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Recharge of Phreatic Zone/Ground Water through Pervious Concrete

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ABSTRACT- The pervious concrete framework and its comparing quality are as critical as its penetrability characteristics. The quality of the framework not as it were depending on the compressive quality of the pervious concrete but moreover on the quality of the soil underneath it for bolster. Previous studies have shown that permeable concrete has lower compressive strength than conventional concrete and can only withstand light truck loads. This project was an experiment to examine the compressive strength of permeable concrete as it relates to the water-cement ratio, aggregate ratio, aggregate size and degree of compaction. To enhance the strength and permeability of concrete, it is crucial to strike a balance between the water-cement ratio and the presence of voids. By optimizing the proportions of water, cement, and aggregates, the goal is to minimize voids without compromising the overall strength of the concrete. This delicate equilibrium ensures improved durability and resistance while allowing for adequate permeability to water and other substances. The aim is to achieve a cohesive and robust concrete mixture that meets both structural and functional requirements.. Pervious concrete pavement is unique and effective means to meet growing environmental demands, by landing rainwater and allowing it to seep into the ground.

KEYWORDS- Phreatic zone, Ground water, Pervious concrete, aggregate, fly ash, cement, noise barriers, Hydraulic structures, Swimming pool decks, Tennis courts.

I. INTRODUCTION

Permeable concrete is a mixture of aggregate, Portland cement and water. It differs from conventional concrete in that it does not contain fines during the mix, but the fines are apparently released during compaction. Aggregates are generally of combined size and are held together at the points of contact by a paste of cement and water. The result is a concrete with a high percentage of interconnected voids that, when functioning correctly, permit the rapid percolation of water through the concrete. Unlike concrete, which has 3-5% porosity, permeable concrete can have 15-35% porosity depending on its application. pervious concrete has a lower compressive strength, Voids within the pervious concrete should be interconnected so they create channels through which water can freely flow.[10]

Many studies have shown that permeable concrete have the following advantages:

- Allows better groundwater flow and prevents infiltration from below ground.
- Back roads, driveways, sidewalks, roads and parking lots.
- Permeable stone is used as a sub-base on pavements, sidewalk gutters.
- Live roads and low-water intersections.
- It reduces the noise from vehicles, does not see the road blast and therefore does not see the disturbance during the night.

The main purpose of the project is to create a stable and durable permeable cement concrete mixture with different water-cement ratio and admixture without affecting the permeability. To find the effect of fine aggregate on density and strength properties of no fines concrete. Find the best mix based on strong patterns for fine-grained concrete. The aim is to achieve maximum compressive strength without compromising the permeable properties of permeable concrete. And also, for following reasons: [7]

- Save shipping space and handle items first.
- Improve site quality and reduce water needs.
- To recharge the groundwater level.
- To investigate the performance characteristics of the pervious concrete such as porosity, compressive strength, infiltration rate etc.….
- Contribute to the beauty of the pavement.

A. Applications of Pervious Concrete

- Pervious concrete as a road pavement.
- Low-volume pavements.
- Sidewalks and pathways.
- Residential roads and driveways.
- Parking lots.
- Noise barriers.
- Hydraulic structures.
- Swimming pool decks.
- Tennis courts.

II. LITERATURE REVIEW

A. V.M. Malhotra et al. (1976)

Discussed its shortcomings in practice and performance. It provides details of properties such as consistency, material ratios, basis weight, compatibility and curing to maximize the permeability of concrete beforehand. Malhotra also conducted multiple experiments on various test cylinders in an attempt to find a correlation between compressive strength and any of the material's properties. He concluded that the compressive strength of pervious concrete was dependent on the water cement ratio and the aggregate cement ratio. It was also concluded that even the best ratios cannot be compared with the compressive strength of conventional concrete. Malhotra went on to study the effect of contraction on compressive strength. Correlation between compressive strength and unit weight with different bone-ash ratios and different ratings. Malhotra also experimented on different types of aggregates and their effect on compressive strength.

