Journal of Basic and Applied Engineering Research
p-ISSN: 2350-0077; e-ISSN: 2350-0255; Volume 5, Issue 2; April, 2018, pp. 67-70

http://www.krishisanskriti.org/Publication.html

Designing a Pervious Concrete off-street Parking for Lucknow City

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Abstract—*The parking is the additional facility provided along with the road construction. The objective of the parking is to maximize the road capacity. For the purpose of maximizing the use of parking, it is needed to make it available accessible throughout the year. During the monsoon season, it is seen that the parking capacity compromises due to water pounding in parking area. For the purpose of overcoming the problem of water pounding, the permeable concrete concept has been introduced by the researchers. This research work is an effort to suggest a material quality and arrangement to achieve suitable permeability in the concrete surface to minimize the chance of restrictions in the use of a parking proposed in Lucknow city. The potential of this research is to arrive on a sustainable and optimal design process of pervious concrete pavement.*

Keywords: *Pervious concrete, compressive strength, porosity, Pounding, permeability, permeable concrete.*

1. INTRODUCTION

The pervious concrete concept has been introduced in research field for achieving quick water draining property from the concrete surface. The strength and the durability is the important parameter is needed to be considered for the design of porous concrete pavement [1, 5]. A lot of works have been done for arriving at suitable design process which can give reasonable performance with minimum efforts. For the purpose of increasing the permeability of concrete, the fine sand portion from the concrete is replaced by coarse aggregate [2]. It is observed that the reduction in fine portion of the concrete results in decreased strength and increased permeability [3]. It is seen that the pervious concrete with 0% of sand has lesser strength and more porosity than the concrete of 15% of sand [4]. A hit and trial method is needed to be adopted for designing a pervious concrete pavement to achieve required permeability by varying the sand content [IRC 44-1976]. The effect of variation of the sand is investigated by the researchers by mixing sand portion 1 to 15% by weight of concrete. Mostly, M15 grade concrete is found suitable for the concrete pavement which is targeted Mix design for this project [5, 6]. It is expected that, in India the pervious concrete concept will soon become more popular in future due to increased urbanization and reduction of groundwater level [7].

2. MATERIALS

The fundamental prerequisite or constituents of pervious bond solid blend are different from the ordinary bond solid blend, aside from in the extent of fixings. The main ingredients are cementitious material, water, aggregate and if required, admixtures.

2.1 Cement: OPC 43 Grade

Ordinary Portland cement of grade 43 was used in this experimental study. The specific gravity of the cement is 3.15. The initial setting time of this cement is 30 minutes. The consistency of this cement is 33%.

2.2 Coarse aggregate

Coarse aggregate of size varying from 12.5 to 16 mm is used for preparing the pervious cube of concrete. The irregular shapes aggregates are used for preparing the sample. The specific gravity of tested coarse aggregate is 2.9 with 0.60% water absorption is characterized for the impact value which found to be 19%. These values are found to be qualifying the standard required. The aggregate of size less than 12.5 mm increases the strength of pervious concrete but the permeability will be very less. In other case the pervious cement with total size over 16 mm diminishes the quality on the grounds that the union between the total and bond will be less and subsequently.

Table 1: Properties of coarse aggregate

S.N.	Properties	Test Results
1	Fineness modulus	6.85
2	Specific gravity	2.7
3	Bulk density A) Loose B) Rodded	1660 Kg/m^3 1740 Kg/m^3
4	Impact value	19%
5	Water absorption	0.6%

2.3 WATER

Water plays a vital and important role in concrete while mixing, it triggers and initiates the reaction takes place between cement and aggregate. The potable water is used in this experimental work.

3. MATERIALS

***Mix Proportion*:** The mix proportion for this pervious concrete is to prepare M15 grade of concrete where it consists of ratio 1:2:4 (Cement: Sand: Coarse aggregate). For example 1 m^3 of M15 grade of concrete, cement is 0.143 m^3 and the sand is 0.286 m^3 and the coarse aggregate is 0.570 m^3. In the above shown ratio, the fine aggregate is completely omitted and in the place of fine aggregate 75% of its volume is replaced by coarse aggregate and rest 25% is replaced with cement. Then water cement ratio of this is taken as 0.3 which is chosen by the experimental test values.

