RESEARCH ARTICLE OPEN ACCESS

The Use Of Permeable Concrete For Ground Water Recharge

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ABSTRACT
In order to develop Smart Cities in India, we need to develop smart technologies and smart construction materials. Permeable concrete an innovative material is environment friendly and a smart material which can be used for construction of several structures. In India, the ground water table is decreasing at a faster rate due to reduction in ground water recharge. These days, the vegetation cover is replaced by infrastructure hence the water gets very less opportunity to infiltrate itself into the soil. If the permeable concrete which has a high porosity is used for the construction of pavements, walking tracks, parking lots, well lining, etc. then it can reduce the runoff from the site and help in the ground water recharge. Such type of smart materials will play an important role for Indian conditions where government is putting lot of efforts to implement ground water recharging techniques. During the research work, the runoff for a particular storm was calculated for a bitumen pavement on a sloping ground. Later after studying the various topographical features, the traffic intensity and the rainfall for that particular area, the concrete was designed and tested for the different proportion and thus the mix design for the permeable concrete was finalized based upon its permeability and strength characteristics. Later by using this permeable concrete the infiltration and runoff for the same storm was compared and studied. The research paper will thus give an account of the properties of permeable concrete where it can be used over an existing road.
Keywords: Ground Water Recharge, Permeable Concrete, Infiltration

I. INTRODUCTION

In recent years, permeable concrete has become popular as an effective storm water management device in area that receives frequent and sometimes extensive rainfalls. Moreover as the urban areas expand, the vegetation cover is being replaced by infrastructure hence the water gets very less opportunity to infiltrate itself into the soil. As urbanization increases in India and many parts of the world the problem of water logging and requirement of drainage is also increased. This is partly due to impervious nature of the bituminous and concrete pavements. Pervious concrete which has an open cell helps significantly to provide high permeability due to its interconnected pores. It is a special type of concrete with a high porosity that allows water from precipitation and other sources to pass directly through, thereby reducing the runoff from a site and allowing groundwater recharge. It is made using coarse aggregates with little to no fine aggregates. In addition to retention capabilities, a properly designed permeable provides durable riding surface. It also eliminates puddles and standing water, resulting in improved skid resistance. The permeable concrete is also called as No fines concrete and Pervious concrete.

General Background:

Permeable concrete is a composite material containing graded coarse aggregates bonded together by a paste of cement and water. The aggregates are generally a single size, usually 10 mm to 20 mm with cement content sufficient to provide adequate strength without reducing the porosity. The hardened product is an open-textured cellular concrete with a high volume of voids and good permeability properties. It is lighter than the normal- weight concrete and it is comparably strong.

Materials:

During this project, the raw materials used for the production of permeable concrete consisted of Portland Pozzolana cement (PPC), crushed limestone coarse aggregate with size passing through 12.5 mm and retaining on 10 mm and chemical admixture. The masterplast plasticizer with 0.2% of the weight of the cement was used to enhance the workability of the concrete mix.

Mixture properties: The different aggregate-cement ratios, namely 4:1, 4.5:1, 5:1 were use. Concrete batches were mixed at a constant water-cement (w/c) ratio of 0.4 throughout. This w/c ratio produced a mixture which had a wet metallic appearance which is desirable for such type of concrete. The consistency of permeable concrete was satisfactory as no cement paste flowed away from the aggregate particles.

Mixing, Casting and Curing of Specimens: The mixing was done using a counter-current pan mixer. The aggregates and the cement were dry

mixed and then water along with the plasticizer was added until a homogenous mixture was obtained. Hand Roding was adopted to fill the moulds, each layer was tapped 25 times with a rammer. After compaction the top surface was evenly trimmed with the help of spatula. The moulds were left undisturbed for 24 hours. After 24 hours the casted moulds were unmolded and their densities were determined. All samples were placed in the curing tank with water at room temperature. The samples were cured for 3 days, 7 days, 14 days and 28 days.