B. Richard Meininger et al. (1988)

Published the results of his experiments on permeable rocks. Several models with different characteristics were examined. These factors include the water-cement ratio, aggregate-cement ratio, degree of compaction, and cure time. The results are similar to those found by Malhotra in 1976. Meininger found a good correlation between 28-day compressive strength and moisture content when using a 3/8" size and an equal-cement ratio of 6.

Meininger studied the relationship between 28-day compressive strength and unit weight. Finally, Meininger re-examined the relationship between 28-day compressive strength and moisture content, but distinguished between bone-ash ratio and aggregate size. The results of these tests led Meininger to determine the best water-cement ratio that maximizes water permeability but does not need to increase compressive strength, and also determines that the concrete permeability together gives a strength of less than 13 marks and is therefore only for limited or light vehicle use. . . Working area. Meininger continued to examine the relationship between air content and compressive strength. As expected, the increase in air content decreases the compressive strength of concrete.

This is because the space once occupied by the aggregate is now filled with air, reducing the material used in the concrete.

C. Nader Ghafoori et al. (1995)

Conducted extensive research on various permeable rock types. One study investigated several facilities in the United States using permeable pavement techniques. His research led to a comparison of the compressive strength obtained for each area. It also checks for various faults (if any) and water cement and aggregate cement ratios. Next, Ghafoori looks at permeable concrete applications outside the US and again compares compressive strength.

Ghafoori also discusses in detail the pavement thickness design of permeable rock. He concluded that compressive strength depends on the water-cement ratio, aggregate-cement ratio, compression and curing. It also shows the effect of different cement ratio and compression strength on compressive strength and permeability. Ghafoori conducted extensive tests on four different samples of permeable concrete to determine the relationship between compressive strength and various parameters such as repair, water-cement ratio, aggregate-cement ratio and degree of compaction. These samples have different water-cement ratios and aggregate-cement ratios.

D. Paul Klieger et al. (2003)

Conducted an experiment to investigate the effect of air infiltration on the strength and durability of concrete. Although the amount of voids in the permeable stone (15%-35%) has never been used, his researches show the formation of air in the building material. He concluded that as the particle size increased and the cement content decreased, the reduction in compressive strength due to air also increased. All this is due to the reduction of water. Research over the past 30 years has come to similar conclusions.

The compressive strength of permeable concrete depends on the water-cement ratio, aggregate-cement ratio, aggregate size, degree of compaction and curing. These tests also show that permeable rocks are most beneficial and should be restricted to traffic-free areas. Scientists disagree on whether permeable rock can achieve the same compressive strength as conventional concrete.

E. Nishith M N et al. (2016)

Author's Study on Permeable Concrete Pavement. The basis of this study is to obtain the compressive strength, flexural strength and damage value of the permeable rock and the porosity value. The main purpose of this study is to provide and increase the strength of permeable rocks. Determine the porosity, permeability and strength required to complete the concrete mix. Cubes used for definitive evaluation were poured on days 7, 14, and 28 of treatment.

- Minimum compressive strength obtained in 0% fine aggregate in 7, 14, 28 days id.
- 10% mixture provides high strength and thus maximum compressive strength.
- As the hardening time increases, the compressive strength also increases.
- Porous gaps can be filled without using a better collector.
- Porosity is highest at 10% fineness with superplasticizer and at least 0% fine without superplasticizer.

III. METHODOLOGY AND MATERIAL

In this section, we focus on techniques used to construct and test permeable concrete. Tests and experiments should be carried out to arrive at appropriate conclusions regarding the selection of the appropriate mixture for permeable concrete. Compressive strength is best determined by making the concrete permeable and carrying it up to fracture.

The transportation and capacity of the new stations will be determined by evaluating the existing stations with similar characteristics. Calculating the actual traffic to these available sites is the most accurate measure to generate this information.

However, water flow calculations were not possible for this study due to time constraints. Traffic charts are used to estimate traffic and freight.

