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Study of Workability, Compressive Strength, Density and Void Ratio of Concrete Containing No Sand

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ABSTRACT

High strength concrete assumes a significant part in urbanization. Because of impermeable concrete pavements, water can't seep into the ground water table. Subsequently, in this analysis we stressed on pervious concrete roadways as a substitute to the circumstance. In current review, no sand pervious concrete was casted utilizing plasticizer with various sizes aggregating 4.75 mm to 20 mm. Compressive strength, density, permeability, workability of the vast majority of the cubes goes from 5.51 N/mm^2 to 20.10 N/mm^2. Void proportion of the relative cubes was extremely high ranges from 0.117 to 0.381. The porosity of the mixtures of blends emerges to be exceptionally high as void proportion is high, goes from 9.4% to 27.6%. Density of pervious Concrete is low when contrasted with ordinary Concrete because of its high porosity. The normal density of all mixes is determined as 2072.59 kg/m^3. The density of all mixes is in the reach 1985.185 to 2136.296 kg/m^3. Accordingly, pervious Concrete can be applied to the both pavements and pathways where less strength of Concrete is required.

Keywords: *Pervious Concrete, Plasticizer, Compressive strength, Density, Permeability, Workability.*

INTRODUCTION

Concrete assumes a critical part in the development of structures, person on foot walkways, etc. Concrete is the world's most consumed building material on account of its phenomenal mechanical and strength properties. It is one of the most widely involved building materials on the planet. There is no penetration in concrete asphalts and trails which results fast overflow with more prominent pinnacle stream which causes flooding, stifling of sewerage line since seepage frameworks are by and large not intended for such condition. So there is a need of pervious Concrete having comparative penetrability to that of existing soil in a space with higher compressive strength.

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Because of quick urbanization, the majority of the spots are covered with impervious surfaces like Concrete. This significantly affects the ground water table. Pervious Concrete asphalt is a compelling method for limiting this issue. Pervious Concrete is an open evaluated structure with interconnected voids through which downpour and tempest water is allowed to permeate into the spring. It comprises of Concrete, coarse-grained, a few fractions of fine aggregate and water. Aggregates can have an immediate impact in the penetrability of Concrete. A similar size large aggregate with certain fine aggregates is ideal for the greatest porousness.

A plasticizer is a material which when added to a concrete blend makes it adaptable and simpler to deal with. It very well may be utilized to further develop concrete functionality, without expanding additional water. A huge expansion in compressive strength of Concrete should be visible with the addition of plasticizer because of removal of air hole in Concrete.

Pervious Concrete is an exceptional sort of Concrete containing cavities which permit storm water to go through it to the soil underneath. This stops spillover water from downstream metropolitan flooding. It likewise breaks the pattern of water treatment plants expecting to treat storm water where cities have joined sewer and tempest water frameworks. Pervious concrete roadways are "best management practices" (BMP's) to ground water in metropolitan regions. This generally dispenses with the requirement for confinement/maintenance lakes, consequently lessening construction costs, security issues and repairs costs.

Pervious concrete roadway is an interesting and successful means to resolve significant natural issues and backing green and viable development. The pervious concrete roadways serve to increments ground water re-energize and simultaneously diminishes flooding. It additionally diminishes highest tempest water releases from roadways. Hence, when pervious concrete roadways are utilized, storm water permeates into the ground underneath, re-energizing the normal water table as opposed to running off and causing disintegration.

MATERIALS AND METHODS

2.1 Material used

2.1.1 Cement

Cement is made by heating the above mentioned substances to 1450 °C in an oven and this cycle is known as calcination. Cement is a fine material made by calcination of lime and clay, blended in with water to develop mortar or blended in with sand, gravel, and water to make Concrete. Normal materials used to fabricate cement contain limestone, shells, and chalk or marl mixed with shale, clay, slate, blast furnace slag, silica sand and iron oxide. OPC43 grade made by UltraTech Cement Limited was utilized in this experiment.

2.1.2 Plasticizer

The plasticizer "Conplast SP430 G8" as displayed in figure 3.3 below was utilized as water reducing agent in the study. It conforms to IS:9103:1999 and BS:5075. The plasticizer was utilized in liquid form. Its specific gravity was 1.24-1.26 and chloride content was zero according to IS:456. This plasticizer was precisely utilized in the investigation work since it produces high strength concrete by significant decrease in water and upgrades workability of Concrete requiring practically zero vibration during setting. It gives high binding force to the Concrete (hazard of isolation and draining is limited).

