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Fibre Reinforced Pervious Concrete Using Banana Fibre

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ABSTRACT

Pervious concrete is a composite material consisting of coarse aggregate, Portland cement and water. It is different from conventional concrete in that it contains no fine aggregate in the mixture. The result is a concrete with high percentage of interconnected voids that, when functioning correctly permits the rapid percolation of water through the concrete. Pervious concrete is used in parking areas, residential streets, pedestrians' walkways etc. It is an important application for sustainable construction. The project aims at studying the engineering properties and prove the importance of banana fibre reinforced pervious concrete in ground. Tests like compression test, split tensile strength test and permeability tests are carried out on test specimens with different percentages of banana fibres and the properties will compared with that of plain pervious concrete samples.

Keywords-- Fibre reinforced pervious concrete, sustainable construction, permeability

I. INTRODUCTION

Increasing in infrastructure development and resulting increase in urban storm water over the past few decades have led to increase in pollution and runoff problems. As more available land area in the major cities gets paved over, a maximum quantity of rainfall ends up falling on impermeable surfaces such as parking area, driveways, sidewalks, and highways rather than to pass into the ground. This leads to environmental issues such as erosion, decrease in ground water table, pollution of rivers, lakes, and coastal waters as rainwater flowing across pavement surfaces picks up everything from oil and grease spills and chemical fertilizers. One of the simple solution to avoiding these problems is to install the Pervious Concrete pavement which allows water to percolate through its pores reducing surface runoff and offering durability; unlike Conventional Concrete or asphalt pavement.

Pervious concrete is a composite material consisting of coarse aggregate, Portland cement and water. It is different from conventional concrete in that it contains no fine aggregate in the mixture. Because the mix contains little or no sand, the pore structure has many voids allowing water and air to pass through. Due to its high porosity it can used for concrete flatwork applications that allows water from precipitation and other sources to pass directly through, thereby reducing the runoff from a site and allowing ground water recharge. The concrete paste then coats the aggregates and allows water to pass through the concrete slab. Pervious concrete is used in parking areas, areas with light traffic, residential streets, pedestrian walkways, and greenhouses.

It is an important application for sustainable construction and is one of many low impact development technique used by builders to protect water quality. It is usually a mixture of 9mm to 13mm average diameter aggregate, cement and water. Pervious Concrete contains voids and these voids are held together by cement paste, after the installation. The water cement ratio used in this study is 0.36. To reinforce pervious concrete with various proportions of banana fibre (i.e. 0.1%, 0.2%, 0.3%, and 0.4% of volume of concrete).Fibre reinforced pervious concrete pavements are more efficient than ordinary cement concrete pavement. The fibres may be of steel, polymer or natural materials. Banana fibre is used in this study.

1.1 OBJECTIVES OF THE STUDY

1. By using various proportions of banana fibre we are casting pervious concrete (i.e. 0.1%, 0.2%, 0.3% and 0.4% of volume of concrete).
2. To study the engineering properties of pervious concrete reinforced with banana fibre.
3. To compare the behaviour of plain pervious concrete and banana fibre reinforced pervious concrete.

II. LITERATURE SURVEY

Anush K Chandrappa, Krishna Prapoorna Bilgiri (2016) presented a paper on "pervious concrete as a sustainable pavement material-Research findings and future prospects: A state of art review".This research studies recommend different mix designs and proportioning systems for pervious concrete based on various principles. The most common principle of mix design is to provide enough cement coating to the aggregate. The cement to aggregate ratio adopted in the range of 1:4 to 1:12.The water cement ratio used in the range of 0.28 to 0.36.The water cement ratio used in 1:4 mix is 0.36.This study also indicated that the use of fibres can optimize the strength and drainage properties of pervious concrete.

Marwan Mostafa, Nasim Uddin (2016) presented a paper on "Experimental analysis of compressed earth block (CEB) with banana fibres resisting flexural and compression forces."This study summarizes the average compressive and flexural strength results in seven mixes. The fibre reinforced blocks with fibre length of 6mm and 7mm recorded for the highest in both compressive strength and flexural strength compared to all fibre reinforced blocks with fibre length ranges from 5mm to 10mm.And the experimental work is concluded that the blocks constructed by adding banana fibres throughout the mix performed better than the block with no fibres in both compressive and flexural strength.

