EVALUATION OF INFILTRATION RATE OF PERVIOUS CONCRETE PAVEMENT MODEL BY VARYING PERFORATION PATTERNS OF PIPES

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ABSTRACT. This paper presents the process of evaluation of the infiltration rate of pervious concrete pavement by changing the perforation of drainage pipes. The paper starts with studying of the literature available on pervious concrete for finding out the infiltration rate and construction methodology of pervious concrete pavement. The evaluation of the infiltration rate of the pervious concrete is made according to the ASTM standards which includes the study of different types of perforation effects on the discharge from the miniature scaled down pervious concrete pavement model. For the investigation, cement content is used of 375 kg/m^3 and w/c kept as 0.4. The aggregate/cement ratio is kept as 4. The pervious concrete is made by using the 4.75-10 mm size aggregates. For the measurement of discharge through pervious concrete, 10 cm diameter pipe is used. Four different types of perforation patterns are employed and out of that zigzag pattern is considered as the best type of perforation to get maximum discharge from the pervious concrete pavement.

Keywords: Discharge, Pervious Concrete, Infiltration Rate, Perforated Pattern

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INTRODUCTION

Pervious concrete is also known as porous concrete made from cement, water, coarse aggregate and admixtures (if required). The pervious concrete due to the absence of fine aggregate serves the purpose of infiltration of the water through the pores present in it. The density of pervious concrete must be between 1600kg/m^3 to 2000kg/m^3 [7].

Pervious concrete has been increasingly used all over the world to reduce the amount of runoff water and improve the water quality near light volume pavements and parking lots, but its use in India is however a question of concern. So many researches have been done but still no codal provision have been prepared for pervious concrete in India.

Pervious concrete pavement has been constructed widely in different parts of the world and tests have been done on them. Results have shown that if pervious concrete pavement casted according to the guidelines of the NRMCA (National Ready Mixed Concrete Association) than the pavement can give the strength of 20.68MPa and permeability of 0.211 cm/sec [6].

A normal pervious concrete pavement consists of plain cement concrete layer at the bottom, base of aggregate layer and sub base of aggregate layer and the pervious concrete pavement at the top. Drainage pipe plays a vital role in safe supply and storing of the storm water draining from the pervious concrete pavement. This drainage pipe must be of proper size and perforation type to drain the water as quickly as possible and avoid the dead storage in the pervious concrete pavement.

LITERATURE REVIEW

Netinger [1] describes the infiltration ratio, compressive strength, void ratio, density of the pervious concrete made by using the three different type of aggregates (slag, diabase and dolomite) and two different aggregate fractions (4-8 mm and 8-16 mm). Hence a total of 6 mix designs were prepared. The author checked the infiltration rate with 3 methods i.e. is falling head method, constant head method and method mentioned in the ASTM C1701, the accurate results were obtained from the third method i.e. checking the infiltration rate using the ASTM C1701. Compressive strength was in the range of 10.31 to 25.04 MPa and infiltration rate from 0.14 to 1.11 cm/s.

NEED OF THE STUDY

The pervious concrete pavement needs to have adequate amount of strength, density, void ratio, infiltration rate to give its better performance. For the construction of pervious concrete pavement fine aggregates are not used. Due to that concrete become porous, water can pass through easily from the pavement. So, proper drainage system is required to design below pervious concrete pavement. This study focuses on the different perforation pattern effect on the infiltration rate of pervious concrete.

MATERIALS AND METHOD

Ordinary Portland Cement

As per the Indian Standard Specification IS 8112:1889 [8] ordinary portland cement was used. The physical properties of the ordinary portland cement have been mentioned in the Table 1.

Table 1. Physical Properties of ordinary Portland Cement

	VALUES	VALUES AS PER IS
Fineness in kg/m^3	309	Min 225
Soundness by Le Chatelier's method in mm	1	Max 10
Initial setting time in min	35	Min 30
Final setting time in min	240	Max 600
7 days compressive strength in MPa	41.46	Min 37

Aggregate

Locally available 4.75 – 10 mm crushed aggregates were used as the coarse aggregate for the pevious concrete. The aggregates were tested as per the Indian Standard Specification IS 383:1970 [9]. The physical properties of the aggregates are as shown in the Table 2.

Table 2. Physical Properties of Coarse Aggregate

PROPERTIES	RESULTS
Specific Gravity	2.79
Water absorption in %	1.27
Elongation index in %	5.2
Flakiness index in %	30.5
Loose bulk density ratio in kg/m^3	1350
Compacted bulk density in kg/m^3	1510

Admixture

Superplasticizer E5 Naptha based was used in the design as the retarder having the specific gravity of 1.10.

MIX PROPORTION

The pervious concrete was designed to attain the proper adequate properties like strength, density and void ratio. The mix proportion include the materials like cement, aggregate, water and admixture. The mix proportion used for the pervious concrete is as shown in the Table 3.

