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Experimental Investigation of Basalt fiber in Concrete

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Abstract: *Adding fiber can improve the brittleness of plain concrete. Compared with plain concrete, basalt fiber –reinforced concrete has the advantages of strengthening, toughening, and crack resistance. Compared with steel fiber-reinforced concrete, basalt fiber-reinforced concrete has better construction performance. Basalt fiber concrete is a type of inorganic material with environmental protection and high mechanical properties.* ***.*** *The main aim is to study the effect of different proportions of basalt fiber added as 5%, 10%, 15%, and 20% in the mix and to find the optimum range of basalt fiber content in the mix.*

Key Word: *Fiber, Basalt fiber, Concrete, Construction performance, environmental protection*

I. INTRODUCTION

Concrete is an artificial material, which has wider application in construction industry. The basic ingredients of concrete are Cement, Sand, Coarse aggregate, water. Now a day concrete is being used for wide varieties of purpose tomakeitsuitableindifferentconditions.Intheseconditionsordinaryconcrete may fail exhibit the required quality performance or durability. In such cases, admixture is used to modify the properties of concrete so as to make it more suitable for any situation**.** Since the cost of cement and sandhaveincreasedduetoincreasedcostofproductionandorincreaseddemand, there is an urgent need to replace them partially or wholly by cheaper material.

Cement concrete is a major construction material used worldwide. Due to the infrastructural needs of the developing countries, the need for concrete increases and consequently cement is needed at a large quantity. Unfortunately the production of cement releases large amount of CO_2 in to the atmosphere. This gas is a major contributor to the greenhouse effect and the global warming of the planet. In view of the global sustainable development, it is imperative that supplementary cementing materials such as admixtures should be used to replace large proportions of cement in the construction industry and must be cost effective.

II.MATERIAL AND METHODS

CEMENT:

OPC of 53 grade in one lot was procured and stored in air tight container. The cement used was fresh ie. Used within three months of manufacture. It should satisfy the requirement of IS 12262. The properties of cement are determined asperIS4031:1968andresults are tabulated.

S. No	Property	Value
1	Fineness	10%
2	Initial setting time	60 min
3	Final setting time	24 hrs
4	Standard consistency	29%
5	Specific gravity	3.15

Table1CementProperties

FINE AGGREGATE:

Fine aggregate generally consist of naturals and or crushed stone. Manufactured sand is a substitute of rivers and for construction purpose. The crushed sand is of cubical shape with grounded edges washed and graded to as a construction material. The size of M sand is less than 4.75mm.

COARSEAGGREGATE:

The coarse aggregate is strongest and porous component of concrete. Presence of coarse aggregate reduces the drying shrinkage and other dimensional changes occurring on account of movement of moisture. The coarse aggregate used to passes in 19 mm andretainedin11.4mmsieve.Itiswellgradedandcubicalinshape.

BASALT FIBER

Basalt is a natural, hard, dense, dark brown to black volcanic igneous rock originating at a depth of hundreds of kilometers beneath the earth and resulting the surface as molten magma. And it's gray, dark in colour, formed from the molten lava after solidification. The production of basalt fiber consists of melt preparation, extrusion, fiber formation, application oflubricatesandfinallywinding.methodisalsoknownasspinning.Afiberisa material made into a long filament with density generally in the order of300g/cm2 of 50cm. The aspect ratio of length and diameter can be ranging from thousand to infinity in continuous fibers. It is do not undergo any to xicreaction with water and do not pollute air also. The functions of the fibers areto carry the load and provide stiffness, strength, thermal stability and other structural properties in the BFRP.

PRINCIPLEOFFIBREREINFORCEDCONCRETE:

Fibers help reduce hazardous spelling at high temperatures, increase absorption of energy, increase strength, and reduce shrinkage cracks. There are various reasons for adding fibers in concretes. The homogenous distributions in the concretes are one of the major fiber benefits. Fiber-reinforced concrete has more tensile strength when compared to non-reinforced concrete. It increases the concrete's durability. It reduces crack growth and increases impact strength.Fibre-reinforcedconcreteimprovesresistanceagainstfreezingandthawing.

PROPERTIES

- To increase the strength of the ordinary concrete by adding basalt.
- To reduce the crack formed.
- To increase the durability.
- To find optimum amount of fibers

MATERIALTEST:

Fine aggregate

Determination of specific gravity of fine aggregate:

Weigh the clean and dry pycnometer with conical top(W1). Take200gm's sand in pycnometer bottle and determine its weight with the conical flask (W2).Add water without air bubble sand determine the weight with the conical top(W3). Remove the soil and water from the pycnometer. Fill the bottle with water and take the weight with conical top (W4).