GauravUttamShinde, Dr S.S Valunjkar (2015) presented a paper on "An experimental study on compressive strength, void ratio and infiltration rate of pervious concrete". The paper represents the experimental methodology and experimental results related to compressive strength, void content and infiltration rate. Various mix designs of pervious concrete was tested, results were determined and analysed. Cube size of 150mm x 150mm x 150mm was prepared to investigate compressive strength, void ratio and infiltration rate. Different concrete mix proportion such as 1:4, 1:5 and 1:6 with different size of gravels such as 9mm to 12mm was used to check these properties of pervious concrete. It was observed that when void ratio increases, infiltration rate also increases and compressive strength decreases and vice versa.

Rui Zhong, Key Wille (2015) presented a paper on "Material design and characterization of high performance pervious concrete. "In this paper 12 mixture were proportioned with various matrix and compressive and flexural strength test were conducted. This research results show that compressive strength and elastic modulus increase by upto 150% and 100% respectively. In this research highlight that the development and characterization of high performance pervious concrete aiming at improved mechanical and advanced durability properties. It was observed that incorporation of appropriate amount of fibre reinforcement could further improve the durability of pervious concrete.

Dang Hanh Nguyen, Nasim Sebaibi (2014) presented a paper on "A modified method for the design of pervious concrete mix". In this research conducted binder drainage test for determination of optimum water cement ratio. In this test, prepare fresh concrete for different water cement ratios such as 0.30, 0.32, 0.34, 0.36, 0.38 and 0.40 and discharge it to a metal sieve. The holes diameter depends on size of aggregate. Vibrate the metal sieve for 15 s with vibrating table. The result summarizes that in 0.36 ratio there is no cement paste in the sieve and 0.38 and 0.40 ratio the paste cement is liquid and it starts drain down under the effect of vibration. So water cement ratio 0.36 is optimum in pervious concrete without admixtures.

Nalini Thakre, Hirendra Rajput, Jaya Saxena, Harish Mitangale (2014) presented a paper on "comparative study on strength and permeability of pervious concrete by using nylon and polypropylene fibre. The fibres are used in various proportions i.e., 0.1%, 0.15%, 0.2% etc. of volume of concrete. Also the paper says about types of fibres help to increase the properties of pervious concrete. The fibres are glass fibres, natural fibres like flax, hemp, kenaf, jute, banana and coir, synthetic fibres like nylon, polypropylene, carbon, polyester etc. Natural reinforcing materials can be obtained at low cost and low levels of energy using local manpower and technology. The test result also indicated that the compressed strength of nylon and polypropylene fibre up-to 0.2% of used result get increased. And the permeability of fibre mixed pervious concrete is increased as comparison to the plain pervious concrete.

Hussam A.A Rahman (2012) conducted a test on "some properties of fibre reinforced no fine concrete". The paper focuses on studying the mechanical characteristics of polypropylene and carbon fiber reinforced no fine aggregate concrete containing a different percentage of fibre. Tests to determine workability, density, compressive strength, split tensile strength and modulus of rupture were carried out. It was found that pervious concrete mixes with fibres have higher density than normal pervious concrete mixes containing polypropylene and carbon. The test results also indicated that the inclusion of fibre to the pervious concrete mixes increases compressive strength, split tensile strength and modulus of rupture.

Dhawal Desai (2010) studied the "effects of material properties on porosity of pervious concrete." This paper describes the effect of size of aggregates and proportion of cement, aggregate and water on porosity of pervious concrete. Different sample blocks were made in lab with variations in mixture to see the porosity for final conclusion. The samples in which aggregates above 20 mm were used were not porous from the base because of larger voids, the cement slurry settles down. Also in all those cubes in which compaction was done, the cement slurry settles down and thus made a flat bottom surface. So finally the conclusion was to use aggregate in the range of 9.5 mm - l9 mm and to reduce compaction while filling to

yield the best results. Also the density of the concrete is less than the normal one because fine aggregates where not used. Its strength is lower than normal concrete.