2.1.3 Water

In the current review, new and clean regular water was utilized for casting and curing of concrete samples. This water was additionally utilized while testing the void ratio and concrete porosity. The water was generally liberated from natural matter, sediment, oil, sugar, chloride and acidic substance according to Indian norms.

2.2 Calculation of compressive strength of cement

Compressive strength of cement is determined from cubes of 70.6 mm X 70.6 mm X 70.6 mm in size, made of cement mortar with one part of cement and three parts of standard sand. The compression testing machine is shown in figure 3.6.

The quantity of materials for each cube taken is given below:-

Cement : 200 g

Standard sand : 600 g

Water = (P/4+3.0) percent (%) weight of cement and sand

Where P is the ratio of water needed to make a paste of usual uniformity determined.

2.3 Workability of pervious Concrete

Workability is that property of newly mixed Concrete or mortar which decides the easiness and uniformity with which it tends to be mixed, put, united, and finished. Workability isn't simply founded on the characteristics of the Concrete, yet in addition on the idea of the application.

Slump Flow test was utilized for tracking down workability of newly pre-arranged pervious Concrete in a lab in this examination.

Table 1: Slump and Degree of Workability of Concrete

Degree of Workability	Slump (mm)	Applications
Very Low	0-25	Vibrated Concrete in roads or other large sections.
Low	25-50	Mass concrete foundation without vibration. Simple reinforced section with vibration
Medium	50-100	Normal reinforced work without vibration and heavily reinforced section with vibration.
High	100-180	Section with congested reinforcement. Not normally suitable for vibration.

2.4 Compressive strength of pervious Concrete

The amount of Concrete, coarse aggregates (20-16.5 mm and 12.5-10 mm), fine aggregates (4.75-2.36 mm) and water for each group were weighed independently. Every one of the three sizes of aggregates was put in the mixer and mixed for 2 minutes. The cement was first mixed dry with the aggregates in a mixer. Water was then added to the mixer and mixed completely for 3 to 4 minutes in mixer.

The moulds utilized for casting were cleaned and oil was applied on its internal surface. The shape was filled 1/3 with the Concrete and vibration was done. Again the interaction was repeated two additional times for totally filling the shape. The outer layer of the Concrete was finished level with the top of the mould. The completed samples were left to solidify in air for 24 hours. The samples were separated from the moulds following 24 hours of casting and were set in the water tank filled with drinkable water in the lab.

Samples were taken out from the curing tank at the ages of 14, 28 and 56 days. Surface water was cleared off and examples were quickly tried on expulsion from the curing tank. The compressive strength of concrete cubes was found on UTM by applying load steadily without shock till the failure of the samples appears.

2.5 Density of pervious Concrete

The density of Concrete is characterized as mass per unit volume of concrete specimen. The density of plain cement concrete is around 2400 kg/m3 and the density of lightweight Concrete is roughly 1750 kg/m3. The density of concrete specimen is found by estimating the weight of three examples of each mix on weighing machine and accepting their average as the mass of mix. Volume of each mix is constant for example 0.15 m X 0.15 m X 0.15 m. Three cubes from each mix were dried for one month in conceal before testing the mix's density.

2.6 Void ratio of pervious Concrete

The void ratio (e) of any concrete sample is characterized as the ratio of volume of voids (Vv) to the volume of solids (Vs). Void Ratio (e) is additionally connected with porosity (n). Strength of the concrete samples can be decided from its void ratio. Greater the void ratio lesser will be the strength vice versa. Void ratio (e) is found by basic trial executed in a laboratory by submerging the 28 days cured block in the container filled with water. The device made locally by utilizing a can is displayed in figure 3.7. An opening was made in the bucket to keep up with the steady level of water. When the cube is submerged in the bucket, the water level rises. The cube is permitted to soak. At the point when air bubbles vanish, the opening in the bucket is opened and water is permitted to escape from the bucket and gathered in containers. The volume of dislodged water was estimated precisely by measuring container. This volume of water is equivalent to the volume of solids (Vs). The volume of solids (Vs) is subtracted from the total volume of the cube (V) to get the volume of voids (Vv) in the concrete cube. Void ratio calculated from the equation given below:-

$$\text{Void Ratio, e} = \frac{\text{Volume of voids}}{\text{Volume of solids}} = \frac{\text{Vv}}{\text{Vs}} = \frac{\text{V} - \text{Vs}}{\text{Vs}}$$

