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CONCRETE FILLED STEEL TUBULAR COLUMN WITH BAMBOO INFILL

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Abstract - *Composite columns are structural members which are subjected mainly to axial compressive forces and end moments. CFST columns are type of composite column. Concrete filled steel tubular columns have been used widely in the construction nowadays. Research about CFST columns are going over years. This project mainly investigate about the ultimate load carrying capacity of bamboo infilled CFST columns. Load deformation behaviour of bamboo infilled CFST columns have also been studied.10 specimens have been casted. Both square and circular specimen have been casted. For experimental study different cross sectional area of bamboo has been taken. The results indicate that the bamboo infilled CFST specimen has higher strength-weight ratio compared to control specimen. It has been found that square CFST bamboo infilled columns has higher energy absorption capacity compared to control specimen. It has also been found that by the use of bamboo as an inner core element the amount of concrete can be reduced. Bamboo infilled CFST specimens have lower load carrying capacity compared to CFST columns.*

***Key Words*: CFST, Bamboo, Load deformation, Strength-weight ratio, energy absorption capacity.**

1. INTRODUCTION

Concrete filled steel tubular columns (CFST) is a type of composite columns in which steel tube filled with concrete. It has been used widely in construction practices because of its high strength, high ductility and higher fire resistance compared to steel or concrete columns. It comprises of steel hollow section of circular, square and rectangular shape filled with plain concrete. It has the composite action of both steel and concrete.Sankar et.al [3],Uenaka [4] Yan [6] have determine the mechanical behaviour of CFST and CFDST columns experimentally.Tohid et.al[11] describes about the load carrying capacity of concrete filled steel tubular columns with timber infill.Wen[13] describes about the axial load behaviour of structural bamboo filled with concrete. Based on the above literature a bamboo is placed on the CFST columns and inside the bamboo concrete is placed.

2. EXPERIMENTAL INVESTIGATION

10 concrete filled steel tube (CFST) specimens, 3 plain concrete filled and 7 bamboo infilled CFST specimens are taken for the study. Specimens of both circular and square shape CFST specimens are taken for the study. Various cross-sectional area of bamboo are used for the study. The details of the specimen are shown in Table1. The constituent materials were weighed in weighing balance with maximum capacity of 300 kg. Concrete mixer was used for mixing concrete. Initially the coarse aggregate was added in the mixer. Subsequently, fine aggregate and cement were added. Then required quantity of water was added slowly into the mixer to form consistent mixture. The diagrammatic representation of specimens are given below in Fig 1.

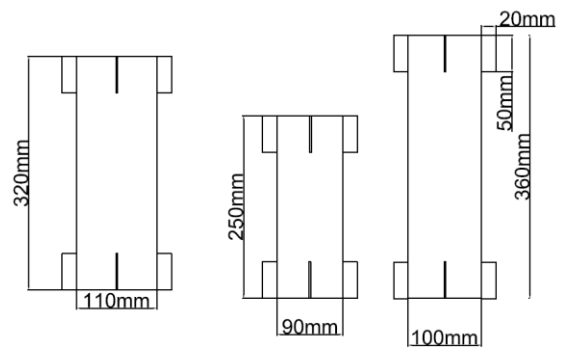

Fig-1 : Front view of specimens

2.1 Materials

Before testing the column, the mechanical properties of steel, concrete and bamboo has been determined. Mild steel has been used in the study. The properties of mild steel has been given in table 2.The average compressive strength of concrete is given in table 3 and the properties of bamboo are given in table 4

2.2 Casting of Specimens

Hollow square and circular steel tubes are placed on the smooth plane surfaces. Bamboo is placed centrally on the steel tube. Node inside the bamboo is drilled out. Concrete filled inside the steel tube and inside the bamboo and compacted using the compaction rod. Curing of CFST columns are done by applying paint on the exposed surfaces. After 28 days of curing specimens are ready for testing.

