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Experimental Study on Properties of Pervious Concrete Pavement Material and its Implementation in Heavy Traffic Area at Mumbai

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Abstract - Pervious concrete is the construction material that has pores that can be penetrate by water. Due to voids present in concrete it used to absorb runoff from the surface and simultaneously increase soil water content. With applied to pavement or low traffic road like open parking areas in city, water runoff from the surface is expected to absorb into the soil and can be reduced clearance of water discharging into drainage channel or allow to percolate into the soil for the purpose of increase water table. Porous concrete pavements are more suitable than other conventional concrete especially in parking lots, sidewalks and driveways to control surface runoff. It also requires low cost as compare to conventional concrete and also properly manage rainwater harvesting. then Utilization of that modify concrete on actual site in Mumbai region study the durability

Keywords - Pervious concrete,drainage,durability

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INTRODUCTION

Due to industrialization various environmental issues such as global warming, water pollution, air pollution, marine pollution, soil pollution etc. are increasing day by day and the measures need to be taken to prevent them. If we turn to sustainable constructions, it can minimize environmental impacts as well as reduces cost of project.

In Civil engineering, due to urbanization the demand for construction material increases, with the increase in demand there is a strong need to utilize alternative materials for sustainable development however the effective management of waste is important aspect of sustainable buildings. The building construction industry produces the second largest amount of demolition waste and greenhouse gases about 35-40%.The effective utilization of locally available waste materials has great importance in sustainable building construction. In recent past years, the various materials such as flyash, coconut shell, ceramic dust, steel scrap, thermocol, polyurethane foam etc. were used as alternative smart materials in construction

Significance: The demand for material has been continuously rising with the increasing need for housing both in rural and urban areas.

The resource used to manufacture construction materials affect the environment by depleting natural resources, using energy, and releasing pollutants to the land, water.

Commercial exploitation of traditional building materials by various industries has aggravated the situation. It has, therefore, become necessary to think over this problem seriously and to provide some sustainable solution to make the alternative materials available to solve the housing problem. A larger amount of rainwater ends up falling on impervious surfaces such as parking lots, driveways, sidewalks, and streets rather than soaking into the soil. This creates an imbalance in the natural ecosystem and leads to a host of problems including erosion, floods, ground water level depletion as well as traffic jams on busy streets. Hence to avoid these problems introduction of pervious surface can solve the problem

LITERATURE REVIEW

Alessandra Bonicelli, (2016) " Due to addition of fibres and sand gravels leads to drain ability reduction due to the increase of paste volume that reduces the voids of the matrix. For these reasons the design of pervious concrete is strictly related to the final use the type of traffic loads that are applied to the pavement and the ecological needs of the environment. A field study for the definition of the correspondence between laboratory and in-situ compaction is suggested for future developments of this research.

AASHTO (American Association of State Highway and Transportation Officials). 1993. "AASHTO Guide for Design of Pavement Structures provides a comprehensive set of procedures which can be used for the design and rehabilitation of pavement; both rigid and flexible and aggregate surfaced for low volume roads. The guide has been developed to provide recommendation regarding the determination of the pavement structures. The procedure for design provide for the determination of alternate structure using a variety of material and construction procedures.

ACPA (American Concrete Paving Association). 2009. "According to American Concrete Paving Association the regional applicability for pervious concrete pavement can be applied in most regions of the country, but the practice has unique challenges in cold climates. Design of the system should ensure that washout from adjacent (soil) areas is not allowed to drain onto pervious concrete pavement surfaces. Care should be taken with regard to sand being applied to the pavement surface for deicing because the sand may become lodged in the pavement surface. This is not to imply that it is impossible to use pervious concrete pavement in cold climates. In fact, anecdotal evidence suggests that snow-covered pervious concrete pavement actually may clear more quickly than impervious surfaces, reducing the need for snow plowing. Additionally, melted snow and ice will drain through the pervious concrete pavement rather tha

OBJECTIVES

1. To study properties of Conventional Concrete Ingredient Specific gravity, Water absorption, Fineness Modulus.
2. To Study the Need of pervious concrete in Metro Cities
3. To analysis Comparative Study of Conventional Concrete and pervious with the Tests
4. To evaluate Cost analysis and suitability of pervious concrete on Indian construction industry.
5. To implement this pervious concrete on actual road sites

METHODOLOGY

Step 1- To study properties of Conventional Concrete Ingredient.