Specific gravity, G=(W2-W1)/[(W4-W1)-(W3-W2)]

SL NO	W1(gm's)	W2(gm's)	W3(gm's)	W4(gm's)	SPECIFIC GRAVITY
1	655	980	1700	1500	2.6
2	655	990	1720	1530	2.16
3	655	980	1700	1510	2.4
	Mean specific gravity			=	2.3

Table 2specific gravity

Determination of fineness modulus of fine aggregate:

First sieve the1000gms of fine aggregate through4.75mm sieve and weigh the residue left behind on it and record it. The residue is then sieved through 2.36mm sieve and left over is weighed and tabulated. The above procedure is repeated. After tabulating the results compile the percentage of material retained in each of the sieve. Calculate the cumulative percentage of material retained one ach sieve and percentage of passing.

SLNO	**IS Sieve in mm**	**Aggregate In mm**	**Weight Retained In mm**	**%of weight retained**	**Cumilative percentage of weight retained**	**Percentage of passing**
1	4.75	4.75	30	3	3	97
2	2.36	2.36	14	1.4	4.4	95.6

3	1.18	1.18	44	4.4	8.8	91.2
4	600	600	194	19.4	28.2	71.8
5	300	300	246	24.6	76.6	23.2
6	150	150	150	15	95.9	4.1

Table 3Finenessmodulusof fine aggregate

Coarse Aggregate

Determination of specific gravity of coarse aggregate

Weigh the clean and dry pycnometer with conical top (W1) .Take 1000gms aggregate in pycnometer bottle and determine its weight with the conical flask (W2). Add water without air bubbles and determine the weight with the conical top (W3). Remove the aggregate and water from the pycnometer. Fill the bottle with water and take the weight with conical top(W4).

Specific gravity, G=(W2-W1)/[(W4-W1)-(W3-W2)]

S. No	**W1(KG)**	**W2(KG)**	**W3(KG)**	**W4(KG)**	**Specific Gravity**
1	0.655	1.66	2.34	1.72	2.82
2	0.655	1.65	2.38	1.69	2.84
3	0.655	1.64	2.30	1.67	2.76
4	MEANSPECIFICGRAVITY=2.80				

Table4Specificgravityofcourseaggregate

Shape Test Elongation Index:

The sample is sieved (63mm–6.3mm). A minimum number of200aggregateof each traction is taken and weighed. Now weigh aggregate retained on different sieve and noted one the total weight (W1). Each fraction is then gauged individually for length in a length gauge. The particles which are not passed or retained on the length gauge are weighed is(W2).

Elongation index=W1/W2 *100

Sl no	PASSING	RETAINED	LENGTHOFGAUGE	Weightoffraction200 Pass in kgm	Weight of aggregate in each fraction length gauge
1	63	50	81	0.233	0.233
2	50	40	58.50	-	0.169
3	40	31.5	40.5	-	0.184
4	25	20	32.4	0.340	0.340
5	20	16	25.4	0.195	0.195
6	16	12.5	20.2	0.119	0.119
7	12.5	10	14.2	0.020	0.020

Table5Elongationindex

- Elongation index =0.887/1.250* 100=70.96%

Flakiness index:

The sample is sieved with the sieve. In order to separate flaky material each fraction is then gauged for thickness on thickness gauge. Then the amount of flaky materials passing the gauge is weighed to an accuracy of atleast0. 1%of test sample (W1).

Table6Flakinessindex

Sln o	PASSING	RETAINED	Thickness of gauge	Weight of fraction	Weight of aggregate in each fraction passing
1	63	50	33.90	16.5	16.5
2	50	40	27	-	125
3	40	31.5	19.50	930	930
4	31.5	25	16.50	12.4	12.40
5	25	20	13.50	405	405

Fakiness index = 2740/ 3000*100 =91.33%

BASALTFIBER

- Chopped strand for composite applications is entirely made of 100% basalt continuous filaments.
- Moisture content -<0.30%
- Melting point -1350^{0C}
- Length -12mm

Procedure methodology

The following sequence was followed for this experimental study
The following sequence was followed for this experimental study

