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Effectiveness of Pervious Concrete by Maintaining the Relationship between Porosity and Strength

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Abstract *Pervious Concrete is a Porous material, which is a mixture of cement, gravels, with water. Since the nature of it is porous, it allows the water to percolate down from it. Its tendency to allow water and air to pass through it, make it important in solving many environmental issues and building issues. Pervious concrete can also be used in pedestrian walkways, greenhouse, residential streets, parking area. It has great importance and application in sustainable construction and low impact development techniques which is used by builders to maintain and protect the water quality.*

The aim of this study is to determine the variation of strength and porosity at different water to cement ratio (w/c) and with different dosage of superplasticizer. Different combination of cement, aggregates, water to cement ratio (w/c) and superplasticizer were made to balance the desired porosity and strength, since both of them are inversely proportional to each other.

Due to increase in content of water to cement ratio and super plasticizer, the porosity decreases because the cement paste volume and flow ability increases. Above 0.36 w/c ratio, the porosity decreases since, cement paste accumulates down at the base leaving less pores open. Thus it has been concluded that desired strength is achieved at 0.34 w/c ratio. Further tests are performed on duration of 7days and 28days.

There are various tests which have been performed on Pervious Concrete to make it perfect for construction. Test such as Bulk Density and Specific Gravity are used to test aggregates, Slump Test and Vebe Test are performed to test the workability of concrete. Further, Compressive Strength Test, and Porosity Test have been performed which are basic to analyze the effectiveness of pervious concrete.

Key Words: **Pervious Concrete, Water-to-Cement Ratio (w/c), Porosity, Compressive Strength, Aggregates and Super Plasticizer**

1.INTRODUCTION

Pervious concrete is a mixture of water, cement, stone or gravel with super plasticizer. Pervious concrete is a special type of concrete with high porosity which can be used for concrete flat work applications that allows the water to percolate or precipitate and other sources to pass through it. The cell structure and tendency of it to pass water reduces the problem of runoff from site and thus allowing the recharge and refill of groundwater.

Pervious concrete is also called Porous Concrete, Permeable Concrete and No-Fines Concrete. Figure 1 shows the Pervious Concrete. Some traditional areas where pervious concrete is used are residential streets, Light traffic areas, parking area, roads, pedestrian walkways and greenhouse. Other applications concerned with Pervious Concrete [1] are slope stabilization, Road pavement, Sidewalks, Hydraulic structure and many more. It can allow the rain water to percolate down the ground thus, helping the plants to grow without extra water and also helps in procuring the natural disaster such as Landslide. On the other hand, if water level is exchanged the humidity level and temperature conditions can be well satisfied. Usage of pervious concrete reduces the storm water runoff, therefore eliminating the need of detention ponds.

Fig -1: Pervious Concrete [2]

There were many problems plagued to it initially, such as pores becoming clogged which stops the water runoff, decreasing the porosity thus, causing pond formation and

reducing skid resistance of the road surface. The aim of this research is to analyze the effectiveness associated to pervious concrete by maintaining the relationship between porosity and strength, since both holds the inversely proportional relationship between them.

2. LITERATURE REVIEW

The advantages associated with Pervious Concrete have motivated many researchers in the past to work on it by performing different methodologies. Some of the methodology has been stated which has motivated us to take the Pervious Concrete Research a step ahead.

Slippery behavior of pavement in icy circumstances has been evaluated by biomechanical methodology by the author [3]. Embedded force plates and Gait Motion has been used to analyze the mobility of wet pervious which is used to track electromyography and videography. Slipping can further be reduced by using controlled Gait Cycles.

Various kinds of fine aggregates such as Crushed Stone and River Sand has been used in varying quantities to get various mixtures. The properties concerned to the mixtures are clogging, potential, compressive strength, flexural strength, abrasion resistance and permeability. Author [4] has further focused on the advantages associated such as water cycle improvement, plant growth and vehicle performance.

Two factors related to pervious concrete are strength and porosity. Authors have used Latex Polymer to strengthen the pervious concrete. Mixture is formed by using one type of polymer i.e. SBS Latex and three types (12.5mm, 9.5mm and 4.75mm) of single sized limestone aggregates. For testing the mixtures such as air void test, permeability test, mix design test has been performed by authors [5].

