A Study on Structural Characteristics of Basalt Fibre Mix Concrete

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Abstract - *Addition of unsystematically spaced discontinuous fibre helps to slow down the spreading of micro and macro cracks and also aids in decreasing the crack width. This decreases the permeability of concrete. Addition of fibres also increases the mechanical properties of concrete such as fracture resistance, resistance to impact and dynamic load. In the recent years, use of composite material has been rapidly growing specially use of fibre reinforced polymer (FRP). Advances in FRP technology have resulted in increase in demand to introduce new types of fibres such as basalt fibre. Basalt fibre has attracted attention due to its temperature resistance, freeze-thaw performance and ease of manufacture. In this research, mechanical and elastic properties of concrete mixed with chopped basalt fibre are investigated. Basalt fibre specimens were cast using chopped basalt fibres of different lengths (12mm, 18mm and 24mm) and of different dosages (4 kg/m3, 8 kg/m3 and 12 kg/m3 of volume of concrete). The results indicated that 18mm length basalt fibre with dosages of 8 kg/m3 provides optimum compressive strength and 24mm length basalt fibre with dosage of 12 kg/m3 provides optimum flexural strength and split tensile strength when compared with plain concrete. 24mm length basalt fibre has shown greater performance under elastic properties than that of 12mm basalt fibre, 18mm basalt fibre and plain concrete.*

Key Words: Basalt fibre, Basalt fibre mixed concrete, Mechanical properties.

1.INTRODUCTION

Concrete is world's most commonly and widely used construction material, as it is very strong and versatile mold able construction material. But due to presence of numerous micro-cracks concrete is weak in tension. But addition of randomly spaced discontinuous fibre helps to slow down the spreading of micro and macro cracks and also aids in decreasing the crack width. This decreases the permeability of concrete. Addition of fibres also increases the mechanical properties of concrete such as fracture resistance, resistance to impact and dynamic load. In the recent years, use of composite material has been rapidly growing specially use of fibre reinforced polymer (FRP). Advances in FRP technology have resulted in increase in demand to introduce new types of fibres such as basalt fibre.

2. Past work

John Branston et al. (2016), this paper deals with relative merit of two types of basalt fibre that is bundle dispersion fibre and minibars in improving the mechanical properties of concrete. The specimens of concrete were cast with three different quantities of each basalt fibre and then analysed on the basis of flexural and drop weight test. Investigation of interfacial properties was done by electron microscopy scanning. The achieved results indicated that both types of fibres help in increasing pre-cracking strength, but it is observed that due to protection from polymer only minibars improved the post-cracking behaviour.

Fareed Elgabbas et al. (2017), the experimental study of determining the bond-dependent coefficient and the structural performance of basalt fibre reinforced polymer is presented through this thesis. Total six numbers of concrete beams of basalt fibre reinforced polymer bar were casted and tested up to its failure. 10, 12 and 16 mm basalt fibre reinforced polymer sand coated and helically wrapped bars were used. Beam specimens were tested under four point bending over 2700 mm clear span until its failure. The test results were observed for cracking behaviour, deflection and failure modes. The test results were achieved an average bond dependent coefficient of 0.76, whereas 0.8 is recommended by CSA S6-14 for sand coated bars.

Huang Zhang et al. (2017), in this paper, the impact behaviour of basalt fibre reinforced concrete with various volume contents subjected to various high strain rate was determined using a 74 mm diameter split Hopkinson pressure bar apparatus. According to the stress strain curve obtained by the experiment the effect of volume fraction and strain rate on dynamic compressive strength and toughness were studied. The research on the micro properties and pore structure of basalt fibre reinforced concrete is done by analysing the scanning electron microscope photographs. The distribution of fibre and interface between cement and fibre were observed. By observing the micro properties and pore structure of basalt fibre reinforced concrete, the strengthening mechanism and interface properties were analyzed.

J. F. Dong et al. (2017), an investigation on mechanical properties and microstructures of basalt fibre reinforced recycled aggregate concrete is highlighted through this paper. The replacement ratio of recycled coarse aggregate and content of basalt fibre are the main parameters considered in the study. The influence of the of parameters on the failure mode like compressive strength, tensile strength, elastic modulus, Poisson's ratio and the ultimate strain of basalt fibre reinforced recycled aggregate concrete is mainly focused in the research work. Observations and obtained results shows that the basalt fibres accumulated in pores and attached on the surface of mortar does not only strengthen the recycled aggregate concrete but also improve the microstructure of the interfacial transition zone, which helps in improving the strength and ductility of the recycled aggregate concrete. Hence, the basalt fibre reinforced recycled aggregate concrete can be used in construction to reduce the environmental hazards from large amount of earthquake waste from collapsed building.