Table -1: Details of Specimens

SI No	Shape of Column	Thickness (mm)	Length (mm)	Diameter or size of steel column (mm)	Bamboo outer dia (mm)	Bamboo inner dia (mm)	Specimen Designation
1	Circular	2	250	90			SC-1
2	Circular	2	250	90	42.1	31.4	SC-2
3	Circular	2	250	90	33.1	11.84	SC-3
4	Circular	2	250	90	51.08	32.26	SC-4
5	Square	2	360	100			LS-1
6	Square	2	360	100	53.86	33.84	LS-2
7	Square	2	360	100	65.3	28.94	LS-3
8	Circular	3	320	110			LC-1
9	Circular	3	320	110	44.26	17.86	LC-2
10	Circular	3	320	110	68.34	33.14	LC-3

Table 2- Properties of mild steel

Properties	Value
Yield strength	250 Mpa
Ultimate tensile strength	410 MPa
Poisson's ratio	0.3
Modulus of elasticity	200 GPa

Table 3- Properties of concrete

Property	Value
Average Compressive strength	31.23 N/mm^2

Table 3- Properties of Bamboo

Property	Value
Tensile strength	94.26 MPa
Compressive strength	53.67 MPa

Fig-2 : Casting of CFST specimens

2.4 Experimental Test setup

CFST columns are subjected to an axial loading and is tested on compression testing machine of capacity 2000 kN.The dial gauge is placed on the bottom of the loading plate.The test specimens are placed centrally and concentric loading is given on the specimen.For every 25 kN the dial gauge readings are noted.Similarly the load deformation graph are obtained .The test setup is shown below Fig 3 and Fig 4.

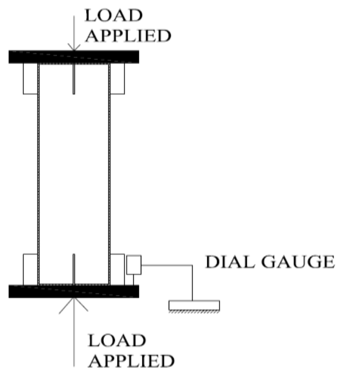

Fig-3 : A schematic view of test setup

Fig-4 : Experimental test setup

3. RESULTA AND DISCUSSIONS

A total of 10 bamboo infilled CFST specimens were casted. The tests were conducted to determine the ultimate axial load carrying capacity of bamboo infilled CFST column (CFSTB) and also to study the load deformation behaviour, failure modes and energy absorption capacity.

The test results are given below

Table 5- Test results of CFSTB circular specimen with 90 mm diameter

SI No	Specimen designation	Ultimate load (kN)	Ultimate deflection (mm)
1	SC-1	450	9.25
2	SC-2	402	9
3	SC-3	385	7.5
4	SC-4	290	6.98

Table 6- Test results of CFSTB square specimen with width 100 mm.

SI No	Specimen designation	Ultimate load (kN)	Ultimate deflection (mm)
1	LS-1	520	4.7
2	LS-2	510	5.1
3	LS-3	500	4.44

Table 7- Test results of CFSTB circular specimen with diameter 110 mm

SI No	Specimen designation	Ultimate load (kN)	Ultimate deflection (mm)
1	LC-1	580	4.6
2	LC-2	520	4.38
3	LC-3	470	4.05

3.1 Ultimate Load

The Chart 1 shows the variation of ultimate load of circular specimen with dia 90 mm and 250 mm height. From below Fig we inferred that ultimate load carrying capacity of control specimen (SC-1) is higher compared to bamboo infilled specimen. It is because the amount of concrete present in the bamboo filled specimen is less compared to control specimen.SC-4 has lower load carrying capacity because it has highest cross sectional area of bamboo.