This paper [6] uses various binary combinations of three type of coarse aggregates to achieve Packing Density Value (PD) with Uniformity Coefficients (UC). Pervious Concrete mixtures are further mixed with fixed water to cement ratio i.e. 0.30 for inter particle void index determination. Tensile and Compression strength, porosity and permeability are also determined, which are the effects of aggregation size and gradation. Further test such as Paste Volume to Inner Particle Void (IPV) is used to increases the strength and Porosity.

Sieve Analysis [7] of coarse aggregate with concrete strength test on concrete has been performed to conclude that smaller sized coarse aggregate are best suited for pavement construction.

Strength can be increased by adding material such as steel fiber and silica as stated by author [8] with different admixtures.

The advantage of Pervious Concrete to conventional concrete pavements is its ability to absorb acoustic [9]. This property of pervious concrete is due to porous nature of it. Authors have studied different aggregate sizes and gradation and have resulted that, acoustic absorption increases with the increase in permeability and porosity of material.

This paper [10] illustrates the comparison studies of cast specimen over pavement cores on the basis of density, infiltration and porosity. Proctor hammer consolidation produced density and porosity closest to pavement in three projects. Three projects were conducted in three different locations, on different areas, materials and design pervious concrete thickness.

This paper investigates the properties on mechanical-hydrological-durability, environmental, field performance and economical aspects of pervious concrete. Purification of storm water has been focused and illustrated. Author has further mentioned about the use of pervious concrete in low volume road applications [11].

Flexural and Compressive strength, fatugue property and fracture energy of Pervious concrete has been analyzed with polymer intensified or supplementary cementitious materials (SCMs) [12]. This study shows that Polymer intensified pervious concrete has more flexural strength and flexural to compressive strength ratio when compared to SCM modified pervious concrete (SPC). Test states that fracture energy increases as the dosage of polymer increases. Further at any stress level PPC displays longer lifetime when compared to SPC.

3. PROPOSED METHOD

The main objective of this research study is to achieve the strength in parallel to porosity. Figure 2 show the block diagram of the proposed system for testing the mixture and getting the balance of Porosity and Strength.

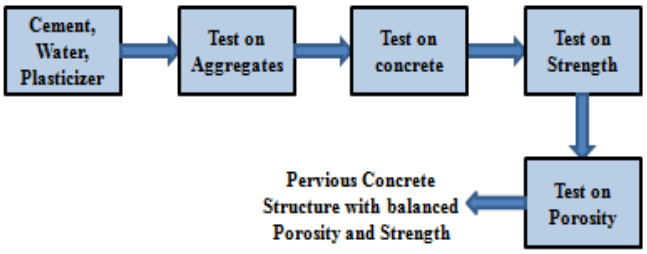

Fig-2: Proposed Method

A. Material for Testing

The material used for testing and achieving the balanced porosity and strengthened pervious concrete are: Water, Cement, and Super Plasticizer. Pervious Concrete specimens are cast with 1622 kg/m^3 aggregate (6.35-10 mm and 10-12.5 mm size aggregate mixed in equal proportions by weight) and 400 kg/m^3 cement.

B. Test for Aggregates

Different Types of aggregates of different shape and sizes are used to test Bulk Density and Specific Gravity. Bulk Density denotes the mass of aggregate which is required to fill the unit volume container after aggregate are batched on the bases of volume.

Specific Gravity is the ratio of substance density to the reference substance density. This test was conducted as per IS:2386-3(1963). Pycnometer was used to determine the specific gravity of aggregates.

C. Test to obtain workability of Concrete

Workability of the concrete is performed by performing Slump Test, Vebe Test and Compassion Factor Test.

Slump Test measures the workability of concrete in a batch. This test was conducted as per IS:7320-1974.

D. Test for Porosity

Lastly, the test on porosity is done to check how much water can percolate and at what speed can it percolate. Porosity is the ratio of voids volume to the total solid volume. Volume of void is obtained by subtracting total volume of liquid soaked in the solid from the total volume of the solid. This test is conducted on the basis of ASTM C1754.