Table 3. Mix Proportion

MATERIALS	QUANTITY
Cement in kg/m^3	375
Aggregate in kg/m^3	1489.54
Type of Aggregate	Crushed Aggregate
w/c ratio	0.4
Chemical Admixture in % of cement content	0.9

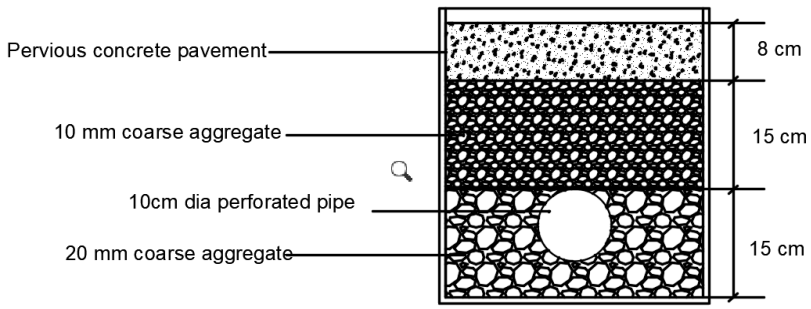
EXPERIMENTAL PROGRAM

Construction of Miniature Model

To conduct the infiltration rate and the water collection from the drainage pipes of the pervious concrete pavement the miniature model of the pervious concrete pavement was made from the PVC (Polyvinyl chloride sheets) material. The dimension of the miniature model was 1 m×0.40 m×0.35 m as shown in the Figure 1(a). The cross sectional view of the miniature model is as shown in Figure 1(b). The miniature model was able to withstand all the component of the pervious concrete pavement like base, sub base and the upper layer of the pervious concrete pavement. The miniature model contained the 20 mm crushed coarse aggregate layer of 0.15 m in height sub base of 10 mm crushed coarse aggregate layer of 0.15 m in height and pervious pavement of 0.08 m in height. The Miniature model had a slot made of diameter 0.1 m whose centre was located at 0.15 m from the base. This slot was used to collect the water from the drainage pipe and insert the different pipes in the miniature model. The miniature model was enough able to take the load of each load of the component of the miniature pervious concrete pavement.

Figure 1(a). PVC miniature model

Figure 1(b). Cross section of the pervious concrete miniature model



Perforated Drainage Pipes

PVC (Polyvinyl Chloride) pipes of diameter 10cm were taken and 4 different patterns of perforation were made. The perforation includes the holes, slots and combination of them of different sizes. As shown in the Figure 2(a) in the type 1 pipe the holes of size 3 mm in diameter were made in a zigzag manner. In type 2 pipe, slots were made above and below the

pipe at an interval of 10 cm as shown in the Figure 2(b). In type 3 pipe, slots and perforations were put together as shown in the Figure 2(c). In type 4 pipe, perforations were made on the bottom periphery of the pipes as shown in the Figure 2(d). These four drainage pipes were used as the specimen as drainage pipes and the water collected from these pipes was measured. All the pipes were 1.2 m in the length.

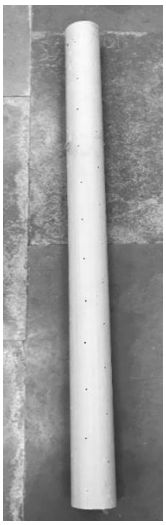


Figure 2(a)
Type 1 Pipe

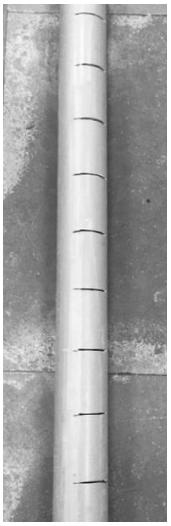


Figure 2(b)
Type 2 Pipe

Figure 2(c)
Type 3 Pipe

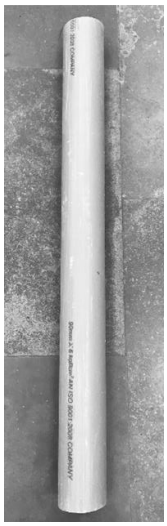


Figure 2(d)
Type 4 Pipe

Preparation of Specimen

For the testing of pervious concrete properties like compressive strength, void ratio and density the 6 cubes were casted of size 15 cm×15 cm×15 cm and the panel of size 800 cm×330 cm×8 cm was constructed to check out the infiltration rate and through which the water will percolate in the miniature pervious concrete model.

Compressive Strength

The compressive strength of the cubes was tested after casting and curing till 7 and 28 days. The 7-days and 28-days testing was done. The compressive strength of pervious concrete has been evaluated on hydraulic testing machine in accordance with the test procedures given in IS: 516-1959 [3].

Infiltration rate

The infiltration rate of the panel was checked by using a 300 mm diameter infiltration ring on the pervious concrete panel. The infiltration ring was made according to the specification mentioned in the ASTM C1701[4].

Void ratio

Void ratio is most important properties upon which the whole performance of the pervious concrete depends upon. The void content is defined as the total percentage of voids present by volume in a specimen. The void content was determined according to the ASTM C1688 [5].

