BEHAVIOUR OF CONCRETE WITH PERFORATIONS

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ABSTRACT

Flood is considered to be one of the most frequent disasters in the world. It occurs due to rainfall excess which causes huge run-off. During flood streets get filled with water and storm water sewer gets flooded and filled to their maximum capacity. This is due to laying of impervious bed everywhere. No fines concrete pavement had been used in many countries to overcome the problem of excess surface run-off. But the problem with no fines concrete is, it has less strength also it clogs more often. In this paper, a solution is suggested tonegotiate the problem by using perforated concrete as pavement material. This pavement can be made by providing through holes in concrete block with holes of different diameter and cavity percentage. A mix proportion for M40 grade concrete was designed and cubes were tested for 7, 14 and 28days. The compressive strength of perforated blocks was tested. The strength of perforated block was reduces a % cavity increases. However, the strength of block can serve the purpose for footpath, low volume traffic pavement and parking area.The perforated blocks will prove to be better substitute for no-fines concrete giving higher strength and lesser clogging problem than no-finesconcrete.

Key Words: *Perforated Concrete, Compressive Strength, Hole Pattern, Cavity Percentage.*

I. INTRODUCTION

Floods occur due to severe wind over water, unusual high and also due to the rainfall excess which causes huge runoff. Flooding has many impacts. It damages property and endangers the lives of humans and other species also soil erosion is caused due to rapid runoff. In last decade, flood damaged more lives and economy than any other disasters. India had faced many floods like in 1943(Chennai), 1979(Rajkot, Gujarat), 1989(Bihar), 2005(Mumbai, Maharashtra), 2013(Uttarakhand), 2016(Assam), 2017(Gujarat) and the most recent was witnessed in Kerala which proved to be the worst floods in India till date. Different floods management techniques had been developed and applied. The dams purpose is to store water in large quantity and prevent floods. In similar ways many techniques were brought into action but still floods are proving to a disaster in modern day too in specifically in city area.

Floods are caused more frequently and also water cannot be drained adequately. Streets are being filled with water during floods and water was finding no way out. As storm water sewers are not sufficient in this period of time obviously they get flooded and filled to their maximum capacity. This is due to construction of roads everywhere. Hence water is not reaching ground surface resulting in no percolation.

Hence, roads or pavements must be designed in such a way that water should flow through pavement to reach the ground surface and further percolates reducing the risk of flood and increases the ground watertable. The term perforated means that water can flow through the material via through holes in concrete pavement. It is a special type of concrete with a high cavity percentage used for concrete that allows water to pass directly through it. Thereby reducing the runoff from a site and allowing groundwater recharge. The perforation in concrete can be introduced by introducing through holes in it. The different hole combinations having different area of cavity can be introduced. Strength of different percentage of cavity in concrete will be different. Hence, cavity percentage for maximum strength is to be determined so that rigid pavement can be designed for desired load.

II. LITERATURE REVIEW

Tripathi (2015)gave trends and preparedness of floods and disaster in India. He illustrates the whole scenario of flood disaster, its impact and danger to humans and property. Flood is most prevalent and costliest natural disaster in the world which devastates both life and economy at a large extent. The distribution of rain in India is not similar at every place, some areas are not traditionally prone to floods also experience severe inundation due to downpour and cloud-bursting. The urban flood had became one of the major problems nowadays. One of the primary causes of flood is poor natural drainage system. Along with this primary factor, there are various factors which intensify the occurrence and impact of flood on the affected people. He also stated that, the number of flood disaster is growing which is mainly driven by 'changes to catchments' (such as deforestation or urbanization) that leads to increased run- off. If we look at top ten disasters in the last ten years, it can be seen that flood alone had killed nearly 84% of the total person killed by the top ten disasters.

Mageswari (2016)studied that no fines concrete was a form of light weight concrete obtained when fine aggregate was omitted i.e. consisting of cement, water and course aggregate only. No fines concrete was thus an agglomeration of course aggregate particles each surrounded by a coating of cement paste up to about 1.25 mm thick. Due to the absence of fine aggregate in no fine concrete, there was high percentage of void space which results in high permeability. The compressive strength tests were conducted to ensure a minimum strength was achieved by the particular mix for M20 concrete with W/C ratio of 0.36, course aggregate of nominal size 20 mm passed and 10 mm retained, with cement was partly replaced with 30 % of Ground Granulated Blast furnace Slag (GGBS). The minimum percolation rate acceptable for no fines concrete pavement is 2.5mm/hr.

