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Basalt Fiber Reinforced Interlocking Concrete Paving Block

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ABSTRACT:

Concrete Block Pavement (CBP) is getting popularity in areas where normal flexible pavement does not last long. Application of CBP is developing very fast for various reasons such as high resistance to deformation, durability, easy and rapid quality construction, ability to carry traffic immediately after construction, compatibility with the environment and aesthetic features etc.

The structural behavior of CBP is similar to flexible pavement. However, the performance of CBP depends upon on block shape, size, thickness, type of bedding and jointing sand, joint width.

The process of manufacturing is simple and standardized. Cement concrete is a mixture of cement, sand and stone chips in correct proportions. The items are mixed in water and churned thoroughly in a concrete mixture. The process involves proportioning, Mixing, Compacting, Curing & Drying. A concrete mix of 1:2:4cement: sand: stone chips by volume are used for making paving blocks.

Concrete paver blocks are used in various applications like street road, small and medium market roads, low volume roads and other construction places.

Recently in concrete paver block fibers are introduced to increase strength, durability and reduction in cracks. Fibers in concrete paver block improve properties of paver block. The concrete paver block maintenance is low and economic when compared with other pavements. Experimental investigations show that compressive strength and flexural strength of Polypropylene concrete paver block is higher than the normal paver blocks. Hence it can be used in heavy traffic area and give surface resistance for longer life. By using fibers in concrete paver block, it increases resistance to impact/abrasion and greatly improves quality of construction. Therefore, paver blocks with fibers do not easily crack, break or buckle.

Basalt fiber offer prospect of completely concrete. They have potential to high performance and cost effectively replaces of fiberglass, steel, new range of composite materials and product. Low cost high performance fibers offer potential to solve the largest problem in the cement and concrete industry, cracking and structural failure of concrete. They have potential to high performance and cost effectively replace of fiberglass and steel.

Keywords: Paver blocks, fibre, concrete, sand, chips

1. INTRODUCTION

The use of composite materials, due to their interesting physical and mechanical properties, is nowadays widely spread in many engineering fields, with advanced technical applications in civil, mechanical, aerospace, and biomedical scenarios. The use of fibers produced by molten ballast rock has gained in year 2017 an increasing interest as a result of the good physiochemical properties that can be achieved. Basalt fibers exhibit good strength and stiffness properties also at high temperatures, long-term durability, high acid and solvent resistance, low water absorption, remarkable heat and sound insulation properties, good process ability, as well as their fabrication process is generally significantly cheaper than carbon and glass fibers. Basalt fibers and composite materials made from them can be retained to have a successful relationship between quality and costs in comparison with other types of fibers such as those based on glass and carbon .Basalt fibers are used for realizing innovative building materials, defined as the proper mixture of a concrete matrix with short (staple) or cut (chopped) basalt fibers, so to improve the material strength-to-weight ratio.

1.1 OBJECTIVE OF STUDY

This study has the following objectives:

- To prepare M40 mix design using IS code
- To get the optimized proportion of chopped basalt fiber in concrete.
- To check the effect of Compressive strength of basalt fiber reinforced paving block
- Comparing the performance of chopped basalt fiber reinforced concrete paving blocks with other concrete paving blocks.

2. LITERATURE SURVEY

1) **Sun, Zhen Gao, Peng Cao, Changjun Xinjian Zhou et al.(2019),** In this study test that were conducted to get mechanical properties of concrete are Compression test, Splitting tensile strength and Bending strength. The proportion of basalt fiber used in this study gradually by 1% and added in freshly prepared concrete.The strength grade used isC25. From the test results it is concluded that the compressive and splitting tensile strength of concrete increased first followed by decreasing. The bending strength increases with the increase in fiber volume. According to the compressive and splitting tensile strength it is observed that, mechanical performance of concrete with 6mm fiber was that of 12 mm fiber.
2) **P.O.Limda, M.R.Gore Ketan, Suhasini M. Kulkarni. Et al. (2018) ,**The aim of the research is to prepare strength of the concrete of M40 grade with local availability. Then to study the effect of different proportion of Basalt fiber and to find optimum range of basalt fiber. The size of basalt fiber used is 7 to 15 Mm in diameter and density 2650 kg/m3. The Test perform on cement concrete are Compressive strength, split tension strength, flexural strength, and other test were conducted for cement, chemical admixture, coarse aggregate and fine aggregate. As far from the work done that initial when adding fiber in high strength concrete is decreasing on 7 days and 14 days. But from reference of research paper the strength of basalt fiber will gain more than the design mix after 28 days. Basalt rock fiber have no toxic reaction with air or water, are non- combustible and explosion proof.
3) **Mr. Navnath Raut, Mr. Urmila Kawade. Et al. (2017) ,** In the study the effect of inclusion of basalt fibers on the compressive strength, flexural strength, and splitting tensile strength of fiber concrete was studied. In this experiment basalt fiber having length 18 mm and diameter is 13 micron size was used. The influence of addition of 0.1, 0.2, 0.3, 0.4 and 0.5 % basalt fiber volume fraction in five different mixes of total volume of concrete is investigated and compared it with conventional concrete. The experimental results showed that the addition of basalt fiber up to 0.3% basalt fiber volume together with concrete improved the compressive strength and flexural strength and there is negligible influence of fiber addition on the splitting tensile strength as the percentage of basalt fiber in concrete increases

workability of concrete decreases. It was found from the failure pattern of the specimens that the formation of cracks is more in case of concrete without fibers than the basalt fiber concrete.