3. Materials and Methods

1. **Cement** – Ordinary Portland cement (OPC) of 43 grade is used for mixed concrete.
2. **Coarse aggregate** – Well graded and normal weight gravel of size 20mm (70% of total weight of aggregate) and 10mm (30% total weight of aggregate) was used for mixed concrete
3. **Fine aggregate** – Well graded and normally weight river sand of zone I is used for mixed concrete.
4. **Chopped basalt fibre** – Chopped basalt fibre of various lengths at various dosages is used in mixed concrete. 12mm, 18mm and 24mm length of basalt fibre is used at dosages of 4 kg/m3, 8 kg/m3, 12 kg/m3 of volume of concrete of each length.
5. **Admixture** – MasterRheobuild 1125 super-plasticizer is used in mix concrete which helps to produce high performance concrete with longer workability retention.

Table 3.1, significant properties of material used

Materials	Specific Gravity
Cement	3.15
Fine Aggregate	2.78
Coarse Aggregate	3.03

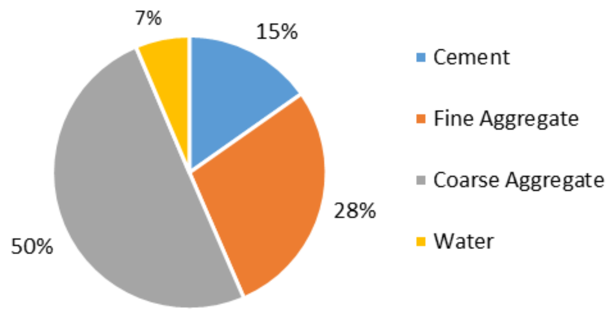
3.1. Mix Design

Mix design is carried out using IS 10262 – 2009 for M40 grade of concrete. The coarse aggregate was tested with reference to IS: 2386 – 1963. The specific gravity of coarse aggregate is found to be 3.02 and fineness modulus is 2 .75. Water absorption of coarse aggregate with reference to IS: 2386 (Part III) – 1963 was determined as 20 .6%. To determine the toughness of the aggregate the impact test was performed and the impact value obtained is 46.5%. To find compressive strength of coarse aggregate the crushing test was carried out and found to be 30.3%. Locally available river sand of bulk density 1860 g/m3 and specific gravity of 2.78 is used. The fineness modulus of river sand is 2.69. Ordinary Portland cement (OPC) of 43 grade is used in the experimental investigation confirming to IS: 12269 – 2013.

Table 3.2, Mix design for M40 grade concrete

	Cement	Fine aggregate	Coarse aggregate	Water
Quantity Kg/m3	400	742	1316	168
Ratio	1	1.86	3.29	0.42

Mix proportion for M40 grade concrete



Addition of Basalt fibre in concrete: -

Basalt Fibre (mm)	Kg Per volume of concrete
12 mm	4 Kg/m³
	8 Kg/m³
	12 Kg/m³
18 mm	4 Kg/m³
	8 Kg/m³
	12 Kg/m³
24 mm	4 Kg/m³
	8 Kg/m³
	12 Kg/m³

4. Experimental Program

4.1 Testing Specimens

The experimental program consisted of casting and testing of specimen's size of cubes 150 X 150 X 150 mm, cylinder 150 X 300 m and beam of 100 X 100 X 500 mm.

4.2 Compressive Strength

Table 4.1, Compressive strength of plain concrete specimen and basalt fibre mixed concrete specimens of various lengths at various dosages

Specimen	Basalt Fibre Dosage	Avg. compressive strength (N/mm2)	
		7 Day	28 Day
PC	–	26.68	43.53
BF (12 mm)	4 kg/m³	47.81	57.53
BF (18 mm)		47.89	57.30
BF (24 mm)		48.85	56.04
BF (12 mm)	8 kg/m³	46.02	56.58
BF(18 mm)		46.48	57.55
BF(24 mm)		44.59	55.53
BF (12 mm)	12 kg/m³	43.21	52.78
BF (18 mm)		42.82	51.57
BF (24 mm)		45.83	56.28

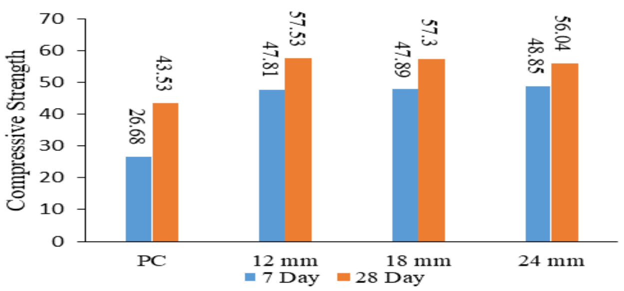


Fig 4.1, Compressive strength of basalt fibre mixed concrete specimens at dosage 4 kg/m³

