Flexural Behaviour Of Basalt Fibre Reinforced Concrete Filled Mild Steel Tube Beams

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Abstract- *Plain Concrete has a major deficiency of low tensile strength. The tensile strength of concrete is very low because normally concrete contains numerous micro cracks. This deficiency has lead to considerable research for improving the tensile strength of concrete. This paper introduces an innovative reinforced concrete filled steel tube beams for improved flexural behaviour and tensile strength of steel and concrete composite structures. The strength and ductility of the core concrete are the important factors that influence the bearing capacity of concrete – filled steel tube structures.*

The study is aimed at the effect of basalt fibre on the flexural behaviour of Concrete Filled Mild Steel Tube Beams. Basalt fibre of 12mm length and 13µm diameter is used for the study. The fibre is mixed with M30 grade concrete.

Conventional concrete is tested for its compressive strength, and split tensile strength using 9 cubes, and 9 cylinders respectively at the age of 3,14 and 28 days. Basalt Fibre Reinforced Concrete is also tested for the above properties.

Basalt Fibre Reinforced Concrete in – filled rectangular mild steel tube beams of sizes 2"x4" and 5.5"x4" and conventional size concrete beams with and without fibre reinforced are tested for the flexural behaviour under four – point load test and the comparative values are recorded and analysed.

Keywords- Concrete Filled Steel Tubes (CFST), Fibre Reinforced Concrete (FRC), Basalt Fibre, Basalt Fibre Reinforced Concrete (BFRC) Flexural Strength.

I. INTRODUCTION

Concrete-filled steel tubes (CFST) are composite materials formed by filling concrete into thin-wall steel tubes. Characterized by advantages such as excellent bearing capacity, rapid construction, and good anti-seismic performance, these structures have extensively utilized in bridge and architectural engineering. The load-bearing capability of CFST structures greatly depends on the performance of core concrete greatly influence on, and previous studies have demonstrated that the mechanical property of core CFST is the key factor determining the bearing capacity of steel tubes and its other properties. The incorporation of fiber has become the main approach for improving the mechanical properties of concrete. At present, fibres used in concrete mainly including basalt fibre.

II. EXPERIMENTAL PROGRAM

A. Materials Used

1. Ordinary Portland Cement

Portland cement is the most common type of cement in general use around the world, used as a basic ingredient of concrete, mortar, stucco, and most non-specialty grout. It was developed from other types of hydraulic lime in England in the middle 19th century and usually originates from limestone.

TABLE 1 Physical Properties of Cement

S.no	Property	Result
1	Standard consistency	32%
2	Initial setting time	34mins
3	Final setting time	7hr 35mins
4	Fineness of cement	5%
5	Specific gravity	3.15

2. Fine Aggregate

Sand was used as fine aggregate for the experiments. Various tests were conducted to determine the properties of sand which are shown in table 2. Grading is the particle-size distribution of an aggregate as determined by a sieve analysis. The test was done according to IS: 2386 (Part 1)-1963.

TABLE 2Properties of Fine Aggregate

S.no	Property	Result
1	Specific gravity	2.74
2	Fineness modulus	2.1
3	Grading zone	2
4	Water absorption	1.2%
5	Type	Medium

3. Fine Aggregate

Aggregates of 12mm size were chosen for the experiment which is clean and free from deleterious materials. The following table 3 shows the tests conducted in order to determine the properties of this aggregate.

TABLE 3 Properties of Coarse Aggregate

S.no	Property	Result
1	Specific gravity	2.78
2	Type	crushed
3	Water absorption	0.4%
4	Aggregate size	12mm

4. Basalt Fibre

a) Physical Properties

- Colour - It is available in golden brown in colour.
- Diameter - 13µm
- Length- 12mm
- Density - density of basalt fibre is 2.75 g/cm^3
- Coefficient of friction - The coefficient of friction may be 0.42 to 0.50.

b) Chemical Properties

- Basalts are more stable in strong alkalis.
- Weight loss in boiling water, Alkali and acid is also significantly lower.
- Possess resistance to UV- Light & biologic and fungal contamination.

B. Concrete Mix Proportion

The mixture proportioning was done according to Indian Standard Recommended method IS – 10262 – 2009. The target strength was 30 MPa. The total cement quantity was 440 Kg/m^3, fine aggregate quantity is 831.6 Kg/m^3, coarse aggregate used was 12mm in size and the quantity used was 948.68 Kg/m^3, Water Cement Ratio was kept as 0.45. The hollow mild steel tube beams used was of two sizes 4x2" and 5.5x4". The CFST beam specimens were casted and kept in curing for 28 days.