E. Test for Strength

Further test for strength are made to check, that how much pressure and force a structure can sustain. This test was conducted as per IS:516-1959. Strength test was conducted on cubes of size 15cm × 15cm × 15cm. After casting these cubes, the strength test was performed after 7days and 28days in the Universal Testing Machine.

4. EXPERIMENTAL RESULTS

Pervious Concrete specimens of 15cm breadth, height and length each are casted with 1622 kg/m^3 aggregate and 400 kg/m^3 cement. Water-to-cement ratio and superplasticizer content of the mixes are varied. Further Compressive strength and Porosity tests have been conducted. The details for various test performed have been listed below in Table 1.

Porosity of the specimens has been evaluated using water replacement method based on Archimedes' principle. Porosity decreases with increase in water-cement ratio and super plasticizer content as observed in normal concrete because of increase in cement paste volume and flow ability. Above 0.36 w/c ratio, cement paste is found to accumulate at the base leaving less pores open.

Table 1: Details of Pervious Concrete Mixes

Aggregate weight (kg/m^3)	Cement (kg/m^3)	Water-cement ratio	Super plasticizer-cement ratio (w/w)
1622	400	0.3	-
		0.32	-
		0.34	-
		0.35	-
		0.36	-
		0.3	0.001
			0.002
			0.003
		0.32	0.001
			0.002
			0.003

It seems that for w/c ratios above 0.34, increment in strength due to decrease in porosity is more than decrement

in strength due to increase in w/c ratio as seen in Fig. 3&4. It is observed that maximum strength is obtained at 0.34 w/c ratio.

As super plasticizer improves the flow characteristics of cement paste, porosity has decreased with increase in its dosage. When the dosage is above 0.3% (w/w), cement paste has accumulated at the base closing almost all the pores and pore distribution has also varied along the height of the specimen. Slightly higher strength is observed in the mixes with super plasticizer as shown in Fig. 5&6.

