

# DYNAMIC BEHAVIOR OF COMPOSITE FILLED CIRCULAR STEEL TUBES WITH LIGHT WEIGHT CONCRETE AS INFILL

Mohd Rizwan Panwar<sup>1</sup>, E. Ramesh Babu<sup>2</sup>, N S Kumar<sup>3</sup>

<sup>1</sup>Master of Technology Student, Civil Department, Ghousia College of Engineering, Ramanagaram, Karnataka, India

<sup>2</sup>Associate Professor Civil Department, Ghousia College of Engineering, Ramanagaram, Karnataka, India

<sup>3</sup>Professor & Director (R&D) Civil Department, Ghousia College of Engineering, Ramanagaram, Karnataka, India

## Abstract

An experimental and analytical investigation of concrete-filled steel tubular (CFST) columns is presented. Composite circular steel tubes with light weight concrete as infill for three different grades of light weight concrete say M20, M30 and M40 are tested for ultimate load capacity and axial shortening, under cyclic loading. Steel tubes are compared for different lengths, cross sections and constant thickness. From this research study it is expected that regression models which were developed with minimum number of experiments based on Taguchi's method predicted the axial load carrying capacity very well and reasonably well at ultimate point. Cross sectional area of steel tube has most significant effect on ultimate load carrying capacity also it is observed that, as length of steel tube increased- load carrying capacity decreased.

**Keywords:** Composite Columns, Hollow Steel Tubes, Light Weight Concrete Filled Steel Tubes, light weight concrete

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## 1. INTRODUCTION

As the light weight concrete has lesser density (300kg/m<sup>3</sup>-1850kg/m<sup>3</sup>) than conventional concrete density (2200kg/m<sup>3</sup>-2600kg/m<sup>3</sup>) it will have ease of handling, transporting & reduced dead load in case of High rise building. Also its cellular structural arrangement helps in good insulation from heat & sound. In order to reveal the performance of CFT columns, specimens will be designed for Axial compression Cyclic loading. The Concrete that will be considered is Light weight concrete for infill in steel tubes. Based on these factors, failure patterns & influence of Light weight concrete slenderness ratio to Ultimate load ratio, Energy absorption capacity, & Modulus of resilience are analyzed. Practical importance of this study is in the application of this system to "seismic resistance structures prone to earthquakes".

### 1.1 CFST (Concrete Filled Steel Tube)

Composite Steel Concrete construction has been widely used in many Structures such as Building and Bridge. The concrete encased composite column is one of the common composite structural elements. At the same time, due to the traditional separation of structural Steel and Reinforced Concrete Design and Construction, this type of Column has not received the same level of attention as Steel or Reinforced Concrete Column. Composite Structures from Concrete Steel section show considerable larger stiffness, stability and load carrying capacity in comparison with steel construction. An increase of corrosion and fire resisting is an addition advantage of concrete element. The use of steel-concrete composite columns, such as concrete-encased steel (CES) and concrete-filled steel tube (CFT) columns, has increased in the construction of high-rise buildings and long-span structures.

### 1.2 Light Weight Aggregates

Light weight aggregates are the aggregates which possess a very light density which makes it advantageous over conventional aggregates since it provides better block work and faster work facilitation.

### 1.3 Materials Used and Mix Proportions

#### 1.3.1 Materials Used

##### Steel

**Material: TATA steel**

Young's modulus  $E=310000\text{Mpa}$

Poisson ratio  $\nu=0.3$

Density  $\rho=7850\text{kg/m}^3$

##### Concrete

#### Light Weight Concrete

Grade of concrete =M20,M30,M40

$E=22360.70000\text{Mpa}$ (M20), $27386.12$ (M30),and  
 $31622.78$ (M40).

Poisson ratio  $\nu=0.2$

Density  $\rho=1850\text{kg/m}^3$

#### Fine Aggregates

The aggregate which is passing through 2.36 mm sieve is known as fine aggregate. Locally available river sand which is free from organic impurities is used sand passing through 2.36mm sieve and retained on 150 micron IS sieve is used in this investigation. The physical properties of fine aggregate like specific gravity, bulk density, gradation and fineness modulus is tested in accordance with IS: 2386-1975.

### Light Weight Coarse Aggregates

The LW coarse aggregate of 12mm sieve 10 mm retained rounded obtained from the local crushing plant; (BANGALORE, Karnataka) is used in the present study. The physical properties of coarse aggregate like specific gravity, bulk density, gradation and fineness modulus are tested in accordance with ACI211.2-98

### Cement

Ordinary Portland cement of 53 grade was used and tested for physical and chemical properties and found to be conforming to various specifications as per IS: 12269-1987.

Specific gravity= 3.10

Normal consistency =30%

Initial setting time =38min

Compressive strength (i) for 7 days=36N/mm<sup>2</sup> (ii) for 14 days=43 N/mm<sup>2</sup> (iii) for 28 days=53 N/mm<sup>2</sup>

### Water

As per IS 456:2000, water used for both mixing and curing should be free from injurious amount of deleterious materials. Portable water (tap water) is generally considered satisfactory for mixing and curing concrete

### 1.3.2 Mix Proportions

#### Mix Proportion for M30 grade

Converting Into LWC Proportions: The normal concrete mix proportions are modified as per ACI specifications and different trial mixes and cast. By considering the fresh properties and harden properties of the mixes LWC mixed proportions are