4) **John Branston, Sreekanta Das, Sara Y. Kenno, Craig Taylor et al.(2016),** In this study two different lengths of chopped basalt fiber were used 36mm and 50mm. concrete specimen used in this study were cast with 0.5W/C ratio and proportions of 1:1.4:2.8 by mass of cement, fine aggregate and coarse aggregate. Tests were conducted are flexural test and impact resistance test.
5) **Fathima Irine I.A. et al. (2014) ,**The aim of this research paper is to investigate and compare the compressive, flexural and splitting tensile strength of basalt fiber reinforced concrete with plain M30 grade concrete. Based on the laboratory experiment on basalt fiber reinforced concrete, cube, beam, and cylindrical specimens have been designed with basalt fiber reinforced concrete containing 1 kg/m3, 2 kg/m3 and 4 kg/m3 basalt fibers.

6) **Ahmet B. Kizilkanate, Nihat Kabay, SwaptikChowdury et al. (2015) ,** The tests were done in this study are compression test, splitting tensile strength and three point bending test.The water cement ratio of the concretes is kept constant at 0.45 for all mixes.

2.1 **Materials:**

- **Cement** - Ordinary Portland cement 53 grade was used. The test were carried out according to the IS 456- 2000Standard.
- **Aggregate: Coarse aggregate-** Ordinary granite broken stone aggregates of size less than 12mm are used for thestudy.
- **Water:** Potable water is used for mixing and curing as per IS 456:2000. From durability consideration water cementratio should be restricted as in case of normal concrete and it should preferably be less than 0.45.

2.2 Test on Materials:

1. Specific Gravity:

The Specific gravity of the aggregates that are used is tested by following the Indian Standards specification by following IS 2386 (Part III) – 1963. The specific gravity is one of the important factor that everything depends on the design mix also depends on the specific gravity of the materials that we use. Asthe particle size is less we will use pycnometer for sand. The empty weight of the pycnometer is measured and then it is filled with sand up to a mark andthe weight is measured. Then water is filled with water and the weight is measured. Then weight of the pycnometer only with water is measured and the specific gravity of the fine aggregates used is calculated.

2. Workability:

The workability is one of the physical parameters of concrete which affects the strength and durability and the appearance of the finished surface. The workability of concrete depends on the water cement ratio and the water absorption capacity if the aggregates. If the water added is more which will lead to bleeding or segregation of aggregates. The test for the workability of concrete is given by the Indian Standard IS 1199-1959 which gives the test procedure using various equipments. In our case we have used slump cone test for measuring the workability of concrete. We have measured the height of the fall of the cone of concrete for various water-cement ratios and recorded the values for ordinary concrete. Then the same procedure is done with the concrete having mix proportion of basalt fiber.

Sr No	Properties	Fine Aggregates	Course Aggregates
1	Specific Gravity	2.65	2.88
2	Fineness Modulus	3.29	--
3	Water Absorption	2.04	1.28

Table 2.1 Properties of material

3. EQUIPMENT'S REQUIRED

➤ **Universal testing machine**

Figure 3.1 Compression test

Weighing machine

Figure 3.2 Weighing machine

3.1 SPECIFICATION:

1. Size of Paving Block –240mm X 100mm X 80mm
2. Cement used – Ordinary Portland Cement of Grade53
3. Concrete – GradeM40
4. Coarse aggregate –12mm
5. Fine aggregate –4.75mm

3.2 **Quantity of material used for casting:**

1. Paving Block
2. Chettinad Cement (OPC) 53 grade – 1Bag
3. Coarse Aggregate.
4. Natural Sand

5. Basalt Fiber Brown pigment (IS44)

3.3 MIX DESIGN :

Data Required for Concrete Mix Design

(i) Concrete Mix Design Stipulation

(a)Characteristic compressive strength required in the field at 28 days grade designation — M40

(b) Nominal maximum size of aggregate — 12 mm

(c) Shape of aggregate —Crushed angular aggregate

(d) Degree of workability required at site — 80 mm (slump)

(e) Degree of quality control available at site — As per IS:456

(f) Type of exposure the structure will be subjected to (as defined in IS: 456) — Moderate (g)Type of cement: PPC conforming IS: 456

(ii) Test data of material (to be determined in the laboratory)

(a)Specific gravity of cement — 3.15

(b) Specific gravity of FA — 2.65

(c) Specific gravity of CA — 2.88

(d) Aggregate are assumed to be in saturated surface dry condition.