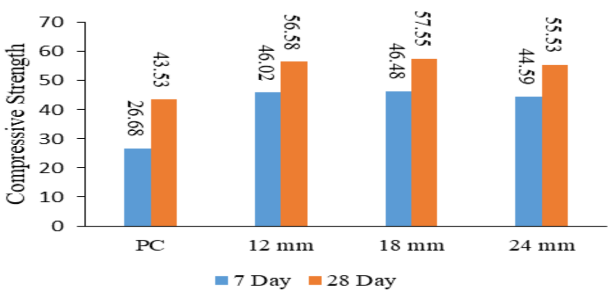


Fig 4.2, Compressive strength of basalt fibre mixed concrete specimens at dosage 8 kg/m³

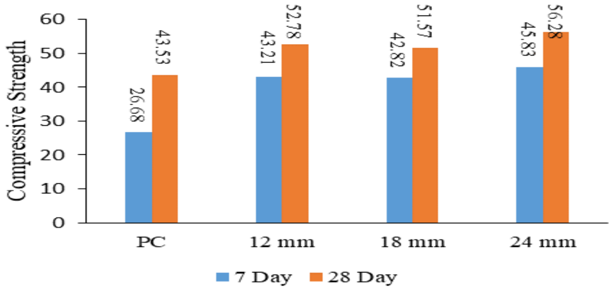


Fig 4.2, Compressive strength of basalt fibre mixed concrete specimens at dosage 12 kg/m³

4.3 Split Tensile Strength

Table 4.2, Split tensile strength of plain concrete specimen and basalt fibre mixed concrete specimens of various lengths of dosage 4 kg/m³

Specimen	Basalt Fibre Dosage	Avg. Tensile strength (N/mm2)	
		7 Day	28 Day
PC	–	3.51	4.05
BF (12 mm)	4 kg/m³	3.29	4.30
BF (18 mm)		3.19	4.27
BF (24 mm)		3.65	4.74
BF (12 mm)	8 kg/m³	3.38	4.41
BF (18 mm)		3.32	4.37
BF (24 mm)		3.71	4.72
BF (12 mm)	12 kg/m³	3.68	4.75
BF (18 mm)		3.33	4.78
BF (24 mm)		3.75	4.79

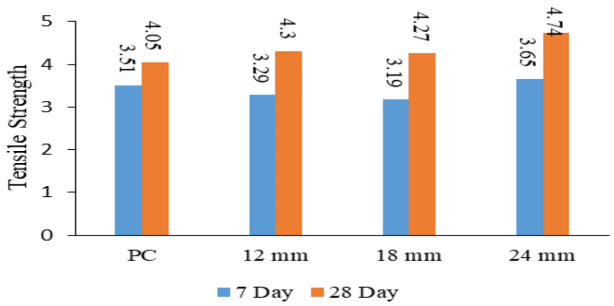


Fig 4.4, Split tensile strength of basalt fibre mixed concrete specimens at dosage 4 kg/m³

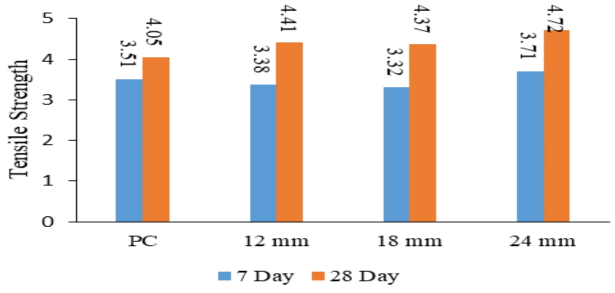


Fig 4.5, Split tensile strength of basalt fibre mixed concrete specimens at dosage 8 kg/m³

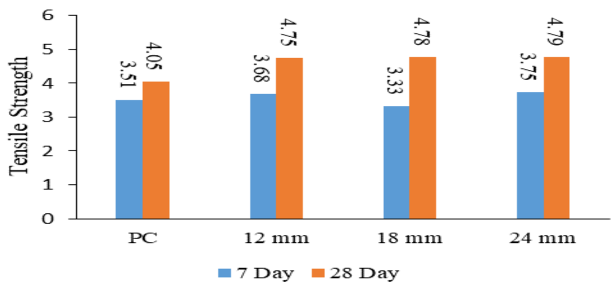


Fig 4.6, Split tensile strength of basalt fibre mixed concrete specimens at dosage 12 kg/m³

4.3 Flexural Strength

Table 4.3, Flexural strength of plain concrete specimen and basalt fibre mixed concrete specimens of various lengths of dosage 4 kg/m³