A. Methodology for undertaking the project is listed below

- Collections of materials
- Physical test on materials [8][9]
- Preparation of samples
- Testing of samples for 3,7,28 days
- Comparing compressive strength values for different cement to aggregate ratios [11]
- Trial mix till 25mpa strength is achieve

IV. TESTS

A. Test for compressive strength [11]

Compressive strength testing was performed in general accordance with the IS standard test method for compressive strength of cube concrete specimens. Failure was considered to be the ultimate load applied to the sample before it could no longer support further load. Refer table 7, 8 and 9 for the reference.

B. Permeability test

ACI approved equipment is designed to measure the permeability of permeable concrete above. A schematic diagram of the permeability test used to determine PC permeability is shown. The load loss method is used. Permeability was measured with a 300 mm head. Refer table 6 for the details.

A 150 x 150 mm cylinder was cast to measure the permeability of the permeable concrete. The cylinder is cast from PVC pipe. In this study, the permeability of permeable concrete was measured after 28 days. The permeability of permeable concrete is calculated by the loss of the load equation.[12].

It was calculated as

$$K = 2.303\ (A1L/\ A2t) * (\mathrm{Log}\ h2/h1)$$

Where,

k = water permeability (mm/min),
A_1=cross-sectional area of the PC specimen (mm^2),
A_2 = cross-sectional areas of the tube (mm^2),
l = length of the specimen (150 mm),
t = time (min),
h_1 = the initial water head (300 mm),
h_2 = the final water head (mm)

V. MIX DESIGN

The special permeable concrete mix design obtained with this project is based on an effective design model obtained from different papers and competitive mixing method is adopted. The mix consists of a mixture of 12.5-20mm fine stone aggregate and OPC cement; These materials are used to improve the relationship between cement and coarse aggregate and thus increase the strength of concrete. Mix proportions for nine cubes as shown in table 1. [7] [11]

A. Design Specification

- w/c = 0.26-0.45
- Fly Ash = 5-25 % of cementitious material
- Cement content = 270 – 415 Kg/m^3
- Coarse Aggregate = 1190 – 1480 Kg/m^3
- FA If required
- Coarse Aggregate of size = 12.5 – 20 mm
- Compressive Strength in between 10-25 MPa
- Permeability = 100-180 mm/min
- Relationship of conventional concrete will not apply here
- Void content 15% or more is required
- Lower value will result in insufficient permeability, lower permeability, higher the strength. Therefore, A tradeoff is desired
- No stringent specification is applicable
- Mix proportion Kg/m^3 (for nine cubes)

Table 1: Mix proportions for nine cubes (kg/m^3)

Material	Trail 1	Trail 2	Trail 3	Trail 4	Trail 5
Cement Content (Kg/$m^{3)}$	400 Kg/ m^3 12.15 Kg	340 Kg/m^3 10.32 Kg	300 Kg/m^3 9.11 Kg	270 Kg/m^3 8.20 Kg	370 Kg/m^3 11.23 Kg
Coarse Aggregate Kg/m^3	1400 Kg/m^3 42.5 Kg	1300 48 Kg/m^3 39. Kg	1260 Kg /m^3 37.96 Kg	1200 Kg /m^3 36.45 Kg	1360 Kg/m^3 41 Kg
Admixture (Fly Ash)	25% of cement = 3 Kg	15 % of cement = 1.548 Kg	10 % of cement = 0.911 Kg	5 % of cement = 0.41 Kg	20 % of cement = 2.246 Kg
w/c ratio	0.4 Water = 0.4 *12.15 = 4.86 lit	0.33 Water = 0.33*10.32 = 3.40 lit	0.30 Water = 0.3*9.11 = 2.73 lit	0.26 Water = 0.26*8.2 = 2.132 lit	0.35 Water = 0.35*11.23 = 3.93 lit
Ratio	12.15:4.86 :42.5 = 1:0.4:3.49	10.32:1.548 :39.48 = 1:0.15:3.82	9.11:0.911 :37.96 = 1:0.1:4.16	8.20:0.41 :36.45 = 1:0.05:4.44	11.23:2.246 :41 = 1:0.2:3.65

The main purpose of any panel is to achieve sufficient porosity so that water can easily pass through the system and foundation. Air void formation is achieved by limiting or removing all fine aggregates (such as sand) from the mix design and using the correct mix. The cement content used in the prepared mixture was changed to reduce the content of excess additives. Coarse aggregate and moisture content vary by design. All samples are prepared from the slow mind.