Udawattha*et al.* (2017)realized that population growth and rapid urbanization had led to mass infrastructure development in many sectors such as buildings, roads, urban public areas, etc. However, little attention had been given to human comfort and environmental sustainability of paving blocks. They made an attempt to search for alternative eco- friendly earth paving material for public walkways with both the strength and durable properties of concrete while ensuring pedestrian comfort. An attempt had been made to mix mud with cement to get solid and strong paver which almost gave the strength of concrete paver which is required for pedestrian pathway. Approaches were made to change the fine particle percentage while keeping the sand and gravel constant, once the optimum most practical mixture was known, the standard tests were done. The results obtained revealed that the proposed self-compacting block can be produced by using soil with less than 5% fine particles, 55% of 65% sand particles and 18% of 22% cement by weight together with the moisture content between 14% and 15%. The tested mud concrete paving blocks were already used in practical application in Sri Lankan urbancontext.

III. MATERIAL AND TESTING

A. Material

For preparing perforated (with hole) concrete block, cement, sand, aggregate and water was used. All material was obtained from local area. The material characteristics were determined and concrete mix was designed.

1)Cement:

53 Grade OPC provides high strength and durability to structure because of its optimum particle size distribution and superior crystallized structure. Being high strength cement, it provides numerous advantages wherever concrete for special high strength application is required, such as in the construction of skyscrapers, bridges, flyovers, chimneys, runways, concrete roads and other heavy load bearing structures.

2) Fine Aggregate:

Fine aggregate was used as void filler in concrete. Generally fine aggregate size varies between 4.75 mm to 75µ. The fine aggregate which was used in concrete was free from dirt, dust, organic matter and its specific gravity was between 2.6 to 2.7. Fine aggregate was generally used in all the construction work**.**

3) Coarse Aggregate:

The coarse aggregate was used as a primary ingredient in making the permeable concrete. Larger aggregates provide a rougher surface. Recent uses for pervious concrete have focused on parking lots, low-traffic pavements, and pedestrian walkways. For these applications, the smallest sized aggregate feasible was used for aesthetic reasons. Coarse aggregates were retained on the sieve of mesh size 4.75 mm. Their upper size was generally around 7.5 mm. Specific gravity of coarse aggregate generally observed between 2.6to2.9.

4) Water:

Water to cement ratio should be between 0.34 to 0.40, it was used routinely with proper inclusion of chemical admixtures and those as high as 0.45 to 0.52 have been used successfully.

B. Testing

1) Specific Gravity of Fine and Coarse Aggregate:

Specific gravity is the ratio of the mass of a substance to the mass of a reference substance for the same given volume. The pycnometer was used for determination of the specific gravity of solid particles of both fine grained and coarse grained soil. The pycnometer test carried out for fine and coarse aggregate is shown in Fig.1.

Figure 1: Specific Gravity Test Apparatus

2) Compression Test:

The cube specimen of size 15x15x15 cm was prepared. The test cube specimens were made as soon as practicable after mixing and in such a way as to produce full compaction of the concrete with neither segregation nor excessive laitance. The concrete filled into the mould in layers approximately 5 cm deep. The test specimens were stored in place free from vibration in moist air of at least 90% relative humidity and at a temperature of 27˚ ± 2˚C for 24 hours. After this period, the specimen marked and removed from the mould and cured for 7 days or 28 days.

These specimens were tested by compression testing machine as shown in Fig. 2 after 7 days curing or 28 days curing. The load should be applied gradually till the Specimens fails. Load at the failure divided by area of specimen gaves the compressive strength of concrete.