Cement = 401.85kg/m<sup>3</sup>

Fine aggregate = 646.35 kg/m<sup>3</sup>

Coarse aggregate = 589.6 kg/m<sup>3</sup>

Water =217kg/m<sup>3</sup>

#### The Mix Proportions Are:

**Table-1** Mix proportions for M30 Grade

SL.NO	MATERIALS	MIX PROPORTION
1	CEMENT	1
2	FINE AGGREGATES	1.608
3	COARSE AGGREGATES	1.467
4	WATER	0.541

#### Concrete Mix Proportion for M20 grade

Cement = 332 kg/m<sup>3</sup>

Fine aggregate = 760.75 kg/m<sup>3</sup>

Coarse aggregate = 608 kg/m<sup>3</sup>

Water =186.09 kg/m<sup>3</sup>

#### The Mix Proportions Are:

**Table- 2** Mix proportions for M20 Grade

SL.NO	MATERIALS	MIX PROPORTION
1	CEMENT	1
2	FINE AGGREGATES	1.76
3	COARSE AGGREGATES	1.78
4	WATER	0.6203

#### Concrete Mix Proportion: M40 Grade

Cement = 504 kg/m<sup>3</sup>

Fine aggregate = 544.2 kg/m<sup>3</sup>

Coarse aggregate = 589.6 kg/m<sup>3</sup>

Water =217 kg/m<sup>3</sup>

#### The Mix Proportions Are :

**Table-3** Mix proportions for M40 Grade

SL.NO	MATERIALS	MIX PROPORTION
1	CEMENT	1
2	FINE AGGREGATES	1.079
3	COARSE AGGREGATES	1.1698
4	WATER	0.430

## 2 RESULTS AND DISCUSSIONS

### 2.1 Test for Compressive Strength

The compressive strength of concrete is often considered the most important property of concrete, and is the most common measure used to evaluate the quality of hardened concrete. Compressive strength can be defined as the measured maximum resistance of a concrete specimen to axial loading.

**Table- 2.1** Values of cubes after compression test

Sl. No	Specimen	Specimen no	Age of Cube in Days	C/S Area of cube in mm <sup>2</sup>	Load in tons	Compressive strength in N/mm <sup>2</sup>	Average in N/m <sup>2</sup>
1	M20	1	7	225	28	12.4	13.3

							1
		2			30	13.33	
		3			32	14.22	
2	M20	1	28	225	48	21.33	23.10
		2			55	24.44	
		3			53	23.55	
3	M30	1	7	225	45	20.00	19.84
		2			42	18.66	
		3			47	20.88	
4	M30	1	28	225	71	31.55	32.58
		2			74	32.88	
		3			75	33.33	
5	M40	1	7	225	65	28.88	29.03
		2			67	29.77	
		3			64	28.44	
6	M40	1	28	225	96	42.66	42.36
		2			94	41.77	
		3			96	42.66	

In this investigation light weight concrete cubes of 150mm150mm×150mm size were used for testing the compressive strength. The cubes were tested in a compression testing machine of capacity 2000KN.

Compressive strength is calculated by,

$$f_c = P/A$$

where,  $f_c$  = Cube compressive strength in N/mm<sup>2</sup> P = Cube compressive failure in N A = Cross-sectional area of cube .



Fig-2.1 Specimen subjected to compression.

## 2.2 Test for Split Tensile Strength

The split tensile strength of concrete was obtained indirectly by subjecting concrete cylinders to the action of a compressive force along two opposite generators. In this investigation self compacting cylinder of 150mm dia×300mm length were used for testing the compressive strength The split tensile strength is calculated by using the formula

$$\sigma_{sp} = \frac{2P}{\pi DL}$$

where,

P=Load in KN

D= diameter of cylinder

L=length of cylinder

The test results are tabulated in Table



Fig-2.2 Split Tensile Strength

**Table- 2.2** Values of tensile strength of cylinder

Sl. No	Specimen	Specimen no	Age of cylinder in Days	Size of Cylinder in mm	Load in tons	Split Tensile strength (N/mm <sup>2</sup> )	Avg. Split Tensile Strength (N/mm <sup>2</sup> )
1	M20	1	28	150 dia x 300 length	24	3.39	3.67
		2			28	3.96	
		3			26	3.67	
2	M30	1	28	150 dia x 300 length	28	3.96	4.14
		2			31	4.38	
		3			29	4.1	
3	M40	1	28	150 dia x 300 length	30	4.24	4.66
		2			37	5.23	
		3			32	4.52	

- 1) The compressive strength for **M20**, **M30**, and **M40** grade of cement for 28days have given a satisfactory results as follows **23.1 N/MM<sup>2</sup>**, **32.58 N/MM<sup>2</sup>**, **42.36 N/MM<sup>2</sup>**.
- 2) The LWC developed split tensile strengths ranging from 3.67 N/mm<sup>2</sup>, 4.14 N/mm<sup>2</sup> and 4.66 N/mm<sup>2</sup> for M20

## REFERENCES

- [1] Schneider SP. Axially loaded concrete-filled steel tubes. J struct eng, ASCE1998;124(10):1125-38.
- [2] D.S.Ramachandra Murthy, et.al., "Seismic resistance of the reinforced concrete beam-column joints with TMT and CRS bars", ICI Journal, vol.1, July-Sep.2000, no.2, pp.19-26.
- [3] Elremaily Ahmed, Azizinamini Atorod. Behavior and strength of circular concrete-filled tube columns. J constr steel res 2002;58:1567-91.
- [4] Tao zhong, Han Lin-Hai, Wang Dong-ye. Strength and ductility of stiffened thin -walled hollow steel structural stub columns filled with concrete. Thin Walled struct 2008;46:1113-28.
- [5] IS 10262-1982. India standard recommended guidelines for concrete mix design.

**Fig-2.3** Steel Specimens used.

## 3. CONCLUSIONS

The present study has shown that the use of LWC has a considerable increase in compressive, flexural and split tensile strength with reduced self weight in alternate to normal conventional concrete.