Specimen	Basalt Fibre Dosage	Avg. Flexural strength (N/mm2)	
		7th Day	28th Day
PC	–	3.56	5.41
BF (12 mm)	4 kg/m³	4.53	6.82
BF (18 mm)		4.58	6.97
BF (24 mm)		4.73	7.14
BF (12 mm)	8 kg/m³	4.96	7.20
BF (18 mm)		5.11	7.34
BF (24 mm)		5.24	7.56
BF (12 mm)	12 kg/m³	5.16	7.73
BF (18 mm)		5.48	7.92
BF (24 mm)		5.62	8.04

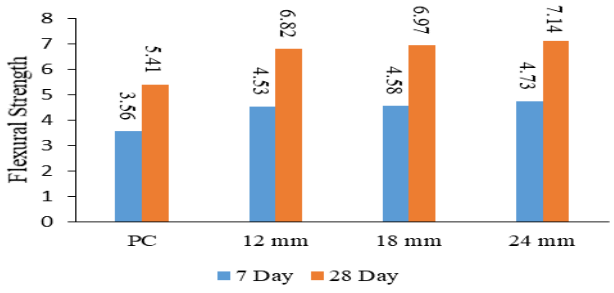


Fig 4.7, Flexural strength of basalt fibre mixed concrete specimens at dosage 4 kg/m³

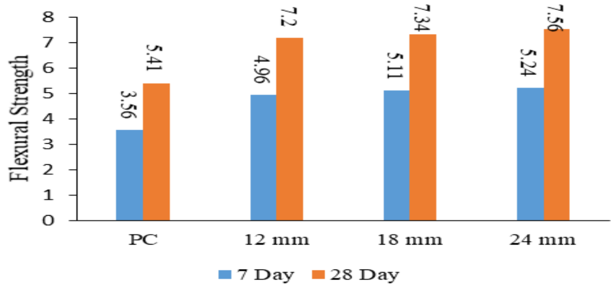


Fig 4.8, Flexural strength of basalt fibre mixed concrete specimens at dosage 8 kg/m³

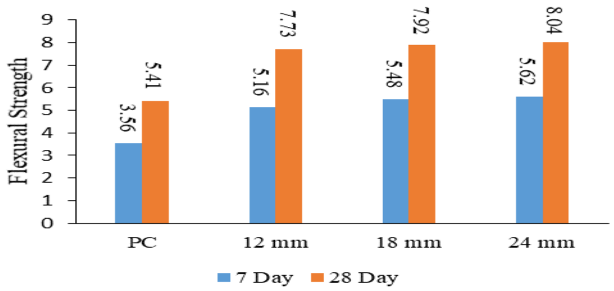


Fig 4.9, Flexural strength of basalt fibre mixed concrete specimens at dosage 8 kg/m³

5. CONCLUSIONS

The conclusions presented here are from the results obtained during this research. The results obtained after tests are specific for mentioned concrete mixed design and basalt fibre dosages. So, results may change for different concrete mixed design and different dosages. During the tests all plain concrete specimens and basalt fibre mixed concrete specimens failed in brittle and sudden manner. The results are concentrated on the mechanical and elastic properties of plain concrete and basalt fibre mixed concrete with different lengths (12mm, 18mm and 24mm) and different dosages of each length (4 kg/m3, 8 kg/m3 and 12 kg/m3) with respect to the volume of the concrete.

During this research, the behaviour of plain concrete and basalt fibre mixed concrete is observed under compressive test, split tensile test, flexural test and also behaviour is observed under elastic properties like plastic shrinkage, elastic modulus and Poisson's ratio. From above results and discussion it is found that there is huge increase in mechanical as well as elastic properties of basalt fibre mixed concrete as compared to that of plain concrete.

Following are the conclusions made on the basis of obtained results,

Effect of chopped basalt fibre on mechanical properties of concrete: -

1. It is found that the basalt fibre mixed concrete containing 24mm length basalt fibre with dosage of 4 kg/m3 has highest compressive strength at the age of 7 days and basalt fibre mixed concrete containing 18mm length basalt fibre with dosage of 8 kg/m3 has highest compressive strength at the age of 28 days. From result analysis it is found that there is almost 32% increase in the compressive strength in comparison with plain concrete.

2. It is found that the basalt fibre mixed concrete containing 24mm length basalt fibre with dosage of 12 kg/m3 has highest tensile strength at the age of 7 days as well as at the age of 28 days. From result analysis it is found that there is almost 18% increase in the tensile strength in comparison with plain concrete.

3. It is found that the basalt fibre mixed concrete containing 24mm length basalt fibre with dosage of 12 kg/m3 has highest tensile strength at the age of 7 days as well as at the age of 28 days. From result analysis it is found that there is almost 49% increase in the tensile strength in comparison with plain concrete.

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