

# Experimental Investigation on the Buckling Behaviour of Timber Filled Steel Tubular Column

Gowri P<sup>1</sup>, Shanmugavalli B<sup>2</sup>

P.G. Student, Department of Structural Engineering, Sethu Institute of Technology, Virudhunagar, Tamilnadu, India<sup>1</sup>

Assistant Professor, Department of Civil Engineering, Sethu Institute of Technology, Virudhunagar, Tamilnadu, India<sup>2</sup>

**ABSTRACT:** In this study, test on hollow columns filled with timber were carried out to investigation the actual behaviour and the load bearing capacity of such columns. Circular sections were chosen for the experimental procedure. The timber filled was found to significantly improve the capacity by preventing local inward buckling. Several tests were conducted on different specimens and the impact of each material was studied on the structural behaviour of these members under axial compression for comparison purpose between the loads and the lateral displacements. The results showed that using timber filling instead of concrete filling will reduce the weight of columns. At the same time, a high load bearing capacity is achieved.

**KEYWORDS:** Circular hollow section, timber filled, axial compression, local inward buckling, strengthening.

## I. INTRODUCTION

Composite columns were used over years for its advantages in fire protection. In recent years it is widely employed in many structural applications including the supporting platforms of offshore structures, bridges, column in seismic zones and more as it combines the tensile and ductile properties of steel with compressive strength of some material such as concrete, timber etc...

And also, Use of composite columns can result in significant savings in column size, which ultimately lead to considerable economic savings. This reduction in column size provides is particularly beneficial where floor space is at a premium, such as in car parks and office blocks. In a composite column both the steel and timber would resist the external loading by interacting together by bond and friction were thoroughly discussed by (Vinay. G, 2015).

In hollow steel sections which are predominantly used in high rise buildings, both inward and outward buckling is found. Whereas for the timber filled steel tube, only outward is found in the tube, and the inner timber fails in a more ductile fashion were examined by (K.Santhiya,2016)

Timbers have been used extensively in building construction. In some countries, timber are overwhelmingly dominant in the building industry because of some significant advantages such as cost effectiveness relative to steel and concrete. Numerous papers are found in the literature investigating the structural behaviour of timber Was carried by Tohid Ghanbari Ghazijahani, 2016. The increase in the stiffness and ductility ratio was evaluated for the strengthened timber members.

The interaction between the timber and the steel section in the composite enhanced it to carry large axial load. The timber in a composite column reduces the potential for buckling of steel section in addition to resisting compressive loading. There is an increase in the lateral expansion of timber filled until it reaches the lateral expansion of the steel, at a particular strain. The micro-cracking in the timber begins to take place whereas the structural steel expansion remains the same at this stage were studied by Hanan Alhayek, 2009.

For the bare timber specimen, failure occurred in the form of a diagonal crack at about 1/4 of the height on a plane inclined at 45°. For bare steel and cruciform timber filled specimens, failure was by elephant foot mode of plastic

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buckling. Inward plastic buckling was dominant for the CHS specimen were explained by Tohid Ghanbari Ghazijahani, 2015.

The purpose of this study was to study the behaviour of composite columns of circular cross-section and the load carrying capacity of timber filled steel tubular columns. All columns were tested up to failure to assess their behaviour.

## II. METHODOLOGY

The following specimens are used for compression test by applying axial compression load for studying the behaviour of column to determine buckling load and deformation for various specimen given below:

1. Hollow steel tube (BT) - 9 specimens
2. Timber tubes (TT) - 9 specimens
3. Timber filled tubes (BT + TT) - 9 specimens



Fig 1: Hollow tubes Section(BT)



Fig 2. Timber specimen



Fig 3. Timber filled with steel tube.

## III. TEST SPECIMEN AND MATERIAL PROPERTIES

Cross sections of CHS specimen are mentioned in table 1. The height of the specimen was fixed as 300mm. The number of the test specimen is 9no's. The circular hollow section tube conforming to IS 3601:2006. Material properties, i.e., yield and ultimate stresses, Poisson's ratio and young's modulus of the steel used for making the specimens were obtained using ring tests. The details of these tests as well as the stress strain curve of the material resulted from the coupon tests.