III. MATERIALS AND METHODS

Materials used in the tests are,
1. 53 grade Ordinary Portland cement
2. Coarse Aggregate of 12mm Size
3. Water
4. Banana Fibre

3.1 METHODOLOGY

1. Mix proportioning:
The coarse aggregate to cement ratio was adopted as 4 by mass. The water cement ratio adopted for the mix was 0.36.
2. Collection of raw materials
All the necessary materials for preparing the fibre reinforced pervious concrete such as
Cement, coarse aggregate, Banana fibre etc. was collected.
3. Preliminary tests on cement and aggregate:
Test to determine specific gravity, fineness, consistency, initial and final setting time was conducted on cement. The physical properties of coarse aggregate were studied. In addition aggregate impact test and Los Angeles abrasion test was also conducted on the aggregate.
4**.** Batching:
Batching is the process of measuring and combining the ingredients of concrete.
5. Casting:
Normal pervious concrete cubes and cylinders are casted for testing. Cubes were cast for testing the compressive strength. Cylindrical specimens were prepared to determine splitting tensile Strength.
6. Curing
The specimens were allowed to remain in water for 28 days and the temperature is maintained at 27±2ºc.

3.2 ALKALI TREATMENT OF BANANA FIBRE

Alkali treatment increases surface roughness resulting in better mechanical bonding and the amount of cellulose exposed on the fiber surface. This increases the number of possible reaction sites and allows better fiber wetting. The banana fibers were cleaned and immersed in 6% NaOH solution for 2 h at room temperature and then thoroughly washed by immersion in a clean water tank to remove the non-reacted alkali until the fibers were alkali free. They were next rinsed under running water and filtered. The filtered fibers were then dried in sun temperature for 24 h.

Fig 2.1 Alkali Treatment of Banana

IV. EXPERIMENTAL INVESTIGATION

4.1 Volume calculations

Volume of 1 cube=3.375x 10^{-3} m^3
Volume of 1 cylinder for strength test=5.30x 10^{-3} m^3
Volume of 1 cylinder for permeability test=6.28x 10^{-3} m^3
Total number of specimens=9(6 cubes, 4 cylinder)
Total volume to be filled with concrete=0.032305 m^3

4.2 Quantity calculations

Total quantity of cement required=21 kg
Total quantity of coarse aggregate required=84kg
Total amount of water required=0.36x21=7.56 liters
Total quantity of fibre required=600gm

4.3 Compressive Strength

Compressive strength is often measured on a universal testing machine of capacity 2000 KN. Measurements of compressive strength are affected by the specific test method and conditions of measurement. Compressive strengths are usually reported in relationship to a specific technical standard.

$$\text{Compressive strength} = \frac{\text{Ultimate load}}{\text{Area of loaded face}}$$

4.4 Split Tensile Strength

Tensile strength is one of basic and important properties of concrete. Split tensile test is also known as Brazilian test. The test is carried out by placing a cylinder specimen horizontally between the loading surface of a universal testing machine and load is applied until the failure of the cylinder along the vertical diameter.

$$\text{Split tensile strength} = \frac{2P}{\pi LD}$$

Where,
P = Compressive load on cylinder
L = Length of cylinder = 300 mm
D = Diameter of cylinder = 150 mm

4.5 permeability Test

Permeability is tested by using Falling head apparatus. At the top of instrument there will be a collecting pipe, it will carry near about 20liters of water. Place the specimen at bottom of the collecting pipe, which is made with different ratios of fibre. After the placing of specimen, pore 20liters of water over the collecting pipe. By removing the cap which is placed on the end of the

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apparatus. The water head will be noted from the scale in 5seconds and the scale is attached over the collecting pipe. Falling head apparatus is prepared in the lab.