Casting of Pervious Concrete: The pervious concrete is casted in the laboratory by a cube mould of standard size 150mmx150mmx150mm. There were four different samples of specimen of pervious concrete with various mix proportion design is casted and the compression strength of the pervious concrete specimen is compared with the compression strength of M15 concrete cubes of same dimension. Then the permeability of the pervious concrete is evaluated.

3.1 Compressive Strength

The compressive strength test is carried out to evaluate the performance of concrete against compression in the pavement. The compressive strength required for the pavement depends upon the traffic characteristics nearby the parking area in Lucknow where it is proposed to be serving. This compressive strength test will be carried out on the permeable concrete specimen at the end of 7, 14, 28 days of curing [According to IS 456 – 2000].

The compressive strength test procedures are followed according.

According to the IS code 516 (1959).

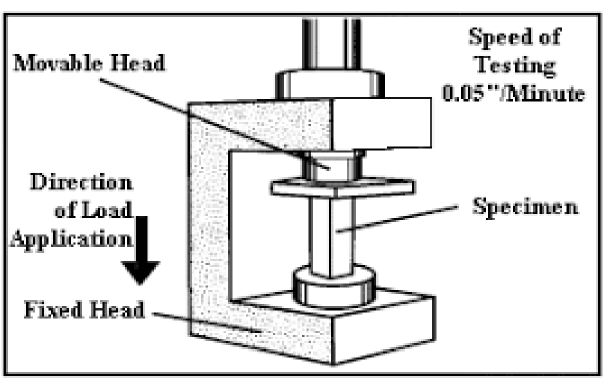

Fig. 1: Compressive strength test setup

3.2 Permeability Test

To conduct the permeability test cubes of standard size 150mm were casted and water cured for 28 days. After 28 days of curing, specimens were placed properly in the six cell permeability apparatus. Fig. 2 shows section of permeability cell. A rubber sheet of 8mm thick and 150 x 150mm size with a focal opening of 100 x 100mm was taken as shown in fig. 2. This rubber sheet was further placed on the top & bottom face of the cube in the permeability cell. Cover plate was tightened properly through the annular space between sample and cell. Suitable arrangements were made for supplying

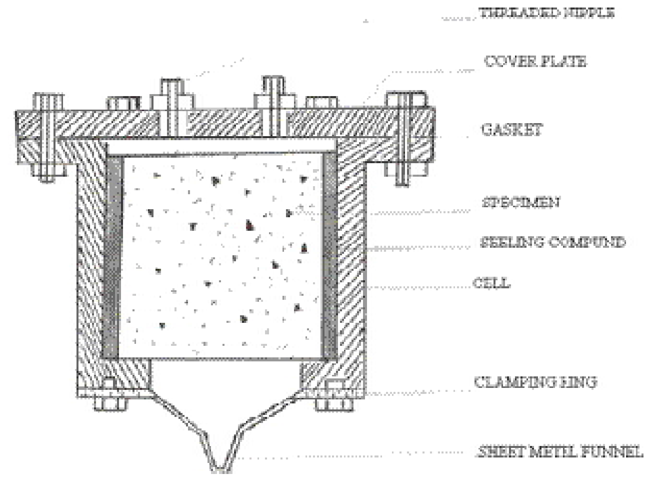

Fig. 2: Enlarged section of permeability cell

Compressed air at 10 kg/cm^2 to the cell by a compressor with an ample supply of cleaned de-aired water for supplying at constant rate of pressurized water. Assembly of container was set under the water discharge to collect the released water from the solid. The test was conducted continuously for 100hrs. After 100hrs cubes were extracted from the cell for finding the coefficient of permeability.