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**Table 1**  
Geometry of CHS specimens.

T(mm)	D(mm)	d(mm)	L(mm)
2.0	88.9	84.9	300

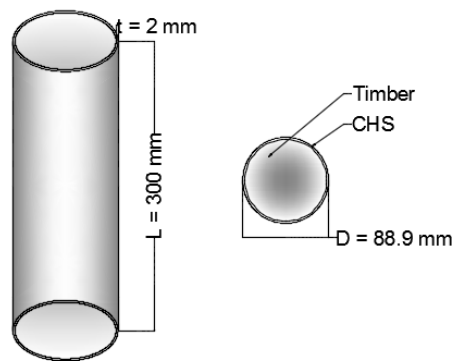


Fig 4:Geometry of tubes and filled with timber details.

The employed timber was chose the *Prosopis juliflora wood*.The heartwood of *Prosopis* species is strong and durable, hardand heavy. The specific gravity of wood of different species is given as 0.7-1.0 (NAS 1980), but wood density is in therange 700-1200 kg/m. The wood of *P. tamarugo* is generallythe heaviest of common *Prosopis* species tested, followed by*P. chilensis*, *P. pallida*, *P. glandulosa* and *P. juliflora*. The wood has a relatively high dimensional stability over other timbers meaning less shrinkage and cracking, and abundant wood elements give a high tensile strength. The length of the timber is 300mm and the diameter of the timber is 85.9mm which is filled in the steel tube and test it.

## IV. EXPERIMENTAL INVESTIGATION

### 4.1 Instrumentation

All tests were conducted in compression testing machine of capacity 1000kN. The experimental set up is shown in fig 5. The specimen were placed, centred and levelled. Linear voltage displacement transducers (LVDT) were used to observe the lateral deformation. The load was applied slowly and the specimen was tested to failure by applying the concentric compressive load in small increment at regular interval. The failure modes, lateral deformation and failure load were recorded up to its ultimate load.

### 4.2 Specimen Preparation

The 6m long hollow steel tube are cut to 300mm long circular hollow tubular specimen. At the time, the grains were formed in the fringe of the specimens; a lathe used to precisely machine the grain was removed and to get the smooth fringe of the specimen.

For the preparation of timber in the shape of cylindrical block, a lathe used to precisely machine the timber such that the external diameter tightly fit into the internal diameter of the CHS. Since machining of circular timbers was quite accurate, insertion of the timber into the CHS was carried out by placing the timber on one edge of CHS and inserting the timber applying a moderate impact with a hammer.

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Fig 5: Experimental setup

## 4.3 Test Specimen

Totally twenty seven specimen consisting of nine 2mm thick CHS specimens, nine cylindrical timber specimens and nine CHS filled with timber specimens. The strengthened specimens were nominated as 2mm thick CHS are BT1, BT2, BT3, BT4, BT5, BT6, BT7, BT8, BT9 and fitted timber specimen are TT1, TT2, TT3, TT4, TT5, TT6, TT7, TT8, TT9, CHS filled with timber are BWT1, BWT2, BWT3, BWT4, BWT5, BWT6, BWT7, BWT8, BWT9.

## V. RESULT AND DISCUSSION

### 5.1 Failure Modes

#### 5.1.1 Bare Tubes

Figure 6 show the failure mode of the bare specimen. The reference specimen were designated as BT1, BT2, BT3, etc.. and were tested with the same loading and boundary conditions under compression. As can be seen, all strengthened control specimen exhibited a



(a)BT1 (b) BT2 (c) BT3

Fig 6: Failure for bare tubes



(a)TT1 (b) TT2 (c) TT3

Fig 7: Failure mode for timber specimen

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distinctive buckling failure. This failure looks like an elephant foot's buckling. This failure is proved as the past researches. Failure mode of BT1 specimen an outward buckling deformation near the mid-length of the column and near the ends of the column was observed.