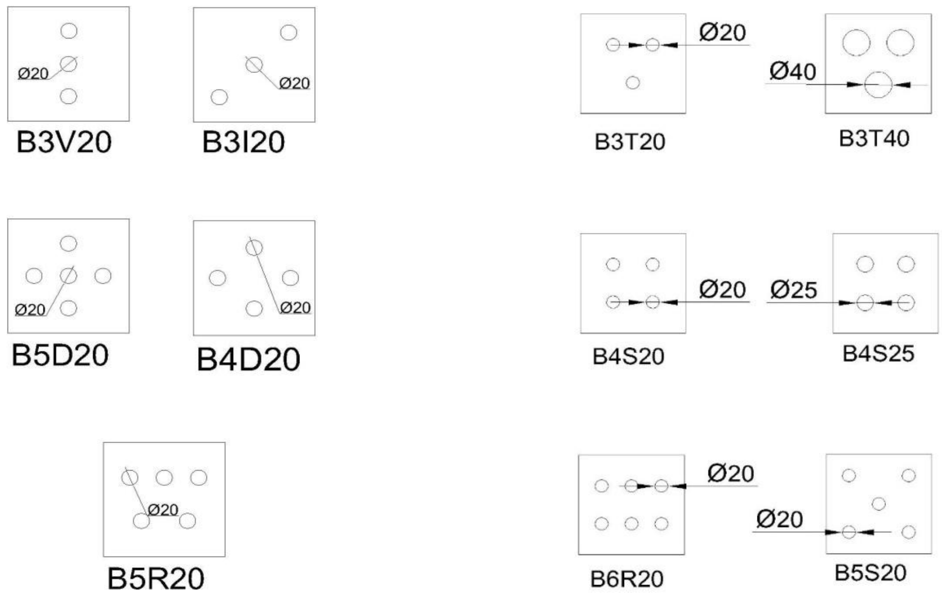
Figure 2: Compression Testing Machine

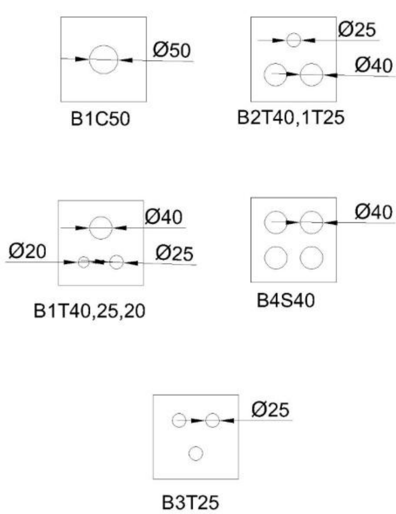
IV. CONCRETE MIX DESIGN

The tests required for concrete mix design such as fineness of sand and aggregate, specific gravity of aggregates were conducted and a detailed mix was developed. The grade of cement considered was OPC53 and grade of concrete considered was M40. The mix design was according to IS 10262. For determination of targeted strength of concrete six cubes of concrete were casted as per mix proportion. The size of mould of cube was 150mm×150mm×150mm. The tests were conducted after 7, 14 and 28 days. The curing was done with potable water in the curing tank.

V. PATERN AND SCENARIO OF HOLE

In order to test the perforated concrete strength, different pattern of holes with varying diameter or % cavity were designed. The different hole diameter, different number of holes and various hole patterns adopted are as shown in Fig. 3.





Nomenclature:

- B- Block
- T- Triangular pattern
- S- Square pattern
- R-Row pattern
- C-Center
- I-Incline pattern
- D-Diamond pattern
- First number indicate no. of holes
- Second number indicate diameter of hole in mm

e.g. B5R20 indicate block with 5 holes in row pastern of 20mm diameter

Figure 3: Hole Pattern Scenario with different diameter

VI. OBJECTIVES OF WORK

The study was focused on determining the compressive strength of perforated block which can be used as pavement concrete. In order to achieve this objective, following target were focused,

- To design M40 grade concrete.
- To plan various pattern of holes in concrete block.
- To determine compressive strength of blocks prepared for 7, 14 and 28 days strength.
- To study effect of perforation on compressive strength.

VII. RESULT AND DISCUSSION

The M40 concrete mix was designed using al local material. The concrete block with various pattern of holes were tested in compressive strength testing machine. In all, 54 cubes were casted for testing with different cavity percentage providing different size holes and with different pattern. The results of all test is discussed below;

Mix design test results
The cubes were tested after 28 days curing in tank. The test results obtained are as shown in Table 1. The compressive strength for 28 days shows that the desired target strength was achieved.

Table 1: Compressive Strength of Mix Design Test Cubes

Sr. no.	Days of curing	Strength (MPa)
1	7	24.77
2	14	32
3	28	42

Table 2 gave the compressive strength of concrete block with different % of cavity for 7, 14 and 28 days after curing. All the blocks were cured in the same atmospheric conditions. The failure patterns of cubes were studied with different pattern of holes. It was observed that in 4- 40mm holes pattern, full collapse with minimum compressive strength of 13.74 N/mm^2 was achieved. This pattern resulting into not suitable for the pavement surface. The minimum cracks with maximum compressive strength was observed in 4-20mm diagonal hole cube. For all other cubes failure was nearly from side corner up to the holes.

Table 2: Compressive Strength of Different Hole Pattern Cubes

Types	%Cavity	7 days Compressive Strength (N/mm^2)	14days Compressive Strength (N/mm^2)	28 days Compressive Strength (N/mm^2)
B3T20	4.2	17.63	19.02	27.37
B4S20	5.6	18.36	20.24	22.60
B5S20	7	14.33	22.93	23.89
B6R20	8.4	14.07	19.40	20.37
B3T25	6.54	18.07	18.55	22.83
B4S25	8.72	14.61	18.50	20.94
B3T40	16.75	13.35	17.62	19.22
B4S40	22.32	8.012	11.45	13.74
B1C50	8.7	12.17	20.45	20.91
B2T40,1T25	13.34	16.93	21.45	24.62
B1T40,25,20	9.16	14.68	15.70	24.46
B3V20	4.2	18.56	30.15	31.54
B3I20	4.2	15.31	16.70	19.02
B4D20	5.6	26.83	30.59	33.89
B5D20	7	15.76	21.97	25.32
B5R20	7	21.97	24.84	30.11

VIII. DISCUSSION

The compressive strength results on various concrete block having different pattern and % cavity shows the variation. To understand the impact of cavity on performance of concrete, it is put forth in terms of effect of % cavity, effect of pattern and position of hole from edge. These points are discussed below.