COLLECTIONOFLITERATUREREVIEW

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SELECTIONOFMATERIALS

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PRELIMINARYTESTONMATERIALS

↓

MIXPROPORTIONSANDMIXDESIGN

↓

CASTINGOFSPECIMEN

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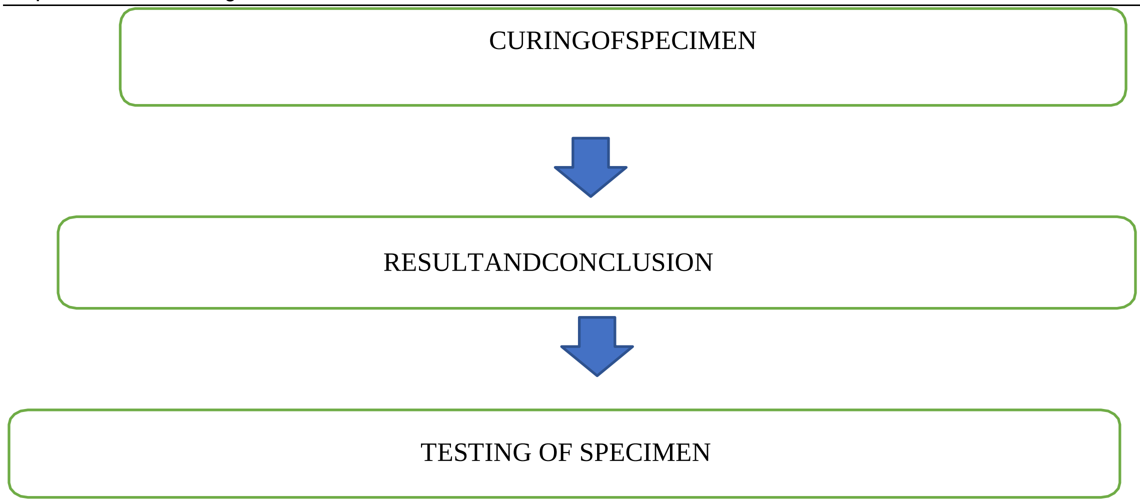


Collection of Literature Review:

We collected and studied the literature reviews based on basalt fiber from internet and many sites like Science direct, Directory of open access of journals, Google scholar e.t.c.

Selection of Material

- Cement
- Coarse aggregate
- Fine aggregate
- Basalt

The above mentioned materials were selected and collected from different local merchant shops. And basalt is collected from Fiber region Chennai.

Preliminary Test on Materials

The materials were selected accordingly through different test conducted like sieve analysis, specific gravity, shape test. And the good quality materials were selected.

Mix Proportion and Mix Design

Mix design is based on the grade of cement taken and the result gained from the test taken for the materials. Through mix design the mix proportions of cement, fine aggregate, coarse aggregate and water is known.

Casting of Specimen

The process include batching, mixing, placing, compacting. The batched materials are first mixed and the fresh concrete test like Slump conetest, Compaction factor test, Flow table test are taken. Then the mixed concrete is placed in the mould through compaction.

Curing of Specimen

The specimen is cured in water after demoulding it form the mould.

Testing of Specimen

Compression strength test and split tensile strength test is done for the specimen of in d out the strength of the concrete.

III.RESULT

Experiment al Investigation

Introduction

Production of quality concrete requires meticulous care exercised at every stage of manufacture of concrete. It is interesting to note that the ingredients of good concrete and bad concrete are the same. If meticulous care is not exercised and good rule are not observed the resultant concrete is going to be of bad quality with the same material if intense care is taken to exercise control ateverystageitwillresultingoodconcrete.Thereforeitisnecessaryforustoknowwhat are the important points to be followed in each stage of manufacture of concrete for producing good quality concrete.

- Preparation of mould
- Batching
- Mixing

- Placing
- Compacting
- Curing
- Finishing

The mould specification, preparation of mould, method of casting and curing are discussed in following

Sl. no	SPECIMEN	SIZE(MM)
1	CUBE	150x150 x150
2	CYLINDER	300x150mm

Table7Mouldspecification

Measurement of Workability

Slump Test

- The apparatus for conducting slump test consists of a metallic mould in the form of a frustum of a cone(bottomdiameter-20cm:topdiameter-10cm;height-30cm).
- For tamping the concrete, a steel tamping rod of 16 mm diameter, 0.6m long with bulleten disused.
- The mould is placed on a smooth, horizontal, rigid and non – absorbent surface. The mould is then filled in four layers . Each layer is tamped 25timesbythetampingrodbygivingstrokesevenlyoverthecrosssection.
- The mould is removed from the concrete immediately by raising it slowly and carefully in vertical direction. This allows concrete to subside and this subsidence is referred as SLUMP concrete.

Table8Slump test value

Sl. no	Percentage of fish scale added	Slump value(mm)
1	0	29
2	5	30
3	10	28
4	15	31
5	20	32

Compaction Factor Test:

Degree of compaction called compaction factor was measured by the density ratio. i.e the ratio of the density actually achieved in the test to the same concrete fully compacted. Standard compacting factor testing apparatus was used for this test.