In the specimen BT2, local buckling deformation near the top and bottom of the specimen was noted, accompanied in BT3 specimen by a local buckling occurred at the top of the specimen was noted.

### 5.1.2 Timber Specimen

The failure in the plain timber specimens were tested with symmetrical loads of the specimens are TT1, TT2, TT3, etc... In the specimen TT1, when occurred crack at top and near mid portion of the timber was observed. Similarly, specimen TT2 occurred crack at the top portion of the specimen was noted, accompanied in TT3 specimen by a crushing occurred at the middle of the specimen was observed which shown in figure 7.



(a)BWT1 (b) BWT2 (c) BWT3

Fig 8: Failure mode for timber filled specimen

### 5.1.3 Timber Filled Specimens

Failure mode are seen in figure 8 of the timber filled specimen were designed as BWT1, BWT2, BWT3, etc.... and were tested with symmetrical load of the specimens. Failure mode of specimen BWT1, the local buckling at the end of the specimen and slightly occurs local buckling at around 1/3 height of the specimen was noted, accompanied in BWT2 specimen by a local buckling deformation occurred at the bottom end and bulge close to the top end of the specimen and also 1/3 height of the specimen was observed. Similarly, specimen BWT3 failed like elephant foot at the bottom of the specimens and near middle of the specimen occurs local buckling deformation was noted.

### 5.2 Strain Response

When a load is applied to a specimen, deformations were occurs. The response between load and deformation of the specimens are usually determined by testing, in which the load and deformation are expressed in term of stress and strain. Figure 9 represents a typical stress-strain curve for a specimen subjected to compression test under normal condition. The specimen lateral deformation is plotted along horizontal axis and the corresponding stress is indicated by the curves. It was observed that the load is increase slowly the specimen was reaching the peak stress. When the specimen start crushing after the specimen reaches the peak value, there was a load return suddenly.

### 5.3 Ultimate Capacity

The main aim of this project is to improve the load carrying capacity of CHS specimens by bonding them internally using timber. It was also investigated, as there was considerable increment in the strength of CHS specimen when compared with filled specimen and it given in table 2.

The ultimate load comparison is illustrated in the figure 9 and the experimental observation are specified in table 2. From the graph it can be note that the increasing percentage of load bearing capacity of filled with timber over bare tube. Compared to bare tube BT1, BT2 and BT3 the enhancement in ultimate load capacity of timber TT1, TT2 and TT3 were 27.24%, 22.56% and 51.18% respectively. And the same is in the filled with timber the increase in load

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bearing capacity is in the range of specimen BWT1, BWT, and BWT3 were 77.46%, 94.48% and 47.33% respectively. Here the filled with timber specimen the increase in load bearing capacity is in twice the value of bare tube load.

### 5.4 Deformation

The deformation detail were observed in strengthened column when it compared with other specimen as shown in fig 9. The timber filled specimen are delay the local buckling compared to bare tubes and here to control deformation of the bare tubes. In case the filled timber specimen decrease the percentage of deformation range are 10 to 50% compared to bare tube specimens. The deformation value of the bare tube are 8.8@165kN, 6.5@195kN, 11.1@173.7kN, respectively and the filled timber specimens are 6.9@378kN, 8.8@464.8kN and 9.8@368kN respectively. The deformation of filled timber specimen decrease the deformation control the deformation with the bare tubes. The filled timber specimen strength were increasing simultaneously.