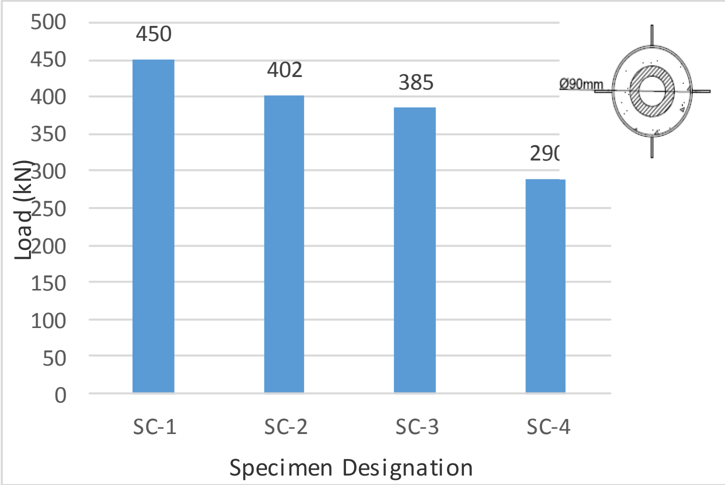

Chart -1: Variation of ultimate load of CFSTB circular specimen with diameter 90 mm

The Chart 2 shows the variation of ultimate load of square specimen of width 100 mm and height 360 mm. From the fig below inferred that ultimate load carrying capacity of control specimen is higher compared to other bamboo infilled specimen .As the area of bamboo specimen increases ultimate axial load carrying capacity decreases.

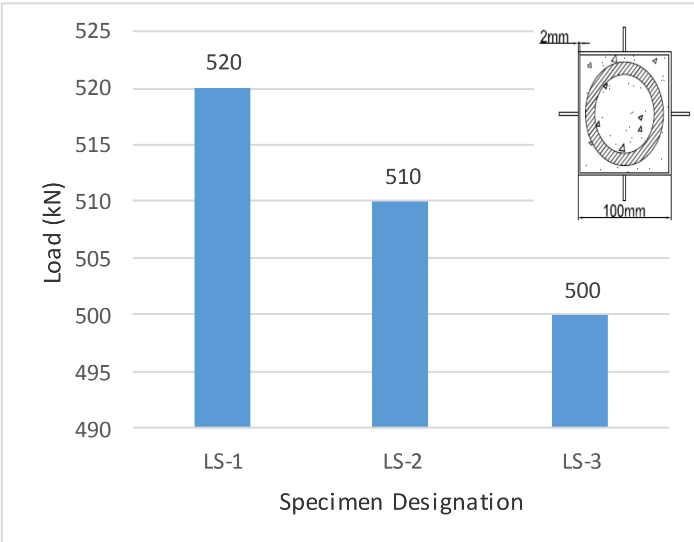

Chart 2 – Variation of ultimate load of CFSTB square specimen with width 100 mm.

The Chart 3 shows the variation of ultimate load of circular specimen with 110 mm diameter and height 320 mm.From the Fig below it is observed that ultimate load carrying capacity of control specimen is higher compared to bamboo infilled specimen.

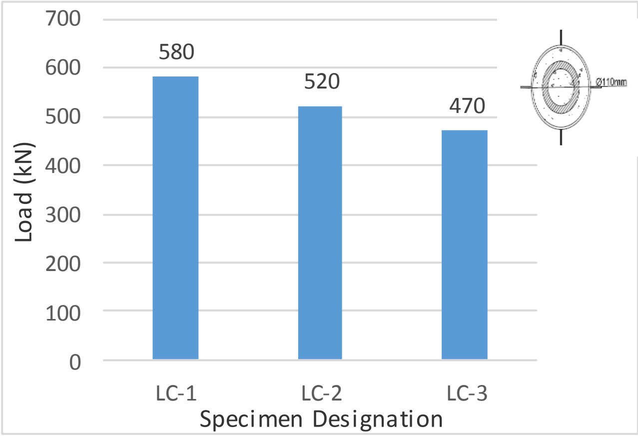

Chart 3- Variation of ultimate load of CFSTB circular specimen with width 100 mm.

3.2 Load deformation graph

Based on the load deformation curve, the specimens experience 3 stages until failure. Stage 1 is the initial stage of loading. The specimens were in elastic phase of loading, the load –deformation graph behave linearly. Stage 2 – when the applied load reaches 60% of ultimate load, the steel tube began to yield and load deformation curves shows elastic to plastic behaviour. Local buckling of steel tube starts initially at the mid height of column. Stage 3- after the ultimate load has reached the load bearing capacity of specimen decreases but the deformation increases. The chart 4 gives the load deformation graph of CFSTB circular specimen with diameter 90 mm.