VI. RESULT AND DISCUSSION

A. Test result on materials

- Test for cement [10]

OPC grade 43 was used for this special precast concrete with a compressive strength of 44.13 N/mm^2 after 14 days. All test results conform to the standard values specified in the specification. The main purpose is to use this type of cement, which is easily available in the market and is easy to test. Table 2 shows the test values for cement.

Table 2: Test for cement

SL.NO	TEST CONDUCTED	RESULT	STANDARD
1	Normal Consistency	37%	Not Specified
2	Initial Setting Time	38 min	Shall not be less than30 minutes
3	Final Setting Time	245 min	Shall not be morethan 600 minutes
4	Specific Gravity	3.12	3.15
5 OPC 43(N/mm$^{2)}$ Grade is used	Compressive Strength 3 days 7 days 14 days	24.05 N/mm^2 36.12 N/mm^2 44.13 N/mm^2	Shall not be less than23 N/mm^2 Shall not be less than 33 N/mm^2 Shall not be less than 43 N/mm^2
6	Fineness	3%	Should be less than10 % of its weight

- Test for aggregate [8] [9]

Table 3: Test for aggregates (20 mm)

Basic test	Result	Standard values
Specific gravity	2.67	2.6-2.8
Dry loose bulk density	1.46g/cc	-
Compacted bulk density	1.56g/cc	-
Impact value	22.46%	<30%
Crushing value	19.47%	<30%
Abrasion value	40.42%	30-45%

The size or size of the pores in the permeable concrete is also an important factor influencing its performance. To create large pores in the material, it is recommended to use a large mixture to create the largest size. permeability across the matrix. However, it should be noted that we must have a certain compressive strength value during the blending process, so here we use a total size of 12.5-20mm to achieve a certain compressive strength.

As we know, the larger the aggregate size, the higher the compressive strength. Therefore, the balance of porosity, compressive strength and permeability is controlled by the matrix.[12]. The values of the tests are given in the tables 3 and 4 respectively.

Table 4: Test for aggregates (12.5 mm)

Basic test	Result	Standard values
Specific gravity	2.62	2.6-2.8
Dry loose bulk density	1.44g/cc	-
Compacted bulk density	1.54g/cc	-
Impact value	23.77%	<30%
Crushing value	27.00%	<30%
Abrasion value	40.42%	30-45%

- Test for Fly Ash

Our main goal is to add fly ash as a mixture to pervious concrete to achieve a special strength and reduce the air porosity larger than the existing pores. A special kind of fly ash to reduce the lack of compressive strength and permeability ratio and balance and to save cement content. Fly ash substitution was found between 5% and 25%. Thus, the cement can be partially replaced by SCM, which not only improves the process efficiency, but also helps to achieve greater strength with less cement content, thus providing effective solutions for the use of products. Different processes such as preparation and processing, determination of density and porosity, permeability and compressive strength were carried out. Higher strength with less cement content provides a good solution for the use of commercial products. Refer table 5 for the test results.

Table 5: Test for fly ash

Basic test	Results	Standard values
Specific gravity	2.37	2.1-3
Compressive strength	91.90N/mm²	-

B. Test for permeability

- Permeability Test Result

Table 6: Comparison of permeability coefficient K (mm/min) for different mix.

Mix	3 DAYS	7 DAYS	28 DAYS
Mix-1	60 mm/min	59.52 mm/min	57.3 mm/min
Mix-2	115 mm/min	113.70 mm/min	112.5 mm/min
Mix-3	137 mm/min	135.25 mm/min	134.7 mm/min
Mix-4	145 mm/min	143.5 mm/min	142.6 mm/min
Mix-5	95 mm /min	94.3 mm/min	92.8 mm/min