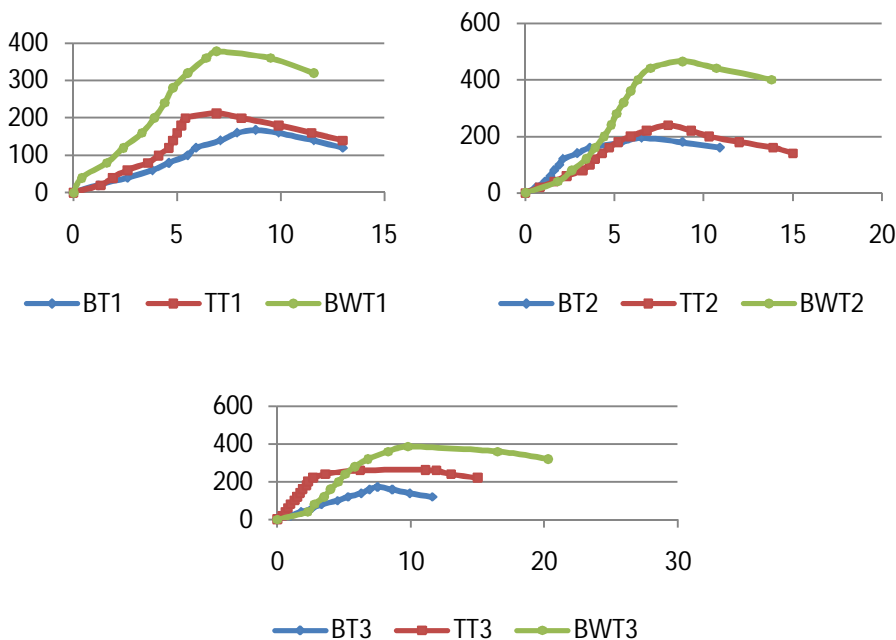


Fig: 9 Comparison of stress-strain curve for specimens

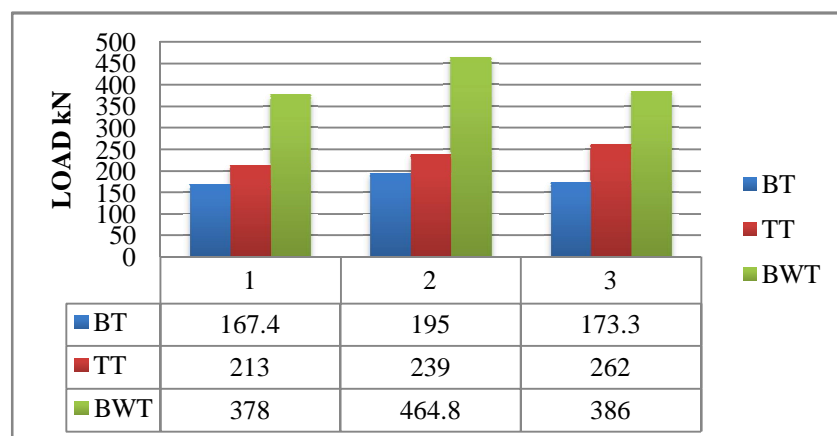


Fig: 10 Comparison of ultimate load for specimens

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**Table 2**  
Experimental Observation

Specimen Details	Ultimate Load (kN)	Maximum Lateral Deformation (mm)	Decrement In Lateral Deformaion (%)	Increment In Load Carring Capacity (%)
<b>BT1</b>	167.4	8.8	-	-
<b>TT1</b>	213	6.9	27.54	27.24
<b>BWT1</b>	378	6.9	0	77.46
<b>BT2</b>	195	6.5	-	-
<b>TT2</b>	239	8	23.08	22.56
<b>BWT2</b>	464.8	8.8	10	94.48
<b>BT3</b>	173.3	11.1	-	-
<b>TT3</b>	262	7.5	48	51.18
<b>BWT3</b>	386	9.8	30.67	47.33

## VI. CONCLUSION

The performance was observed and discussed in terms of failure modes, axial load Vs lateral deformation and load carrying capacity. Based on the axial compression tests on the filled timber CHS columns, the following conclusions can be made:

1. Filled timber tubes have 2.3times higher strength than hollow tubes.
2. The increase in compressive strength of infill increases the load carrying capacity by 70% for filled timber tubes than empty tubes.
3. The decrease in axial deformation corresponding to the ultimate load of control specimen was much greater in case of filled timber tubes over CHS tubes.
4. The lateral deformation was decreased upto 30% than control specimen by using filled timber tubes.
5. when compared to the empty CHS tubes, filled timber tubes is stronger ,and load carrying capacity of filled timber tubes is also higher. And the filled timber tubes are control the deformation over empty tubes.

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