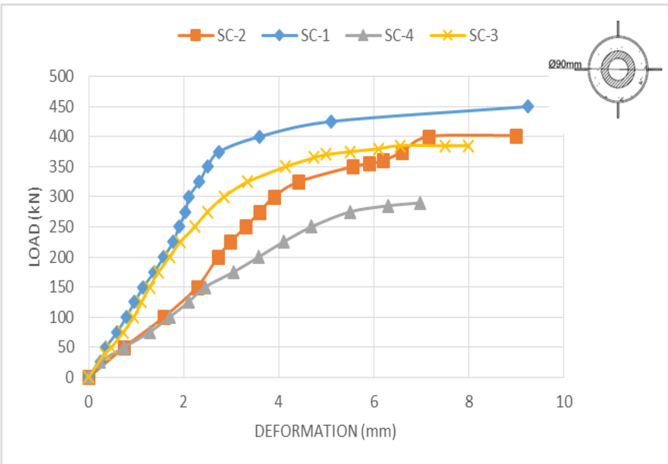

Chart 4- Load deformation graph of CFSTB circular specimen with diameter 90 mm

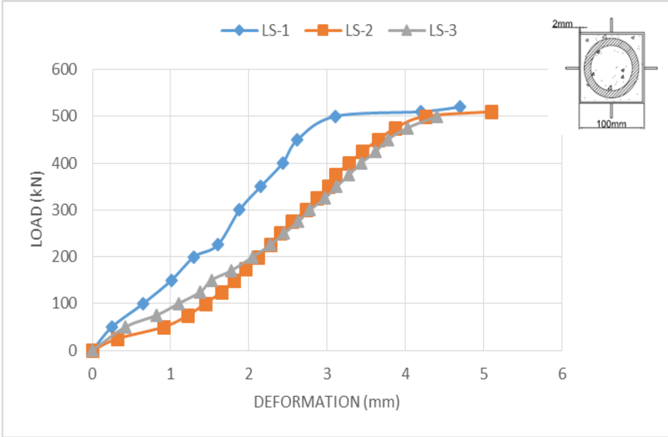

Chart 5 – Load deformation graph of Square CFSTB specimens with width 100 mm

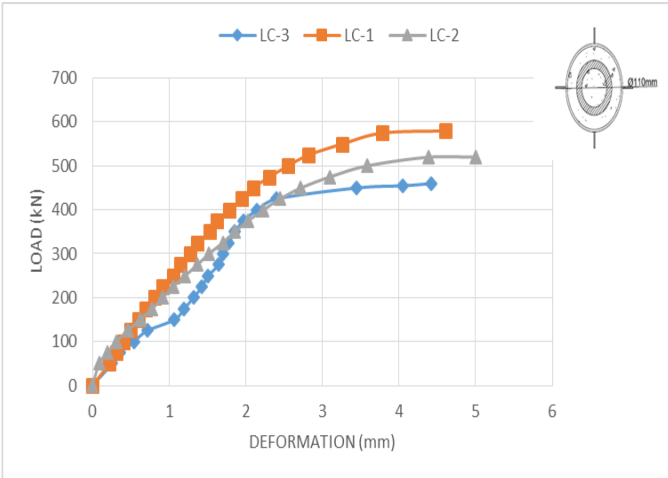

Chart 6- Load deformation graph of circular CFSTB specimens with diameter 110 mm

3.3 Strength-weight ratio

The strength to weight ratio is defined as ultimate bearing capacity divided by weight of the section. The strength to weight ratio can be shown in below figures. The Chart 7 shows the strength-weight ratio of CFSTB circular specimen with diameter 90 mm.The strength-weight ratio of CFSTB columns has higher strength-weight ratio compared to control specimen. It is therefore concluded that higher strength to weight ratio leads to significant savings in material. It can be used in places where more bamboo is available. It can be used in low rise buildings. Cost of bamboo is comparatively less compared to steel. Chart 8 shows the strength-weight ratio of CFSTB square specimen with width 100 mm. The Chart 8 inferred that all CFSTB specimens have higher strength to weight ratio compared to control specimen. It is therefore concluded that higher strength to weight ratio leads to significant savings in material. Chart 9 shows the strength-weight ratio of CFSTB circular specimen with diameter 110 mm.

