Experimental Study on Properties of Pervious Concrete

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Abstract

Rapid infrastructure development and depletion of natural resources demand use of sustainable materials and practices. Pervious concrete by virtue of its high porosity and permeability is a promising solution to the problem of depleting ground water table storm water runoff, heat island effects etc. in urban built environment. This paper present an overview of pervious concrete which includes its ingredients, mix proportioning and strength of that proportions, But insufficient information, guideline and expertize, the mix proportioning is still a trial and error approach especially in developing countries.

Keywords— Mix Proportioning, Pervious Concrete, Proportioning Method, and Strength.

I. INTRODUCTION

The boom in construction industry over the last several decades has exploited natural resources in uncontrolled manner causing their depletion and adversely affecting the environment. The most negative impact of the sector are consumption of large quantities of building materials such as coarse aggregate, fine aggregate, cement, steels etc. and generation of construction waste. This is transforming natural pervious ground into impervious concrete cover especially in urban areas. This leads to increase in storm water runoff, water lagging during rainy seasons, depleting water tables, urban heat island effect etc. There is an urgent need to address these concerns and to develop sustainable materials for futuristic construction.

Over the last few years, pervious concrete has become a very relevant topic in the construction industry. More and more specifications call for pervious concrete in different applications. Pervious concrete (PC) is a special type of concrete with a high porosity used for concrete flatwork applications that allows water from precipitation and other sources to pass through it, thereby reducing the runoff from a site and recharging ground water levels. Typically PC has little to no fine aggregate and has just enough cementations paste to coat the coarse aggregate particles while preserving the interconnectivity of the voids. Pervious concrete is traditionally used in parking areas, areas with light traffic, pedestrian walkways, and greenhouses. It is an important application for sustainable construction [1]. The popularity of pervious concrete continues to rise with the increased awareness of environmental protection and preservation. Pervious concrete is one of the leading materials used by the concrete industry as GREEN industry practices for providing pollution control, storm water management and sustainable design. In the United States, PC typically has high porosity and low strength, which has resulted in the limited use of pervious concrete, especially in hard wet freeze environments (e.g., the Midwestern and Northeastern United States and other parts of the World) [2]. In metro cites percolation of water is less, therefore need of PC. The pervious concrete system and its corresponding strength are as important as its permeability characteristics.

II. Ease of Use

Pervious concrete

(also called porous concrete, permeable concrete, no fines concrete and porous pavement) is a special type of concrete with a high porosity used for concrete flatwork applications that allows water from precipitation and other sources to pass directly through, thereby reducing the runoff from a site and allowing groundwater recharge.

Pervious concrete is made using large aggregates with little to no fine aggregates. The concrete paste then coats the aggregates and allows water to pass through the concrete slab. Pervious concrete is traditionally used in parking areas, areas with light traffic, residential streets, pedestrian walkways, and greenhouses. It is an important application for sustainable construction and is one of many low impact development techniques used by builders to protect water quality.

III. Experimental Work

A. Material slection

For development of Pervious Concrete selection of appropriate materials is very important. As strength of concrete is widely depend on material and its properties hence it is needed to select the material which will give high strength and good properties. Following are the materials selected for development of geopolymer concrete.

a) Aggregates

Aggregates play a vital role in maintaining sufficient voids in pervious concrete. Aggregate to cement ration is a major factor which affects inter connectivity of voids by thickness of cement paste on aggregates. The gradation of aggregate typically consists of uniform / single- sized or gap-graded coarse aggregate. The aggregate size varies from 9.5 to 19mm. It was also found that the type of aggregate has more pronounced effect on porosity as compared to its size.

b) Cementations Material

Generally ordinary Portland cement was used to develop the Pervious Concrete. The cementations binder forms a thin layer of paste around the aggregate and provides strength and durability. The thickness of cement paste layer should be optimum to avoid filling up the void space in packed aggregate.

c) Admixture

Pervious concrete has little to no slump and thus requires chemical admixture to obtain a workable concrete. Water reducer and retarders are usually required for its workability due to low range of w/c ration which varies from 0.25 to 0.35. Air entraining admixtures are usually added to improve freeze thaw resistance of pervious concrete. The large surface area of PC increases curing requirements significantly. The super absorbent polymer based admixture is affective in eliminating the nee of plastic sheets while curing.

d) Additives

Additives such as latex, tire chip, slag, fibres etc. have also been studied to improve the strength properties of pervious concrete. Latex increases the cement paste coating of the aggregates which lead to increase in compressive strength and abrasion resistance, but it has a negative impact on the permeability due to reduced size of voids. Tire chips decreases the compressive strength and flexural strength. The permeability of pervious concrete also decreases due to clogging of voids. Fibres have no significant effect on abrasion resistance or the compressive strength, but it improves the split-tensile strength of pervious concrete.

B. Mix Design

There are no special codal provisions for design of Pervious concrete. From literature available it is clear that Pervious concrete is can be designed as trial and error methods, (several combinations of material taken in to lab and find out its strength and performance that casted material). In this study deign of Pervious Concrete is carried out with the help of ACI 522R-10.