The procedure was developed by Valetta referred in Neville (1981), equivalent to that used in Darcy's Law.

$$K = \frac{D^2P}{2TH}$$

Where

K= Co-efficient of permeability in m/s

D= Depth of penetration in cm

P= Porosity of concrete measured as a fraction

T= Time in sec

H= Pressure head=100m

4. RESULTS

Comparison of conventional concrete and pervious concrete (with no sand) by using of graph and table. The compressive strength result of the concrete cubes tested is listed in the table

2. The graph compressive strength vs duration (days) is plotted in the fig. 3. As usual the compressive strength is increasing with the time of maturity of the concrete cubes.

Table 2: Results for compressive strength

S.NO.	No. of days	Compressive strength of Conventional Concrete (MPa)	Compressive strength of Pervious concrete (MPa)
1	3	28.22	7
2	7	39.78	15
3	28	46.5	22

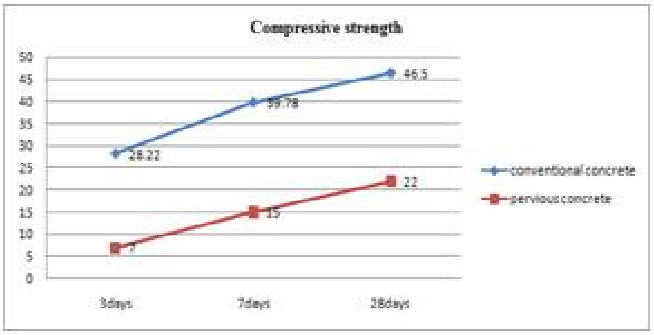

Fig. 3: Comparison of compressive strength.

The mix proportion used for preparing the cubes is listed in the table 3. In this table the water portion is gradually increased and obtained the water quantity required for the mixture preparation.

Table 3: Mix Proportions for Pervious Concrete

Mix number	Cement (kg/m³)	w/c	Aggregate - Cement ratio	Natural Aggregate (kg/m³)	Water (kg/m³)
1	420	0.27	3.7	1554	114
2	420	0.3	3.7	1554	126
3	420	0.32	3.7	1554	135
4	420	0.36	3.7	1554	152

The concrete density and compressive strength is obtained on various proportion of the water content as shown in the table 4.

Table 4: Properties of pervious concrete

Mix ID	w/c	Porosity (%)	Fresh Density (kg/m³)	Compressive Strength (7days) (MPa)	Water Permeability Coefficient (cm/sec)
1	0.27	22	2000	39.78	1.1
2	0.3	21	2010	15	0.76
3	0.32	20	2040	20.32	0.5
4	0.36	12	1998	25.33	0.2

The strength of the cube is investigated along with the permeability of the concrete materials. A per data collected, the rainfall intensity of lucknow city is 6mm per hour. The achieved permeability of the of the concrete is needed to be qualifying the requirement of the drainage yield by the rainfall intensity.

Table 5: Comparative strength and permeability chart

Specimen	Compressive Strength(Mpa) 7 Days	Compressive Strength(Mpa) 28 Days	Permeability (m/sec)
No Fine Concrete	15	22	6.6×10^{-3}
Concrete (1:0.5:4)	20.32	28	5.3×10^{-4}
Concrete (1:1:4)	25	29	1.5×10^{-6}
Concrete (1:1.5:4)	29.5	35	6.3×10^{-7}
Concrete (1:1:4)	33.33	38	6.6 X10--$^{-9}$
Conventional Concrete (1:2:4)	39.78	41.2	5.6×10^{-14}

5. CONCLUSION

As from the results the practical examination result, the pervious concrete with addition of sand increases the strength and decreases in porosity. The strength and porosity are proportional to each other that means as the voids or porosity increases in concrete the strength of concrete is decreased [2]. Pervious concrete with 0% of sand has less strength but more porosity but the concrete with 15%of sand possess less porosity and high strength. So the strength of pervious concrete with no sand or 0.1% of sand compromises of strength equal or equal to the strength of M15 grade of concrete. Most of the time or generally the M15 grade of concrete is used for pavement purpose. Thus the porous or pervious concrete with the 0% to 5%of sand is recommended to use for off-street pavement parking of Lucknow city for the purpose of drainage of rain water and storm water runoff. In India the pervious concrete will become more popular in future due to increased urbanization and reduction of ground water level.

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