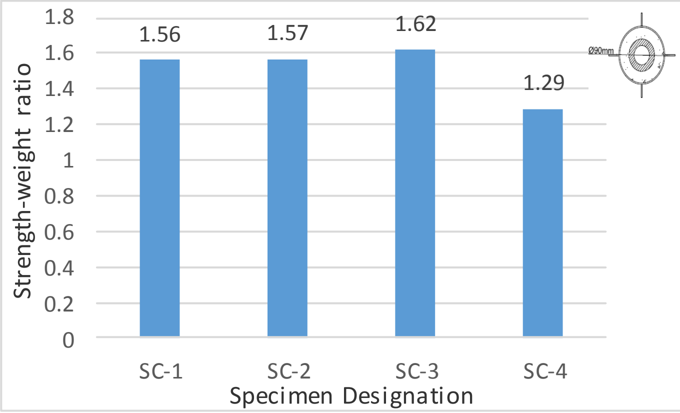

Chart 7-Strength-weight ratio of CFSTB circular specimen with diameter 90 mm

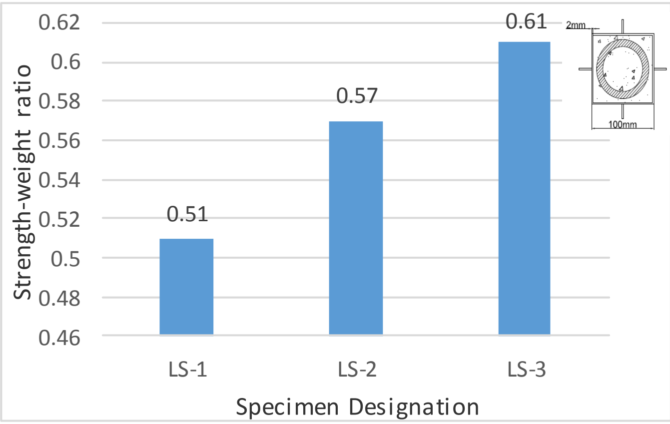

Chart 8 - Strength-weight ratio of CFSTB square specimen with width 100 mm

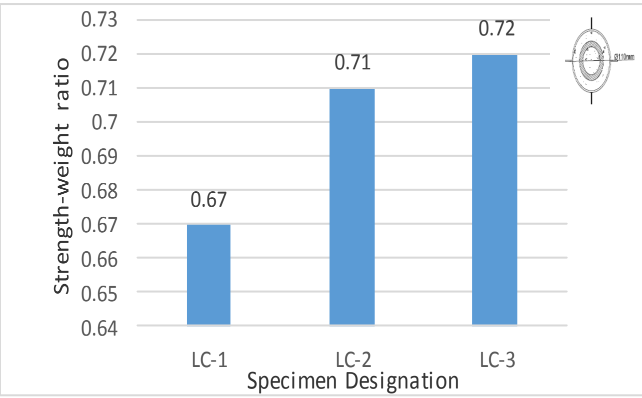

Chart 9 - Strength-weight ratio of CFSTB circular specimendiameter 110 mm

3.4 Failure Modes

The failure modes of the specimen are shown in fig below. Since stiffeners provided at the end of the column local buckling was observed at the mid height of column.