Step 2- To Manufacture the pervious concrete by suitable proportion

Step 3: Different tests will be carried out on cast elements and test results compared with conventional concrete

Step 4-. To evaluate Cost analysis by Comparison in between modify and conventional concrete

DATA COLLECTION

Concrete mix proportion is decided by conducting compressive strength test with proper w/c ratios (0.35) was used with M20 grade of concrete for 7 & 28 days with same size of cubes

DATA ANALYSIS

Overall Results of compressive strength Test:

Table 1: Casting of cubes with crush sand for 7 days

SR.NO	AGE IN DAY	CUBE SIZE (CM)	AREA OF CUBE (CM²)	WT. OF CUBE (GRAM)	COMPRESSIVE STRENGTH		
					LOAD	IND. (N/mm²)	AVG. (N/mm²)
1	7 DAY	15X15X15	225	7890	280	12.44	13.04
2		15X15X15	225	7770	291	12.93	
3		15X15X15	225	7540	309	13.73	

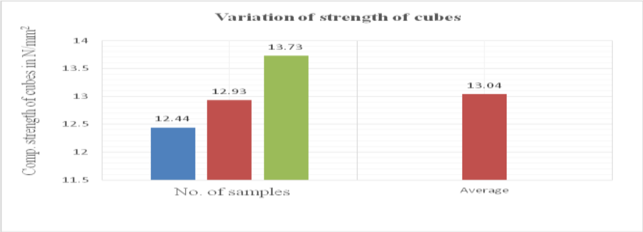


Figure 1: Compressive strength of various cubes

Table 2: Casting of cubes with crush sand for 28 days

SR.NO	AGE IN DAY	CUBE SIZE (CM)	AREA OF CUBE (CM²)	WT. OF CUBE (GRAM)	COMPRESSIVE STRENGTH		
					LOAD	IND. (N/mm²)	AVG. (N/mm²)
1	28 DAY	15X15X15	225	7860	421	18.71	18.59
2		15X15X15	225	7650	426	18.93	
3		15X15X15	225	7820	408	18.13	

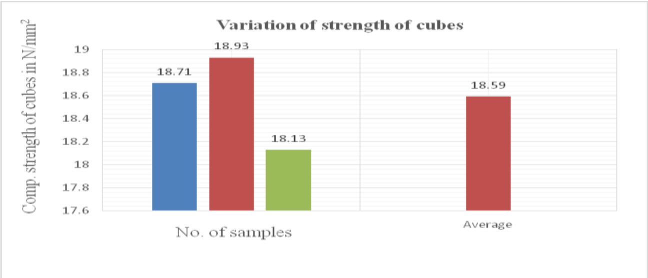


Figure 2: Compressive strength of various cubes

Table 3: Casting of cubes with river sand for 7 days

SR.NO	AGE IN DAY	CUBE SIZE (CM)	AREA OF CUBE (CM^2)	WT. OF CUBE (GRAM)	COMPRESSIVE STRENGTH		
					LOAD	IND. (N/mm^2)	AVG. (N/mm^2)
1	7 DAY	15X15X15	225	7220	267	11.87	12.58
2		15X15X15	225	7410	281	12.49	
3		15X15X15	225	7360	301	13.38	

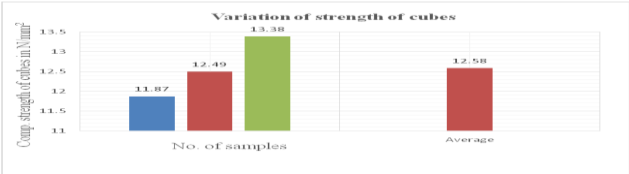


Figure 3: Compressive strength of various cubes

Table 4: Casting of cubes with river sand for 28 days

SR.NO	AGE IN DAY	CUBE SIZE (CM)	AREA OF CUBE (CM^2)	WT. OF CUBE (GRAM)	COMPRESSIVE STRENGTH		
					LOAD	IND. (N/mm^2)	AVG. (N/mm^2)
1	28 DAY	15X15X15	225	7370	379	16.84	17.56
2		15X15X15	225	7280	393	17.47	
3		15X15X15	225	7390	413	18.36	

