ISSN 2395-695X (Print)
ISSN 2395-695X (Online)
International Journal of Advanced Research in Biology Engineering Science and Technology (IJARBEST)
Vol. 2, Issue 4, April 2016

EXPERIMENTAL STUDY OF CONCRETE INFILLED DOUBLE SKIN COLUMN MADE OF STAINLESS STEEL OUTER TUBE AND MILD STEEL INNRE TUBE

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***Abstract*–The comparative behaviour of axially loaded double skin concrete infilled composite column has to be investigated. The outer tube is made of stainless steel and inner tube is made of mild steel. Necessary coupon tests were carried out to determine the properties of stainless steel tube and mild steel tube and the performance of the stainless steel composite columns perform good and can be used widely in structural applications so as to capitalise the benefits like enhanced bearing strength, corrosion protection, fire resistance capacity, faster construction, aesthetic appearance, lower maintenance cost and overall economy in labour, fire proofing, there is no need of plastering and painting**.

I.INTRODUCTION

The use of stainless steel in construction throughout the world is emerging due to its excellent corrosion resistance, high strength, decorative qualities, ease of maintenance and fire resistance. The past few decades have seen the accelerating interest in using stainless steel in the construction industry.

In this paper work an attempt is made to effectively use the stainless steel and concrete in column, which effectively makes use of both the concrete and stainless steel. Concrete-filled stainless steel tubular columns comprised of stainless steel ideally combine the advantages of both stainless steel and concrete.

Stainless steel is the name given to a family of corrosion and heat resistant steels containing a minimum of 10.5% chromium. Just as there is a range of structural and engineering carbon steels meeting different requirements of strength, weldability and toughness, so there is a wide range of stainless steels with progressively higher levels of corrosion resistance and strength. This variety of grades results from the controlled addition of alloying elements, each offering specific attributes in respect of strength and ability to resist different environments.

There are many different types and grades of stainless steel. To achieve the optimum economic benefit from using stainless steel, it is important to select a grade of steel which is adequate for the application without being unnecessarily highly alloyed and costly.

II.SCOPE OF THIS WORK

The scope of this paper is to study and compare the behaviour of concrete filled double skin tube columns consist of stainless steel as outer tube and carbon steel as inner tube with hollow core of various geometrical shapes under axial compressive load and comparing the results with the theoretical results obtained with the guidelines given by the Eurocode:4 (Design of composite steel and concrete structures).

This paper suggest a composite column which adequately have structural, architectural and lifecycle benefits like enhanced strength, ductile behaviour, high corrosion resistance, aesthetic appearance, low construction and maintenance cost, higher fire resistance capacity, high scrap value after demolition, faster construction and reduced dead weight of the structure by reducing the cross section dimension, hence increasing the occupancy space of the building and saving in the volume of concrete.

The aim of this paper work is to evaluate the strength and behaviour of following composite column configurations

1. Concrete infilled stainless steel columns.
2. Concrete infilled column composed of stainless steel outer tube and mild steel inner tube.
3. Hollow stainless steel sections without infill concrete.

To find the most optimum combination of inner and outer tubes from strength, stiffness, and ductility.

III. PROPOSED METHOD MATERIALS

3.1 Cement

A 53 grade PPC cement (Ramco) with specific gravity of 3.15 was used.

3.2 Fine Aggregate

The fine aggregate used was clean river sand passing through 4.75mm sieve with specific gravity of 2.6 conforming to zone II.

3.3 Coarse Aggregate

Stone aggregates which passed through 16mm aggregate and retained on 12.5mm was used. Specific gravity of coarse aggregate is 2.68.

IV. SPECIMEN DETAILS

4.1 Geometric Properties Of Specimens

Specimen 1

It is made of square outer tube in stainless steel, and inner square carbon steel. Dimension of the outer tube is 100 mm and made with 1.5mm thick plate. The size of the inner tube is 43 mm and made of 2 mm plate. The space between the two tubes is filled with concrete. The grade of concrete is $M_{25.}$ Length of the specimen is 1m. Specimen label is concrete filled double skin square tubular section (CFDSST).

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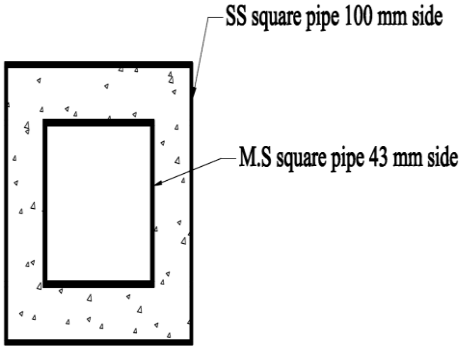

Fig 4.1 Cross section of CFDSST

Fig 4.2 Photographic view of CFDSST before casting.

Specimen 2

It is made of Circular outer tube in stainless steel, and inner Circular carbon steel tube. Dimension of the outer tube is 100 mm and made with 1.5 mm thick plate. The size of the inner tube is 60 mm and made of 2 mm plate. The space between the two tubes is filled with concrete. The grade of concrete is M_{25}. Length of the specimen is 1m. The specimen is labled as concrete filled double skin circular tubular section (CFDSCT).