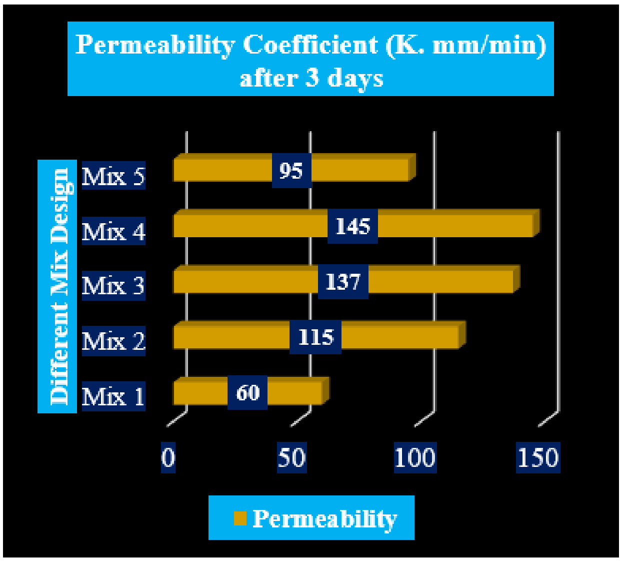

Figure 1: Permeability coefficient K for 3 days

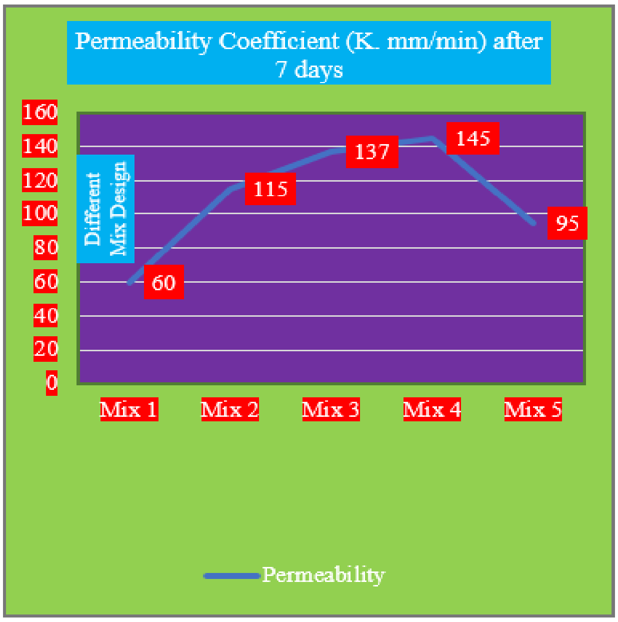

Figure 2: Permeability coefficient K for 3 days

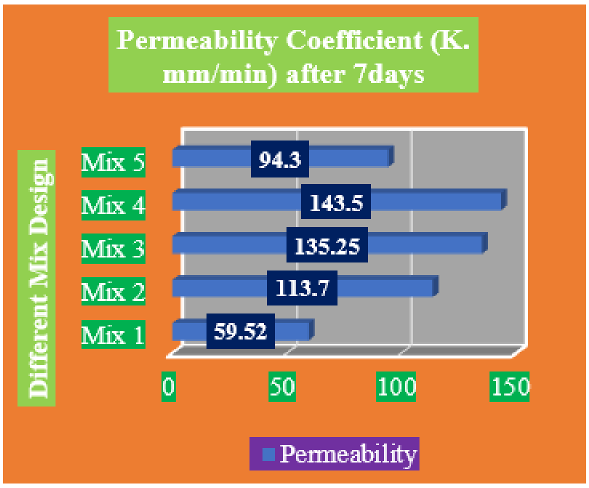

Figure 3: Permeability coefficient K for 7 days

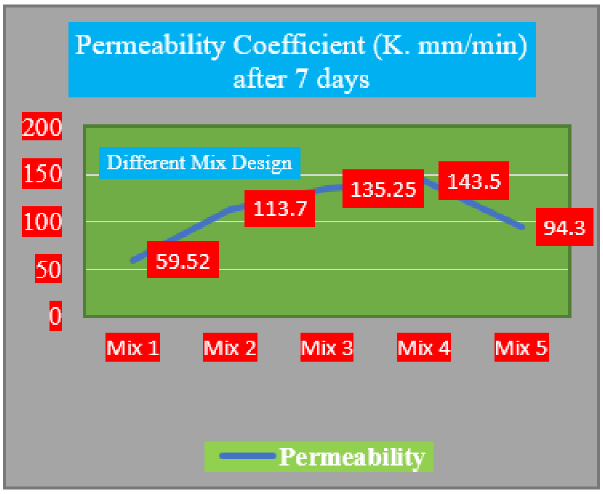

Figure 4: Permeability coefficient K for 7 days

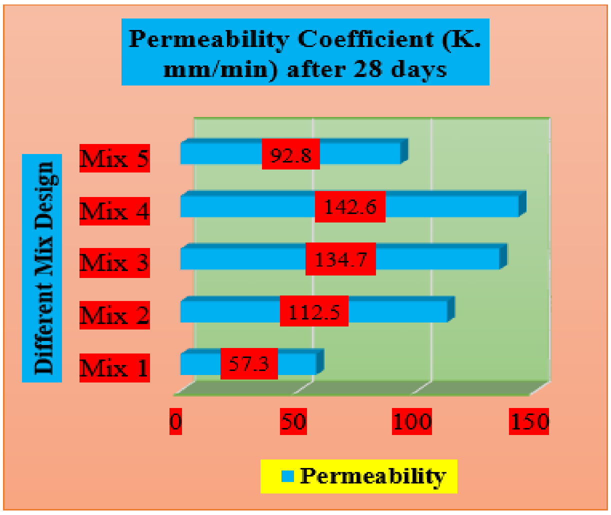

Figure 5: Permeability coefficient K for 28 days

The relationship between the void/air content of permeable concrete mixes and the percolation rate is shown for different mix designs. As the permeability ratio increases with the air void ratio, the compressive strength decreases. The graph between permeability coefficient and Mixes are shown in the fig 1, fig 2, fig 3, fig 4, fig 5 and fig. 6 respectively. The challenge in proportioning permeable concrete mixes is to achieve a balance between optimum permeability and compressive strength.