TABLE 4 Mix Proportion Ratio

Water-Cement Ratio	Cement	Fine aggregate	Coarse aggregate
0.45	1	1.89	2.2

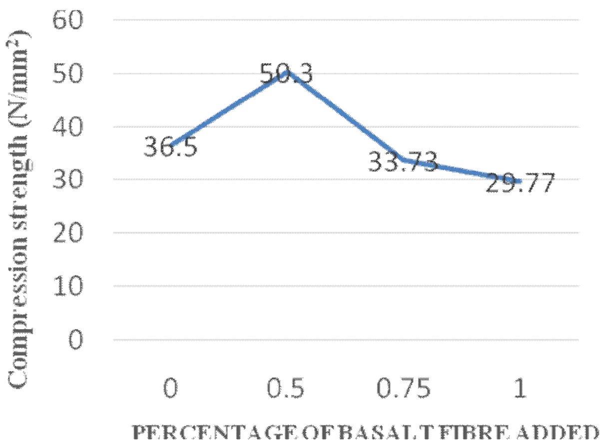
C. Experimental Analysis

(1) Compressive Strength

The compressive strength is the capacity of a material or structure to withstand loads tending to reduce size. It can bemeasured by plotting applied force against deformation in a testing machine. The test results are given below

TABLE 5Compressive Strength Results

% of Fibre	Compressive Strength (N/mm^2)		
	3 days	14 days	28 days
0%	16.51	28.9	36.5
0.5%	18.94	44.5.	50.3
0.75%	14.23	33.27	33.73
1.0%	12.80	21.33	29.77

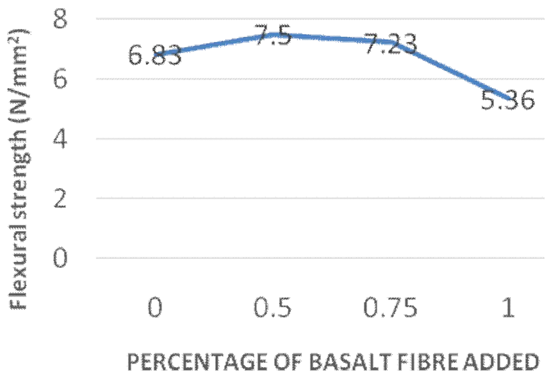


(2) Flexural Strength

The flexural strength for conventional concrete and basalt fibre mixed concrete was tested at 28 days of testing and the results are given below

TABLE 6 Flexural Strength Results

% of Fibre	Flexural Strength (N/mm^2)
0%	6.83
0.5%	7.50
0.75%	7.23
1.0%	5.36

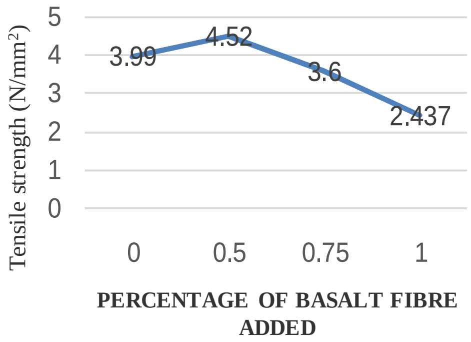


(3) Split Tensile Strength

The split tensile strength test for conventional concrete and basalt fibre mixed concrete were tested at 28 days. The results are given below

TABLE 7 Flexural Strength Results

% of Fibre	Tensile Strength (N/mm^2)
0%	3.99
0.5%	4.52
0.75%	3.60
1.0%	2.437



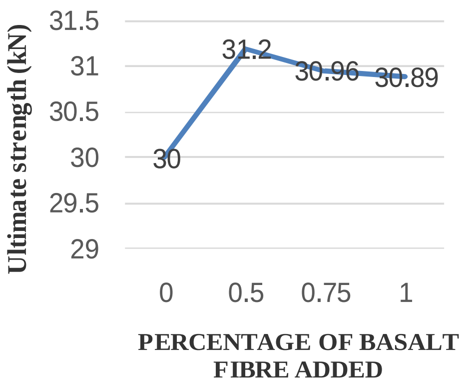
(4) Flexure test on CFST Beams

A total of 8 rectangular beam specimens were tested for this research. All specimens were tested with M30 grade of concrete. The specimens were 4x2" and 5.5x4" in size and 900 mm in length. The beams were classified as four types in both the sizes as 0%, 0.5%, 0.75%, and 1% of Basalt fibre reinforced concrete. The specimens are tested for flexural strength and static deflection. Electric strain gauge was used to note down the readings.