(e) Fine aggregates confirm to Zone III of IS - 383

(f)Water absorption for coarse aggregate -0.250%

(h) Water absorption for fine aggregate -0.80%

(i)Free moisture content for coarse aggregate –Nil

(j)Free moisture content for fine aggregate -2.0%

3.4 **Procedure for Concrete Mix Design of M40 Concrete**

Step 1 — Determination Of Target Strength Himsworth constant for 5% risk factor is 0.825 In this case standard deviation is taken from IS:456 against M40 is 5.0.

ftarget =fck + 0.825 x S

= 40+ 0.825 x 5.0 = 44.10 N/mm2

Where, S = standard deviation in N/mm2 = 5(as per table -1 of IS 10262- 2009)

Step 2 — Selection of water / cement ratio:-

As per IRC: SP: 63-2004 the water cement ratio is in between 0.34 to 0.38 for paving block.

Let us take W:C = 0.36

Step 3 — Selection of Water Content

As per IRC: SP: 63-2004 the water content in the mix be 6% of total mix

Density of concrete = 2400kg/cu.m (as per IS 456)

Water content =6/100 X 2400

=144 lit.

Step 4 — Selection of Cement Content

1. Water-cement ratio = 0.36

2. Corrected water content = 144 lit

3. Cement content =

W: C =Water content / Cement content

0.36=144/Cement content, Cement content = 400kg

As per IRC: SP: 63-2004 (400kg> 300kg i.e. min. cement content for moderate condition)

Step 5 — Estimation of Coarse Aggregate proportion:-

From Table 3 of IS 10262- 2009, For Nominal maximum size of aggregate = 12 mm,

Zone of fine aggregate = Zone I And

For w/c = 0.36,
Volume of coarse aggregate As per IRC:SP:63:2004 proportion of C.A. should be 40% and F.A. 60%

Step 6 — Estimation of the mix ingredients
a) Volume of concrete = 1 m3
b) Volume of cement = (Mass of cement / density of cement) x (1/1000)
= (400/2.93) x (1/1000) = 0.136 m3
c) Volume of water = (Mass of water / Density of water) x (1/1000)
= (144/1) x (1/1000) = 0.144 m3
d) Volume of total aggregates = a – (b + c)
= 1 – (0.136 + 0.144) = 0.71 m3
e) Mass of coarse aggregates = 0.71X0.40X2.88X1000
= 817kg
f) Mass of fine aggregates = 0.71X0.60X2.65X1000
=1128.8kg

Recommended mix proportion for grade of concrete M40:
1:2.82:2.04

3.5 TABLE FOR MIX DESIGN

SR.NO	DATA	RESULT
1	Grade of concrete	M40
2	Type of exposure	Moderate
3	Design mix target slump	100mm
4	Max. size of coarse aggregate	20 mm
5	Fine Aggregate	Zone III
6	Specific gravity of cement	3.15
7	Specific gravity of water	1
8	Specific gravity of coarse aggregate	2.88
9	Specific gravity of Fine Aggregate	2.65
10	Water absorption of coarse aggregate	1.28%
11	Water absorption of Fine Aggregate	2.04%

4. CASTING

5. **CURING**

5. RESULT

➢ **Results on paving blocks**

1. **After 3 days test**

Sr No	% of Basalt Fiber	After 3 Days Compressive Strenth			
		1	2	3	Average
1	0%	19.72	18.87	20.81	19.80
2	0.6%	26.14	23.56	24.29	24.66
3	1.2%	19.92	16.84	16	17.58

2. **After 7 days test**

Sr No	% of Basalt Fiber	After 7 Days Compressive Strenth			
		1	2	3	Average
1	0%	28.72	27.66	28.56	28.30
2	0.6%	31.80	29.46	30.82	30.60
3	1.2%	28.64	29.68	29.76	29.36

CONCLUSION:

Based on experimental observation following conclusion can be established:

- **After Three Days:**
  The compressive strength of normal mix was **19.80** And after importing Basalt fiber at 0.6% it increases to **24.66** (i. e.0.118%) and that for 1.2% its decreases to **17.58** (i.e.0.15 %) than normal mix...
  This concludes that upto 0.6 % replacement increases compressive strength considerably to 0.118%

- **After Seven Days:**
  The compressive strength of normal mix was **28.30** And after importing Basalt fiber at 0.6% it increases to **30.6** (i. e.0.045 %) and that for 1.2% its **29.36** (i.e. 0.043%) than normal mix...
  This concludes that upto 0.6% replacement increases compressive strength considerably to **0.045**

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