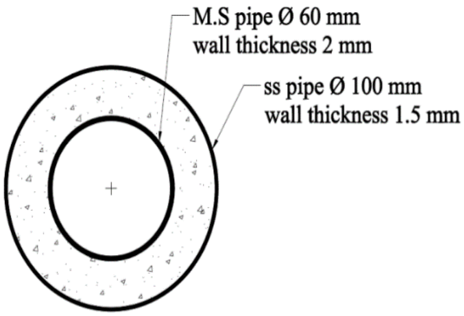

Fig 4.3 Cross section of CFDSCT

Fig 4.4 Photographic view of CFDSCT before casting.

Specimen 3

It is a single square tube filled with concrete. The material of the tube is stainless steel. Dimension of the tube is 100x1.5mm. The hollow portion is filled with concrete. The grade of concrete is M_{25}. Length of the specimen is 1m. The specimen is labled as concrete filled square tubular section (CFST).

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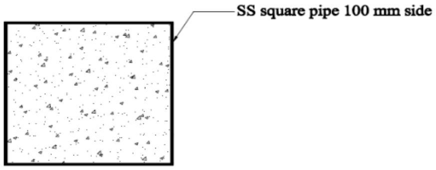

Fig 4.5 Cross section of CFST

Specimen 4

It is a single circular tube filled with concrete. The material of the tube is stainless steel. Dimension of the tube is 100x1.5mm. The hollow portion is filled with concrete. The grade of concrete is M_{25}. Length of the specimen is 1m. The specimen is labled as concrete filled circular tubular section (CFCT).

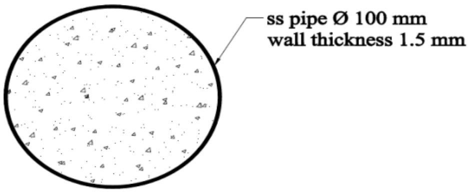

Fig 4.6 Cross section of CFCT

Specimen 5

It is a single square hollow tube. The material of the tube is stainless steel. Size of the tube is 100x1.5mm. The hollow portion is left free. The specimen is labled as stainless steel square hollow tube (SSSHT).

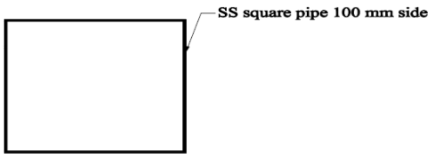

Fig 4.7 Cross section of SSSHT

Specimen 6

It is a single circular hollow tube. The material of the tube is stainless steel. Size of the tube is 100x1.5mm. The hollow portion is left free. The specimen is labled as stainless steel circular hollow tube (SSCHT).

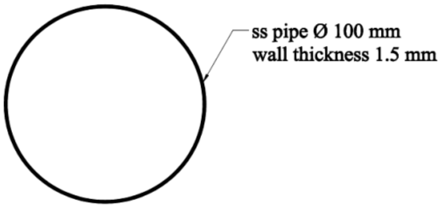

Fig 4.8 Cross section of SSCHT

V. EXPERIMENTAL PROGRAMME

5.1 TEST SETUP

All the column specimens were tested under axial loading. Fig 4.1 shows the test setup of testing arrangement. The specimens were tested in a self strained loading frame of 1000kN capacity. Axial load was applied through a power pack connected to hydraulic jack, which was mounted on the top of the specimen.

The column was hinged on both ends. A load cell was placed between the column and the hydraulic jack. End capping was provided with plaster of paris to prevent premature failure due to crushing at the ends. The arrangement was placed on the test floor. The specimen was checked for verticality using plumb bob.

Three LVDT's were provided on the each axis of the column at a spacing of L/4, and one LVDT was fixed at the top level of the column to measure the axial shortening. The loading was applied gradually up to failure of the specimen.

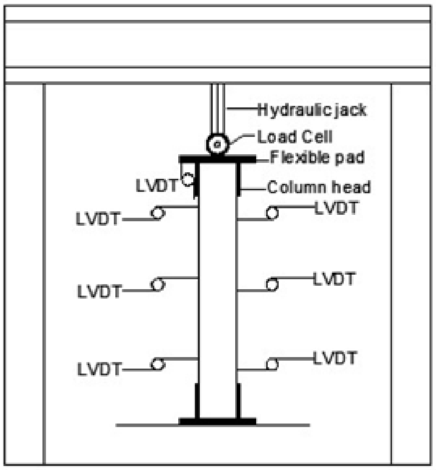

Fig 5.1 Test setup

5.2 TESTING PROCEDURE:

All the column specimens were tested under axial loading to find out the ultimate load carrying capacity and axial shortening of them. A load cell was used to monitor the load. One LVDT was used to measure the axial shortening. The axial shortening and deflection are monitored for every 2kN of increasing load. Load was applied gradually till the failure occurred. And corresponding deflection and axial shortening was noted.