(a) 4x2" CFST beam

2) TABLE 8 Flexural Strength Results

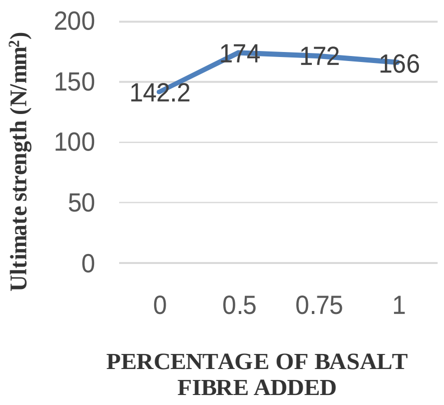
% of Fibre	Flexure Strength (N/mm^2)
0%	30 kN
0.5%	31.2 kN
0.75%	30.96 kN
1.0%	30.89 Kn



(a) 5.5x4" CFST beam

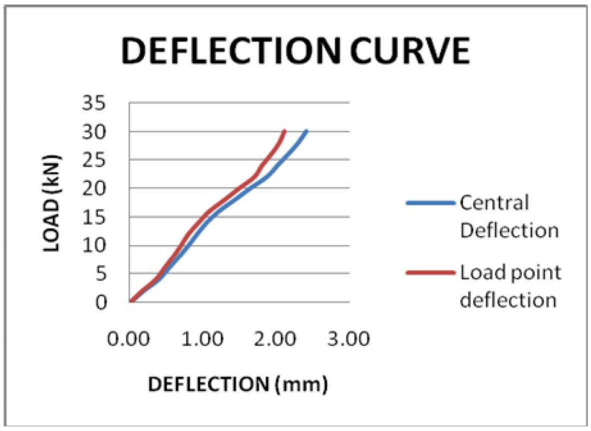
TABLE 9 Flexural Strength Results

% of Fibre	Flexure Strength (N/mm^2)
0%	142.4 kN
0.5%	174 kN
0.75%	172 kN
1.0%	166 kN