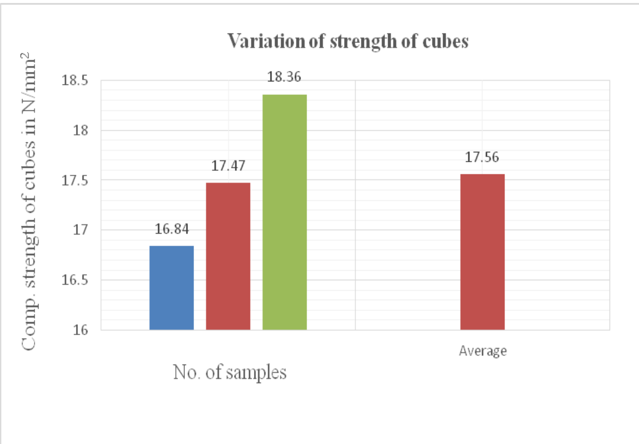


Figure 4: Compressive strength of various cubes

Table 5: Casting of cubes with river sand

Sr.no	Compressive Strength of cubes in N/mm^2				Avg. strength of cubes in N/mm^2	
	No. of cubes	7 days	No. of cubes	28 days	7 days	28 days
1	1	11.87	1	16.84	12.58	17.56
2	1	12.49	1	17.47		
3	1	13.38	1	18.36		

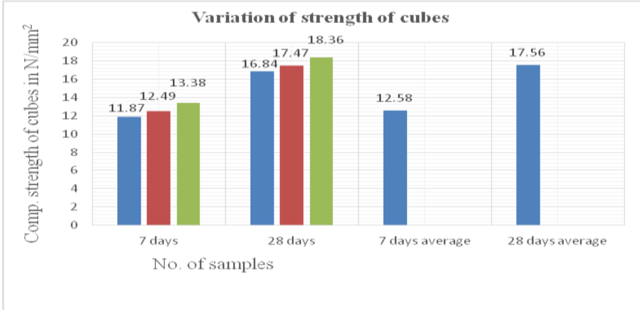


Figure 5: Comparison between strength of different cubes

Table 6: Casting of cubes with crush sand

Sr.no	Compressive Strength of cubes in N/mm^2				Avg. strength of cubes in N/mm^2	
	No. of cubes	7 days	No. of cubes	28 days	7 days	28 days
1	1	12.44	1	18.71	13.04	18.59
2	1	12.93	1	18.93		
3	1	13.73	1	18.13		

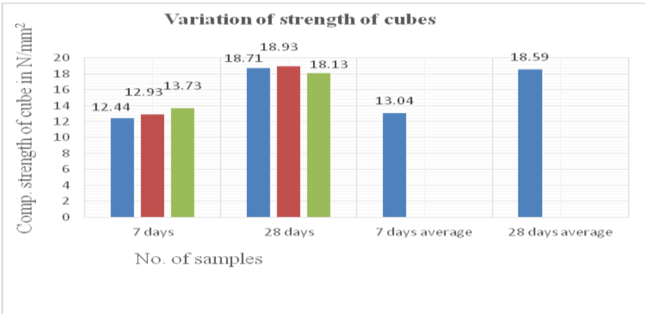


Figure 6: Comparison between strength of different cubes

COST ANALYSIS

Cost factor of pervious concrete compare with conventional concrete.

Cost of conventional concrete for pavement area

Consider length of pavement = 10 M

Width of pavement = 6 M

Thickness of pavement = 0.15 M

Total area of pavement = 9 M^3

To find out quantity of materials required for above concrete by using M20 grade

Consider, wt. of cement = 300 kg

10 mm aggregate = 22 %

20 mm aggregate = 34 %

Fine aggregate = 44 %

W/C ratio = 0.43

1. Volume of cement = (300/3.15) x (1/1000) = 0.095
2. Volume of water = (129/1) x (1/1000) = 0.129
3. Net volume = 0.776
4. Wt. of 10 mm aggregate = 2.91 x 0.22 x 0.776 x 1000 = 496 kg
5. Wt. of 20 mm aggregate = 2.91 x 0.34 x 0.776 x 1000 = 768 kg
6. Wt. of fine aggregate = 2.73 x 0.44 x 0.776 x 1000 = 911 kg

From all above calculations to find out required quantity of materials for area 9M^3 shows in measurement sheet.

Measurement sheet of materials:

Table 7: Measurement sheet of conventional concrete

Sr.no	Description	Quantity (kg)	Total quantity
1	Cement	2700 kg	54 bags
2	10 mm Aggregate	4471.15 kg	1.6194 brass
3	20 mm Aggregate	6862.47 kg	
4	Fine aggregate (river or crush)	8389.18 kg	1.852 brass

From measurement sheet to calculate cost of materials in abstract sheet.

