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Experimental Investigation of Structural Behaviour of CFST Column Under Axial Loading

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Abstract: Cement filled steel cylinder is a composite material which is as of now being utilized in the development of structures which is included a steel empty segment of round or rectangular loaded up with plain or strengthened cement. This postulation displays an investigation on basic conduct of cement filled steel tube in correlation with R.C.C Columns. An ANSYS model is created to foresee the conduct of cement filled steel cylinder to decide the minute conveying limit at extreme point for the Concrete filled steel cylinder bars are examined and confirmed by the limited component program ANSYS against trial information. The fundamental parameters influencing the conduct and quality of cement filled shafts are geometrical parameters, stacking, limit conditions and level of solid restriction. To represent every one of these properties ANSYS model is created. The principle parameters fluctuated in investigation study are trademark quality of in filled cement. The proposed model predicts extreme minute limit with regards to CFST bars. In the numerical investigation, round and square CFT cross areas are viewed as utilizing M25 evaluation of cement. The anticipated qualities are contrasted and test results. Numerical examination has demonstrated that for Circular CFST's a decent binding impact can be given. It is seen that diagnostic outcome from ANSYS are like trial results. It is seen that normal compressive quality CFST round segment is 1.7 occasions more prominent than that of RCC section and 1.57 occasions more noteworthy than that of CFST square segment with 3 mm thickness.

Keywords: Concrete filled steel tubes, R.C.C columns, circular tubes, square tubes, composite section, ultimate moment capacity, finite element analysis (FEA).

I. INTRODUCTION

Cement filled steel cylinder is a composite material which is presently being progressively utilized in the development of structures. The utilization of cement filled steel rounded pillars in tall structures has turned out to be prominent as of late. Cement filled steel cylinder shafts can give phenomenal seismic safe auxiliary properties, for example, high quality, high pliability and enormous vitality ingestion limit. Cement Filled Steel Cylindrical (CFST) individuals use the upsides of both steel and cement. Because of the local and global stability concerns preventing bare steel tubes from developing their full yielding strength, composite columns are initially suggested. There are a wide variety of composite column types of varying cross-section, but the most commonly used and studied are concrete-filled steel tubes. Darshika k. Shah et.al.[10]. It is well known that concrete filled steel tubular columns are may be caused to undertake partially compressive loads through the bearing over the pier. Y.F. Young et.al. [6]. Previous studies on the long-term performance of CFST members under sustained load have been reported. It was found that creep and shrinkage of core concrete in CFST member was significantly lower than that of the exposed concrete studied in You-XingHuaaet.al.[2]. They involve a steel empty area of round or rectangular shape loaded up with plain or fortified cement. They are broadly utilized in skyscraper and multi-story structures as segments and shaft sections, and as pillars in low-ascent modern structures where a vigorous and proficient auxiliary framework is required. Though many works were done as mentioned in previous literatures using CFST, FRP tubes, confining concrete filled tubes (CFT) with FRP still a lot more space is available in this area for further improvement and implementation of new techniques in that field and this study helps to identify such innovations and improvement that can be made in this fixed composite structures. V Aparna et.al. [7]. The formation of development offices for the improvement of a nation is the most significant errand of Civil Engineers. The CFST structural member has a number of distinct advantages over an equivalent steel, reinforced concrete, or steel-reinforced concrete member. Structures subjected to seismic loadings, composite column can provide a better ductility and load retention even after extensive concrete damage Nehla Najeeb et.al. [5]. A multistoried structure assumes an indispensable job in the improvement of framework offices. In the development of elevated structures cement filled steel cylinders is one of such an expansion to new building material, which can withstand most noticeably terrible blend of burdens, with high solidness and encouraging speeder development and looking after economy.