Proportioning procedure

A procedure for producing initial trial batches for pervious concrete is showing below: b/b_0 method—The b/b_0 method for designing pervious concrete mixture can be broken up into a series of eight steps:

1. Determine aggregate weight;
2. Adjust to SSD weight;
3. Determine paste volume:
4. Determine cementations content;
5. Determine water content;
6. Determine solid volume:
7. Check void content: and
8. Iterative trial batching;

a. Test for required properties; and

b. Adjust mixture proportions until the required performance is achieved.

Example—Proportion a well compacted pervious concrete mixture with a void content of a least 20%. The mixture should have a w/c = 0.38. Use a No. 8 coarse aggregate having a dry-rodded density (unit weight) of 1662 Kg/m^3 specific gravity of 2.57, and absorption of 1.75 %. No fine aggregate will be used in the mixture.

Step 1: Determine aggregate weight

For No.8 stone with No fine aggregate recommends b/b_0 of 0.99

Wa= 1662 x 0.99 x 1 = 1645.3 Kg/m^3 (dry)

Step 2: Ajust to SSD weight

Percentage absorbance of 1.2%

Wssd = 1645.3 x 1.0175 = 1674.17 Kg/m^3 (SSD)

Step 3: Determine paste volume

Vp = 0.15 m^3

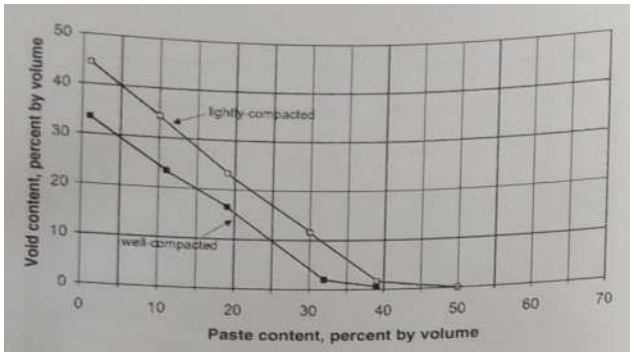

Fig.1 Relationship between paste and void content for No. 8 aggregate size designations.

Step 4: Determine cement content

$c = [Vp/(0.315+w/cm)] \times 1000$

$c = 476.15\ Kg/m^3$

Step 5: Determine water content

$w = c(w/cm)$

$w = 180.95\ Kg/m^3$

Step 6: Determine solid volume

Aggregate volume $Va = 1674.17/(2.57 \times 1000) = 0.651 m^3$

Cement volume $Vc = 476.19/(3.15 \times 1000) = 0.151 m^3$

Water volume $Vw = 180.95/1000 = 0.181 m^3$

Total volume $Vs = Va + Vc + Vw = 0.651+0.151+0.181$

$= 0.983\ m^3$

Step 7: Determine percent voids

Percent void = [(Vtot - Vs) / Vtot] x 100

Percent voids = 26.1%

Step 8: Check estimated porosity

At 26% voids, predicts a percolation rate of approximately 15in./min (450 mm/min).

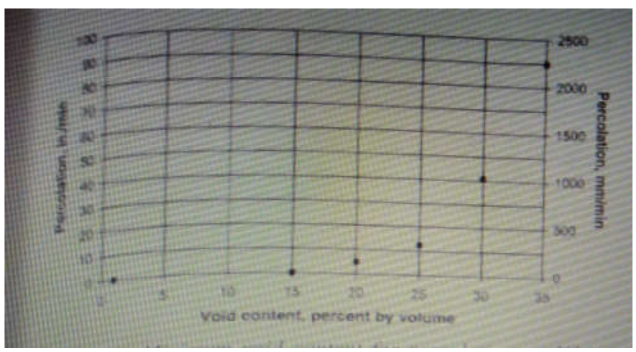

Fig.2 Minimum void content for percolation on NRMCA test and test method.

Material required is given below

Table 1 Material Quantity required for trials

Sr. No.	Material	Quantity(for 2 blocks)		
		Trial 1	Trial 2	Trial 3
1	Coarse aggregate	18.37 Kg	18.37 Kg	18.37 Kg
2	Cement	3.77 Kg	3.77 Kg	3.77 Kg
4	Water	1.44Kg	1.44Kg	1.44Kg

Results obtained from concrete trials for compression with 150 X 150 X 150 mm size blocks.

IV. Results

Table 2 Compression test results

Sr. No.	Loaded Area (mm^2)	Strength (N/mm^2)	Average Strength (N/mm^2)
Trial 1	150 X 150	16.40	16.35
	150 X 150	16.30	
Trial 2	150 X 150	15.30	15.35
	150 X 150	15.40	
Trial 3	150 X 150	17.40	17.45
	150 X 150	17.50	

Fig. 3 Pervious Concrete block testing

Fig. 4 Pervious Concrete block

V. CONCLUSION

The objective of the present work is to design the pervious concrete which gives strength ranging 2.36 to 28MPa.

1. Increase in quantity of cement leads to increase in strength of concrete.
2. Percentage of water decrease then the strength of pervious concrete increase.

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