Fig -5: Failure modes of CFSTB circular specimen with diameter 90 mm

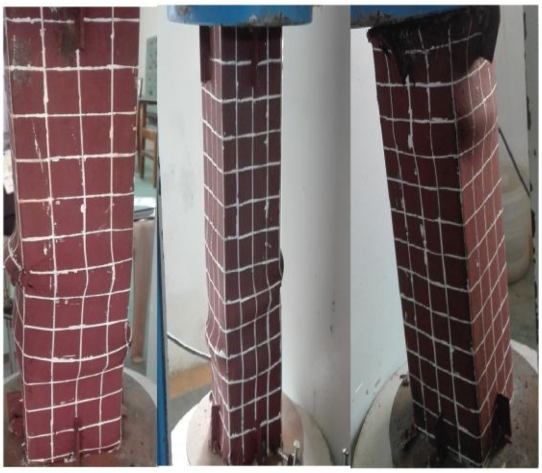

Fig-6: Failure modes of CFSTB square specimen with width 100 mm

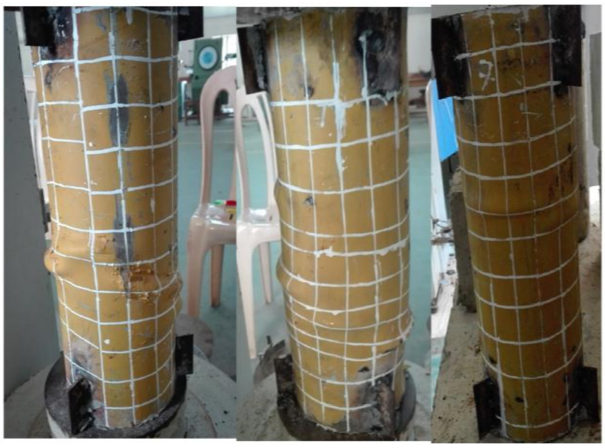

Fig -7: Failure modes of CFSTB circular specimen with diameter 110 mm

3.5 Energy Absorption Capacity

The area under the load deflection curve up to ultimate load is taken as the energy absorption capacity. As the energy absorption capacity of the specimen increases the column can be withstand seismic loads. More the energy absorption capacity, more it can withstand seismic loads. Table 8 gives the energy absorption capacity of the CFSTB circular specimen with diameter 90 mm.Table 9 gives the energy absorption capacity of the CFSTB square specimen with width 100 mm.Table 10 gives the energy absorption capacity of the CFSTB circular specimen with diameter 110 mm.

Table -8: Energy absorption capacity of circular specimen with diameter 90 mm

Specimen designation	Energy absorbed by specimen	Energy absorption ratio	Percentage increase
SC-1	895.87 J	1	
SC-2	799.75 J	0.89	10.7
SC-3	759.2 J	0.847	15.25
SC-4	749.52 J	0.83	16.33

Table -9: Energy absorption capacity of square specimen with width 100 mm

Specimen designation	Energy absorbed by specimen	Energy absorption ratio	Percentage increase
LS-1	815.75 J	1	
LS-2	1087.5 J	1.33	33.31
LS-3	1146.675 J	1.41	40.55

Table-10 : Energy absorption capacity of circular specimen with diameter 110 mm

Specimen designation	Energy absorbed by specimen	Energy absorption ratio	Percentage increase
LC-1	802.2 J	1	
LC-2	740.97 J	0.92	8.26
LC-3	634.55 J	0.79	20.89

From the above results it is inferred that the circular columns energy absorption capacity of bamboo infilled circular columns are less compared to control specimen. As the area of bamboo specimen increases, energy absorption capacity decreases in circular CFST columns, whereas in Square CFST columns the energy absorption capacity increases in bamboo infilled square columns compared to control specimen. In square columns as the area of bamboo increases energy absorption capacity increases.

4. CONCLUSIONS

[1] Square CFSTB specimens have higher energy absorption capacity compared to control specimen. About 40 % increase in energy absorption capacity occurs compared to control specimen. It also has higher strength to weight ratio compared to control specimen, about 19 % increase in strength to weight ratio occurs.

[2] Circular CFSTB specimens have higher strength to weight ratio compared to control specimen, about 10 % increase in strength to weight ratio occurs. It's energy absorption capacity is lower compared to control specimen.

[3] Circular and square CFSTB specimens have lower load carrying capacity compared to control specimen.

4.1 Scope for Future work

The experiment can be done by placing the bamboo with nodes and without filling concrete inside and can compare the ultimate load carrying capacity of with and without nodes. This experiment can be done with different grades of concrete. The experiment can also applied in long columns.

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