Density

The density of pervious concrete was calculated by measuring the weight of the specimen and diving it by the volume of cube hence the density can be obtained in kg/m^3.

RESULTS AND DISCUSSION

The results of the properties like compressive strength, void ratio and density of pervious concrete tested on 7 and 28 days is been shown in the Table 3 below.

Table 3**.** 7 and 28 days tests result of pervious concrete

CEMENT (kg/m^3)	RESULTS (days)	DENSITY ($kg/m^{3)}$	VOID RATIO (%)	COMPRESSIVE STRENGTH (MPa)	AVERAGE COMPRESSIVE STRENGTH (MPa)
		2222.2	16.40	10.8	
350	7	2121.4	17.39	10.9	10.1
		2251.8	15.60	8.6	
		2299.3	15.55	17.4	
350	28	2257.8	15.87	17.0	17.1
		2228.1	16.28	16.8	

The results of the infiltration rate of the pervious concrete panel and the % of water collected from the different perforated pipes is been shown in the Table 4 as shown below.

Table 4. Infiltration rate and % of water collected from different type of perforated pipes

SR. NO.	INFILTRATION TEST		INFILTRATION RATE (mm/s)	COLLECTION OF WATER (kg)	PERENTAGE OF WATER COLLECTED (%)
	TIME ELAPSED (s)	WEIGHT OF INFILTRATED WATER (kg)			
Type 1	118	18	2.32	7.85	43.6
Type 2	116	18	2.36	5.46	30.33
Type 3	125	18	2.19	5.15	28.6
Type 4	120	18	2.28	3.60	20.0

Effect of the % of water collected on Perforation pipe type

As the perforation on the pipes were changed there was significant change found in the collection of water from the miniature model. The column chart is shown in the Figure 3 showing the % of water collected against its perforated pipe type. From the chart the type 1 perforated pipe which had the holes in the zig zag type had the highest % of water collection.

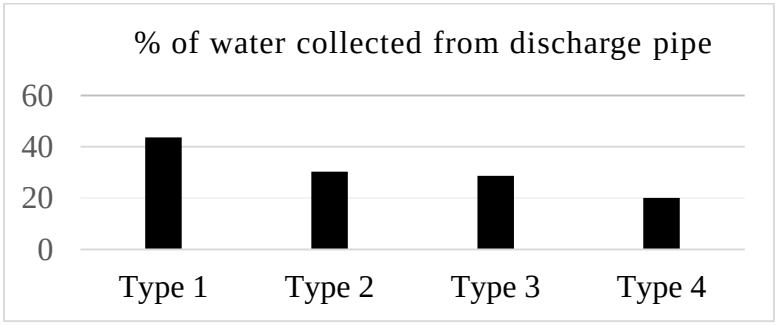


Figure 3. Effect of perforation type on % of water collection.

Effect of Infiltration rate on Perforation pipe type

There is no significant change found in the infiltration rate of the pervious concrete as can be seen in Figure 4 due to the different perforation discharge pipes, hence the perforation type of the drainage pipe does not hold any importance in the infiltration rate of the pervious concrete pavement.

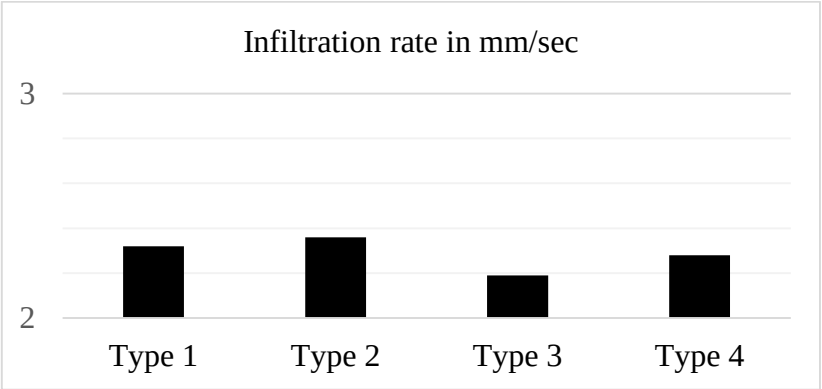


Figure 4. Effect of perforation type on infiltration rate

CONCLUSION

From the experimental analysis following conclusion can be found

- It has been observed as mix design with 0.4 w/c ratio and 350kg/m3 can give a strength of 17.1 MPa with the 16.28% void ratio.
- It was found that water collected from type 1 pattern shows the more percentage as compare to other types. It might be possible that type 1 is having zigzag pattern, efficiency of water collection is more as compared to other types of pattern.
- It is noticed that no significant change found in the infiltration rate of pervious concrete. The different perforation types do not affect the infiltration rate of the pervious concrete pavement.
- It has been concluded that out of the different types of perforation used the type 1 (zigzag) perforation pattern can be considered the most suitable perforation type for the drainage of pervious concrete pavement.

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