Testing Method: The hardened concrete was tested at various ages ranging from 3 days to 28 days. The samples were tested for compression, splitting tension, permeability and porosity. As there is no specific IS Code developed for the permeable concrete the test samples were tested according to IS 515:1959 with rate of loading as 5KN/sec for compressive testing and IS 5816:1999 for splitting cylinder test the rate of loading as 1.8 KN/sec.

Experimental Results:

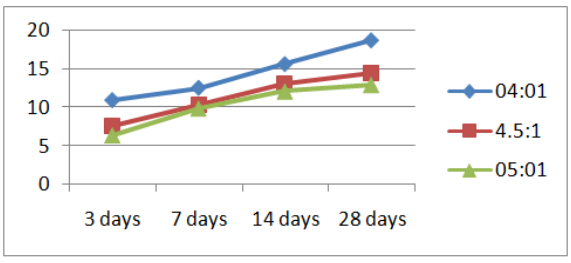
1.) **Compressive Testing:** The compressive testing of the samples was conducted after 3 days, 7 days, 14 days and 28 days of curing. After performing the compressive testing of the test sample the following results were obtained

Table 01: Compressive Strength of Concrete

Curing Period	4:01	4.5:1	5:01
7 days	1.35	1.11	0.91
28 days	2.19	1.66	1.39

From the experimental results it can be concluded that with an increase in the aggregate/cement ratio there is a decrease in the compressive strength of the concrete

Figure 1 Compression test results for samples

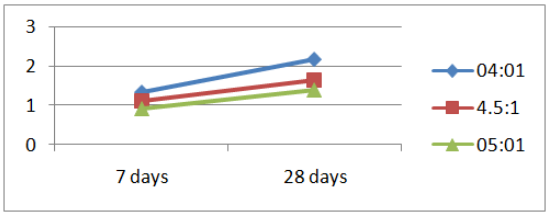


2.) **Tensile Strength:** The splitting cylinder test was performed to test the tensile strength of the concrete. The samples were tested after 7days and 28 days of curing.

Table 02: Tensile Strength of Concrete

Curing Period	4:01	4.5:1	5:01
3 days	10.99	7.54	6.39
7 days	12.58	10.32	9.87
14 days	15.65	13.17	12.1
28 days	18.73	14.51	12.93

Fig 02: Tensile strength results for samples



General Background of the project

After identifying suitable area in the RCOEM campus which receives enough runoff and after studying meteorological data it was decided that 4 patches of permeable concrete should be laid in that area. After studying the rainfall data of Nagpur City for the past 10 years the maximum rainfall was found to be 550.5 mm for the month of July. The catchment area which was identified, measured 90 m^2. Therefore total volume of runoff is equals to (90X550.5/1000)=49.545 m^3, considering 10% losses resulting volume comes out to be 44.59 m^3. Permeability of pervious concrete of grade 4:1 is found to be 0.01021 m^3/s. Therefore volume of water infiltrated is equal to $1m^2 x 0.01021 m/s = 0.01021 m^3/s$.

The size of each patch is proposed as 1.0x1.0x0.3 m. Based on the study, the permeable concrete was designed considering the feasibility and economy. After studying the different proportions comparative study was made between different proportions and the days of curing. 3 proportions viz. 4:1, 4.5:1, 5:1 were designed for testing.

Costing of the Project:

For the project total 4 numbers of permeable patches are proposed having size 1x1x0.3 cum. Total volume of four excavation patch area= 4x(1x1x0.3)=1.2 cum.
Assuming 25% reduction involved, therefore total volume=1.2x1.25 cum.
Taking density of pervious concrete as 2000(kg/cum).
Proportion of pervious concrete is 4:1
Volume of cement required= (1.2x1.25x1)/5=0.3 cum.
1 cum. of concrete requires nearly 30 bags of cement, therefore for above mentioned volume, the nos. of cement bags required = 9 bags.
Total amount of cement= 450kg.
Total cost of cement =9 bags x 290=Rs. 2610/-