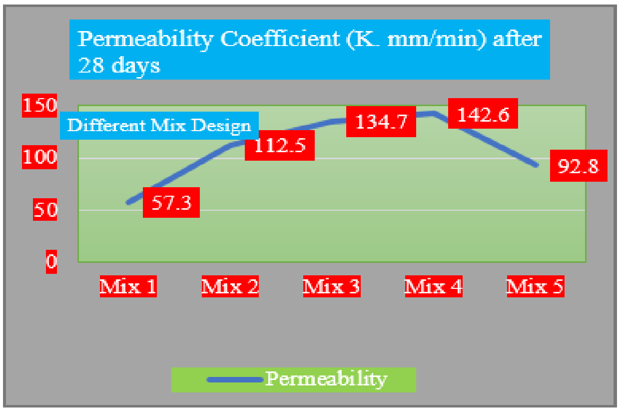

Figure 6: Permeability coefficient for 28 days

- Compressive strength of pervious concrete cubes 3-day curing
  Size of the cube is 150*150*150

Table 7: Compressive strength for 3 days

Mix design	Number of cubes	Compressive strengthN/mm²	Average compressive strength N/mm²
1	1	28.7	26.8
	2	26.65	
	3	23.5	
2	1	17.33	16.21
	2	16.40	
	3	14.93	
3	1	10.90	10.81
	2	10.40	
	3	11.15	
4	1	14.81	14.68
	2	17.50	
	3	11.70	
5	1	21.47	23.58
	2	22.85	
	3	26.43	

Figure 7: Compressive strength for 3 days

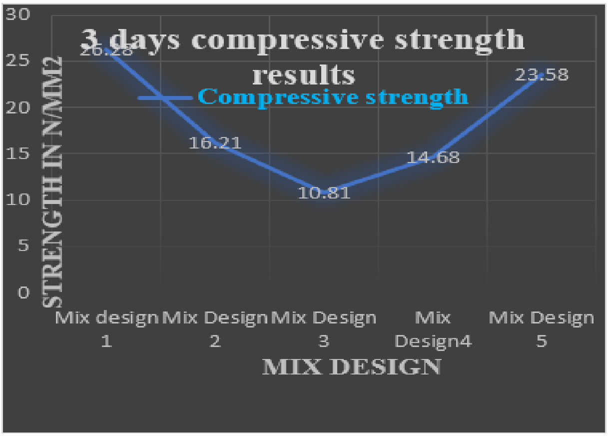

Figure 8: Compressive strength for 3 days

- Compressive strength of pervious concrete cubes 7-day curing
  Size of the cube is 150*150*150