In practical, compaction factor is calculated as,

$$\text{Compacting factor} = \frac{(\text{weight of partially compacted concrete})}{(\text{weight of fully compacted concrete})}$$

Sl no	Percentage of fish scale added	Compaction factor
1	0	0.77
2	5	0.78
3	10	0.79
4	15	0.80
5	20	0.82

Table 9Compactionfactorvalue

Testing of Specimen and Result Analysis

Testing of concrete plays an important role in controlling and confirming the quality of concrete. Cube, beam and cylinder are tested for its strength characteristics. The following are the test conducted.

- Compressive strength test
- Split tensile strength test

Testing of Specimen:

Compressive Strength Test

Compressive Strength Test is the most common test conducted on hardened concrete, partly because it is an easy test to perform, and partly because most of the desirable characteristic properties of concrete are qualitatively related to its compressive strength.

Test Procedure

- Prepare mould for a size of 150mmx150mmx150 mm
- After that mould should be placed in a compression testing machine of proper manner. Then load is applied gradually to the specimen.
- Finally when the specimen getting crack or failure that reading will be taken for calculation.

Formula

Compressive Strength = load / Area

Area=Lx B where

L =Length

B =Breadth

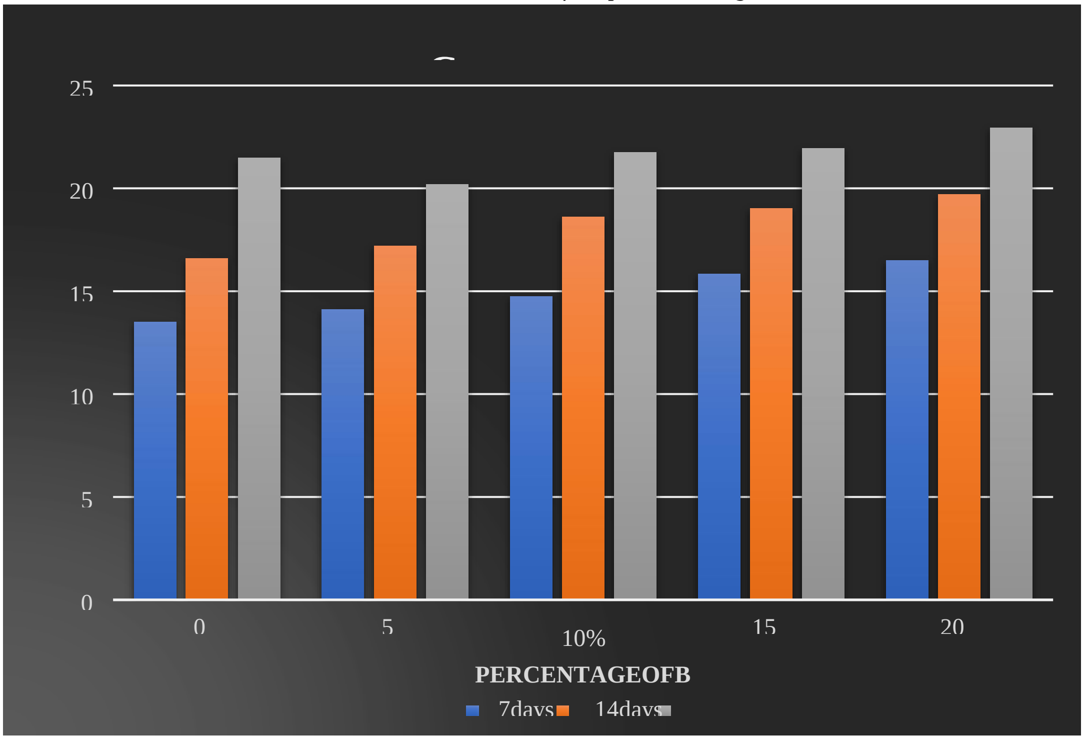
Size of specimen = 150mmX150mmx150 mm Area =22500mm^2

COMPRESSIVESTRENGTHTESTANDRESULTS:

Table10CompressiveStrengthofConventionalConcreteand Basalt

Description	Curing Days	% Replacement of RHA				
		0%	5%	10%	15%	20%
Compressive Strength(N/mm^2)	7	13.5	14.1	14.75	15.85	16.5
	14	16.6	17.21	18.61	19.02	19.71
	28	21.49	20.2	21.76	21.95	22.95

Chart1Barchartofcompressivestrength



Split Tensile Strength Test

The concrete cylinders of 150mm diameter and 300mm height were cast for finding the split Tensile Strength. The prepared cylinders were cured in water for 7, 14 and 28 days. The cured specimens were taken out and dried. After drying, the specimen is placed horizontally between the loading surface of the compression testing machine and the load is applied until the failure of the cylinder along the vertical diameter the test setup for split tensil The split tensile strength of concrete cylinder specimens was investigated by measuring the load and it was calculated by using the equation.

