicate that it was possible to produce pervious concrete mixture with acceptable permeability and strength through the combination of latex and sand. [4] studied the properties of pervious concrete as pavement materials. The study concluded that Silica Fume and Super Plasticizer in the previous concrete can enhance the strength of pervious concrete greatly and water penetration, abrasion resistance,

and freezing and thawing durability of the materials are very good.

Limited amount of work has carried out to use the pervious concrete as sub surface filtration medium in rainwater harvesting for domestic and agricultural purpose. In the present study, an integrated subsurface system has proposed to apply the pervious concrete as effective and long lasting filtration system to harvest the rainwater.

III. Material Characterization

The regular ingredients of conventional concrete are used to produce the pervious concrete.

A. Cement

Commercially available ordinary Portland cement of 53 grade confirming to the requirements as per IS: 12269-1987- reaffirmed on 1999 has used.

Fig 1. Materials used in pervious concrete preparation

B. Fine aggregate

Locally available manufactured sand confirming to Zone II of IS 383-1970 is used in the present study.

C. Coarse aggregate

Coarse aggregate of maximum nominal size 20mm confirming to IS: 383-1970 has been used.

D. Water

Edible water confirming the requirement of IS 456-2000 used in concrete mix preparation.

IV. Experimental Programme

The experimental programme consists of preparation of pervious concrete with different percentage (by volume of concrete) of fine aggregate. Compressive strength and permeability of are studied to assess the suitability of previous concrete as filtration medium in rainwater harvesting.

The details of the different set of pervious concrete are shown in the table 1.

TABLE 1
Mix details of pervious concrete

Specimen	Mix Proportion				
	Cement (Kg/m^3)	Coarse aggregate (Kg/m^3)	Fine aggregate (Kg/m^3)	Water	Total weight (Kg)
PRC 1 (0% FA)	400	1050	0	200	1650
PRC 2 (5% FA)	400	967	83	200	1650
PRC 3 (10% FA)	400	885	165	200	1650

A. Compressive strength of previous concrete

To ascertain the compressive strength of the pervious concrete 100mmx100mmx100mm cube are casted for 7 and 28 days of curing.

B. Permeability

Fig 2. Pervious concrete specimen to determine the infiltration rate of water

A rectangular concrete slab of size 200mmx400mmx50mm casted to determine the infiltration rate in terms of centimeter per second for all specimens. The details of the specimen are shown in figure 2.

C. Model

To simulate the subsurface filtration medium, a cylindrical pervious concrete model of size 150mmØx300mm has prepared (shown in figure 3). Top 40mm of the cylinder is consist of sand bed consist of manufacture sand and 6.3 mm aggregate mixture. Second layer consist of pervious concrete made of 0% of fine aggregate to simulate the rocky boulder in the filtration medium. Pervious concrete made of 5 % of fine aggregate fills the middle 70mm of the height. The bottom most layer consist of 10 % of fine aggregate previous concrete with lesser void space compare to top layers.

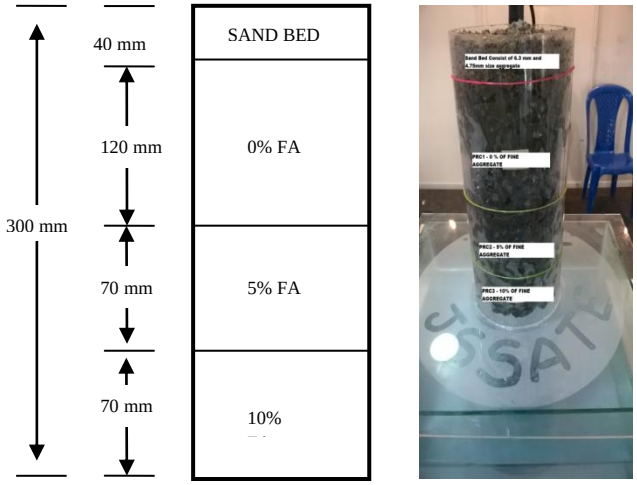

Fig 3. Details of model

V. Result and Discussion

The strength and permeability of the pervious concrete and model respectively are studied to ascertain the suitability of pervious concrete to use as filtration medium in rainwater harvesting. Table 2 indicated the compressive strength and permeability of different specimen.

TABLE 2.

Compressive strength and permeability of pervious concrete specimen

Specimen	Average Compressive Strength	Permeability (Cms/Sec)
PRC 1 (0% FA)	5.27	1.1
PRC 2 (5% FA)	8.26	0.6
PRC 3 (10% FA)	12.32	0.4

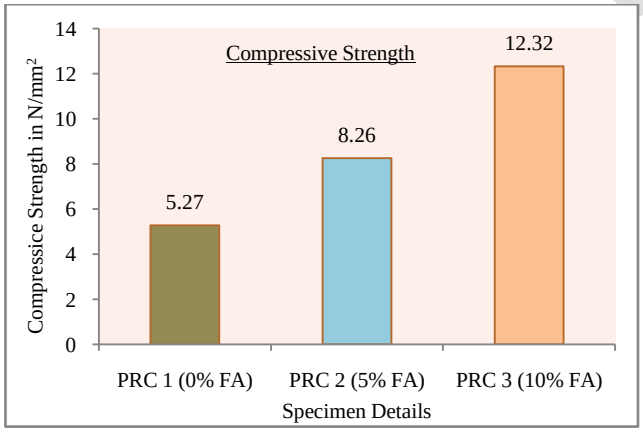

Fig 4. Graphical representation of compressive strength of previous concrete specimen

Due to increase in paste matrix in concrete, specimen PRC3 is showing a compressive strength of 12.32 N/mm2. PRC1 resulted in higher infiltration rate of 1.1 Cms/Sec due to presence of higher void space.

VI. Conclusion

From the present experimental study and the results obtained, the following conclusions may be drawn:

- Pervious concrete will provide a sustainable filtration medium for harvest and store the rainwater.
- Experimental results indicated that, pervious concrete allow sufficient amount of water to infiltrate through it and at the same time with good amount of compressive strength.
- Using pervious concrete as filtration medium, provide good amount of lateral stability to foundation of the structure as well as to the recharge pit.
- Though the initial construction cost is high, still previous concrete filtration medium will provide on time solution to problem associated with recharge filtration medium like clogging, sinking and other.
- Concept of using pervious concrete in rainwater harvesting can be easily implemented for the small residential house in the urban area.
- Pervious concrete will provide a customized filtration medium, which can be designed based on the amount of rainfall.

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