The porosity of the cubes is then computed using

$$\text{Porosity, n} = \frac{\text{Volume of voids}}{\text{Total Volume}} = \frac{\text{Vv}}{\text{V}} = \frac{\text{V} - \text{Vs}}{\text{V}}$$

The relationship between void ratio (e) and porosity (n) is expressed as:-

$$n = \frac{e}{1 + e}$$

RESULT AND DISCUSSION

3.1 Workability of Concrete:

In order to determine the degree of workability, the slump flow test was conducted. For all the mixes, the slump flow of each of the mix given in Table 2 is compared with slump flow v/s degree of workability given in Table 1 of chapter III. Based on this, each mix's workability degree is specified in Table 2.

Table 2: Workability of Concrete

S. No.	Slump (mm)	Degree of Workability
M1	31	Low
M2	67	Medium
M3	57	Medium
M4	56	Medium
M5	34	Low
M6	74	Medium
M7	63	Medium
M8	58	Medium
M9	37	Low
M10	84	Medium
M11	67	Medium
M12	59	Medium

3.2 Compressive Strength of Concrete

The compressive strength test results are shown in Table 3. Figure 1 shows a graphical form of results of compressive strength results at 14, 28 and 56 days of water curing in terms of bar chart.

Table 3: Compressive strength at 14, 28 and 56 days water curing

Mix Designation	Average Compressive Strength (N/mm^2)		
	Day 14	**Day 28**	**Day 56**
MIX 1	**5.51**	7.30	6.88
MIX 2	9.98	11.93	12.84
MIX 3	14.10	18.13	17.96
MIX 4	8.47	11.67	11.14
MIX 5	6.11	7.60	7.83
MIX 6	11.11	13.05	13.83
MIX 7	15.66	**20.10**	**20.14**
MIX 8	9.90	12.15	12.18
MIX 9	5.89	6.82	7.14
MIX 10	11.27	12.17	12.99
MIX 11	15.48	18.16	18.51
MIX 12	9.66	11.20	11.18