There are various unmistakable favorable circumstances identified with such auxiliary frameworks in the two terms of basic execution and development succession. The characteristic clasping issue identified with flimsy walled steel

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cylinders is either avoided or postponed because of the nearness of the solid centre. Moreover, the exhibition of the solid infill is improved because of imprisonment impact applied by the steel shell. The conveyance of materials in the cross segment additionally makes the framework proficient in term of its auxiliary execution. Such basic framework has the benefit of both steel and fortified solid casing. It has the auxiliary solidness and trustworthiness of a cast-nearby fortified solid structure, and the simplicity of dealing with and erection of a basic steelwork. The empty cylinders alone were planned so that they are fit for supporting the floor burden up to three- or four-story stature. Concrete Filled Steel Tubes (CFST) comprise of a steel hollow section of different shape filled with plain or reinforced concrete. CFST could make full use of the properties of steel and concrete for this it is necessary to ensure the steel and concrete materials are working together to form a composite action, which often relies on the bond in the steel-concrete interface. Neethu M.T. et.al. [4]. When the upper floors were finished, the solid was siphoned into the cylinders from the base. A multistoried building plays a vital role in the development of infrastructure facilities. In the light of construction of high-rise buildings concrete filled steel tubes is one of such an innovative new building material, which can sustain worst combination of loads, with high stiffness and facilitating speeder construction and maintaining economy. Vijay laxmi B. V. et.al. [3].
To encourage simple siphoning the cylinders were constant at the floor level. Present day siphoning office and superior solid make siphoning three or four story promptly feasible. Because of the effortlessness of the development succession, the venture can be finished in extraordinary pace. A. States of CFST components. Steel performs good in tension and weak in compression in case of concrete properties are vice versa concrete perform good compression and weak in tension, so for good performance in both we generally use composite structure reinforce concrete structure is also one of its examples. Composite structure is of two types steel incased in concrete and concrete incased in steel i.e., concrete filled steel structure (CFST) it studied in Priyanka Khedkar et.al.[1].
There are a few shapes for the solid filled steel cylinders dependent on the keeping steel cylinder's shape, for example, rectangular, curved, roundabout, square, L-formed and so forth. Roundabout and square segments of CFSTs are the generally utilized ones in development. The main purpose of using CFST members is to provide maximum bearing capacity prior to possible buckling modes. The decrease of the height of the beam could increase the clear height in the workshop & the extra between in two separate beams could late be the wioes run through the slab Dan young ma et.al. [9]. Local buckling is expected in the case of the inadequate confinement effects by steel tube or inadequate concrete core strength in a composite section. The confinement effect is called the radial pressure created by steel tubes. It operates in the same manner as stirrups and alters the buckling mode. Slenderness is also an important effect on the buckling mode determined using the dimensions of members. Burak Evirgena et.al.[8]. The heap conveying limit of CFST segment is extensively influenced by the state of its cross area, measurement to-thickness and width-to-thickness proportions of the steel tube. At the point when static burden is connected, the misshaping for roundabout CFST sections experience versatile flawlessly plastic or strain-solidifying conduct subsequent to yielding. Then again, empty auxiliary steel segments showed a corrupting sort load distortion bend subsequent to yielding under a similar stacking.'