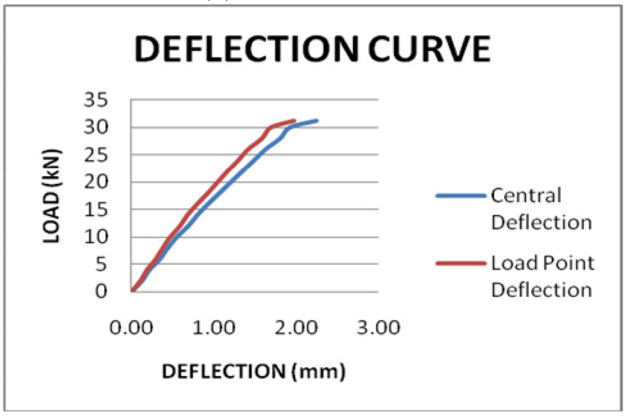


(2) Static Deflection Test on CFST Beams

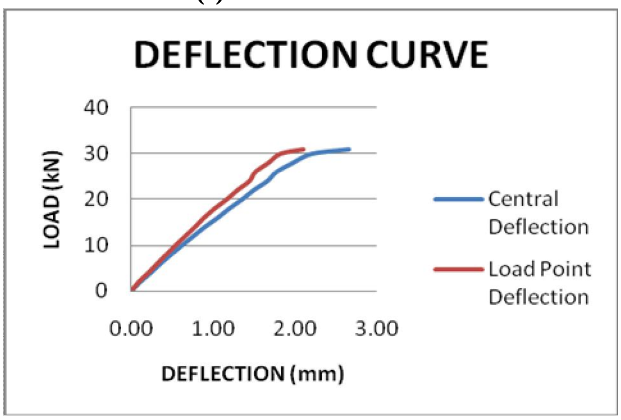
(a) 0% Fibre in 4x2" CFST beams



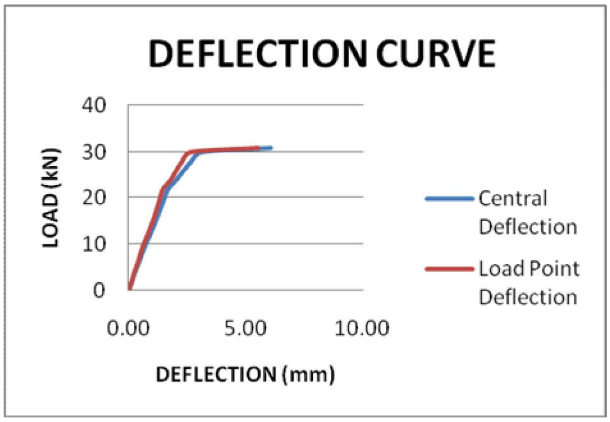
(b) 0.5% Fibre in 4x2" CFST beams



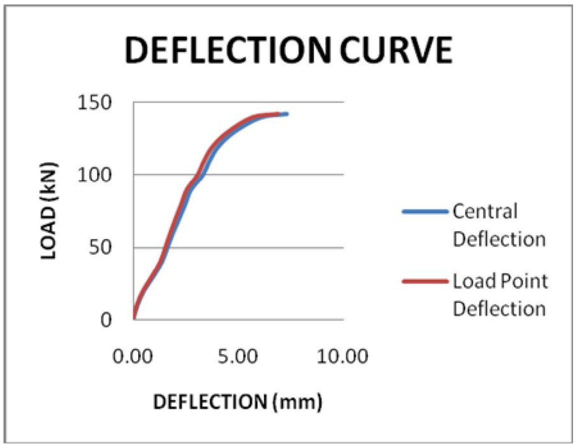
(c) 0.75%Fibre in 4x2" CFST beams



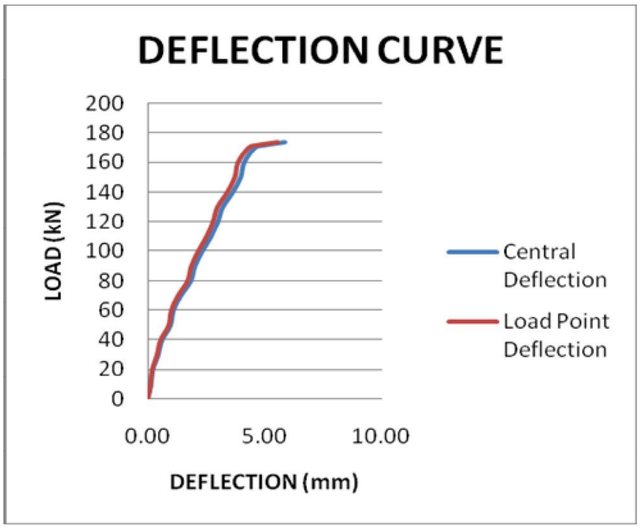
(d) 1.0% Fibre in 4x2" CFST beams



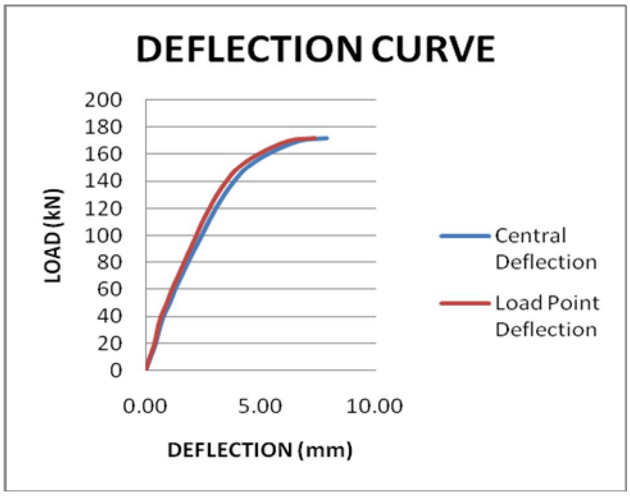
(e) 0% Fibre in 5.5x4" CFST beams



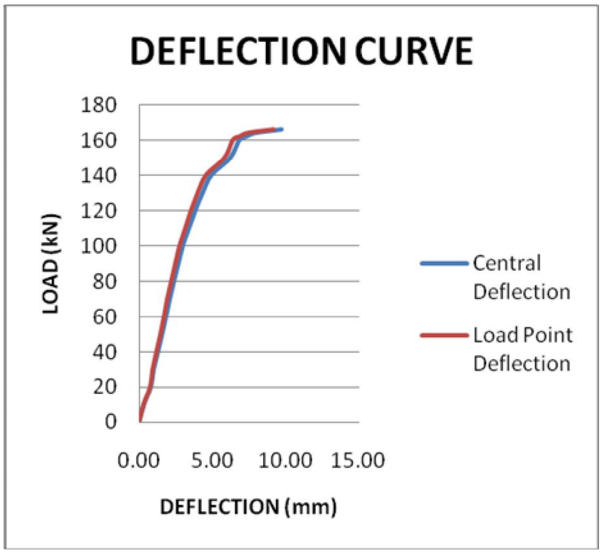
(f) 0.5% Fibre in 4x2" CFST beams

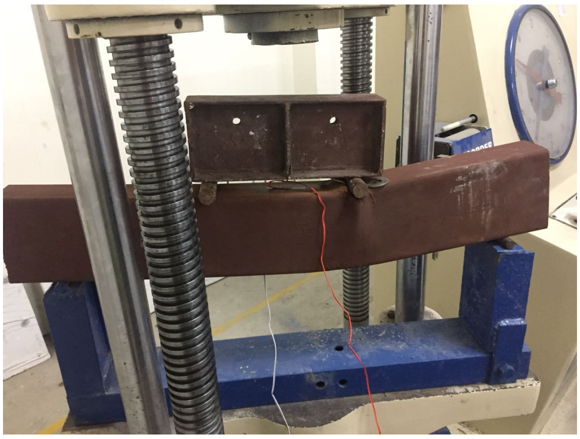


(g) 0.75%Fibre in 5.5x4" CFST beams

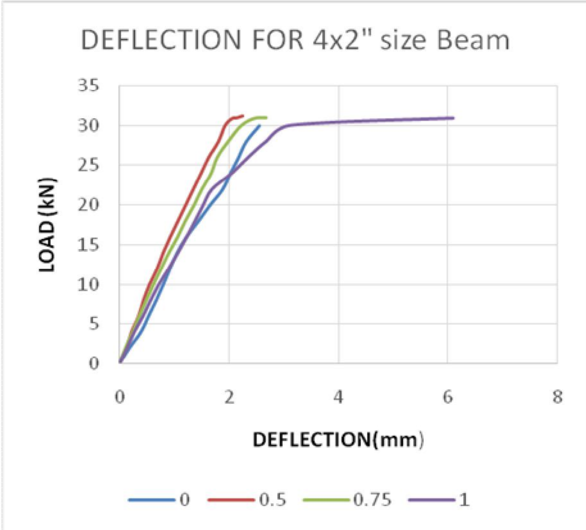


(h) 1.0% Fibre in 4x2" CFST beams





(3) Consolidated Comparison



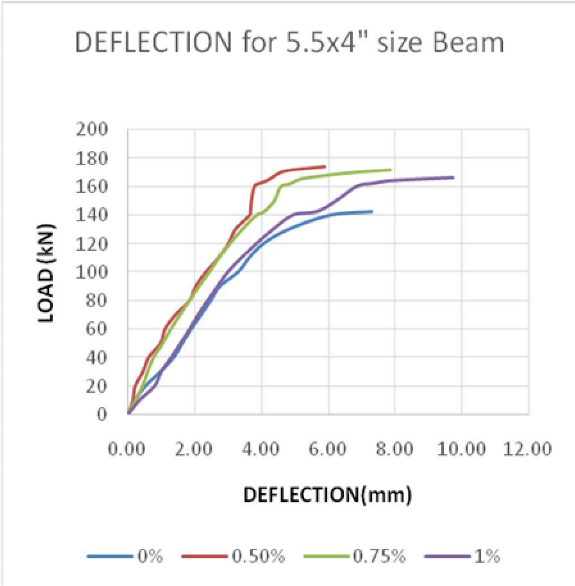


TABLE 10 Consolidated Results

III. CONCLUSION

- When Basalt fibre is in contact with other chemicals they do not produce any harmful chemical reactions that cause damage to the environment.
- Addition of basalt fibre to the Concrete filled steel tube increases the flexural strength of CFST Beams, but it is found that after certain percentage of volume of basalt fibre the strength decreases.
- 0.5% of volume of basalt fibre increases the flexural strength of CFST Beams by 22.19% (for 139.8x101.6mm size beams) & 4% (for 101.6x50.8 mm size beams) and any furthermore addition of basalt fibre leads to decrease in the flexural strength of the specimen.

- Basalt fibre which acts as crack arrestors reduces the deflection of the CFST Beam specimens. 0.5% of basalt fibre reduces 11.76% (for 101.6x50.8 mm size beams) and 19.32% (for 139.8x101.6mm size beams) and addition of furthermore % of fibre increases the deflection of the beam specimen.
- This experimental study shows that the optimum percentage for use of basalt fibre as reinforcing in concrete is 0.5% or any less which increases the flexural strength and reduces the deflection and cracks of CFST Beams.

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