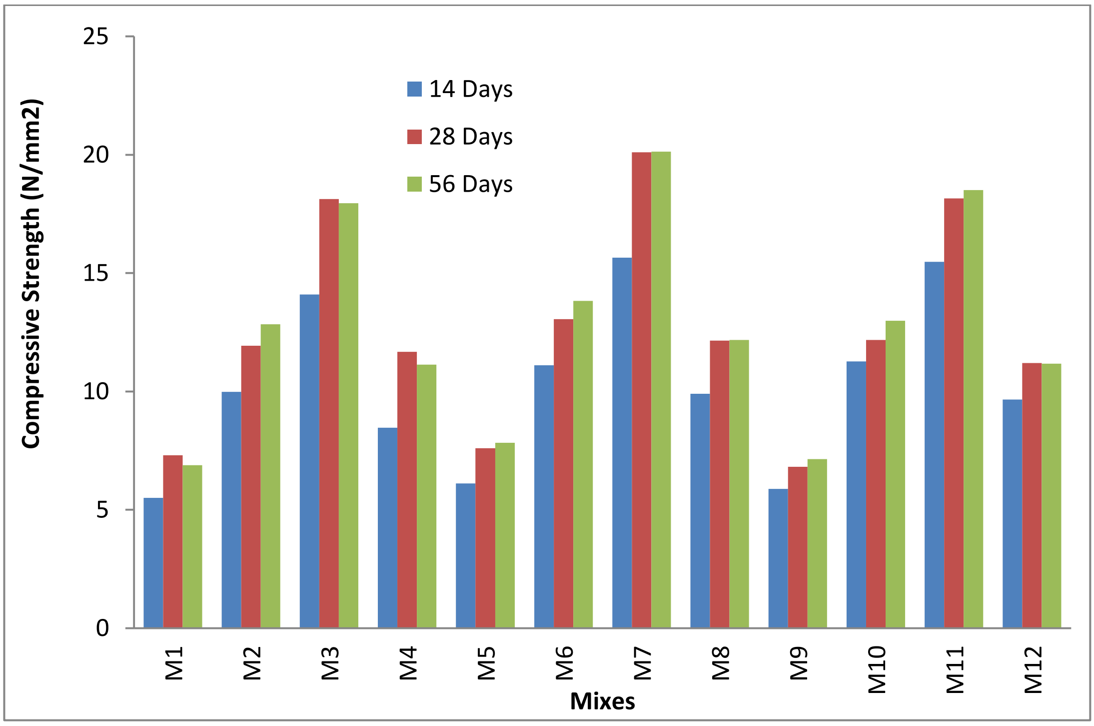

Figure 1 Compressive strength at 14, 28 and 56 days water curing

3.3 Void Ratio/ Porosity of Concrete

Porosity and void ratio of Concrete was tested as per procedure after 28 days of curing. The volume of solid was determined by measuring the volume of water displaced by the concrete cube after its saturation. The volume of voids was determined by subtracting the volume of the solid from the total volume of a cube. Void ratio and porosity values found from tests conducted for each mix are given in Table 3. Figure 2 shows the values of porosity of all the mixes after 28 days of water curing in terms of bar chart.

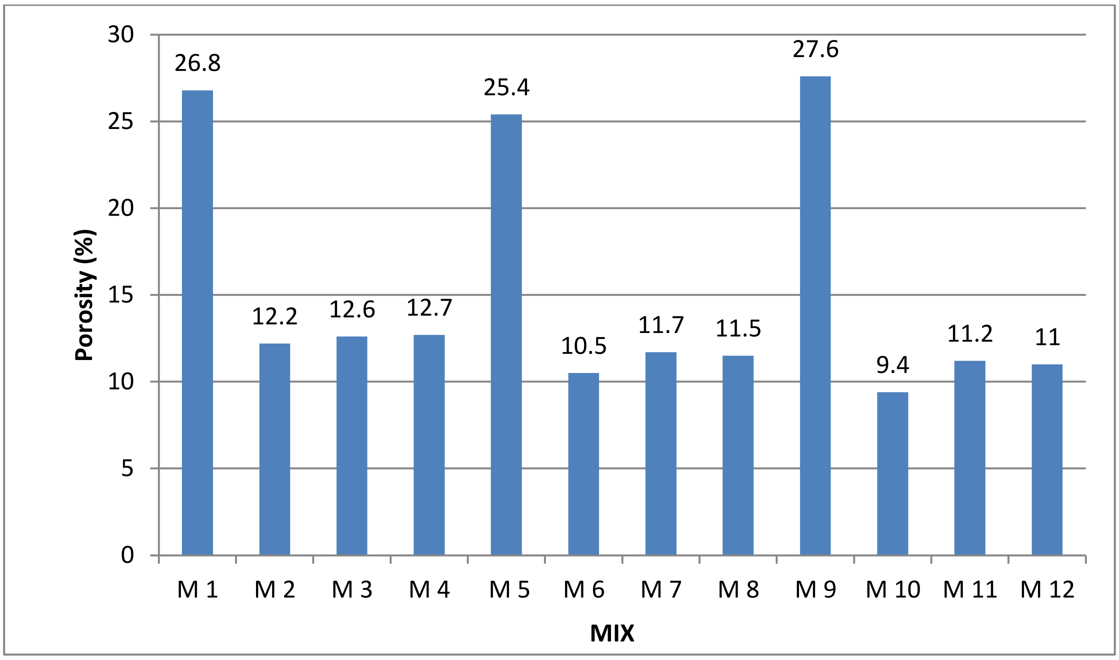

Fig. 2: Porosity of all the mixes after 28 days of water curing

Table 4: Average Void Ratio and Porosity

Mixes	Avg. void ratio, e	Porosity, n (%)
MIX 1	0.366	26.8
MIX 2	0.139	12.2
MIX 3	0.144	12.6
MIX 4	0.145	12.7
MIX 5	0.339	25.4
MIX 6	0.117	10.5
MIX 7	0.133	11.7
MIX 8	0.128	11.5
MIX 9	0.381	27.6
MIX 10	0.103	9.4
MIX 11	0.126	11.2
MIX 12	0.123	11.0

3.4 Density of Concrete

Density of Concrete was found as per procedure after 28 days of curing. Three cubes of each mix were dried for one month in shade. Weight of every cube was measured on a weighing machine. The average weight of three cubes is taken as the weight of the cube. Density of each mix was determined by dividing the weight of the cube by the volume of a cube. Density values obtained for each mix are given in Table 5. The average density of all mixes is calculated as 2064.92 kg/m^3. The density of all mixes is in the range 1917.04 to 2133.33 kg/m^3. The low density of the mixes is due to the high porosity of these mixes as more the pores in a given volume of solid, the lesser will be its density and vice versa.