Volume of aggregate= (1.2x1.25x4)/5=1.2 cum.
Rate of aggregate= Rs. 900 for 1 cum.
After passing the sample from 12.5mm (IS Sieve) and retaining on 10mm (IS Sieve), only 50% sample was recovered
Therefore, total cost of aggregate= 1x1.2x900x2=Rs.2160.
According to calculations 0.2% by wt. of cement plasticizer was added.
Therefore quantity for plasticizer required for above mentioned quantity= 900mL.
Cost of plasticizer =Rs. 250 per liter
Total cost of the materials= Cost of cement+ Cost of aggregate+ Cost of Plasticizer

=2610+2160+250=Rs.5020
Labor Cost:
Sieving cost= Rs.350 per day per labor
Casting cost= Rs 1000
Cost of breaker for punching the roads=Rs.800 per hour
Disposal cost=Rs.350 per Labor
Total cost of breaker= 3x800= Rs.2400
Total disposal cost=350x2= Rs.700
Grand total of Labor cost= 1000+350+2400+700=Rs.4450/-
Overall cost = Cost of Labor+ Material cost= 4450+5020= Rs. 9470/-
Considering contingencies as 5% of the overall cost
Addition of all cost=9470x1.05=Rs. 9944
Therefore cost for 1 cum of permeable patch is 9944/1.2=Rs.8287 approx. Rs. 8300/-

Permeability and Void Content:

The void content is measured as per Standard Test Method for Density and Void Content of Freshly Mixed Pervious Concrete
Void Content (%) = ((T-D)/T)*100
Where, D = (Mc-Mm)/Vm

Mc = mass of measure filled with concrete

Mm = net mass of concrete by subtracting mass of measure

Vm = volume of measure

T = Ms/Vs

Ms = total mass of materials batched

Vs = total absolute volume of materials

Sample calculation for 4:1 Proportion:
For making 3 cubes by cement, with 0% sand and 0.4 w/c, the requirements are
Cement = 4 kg.
Aggregates = 20.25 kg.
Sand = 0 kg.
Water = 1.6 kg.
After 7 days, the average density was found to be 2100 kg/m^3
D = 2100 kg/m^3
T=(4+20.25+1.6+0)/((4/(3.15*1000))+(20.25/(2.71*1000))+(0/(2.66*1000))+ (1.6/(1*1000)))
T = 2499.47 kg/m^3
Void content (%) = ((2499.47-2100)/2499.47)*100 = 15.96%

Based upon the study the Permeability and the void content, the following results were obtained

Table 3: Results showing Permeability and Void Content for Different Proportions

Proportion	**Permeability (m/s)**	**Void Content (%)**
4:1	1.021 $x10^{-2}$	15.96
4.5:1	1.174 $x10^{-2}$	21.35
5:1	1.2 $x10^{-2}$	27.75

II. CONCLUSION

Permeable concrete has the ability to capture storm water and recharge ground water while reducing storm water runoff enables pervious concrete to play a significant role. From the experimental results it can be concluded that with an increase in the aggregate/cement ratio there is a decrease in the compressive strength and the tensile strength of the concrete. Even though the compressive strength of the conventional is higher as compared to the permeable concrete but the permeable concrete have a number of environmental benefits. Due to its low cost construction, if it is utilized in Indian context then it proves to be very beneficial to solve environmental issues and water logging problems which are the major issues in India.

ACKNOWLEDGEMENT

We acknowledge a deep sense of gratitude towards Prof. S. S. Geete and Dr. (Prof.) Vaidehi Dakwale, Assistant Professor in Department of Civil Engineering, Shri Ramdeobaba College of Engineering and Management, Nagpur for providing us with valuable information, guidance and co-operation while working on this project. We would also like to thank Dr. M. S. Kadu, Head of Civil Engineering Department for giving us an opportunity to work on this project. We also thank him for his kind support and also for making available laboratories and resources of the department. We are also thankful to Mr. Jafar and Mr. Ashok Somkuwar who helped us in carrying out necessary tests results and to our families and friends who had faith in us and were constant source of inspiration and also those who directly or indirectly helped us for this project.

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