3.1 Falling head apparatus

V. RESULTS AND DISCUSSIONS

We have casted cubes of 15×15cm and cylinders of 15×30cm size for testing the strength values. Also casted cylinders of size 20×20cm for testing permeability. The water cement ratio used is 0.36. The workability is determined by using slump test and compacting factor test. The given slump in all mix are true slump and the compacting factor value is within the range between 0.8 to 0.9.So the concrete are highly workable. Firstly compressive strength and permeability is calculated in 7 days by using 10mm and 12mm size aggregate, and comparing the test values. When comparing with 12mm and 10mm size aggregates the maximum compression strength will be at 10mm aggregate. But value of 10mm aggregate will not that much increase, when comparing with 12mm size aggregate.

When comparing between 10 and 12mm sized aggregate the permeability will be more for 12mm aggregate. The value have a great difference in permeability. So take both permeability and strength characteristics we conclude that 12mm sized aggregate is more suitable for the research.

5.1 28 DAY COMPRESSIVE STRENGTH TEST USING 12MM SIZED AGGREGATE

Table 4.1day compressive strength using 10mm size aggregate

0% of Fibre	Trial 1 (KN)	Trial 2 (KN)	Trial 3 (KN)	Average value (KN)	Strength (N/mm^2)
0%	234	228	230	230.67	10.25
0.1%	170	172	170	170.67	7.58
0.2%	242	240	245	242.33	10.77
0.3%	210	220	200	210	9.33
0.4%	190	200	180	190	8.44

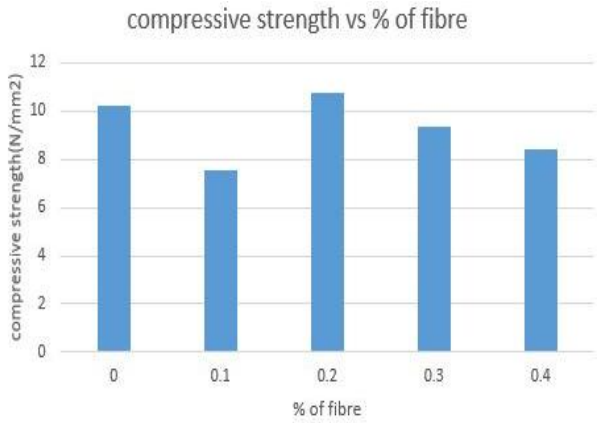

Fig 4.1 Graph of compressive strength vs % of fibre

From this graph it came to understand that the optimum value will be at 0.2% of the fibre in pervious concrete. Further adding the % of fibre it is clear that the compression strength is decreasing. At the normal pervious concrete to 0.1% fibre reinforced concrete the value of compression strength is decreasing and from 0.1 to 0.2% the graph shows sudden increase. The optimum value is $10.77N/mm^2$ at 0.2%.

5.2 28 DAY SPLIT TENSILE STRENGTH TEST USING 12MM SIZED AGGREGATE

Table 4.2 split tensile strength using 12mm sized aggregate

0% of Fibre	Trial 1 (KN)	Trial 2 (KN)	Trial 3 (KN)	Average Value (KN)	Strength (N/mm^2)
0%	58	64	62	61.33	0.867
0.1%	50	48	52	50	0.707
0.2%	90	110	100	100	1.414
0.3%	50	60	55	55	0.778
0.4%	50	40	45	45	0.636

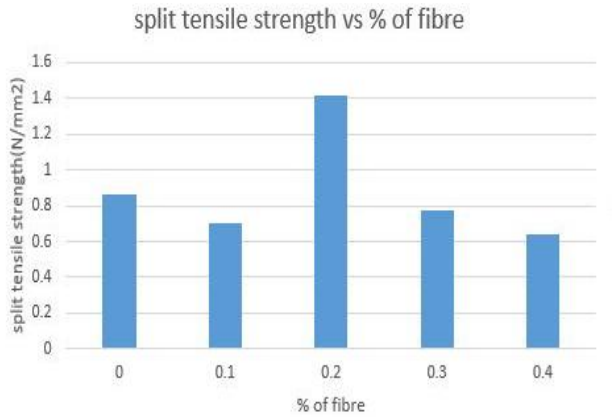

Fig 4.2 Graph of split tensile strength vs % of fibre

From this graph it came to understand that the optimum value will be at 0.2% of the fibre in pervious concrete. Further adding the % of fibre it is clear that the split tensile strength is decreasing. At the normal pervious concrete to 0.1% fibre reinforced concrete the value of split tensile strength is decreasing and from 0.1 to 0.2% the graph shows sudden increase. The optimum value is 1.414N/mm^2 at 0.2%.