Table 5: Density of mixes

Mixes	Mass (kg)	Density (kg/m^3)
MIX 1	6.95	2059.259
MIX 2	7.07	2094.815
MIX 3	7.18	2127.407
MIX 4	6.70	1985.185
MIX 5	6.96	2062.222
MIX 6	7.11	2106.667
MIX 7	7.20	2133.333
MIX 8	6.72	1991.111
MIX 9	6.98	2068.148
MIX 10	7.14	2115.556
MIX 11	7.21	2136.296
MIX 12	6.72	1991.111

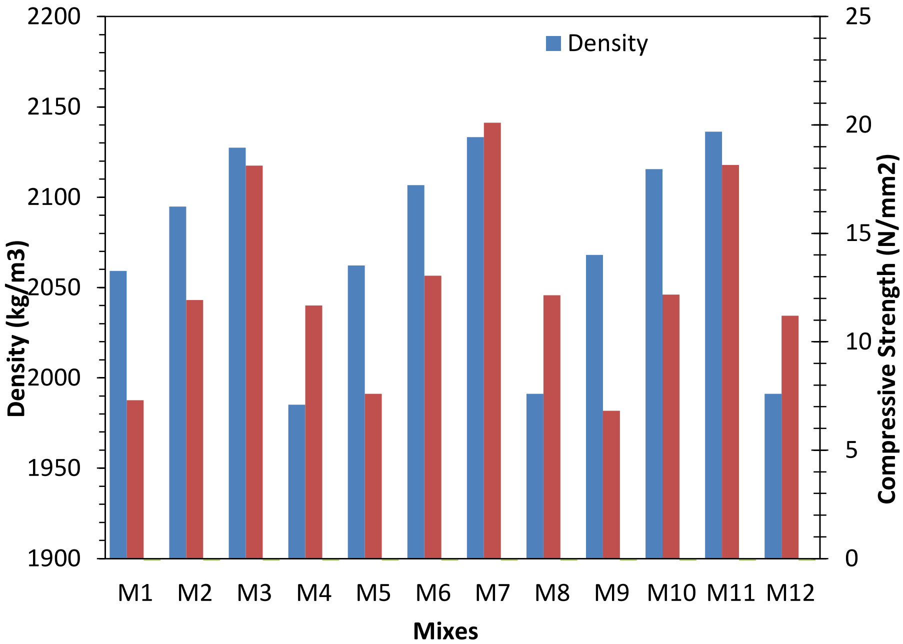

Fig. 3: Relationship between Density and Compressive strength of mixes at 28 days curing age