1. Effect of Cavity Percentage on Compressive Strength of Cubes

The cavity into the blocks makes the reduction in area of concrete which results in decrease in the compressive strength as shown in Table 3. The % reduction was calculated with respect to compressive strength of intact block. As the percentage of cavity increases, the compressive strength of block decreases. The maximum reduction in strength was observed in B4S40 which had maximum % cavity i.e. 22.32% and 4 holes of 40mm in straight pattern while minimum reduction of 19.31% was observed for B4D20 i.e. 4 holes of 20mm diameter in diagonal pattern having 5.6% cavity.

Table 3: Effect of Cavity Percent on 28 Days Compressive Strength of Cubes

Sr. No	Symbol	Percent Cavity	Percent Decrease in Comp. Strength
Triangular Pattern			
1	B3T20	4.2	34.83
2	B3T25	6.54	45.64
3	B1T40,25,20	9.16	41.76
4	B2T40,1T25	13.34	41.38
5	B3T40	16.75	54.24
Square Pattern			
6	B4S20	5.6	46.19
7	B5S20	7	43.12
8	B4S25	8.72	50.14
9	B4S40	22.32	67.28
Row Pattern			
10	B5R20	7	28.31
11	B6R20	8.4	51.5
Diamond Pattern			
12	B4D20	5.6	19.31
13	B5D20	7	39.71

2. Effect of Hole Pattern on Compressive Strength

The pattern of holes was kept different by keeping the % cavity and diameter of hole as same. This results in understanding whether pattern will make any difference on compressive strength. The effect of pattern on compressive strength can be seen Table 4.It was observed from test result that for 3 holes of 20 mm diameter vertical pattern of holes shows least reduction in compressive strength. For 4 holes of 20mm diameter diagonal pattern of hole shows least reduction while for 5 holes, row pattern shows least reduction. Thus it can be concluded that depending upon the number of holes and orientation of these hole, the compressive strength varies..If the distance of hole from edge increases, cracks were propagated from edge to center which increases reduction in strength.

Table 4: Effect of Pattern on 28 Days Compressive Strength

Sr. No.	Pattern	% Cavity	Percent Decrease in Comp. Strength
3 holes of 20mm diameter			
1	B3T20	4.2	34.83
2	B3V20	4.2	24.90
3	B3I20	4.2	54.71
4 holes of 20 mm diameter			
4	B4S20	5.6	46.19
5	B4D20	5.6	19.31

5 holes of 20 mm diameter			
6	B5S20	7	43.12
7	B5D20	7	39.71
8	B5R20	7	28.31

3. Effect of Position of Hole on Compressive Strength

The position of hole from edge i.e. edge distance also influences the compressive strength of concrete block. It was observed that most of the cubes were failed from edge. For the same percentage cavity of 4.2 % (3 hole of 20mm dia.) the strength of straight pattern is more as compare to central and diagonal.

IX. APPLICATION

Depending upon the compressive strength of concrete perforated, this concrete can be used for various civil engineering applications. The following application are proposed for utilization of perforated concrete blocks:

1. Application for Footpath:

Urban footpaths are usually paved with impervious surface, which may become major cause for surface runoff. Hence, the pavement which allows water to pass through it should be used in footpath. The strength of pavement for footpath should range in between 3 to 28 MPa. From these results, perforated concrete blocks satisfy the requirement. Every block with 4.2% to 23% cavity, the strength of all block is more than 10MPa. Hence perforated blocks can be used for footpath.

2. Application for Parking Pavement:

The parking lot requires pavement strength range between 10 -20 MPa depending upon the vehicle to be parked. The perforated concrete block satisfying the strength can be utilized as parking pavement which will serve both purpose of smooth surface and percolation of rain water leading to recharge of the ground.

3. Application for Low Traffic Volume Pavement:

The perforated concrete pavement can be constructed for low volume traffic roads so that surface water will not pill off over the pavement but will percolate into the ground and recharge the ground water.

X. CONCLUSIONS

From experimental work carried out, the following conclusions can be drawn:

- Mix design of M40 grade concrete was in the ratio of ***1: 1.34:2.15***
- As percentage of cavity increases, the reduction in the compressive strength of the concrete block increases.
- The pattern of holes also affect in the strength of block.
- For the same percentage of cavity with different number of holes variations in compressive strength was observed.
- The perforated concrete can be used for footpath, parking pavement and low volume traffic roads pavement.

XI. ACKNOWLEDGEMENT

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