5.3 PERMEABILITY TEST USING 12MM SIZED AGGREGATE

Table 4.3 permeability value using 12mm size aggregate

% of Fibre	Trial 1(liters)	Trial 2(liters)	Trial 3(liters)	Permeability (liters)
0	7.8	7.9	7.3	7.6
0.1	9.4	9.8	9	9.4
0.2	12.2	12	12.5	12.23
0.3	13	12.8	13.2	13
0.4	13.8	13.6	14	13.8

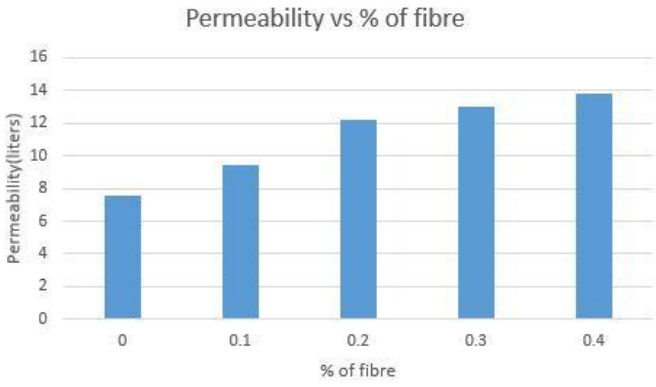

Fig.4.3 permeability vs % of fibre

The variation in the permeability values with respect to changes in fiber content can be observed. The permeability of banana fibre mixed pervious concrete is increased as comparison to plain pervious concrete. This increased permeability is caused due to increase in void ratio. As the number of voids increases, water passing through concrete specimen also increases. From this graph it is clear that, by increasing the fibre content the permeability will increases. From the permeability characteristics, obtained that the permeability in 1 m^2 area is nearly 248liters. So banana fibre reinforced pervious concrete is highly effective.

VI. CONCLUSIONS

The main objective of this study was to evaluate the strength and permeability characteristics of pervious concrete and to compare the behavior of plain pervious concrete and Banana fibre reinforced pervious concrete. The experimental work includes compressive strength tests, split tensile strength tests, permeability tests on concrete specimens. The following observations were made:

1. When comparing with 12mm and 10mm size aggregates the maximum compression strength will be at 10mm aggregate. But value of 10mm aggregate will not that much increase, when comparing with 12mm size aggregate.
2. When comparing between 10 and 12mm sized aggregate the permeability will be more for 12mm aggregate. The value have a great difference in permeability.
3. Comparing the two sized aggregate in compressive strength and permeability, concluding that 12mm size aggregates is convenient for pervious concrete.
4. Then for the particular mix examined of 28 day, the compressive strength values ranges between 7.58 to 10.77 N/mm^2 for 0%, 0.1%, 0.2%, 0.3% and 0.4%. Banana fibre reinforced concrete gets its maximum value at 0.2% banana fibre reinforced concrete.
5. The split tensile strength values ranges between 0.707 to 1.414N/mm2 for 0%, 0.1%, 0.2%, 0.3% and 0.4% banana fibre reinforced concrete gets its maximum value at 0.2% banana fibre reinforced concrete.
6. Compressive strength values and split tensile strength values are highest for 0.2% banana fibre reinforced concrete and decreases with further increase in fibre contents.
7. From the permeability characteristics, obtained that the permeability in 1 m^2 area is nearly 248liters. So banana fibre reinforced pervious concrete is highly effective.
8. We conclude that the amount of fibre used should be in the range of 0.2% to obtain pervious concrete with good strength and permeability characteristics.
9. In literature survey it is analysed that synthetic fibres are mostly used in strengthened to pervious concrete. But the result of this project implies that natural fibres such as banana fibre gives the same result as synthetic fibres give.

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