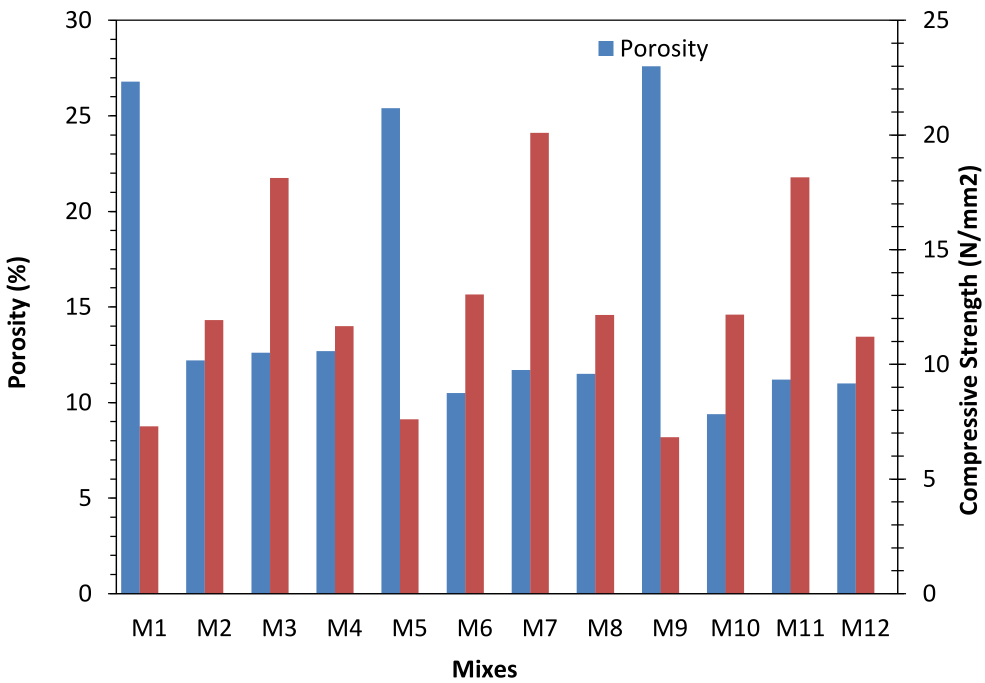

Fig. 4: Relationship between Porosity and Compressive strength of mixes at 28 days curing age

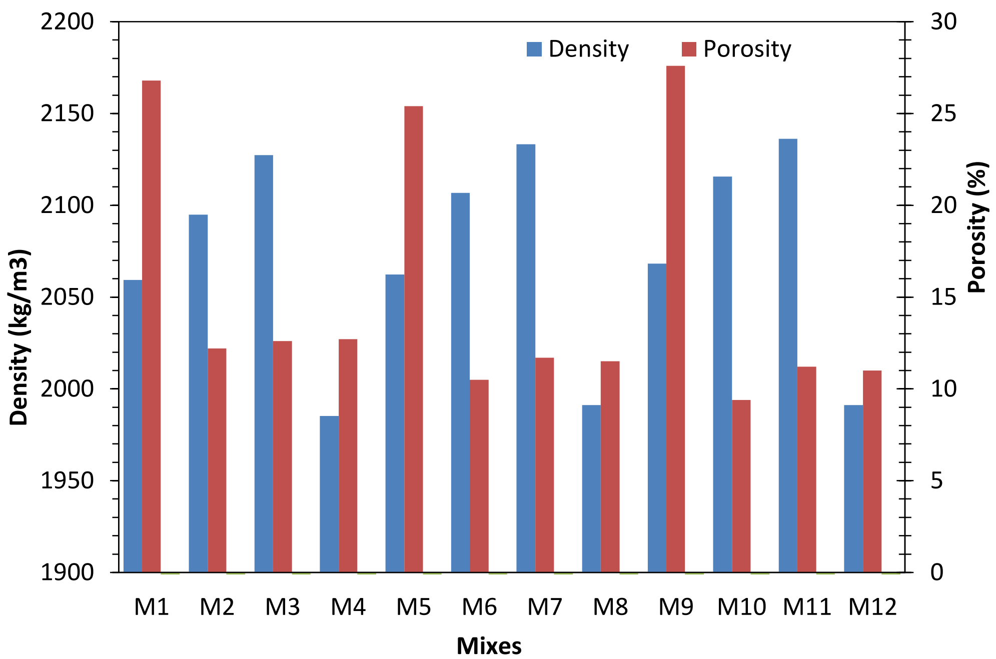

Fig. 5: Relationship between Density and Porosity of mixes

CONCLUSIONS

Because of its excessive porosity, pervious Concrete's compressive strength is low in every case when contrasted with ordinary Concrete. Compressive strength of all the mixes ranges between 5.51 N mm^{-2} to 20.10 N mm^{-2}. The highest compressive strength (20.10 N mm^{-2}) is obtained for the mix M_7at 28 days curing age and the lowest compressive strength (5.51 N mm^{-2}) is obtained for the mix M_1 at 14 days curing age.

Void ratio of all the mixes comes out to be very high ranges from 0.117 to 0.381. The highest void ratio (0.381) is obtained for mix M_9 and lowest void ratio (0.117) is obtained for mix $M_{6.}$

Porosity of all the mixes comes out to be very high as the void ratio is high, ranging from 9.4% to 27.6%. The highest porosity (27.6%) is obtained for mix M_9 and lowest porosity (9.4%) is obtained for mix $M_{10.}$

Density of pervious Concrete is low as compared to normal Concrete due to high porosity. The average density of all mixes is calculated as 2072.5925 kg/m3. The density of all mixes is in the range 1985.185 to 2136.296 kg/m3. The highest density (2136.296 kg/m^3) is obtained for the mix M_{11} and the lowest density (1985.185 kg/m^3) is obtained for mix M_4.

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Author Contribution:
Both authors contributed equally to establishing the research and design experiment topic.

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