Abstract sheet:

Table 8: Abstract sheet of conventional concrete

Sr.no	Description	Quantity	Rate (Rs.)	Amount (Rs.)	Total Amount (Rs.)
1	Cement	54 bags	310	16740	40997
2	Course aggregate	1.61 brass	2400	3885	
3	Fine aggregate (river)	1.85 brass	8000	14816	
4	Fine aggregate (crush)	1.85 brass	3000	5556	

Cost of pervious concrete for pavement area

Total area of pavement same as conventional concrete = 9 M^3

To find out quantity of materials required for above concrete by using M20 grade

Consider, wt. of cement = 300 kg

10 mm aggregate = 25 %

20 mm aggregate = 45 %

Fine aggregate = 30 %

W/C ratio = 0.35

1. Volume of cement = (300/3.15) x (1/1000) = 0.095
2. Volume of water = (105/1) x (1/1000) = 0.105
3. Net volume = 0.8
4. Wt. of 10 mm aggregate = 2.91 x 0.22 x 0.8 x 1000 = 512 kg
5. Wt. of 20 mm aggregate = 2.91 x 0.34 x 0.8 x 1000 = 792 kg
6. Wt. of fine aggregate = 2.73 x 0.44 x 0.8 x 1000 = 961 kg
7. For pervious concrete voids are present so consider average voids present in concrete = 26 %
   = 9 x 0.26 = 6.66 M^3

From all above calculations to find out required quantity of materials for area 6.66 M^3 shows in measurement sheet.

Measurement sheet:

Table 9: Measurement sheet of pervious concrete

Sr.no	Description	Quantity (kg)	Total quantity
1	Cement	2000	40 bags
2	10 mm aggregate	3876	2.39 brass
3	20 mm aggregate	6926	
4	Fine aggregate (river or crush)	4362	0.97 brass

Abstract sheet:

Table 10: Abstract sheet of pervious concrete

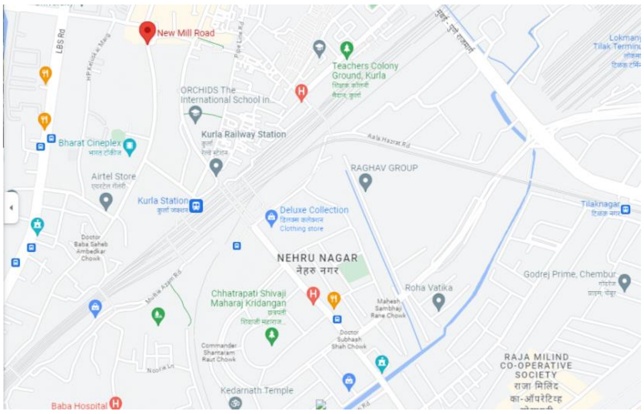
Sr. no	Description	Quantity	Rate (Rs.)	Amount (Rs.)	Total Amount (Rs.)
1	Cement	40 bags	310	12400	25884
2	Course aggregate	2.38 brass	2400	5724	
3	Fine aggregate (river)	0.97 brass	8000	7760	
4	Fine aggregate (crush)	0.97 brass	3000	2910	

Implementation of pervious concrete:

BMC to launched a project called 'Pervious Concrete Road Pavement' on pilot-basis in Mumbai Pervious concrete an innovative, modified form of cement concrete is a cheap and environment-friendly material that can be used for the construction of several types of structures. Pervious concrete could be this country's answer to many effects of global warming, including the urban heat island (UHI) phenomenon. Biggest advantage of using pervious concrete was its heat absorption capacity. The absorption of heat is a very important advantage. Due to this, the light is not reflected into the atmosphere. This means the ambient temperature can be reduced by nearly 10-15 degrees celsius. Also, the surface of pervious concrete slabs are cool to touch. One can walk barefoot on them, something that is impossible on conventional concrete slabs.

BMC must use topmix permeable concrete technology to reduce flooding. BMC which has started concretisation of several major roads. However, it has its adverse effects as rain water does not get absorbed by these roads. Due to this, water-logging takes place, throwing city life out of gear. It is necessary to use topmix permeable concrete technology for the development of roads in Mumbai. This will ensure that water is drained off from these roads and there will be no potholes. It will also help in increasing the underground water level. Using pervious concrete will also help recharge ground water and reduce the burden on the existing stormwater drains. It can also minimise the impact of urban heat islands, as the material absorbs sun's radiation. In the coming days, we need to adopt steps that are environment friendly and better measures towards water conservation. Adopting the concept of porous concrete is one such step towards water conservation. Mumbai, which has a saucer-like topography, witnesses severe water-logging during monsoon. Of late, even a small downpour triggers flooding in several areas. Pervious concrete allows rainwater to permeate, reducing flooding and helping groundwater recharge.