Table 8: Compressive strength for 7 days

Mix design	Number of cubes	Compressive strength	Average compressive
1	1	32.41	32.88
	2	35.52	
	3	30.71	
2	1	16.53	18.16
	2	19.73	
	3	18.22	
3	1	17.30	17.10
	2	14.00	
	3	19.00	
4	1	13.33	15.26
	2	15.15	
	3	17.32	
5	1	25.51	25.65
	2	23.20	
	3	28.24	

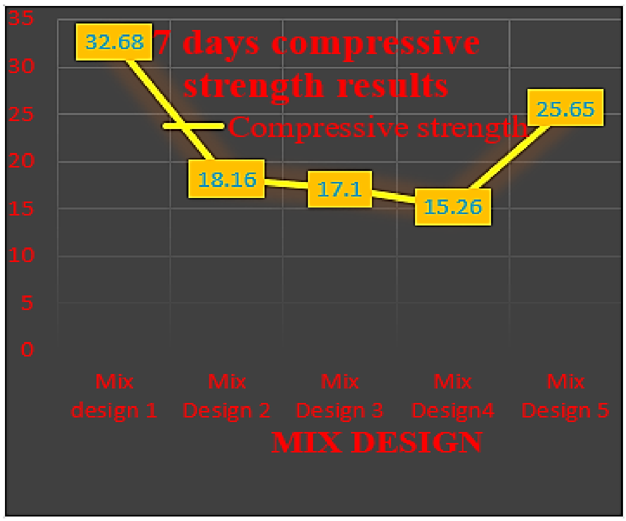

Figure 9: Compressive strength for 7 days

Figure 10: Compressive strength for 7 days

- Compressive strength of pervious concrete cubes 28-day curing

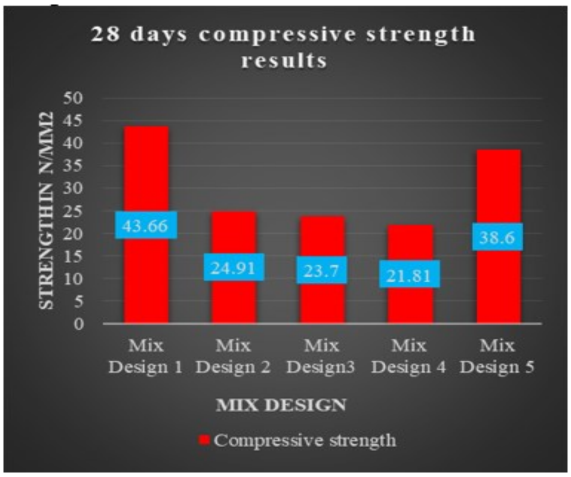

Figure 11: Compressive strength for 28 days

Size of the cube is 150*150*150

Table 9: Compressive strength for 28 days

Mix Design	Number of	Compressive	Average
1	1	43.57	43.66
	2	43.40	
	3	44.02	
2	1	24.80	24.91
	2	25.45	
	3	24.50	
3	1	24.70	23.70
	2	21.50	
	3	24.90	
4	1	19.04	21.81
	2	21.65	
	3	24.74	
5	1	40.5	38.6
	2	36.8	
	3	38.5	