Fig 5.2 Testing in progress

Advantages of concrete infilled double skin stainless steel columns

- Stainless steel is naturally a corrosion resistant material. The passive layer form over the surface of stainless steel prevents the growth of corrosion.
- Reinforcing material of the column is arranged at the outermost part of the column which serves not only effectively to improve the strength of the column but also it acts as corrosion resistant, fire resistant material.
- Shuttering and deshuttering are not required, hence this column can be cast with low workmanship cost and casting of column can complete within short time period compared to R.C.C columns.
- Compared to R.C.C columns the cross section of this column is much reduced and column free space also increases considerably, hence it adds value to the property holders and the occupants of the building.

- Reduced cross section and enhanced ductility of the columns leads to reduction in the dead weight of the structure, hence seismic performance of the structure improves.

Sl.No	Specimen Name	Length (mm)	Slenderness ratio (ʎ)	Theoretical load carrying capacity according to Euro code 4 (kN)	Experimental Load carrying capacity (kN)
1	CFDSST	1000	31.44	402.00	482.00
2	CFDSCT	1000	34.51	284.00	365.25
3	CFST	1000	34.14	396.16	454.25
4	CFCT	1000	39.41	334.85	350.00
5	SSSHT	1000	24.50	N.A	202.50
6	SSCHT	1000	28.28	N.A	170.12

- A considerable amount of saving in the volume of concrete is possible.
- Surface of the column gives aesthetic appearance without any painting or coatings.
- Requires very low maintenance such as periodic washing and cleaning only.
- Scrap value of stainless steel is higher.

VI. RESULTS AND DISCUSSION

The experimental results of all the columns are presented in this chapter. Ultimate load of failure and axial shortening are useful to study the performance of each column. The performance of all the columns such as load at local failure, ultimate load carrying capacity and axial shortening under the axial load are presented in this chapter. And the test results were compared with the theoretical results obtained with Eurocode: 4.

Table I

Discussion of Test Results

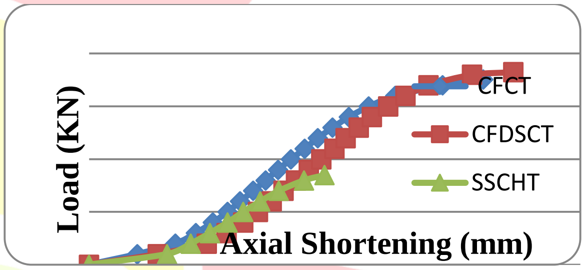

Fig 6.1 Load Vs axial shortening for CFCT, CFDSCT and SSCHT

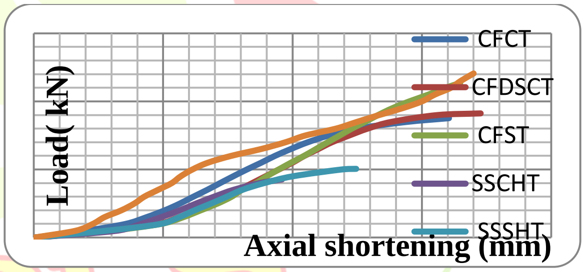

Fig 6.2 Comparison of load Vs axial shortening for all columns

VII. CONCLUSION

The behaviour of concrete infilled stainless steel composite columns was studied in this experimental work. The experimental results were compared with the theoretical results calculated by the Eurocode 4. Eurocode 4 is conservative in predicting the results.

This paper compared the failure of concrete infilled stainless steel columns of square and circular cross sections and double skin stainless steel column consists of mild steel inner tube. The slenderness ratio of the columns ranges between 24- 40. From the limited experimental studies, the following conclusions were drawn:

- Concrete filled stainless steel column's axial bearing capacity is 40-60% more load than the hollow stainless steel columns.
- Concrete filled double skin stainless steel tube with mild steel inner tube columns axial bearing capacity is 40-65% more load than the hollow stainless steel columns and the self weight of these columns is 20% less compared to the concrete filled stainless steel columns.
- Considerable amount of saving in the volume of concrete is possible in concrete filled double skin stainless steel tube with mild steel inner tube columns without any compromise on load bearing capacity.

- Eurocode 4 gives the conservative estimation of the ultimate load carrying capacity of concrete filled stainless steel columns and concrete filled double skin stainless steel tube columns as experimental values are greater than the ultimate load predicted by the Eurocode 4.
- Concrete filled stainless steel columns have good strength, corrosion resistance and fire resistance properties.
- Though the initial cost of concrete infilled stainless steel column is high, the overall lifecycle cost of the construction and maintenance cost reduces due to the faster construction, lesser workmanship requirement, low maintenance cost, higher fire resistance capacity and it adds value to the structure.
- All square columns resist 30-40% more load than the circular columns of same cross sectional area. Hence cross section reduction is possible in the case of square columns.
- The infill and partially infill columns possess lower self weight and higher strength compared to conventional R.C.C columns which will result in better seismic performance and increase usable space inside the building.

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