Name of Road : New Mill Road, Kurla(W) Mumbai



For the test purpose we implement this techniques for 200 ft along the road

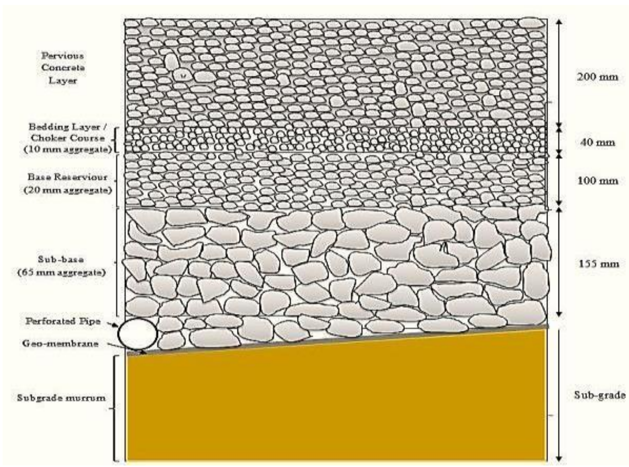
A. Pavement Design

Indian Road Congress issued the first revision of IRC SP: 62 in 2014, which is used to design and construct concrete pavements for low volume roads [18]. Slab thickness of the pavement is a design by using IRC SP: 62 2014 [19]. For the compressive test and flexure test, mix design was prepared for M20M30, and M35. However, the results articulated that the compressive Strength obtained from the M35 grade concrete is suitable for designing pavement. The flexural strength required for design is considered from the beam flexural test, which is 3.95MPa, and the compressive test value is 28.20MPa. The total traffic is 56 commercial vehicles per day for arm 2.

Table 11: shows various design inputs considered for the design of pavement

Design Inputs	Values (Units)
Present traffic	56 c.v.p.d
Wheel Load	$50x10^3$
Tyre Pressure	0.8MPa
Design Period	20 years
Modulus of sub-grade reaction (k)	50 MPa/m or $50x10^{-3}$ MPa/mm
Modulus of Elasticity concrete (E)	30,000 MPa
Poisson's ratio (μ)	0.15
Flexural Strength	$3.95N/mm^2$

The rigid pavement design is based on the fact, for a load of any magnitude; its intensity reduces, as the load is passed on downwards from the surface by virtue of dispersal over an increasingly larger area, by carrying it deep enough into the ground through consecutive layers of granular material. The pavement thickness depends on the way in which loads are dispersed to the subgrade. Hence, the pervious concrete thickness layer was 200mm as per calculation, and it is found safe for edge and corner stresses. The succeeding layers are the bedding layer, base course, and sub-base course, having a thickness of 40mm, 100mm, and 155mm, respectively



CONCLUSION

As performed in the test of the research, it was visible that the occurrence of voids in the river sand was relatively more than crush sand, but the strengths of river sand is slightly less than the crush sand.

Another observation includes that the strength of the porous concrete is relatively less than as compared with the conventional concrete due to the voids present in the porous concrete. But, on the other hand these voids help the porous concrete to percolate the water wherever it is utilized and as a result, it is beneficial to increase the ground water table.

As a cost analysis of pervious and conventional concrete that the abstract sheets of both pervious and conventional cost calculations, cost required for pervious concrete is nearly 37% less than conventional concrete. So we can say that the pervious concrete is a good alternative for pavement construction than the conventional concrete.

The rainfall data implies that the Karanjade area has average rainfall above 1000mm; hence, pervious pavement can be installed.

Total average PCU/Hr. The study area's internal road is 379 PCU/Hr., which shows that the area has low traffic volume, which is observed to be suitable for pervious concrete pavement..The previous pavement design adopted with 200mm thickness was found to be safe. An investigation needs to be carried out before the practical implementation of pervious concrete as pavement. Further work on hydrological behavior, pollutant removal, design life aspects, and approach towards improving the strength parameter of pervious concrete also need to be emphasized.

Future Scope: The study has been conducted and continue to be conducted on the design and installation of porous pavement systems. The study focuses on full-depth porous pavements designed to manage storm water from low to moderate traffic parking areas, sidewalks, pathways and driveways. They have also indicated that the durability was improved when the moisture in the voids was drained and the cement paste air-entrained. Study and implementation of full-depth permeable pavement systems on low-speed/low volume roadways and highways have begun to increase, but the body of knowledge is still lacking in a number of areas. Further research is needed on roadway and highway installations of full-depth permeable pavements to obtain a greater depth of knowledge on the cost and operation and maintenance required for these systems long term.

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