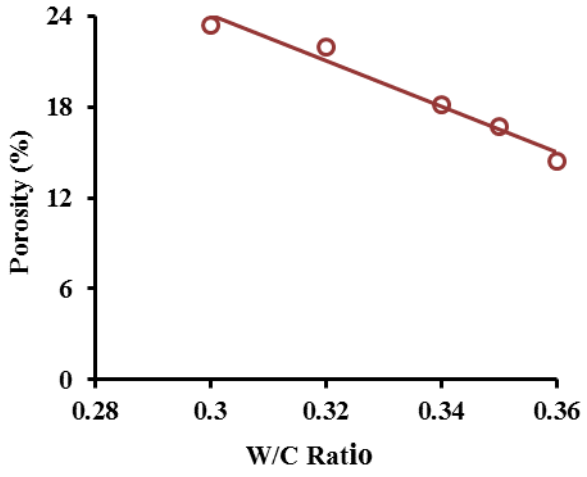

Fig-3: Effect of water-to-cement ratio on porosity

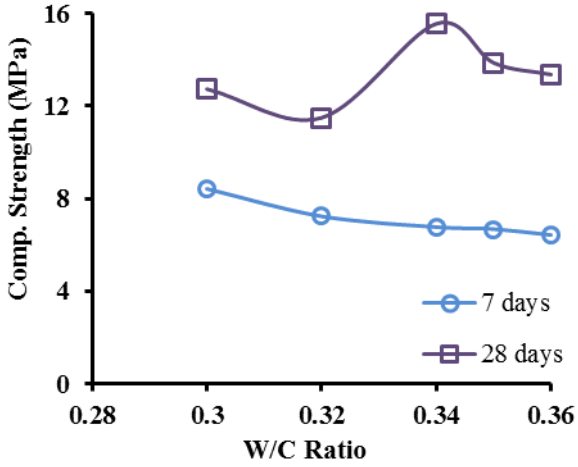

Fig-4: Effect of water-to-cement ratio on compressive strength

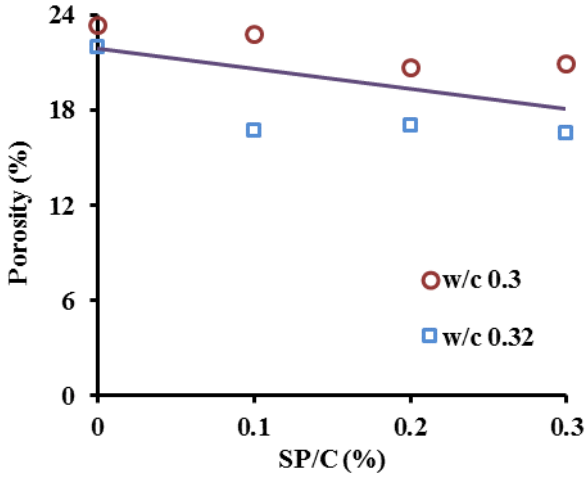

Fig-5: Effect of super-plasticizer on porosity

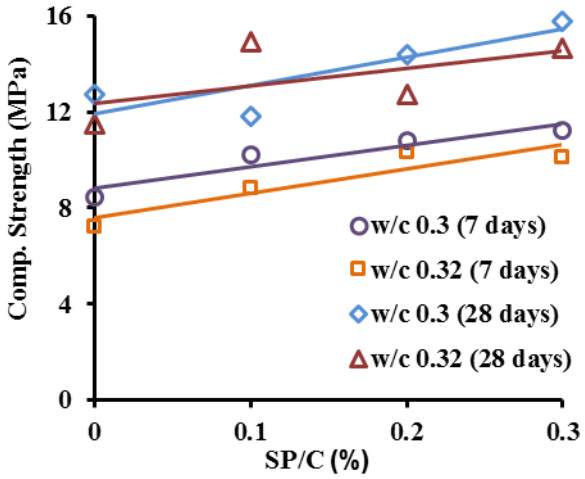

Fig-6: Effect of super-plasticizer on compressive strength

5. CONCLUSIONS

From the previous work done on Pervious Concrete and advantages integrated concludes that pervious concrete can be used efficiently as building material. It can be concluded that porosity and strength are favorable when water-to-cement ratio is 0.34. Further plasticizer can also be used to increase the strength of the material.

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REFERENCES

[1] Shah, D. S., Pitroda, P., & Bhavsar, P. J. (2013). Pervious Concrete: New Era for Rural Road Pavement. International Journal of Engineering Trends and Technology (IJETT), 4(8), 3495-3499.

[2] Prakash, V. S., Manohar, N., Rajesh, K., & Rahul, B. (2014). Effects of Material Proportions on the Engineering Properties of Pervious Concrete. Warangal.

[3] Kevern, J. T., King, G. W., & Bruetsch, A. (2012). Pervious Concrete Surface Characterization to Reduce Slip-Related Falls. Journal of Performance of Constructed Facilities, 26(4), 526-531.

[4] Patil, V. R., Gupta, A. K., & Desai, D. B. (n.d.). Use of Pervious Concrete in Construction of Pavement for Improving Their Performance. Journal of Mechanical and Civil Engineering, 54-56.

[5] Huang, B., Wu, H., Shu, X., & Burdette, E. G. (2010, May). Laboratory evaluation of permeability and strength of polymer-modified pervious Concrete. 24(5), 818-823.

[6] Yahia, A., & Kabagire, K. D. (2014). New approach to proportion pervious concrete. 38-46

[7] Ajamu, S. O., Jimoh, A. A., & Oluremi, J. R. (2012, May 5). Evaluation of Structural Performance of Pervious Concrete in Construction. International Journal of Engineering and Technology, 2(5), 829-836.

[8] Lee, M. G., Huang, Y. S., Chang, T. K., & Pao, C. H. (2011). Experimental Study of Pervious Concrete Pavement. 93-99.

[9] Neithalath N, Weiss J, Olek J. Characterizing enhanced porosity concrete using electrical impedance to predict acoustic and hydraulic performance. Cement Concrete Research 2006;36:2074–85.

[10] Putman, J. B., & Neptune, I. A. (2011). Comparison of test specimen preparation techniques for pervious concrete pavements. *Construction and Building Materials*, 3480-3485.

[11] Biligiri, K. P., & Chandrappa , A. K. (2016). Pervious Concrete as a sustainable pavement material-Research findings and future prospects:A state-of-the-art review. *Construction and Building Materials*, 262-274.

[12] Yu, C., Jin, W. K., & Di, L. (2012). Mechanical properties of pervious cement concrete. *Central south university* , 3329-3334.

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