Formula

Split Tensile Strength = load/area

Area $=\pi$x D x L

Where

D = diameter

L =Length

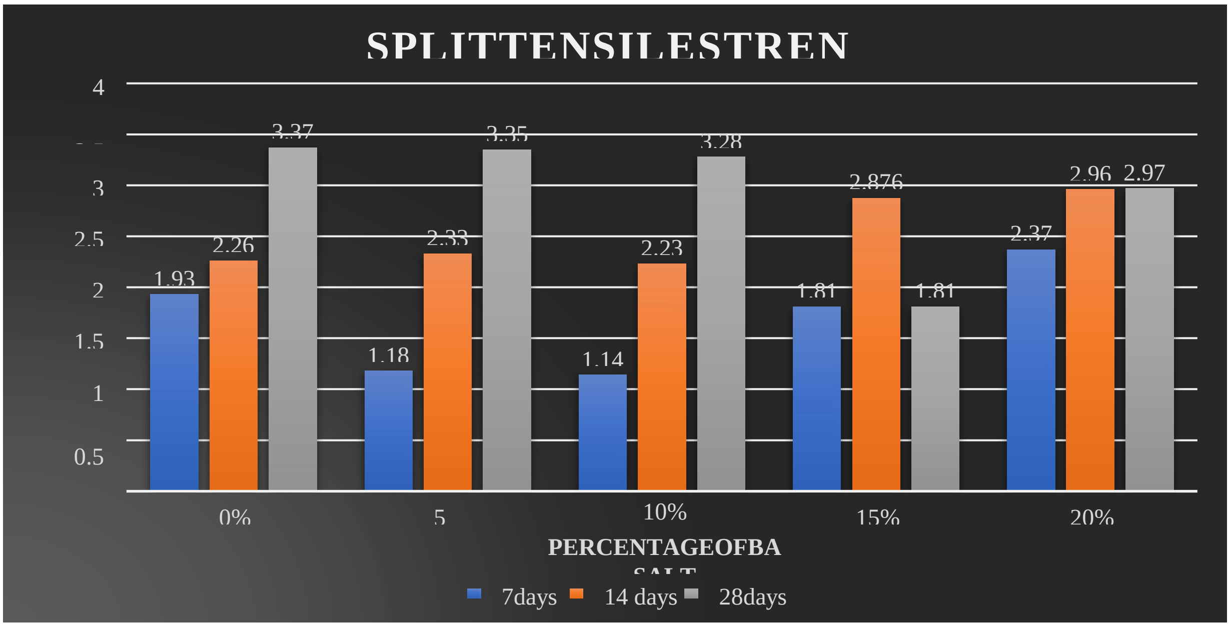
Size of specimen = 150mm x 300 mm Area =141371.7mm^2

Split Tensile Strength

Table11 Split Tensile Strength of Conventional Concrete and Basalt

Description	CuringDays	%of Basalt				
		0%	5%	10%	15%	20%
Split Tensile Strength(N/mm^2)	7	1.93	1.18	1.14	1.81	2.37
	14	2.26	2.33	2.23	2.87	2.96
	28	3.37	3.35	3.28	1.81	2.97

Chart2BarchartofSplit Tensile strength



IV.CONCLUSION

- The basalt fiber is now being a popular choice for the material scientist for the replacement of steel and carbon fiber due to its high rigidity and low elongation or extension at break. The benefit of using fiber is that it is non- corrosive. The strength is very good.
- The basalt fiber has possessed high tensile strength, better chemical and heat resistance. The fatigue strength of basalt fiber

re in forced concrete increases.

- Basalt fiber can be considered environmentally friendly and non-hazardous materials. It is not a new material, but its applications are surely innovative in many industrial and economic field.
- The impact resistance of basalt fiber reinforced concrete was found to be more than double as compared to normal concrete.
- The properties of basalt fiber were studied in which it was observed that basalt fiber are definitely a potential building material having higher thermal stability and high mechanical properties.
- Basalt rock fiber have notoxicreaction with air or water, are non–combustible and explosion proof.
- When in contact with other chemicals they produce no chemical reactions that may damage health or environment. Basalt is more cheaper than fiber glass and carbon fiber. Thus the cost of basalt fiber is considerably lower than that of similar material.
- From this study that the strength of basalt fiber will gain more than the design mix after 28days. The mix of 20% has attained the maximum compressive strength than the normal mix.

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