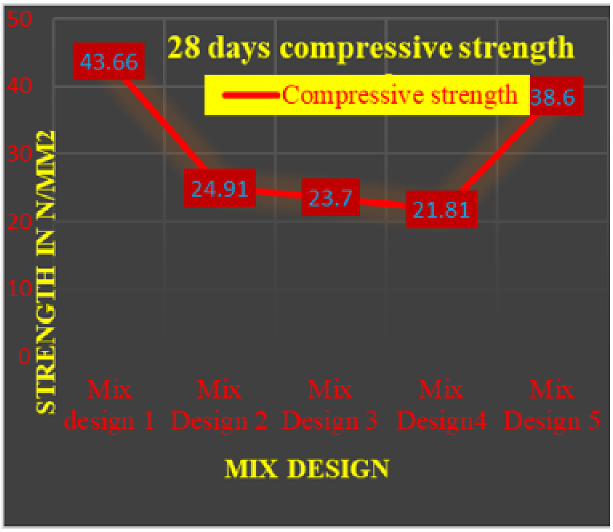

Figure 12: Compressive strength for 28 days

Compressive strength has been established according to the different mixing ratios above. It would be helpful to find that a mix has better compressive strength so that it can be used in the construction of low to medium flow permeable concrete pavements rather than conventional rigid pavements. It can be used to collect rain water to reduce traffic speed on rainy days, reduce water flow on the road, improve and increase shock, as it can prevent water accumulation on the road and slow down traffic. groundwater levels. Refer the fig 7, fig 8, fig 9, fig 10, fig 11 and fig 12 the plots. When we move on to other designs, the compressive strength is different but lower than the specific value of 5Mpa-25Mpa. These can be found in parking lots, low-traffic rural areas, roads, sidewalks, university lawns, etc. available. Compressive strength and permeability are inversely proportional to each other. As the porosity increases, the compressive strength decreases. Then, as we saw in the results above, mixtures such as fly ash will be used up to a certain value to maintain the compressive strength.[11,12]

VII. CONCLUSION AND FUTURE SCOPE

The ability of permeable concrete to retain rainwater and return groundwater and dampen storm surges enables permeable concrete to play an important role. From the experimental results, it can be concluded that the compressive strength of concrete decreases as the mixture/cement ratio increases. Although concrete panels have greater strength than permeable concrete, permeable concrete has many environmental benefits. Due to low construction costs, if used in India, it would be useful in solving India's major environmental and water supply problems.

This study was carried out to prepare permeable concrete and to examine its properties.

After reviewing the data and following the different rules and instructions, complete the assembly and grade and mix. Permeable concrete is prepared by mixing normal Portland cement with 12.5 mm and 20 mm natural crushed aggregate and controlling different water-cement ratios. The prepared polycarbonate was tested for its hydraulic properties and mechanical properties. For hydraulic materials, porosity and permeability are measured, and as mechanical properties, density and compressive strength are measured.

Results are based on criteria given in ACI 522R (2010). The compressive strength of all samples is over 10 MPa and the highest value is 21-45 MPa. However, according to research, the compressive strength of concrete in the past can reach up to 25 MPa, which is suitable for lighting installations. The pavement of the mid-highway should use permeable concrete with stronger compressive strength instead of the rigid pavement stone.

- The 1st percent is compared to conventional concrete. By comparison, the compressive strength of permeable concrete is reduced from 50% to 75%.
- Permeable concrete has a void percentage of 15% to 35% compared to conventional concrete. Therefore, it has high air permeability.
- Density is 30% lower than normal concrete.
- The larger the aggregate size of the coarse aggregate, the greater the porosity.
- The compressive strength of the cube decreases as the mass increases.
- Adding fly ash increases overall strength but reduces permeability to some extent.
- As the aggregate size increases, the permeability increases.
- The use of chemicals is necessary to reduce the water-cement ratio.
- Concrete is stronger when porosity is between 15% and 25%, but water permeability is better with less porosity.

As a result, PC can be prepared using native hardware with required components.

PC application mainly depends on hydraulic performance. However, this is not a sufficient condition because the PC must have enough power for different loads. However, more research is needed for widespread PC use. Some tips:

- The effects of freezing and thawing in cold weather.
- Pressure for PC in hot environment.
- Effect of dynamic loads on PC vibration.
- Durability of PC top surface due to heavy loads.
- The Effect of Aggregate Flatness and Elongation Index on Polycarbonate Hydraulic Properties.
- Extended use occlusion course on PC.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest

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