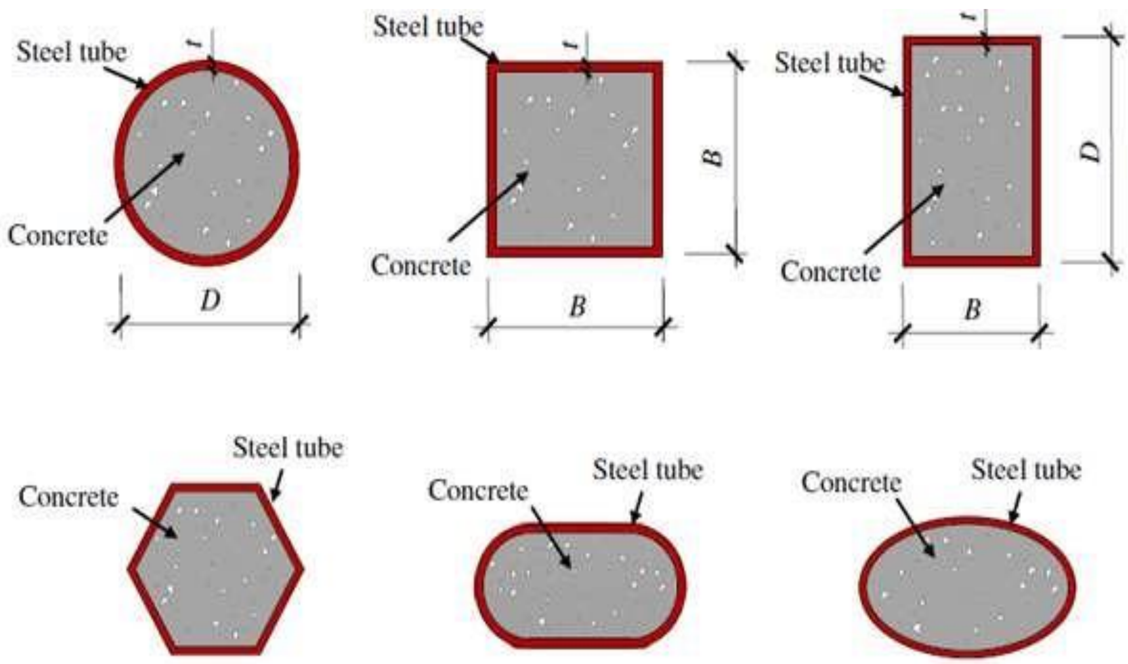

Fig.1 Shapes of CFST elements

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B. Failure modes

There are various modes of failure for the CFST based on their material properties and geometric configuration. However, the most dominant failure mode is the local buckling of the steel tube. When compared with the empty steel tube, the local buckling in the CFST column is delayed due to the presence of concrete infill. The concrete prevents the steel tube from buckling inward; instead, it forces the tube to buckle in an outward mode as shown in Figure 2

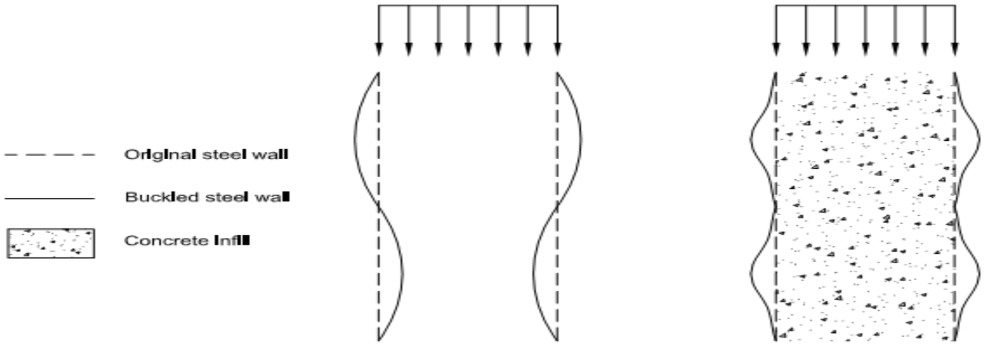

Fig 2. Changes in buckling mode with length due to the presence of infill

C. Aim

- To study the structural behavior of square and circular CFST columns under axial loading.

D. Objectives

- Experimental investigation to find the load carrying capacity of Circular CFST, Square CFST, RCC Columns of same cross-sectional area.
- To compare compressive strength of the concrete for Circular CFST, Square CFST, RCC Columns.
- Develop a finite element model using ANSYS workbench and verify it using the experimental results to evaluate normal stress, shear stress and principal stress for RCC, square and circular section.

II. MATERIALS & METHODOLOGY

A. General

Limited component examination is helpful numerical instrument for investigation of section to structure in this investigation FEM device ansys.16 is utilized to recreate CFST, CCFST, TCFST, RCFST for discretization triangular lattice is utilized Basic numerical condition [F]=[K][U] The limited component technique (FEM) is the most mainstream reproduction strategy to anticipate the physical conduct of frameworks and structures. Since diagnostic arrangements are when all is said in done not accessible for most day-by-day issues in designing sciences numerical techniques like FEM have been developed to discover an answer for the administering conditions of the individual issue. Much research work has been done in the field of numerical demonstrating during the most recent thirty years which empowers designs today to perform re-enactments near the real world. Nonlinear wonders in auxiliary mechanics, for example, nonlinear material conduct, enormous distortions or contact issues have turned out to be standard displaying assignments. As a result of a quick improvement in the equipment area bringing about an ever-increasing number of incredible processors together with diminishing expenses of memory it is these days conceivable to perform reproductions notwithstanding for models with a great many degrees of opportunity. In a scientific sense the limited component arrangement in every case just gives one an estimated numerical arrangement of the thought about issue. At times it isn't constantly a simple errand for an architect to choose whether they got arrangement is a decent or a terrible one. In the event that test or expository outcomes are accessible it is effectively conceivable to confirm any limited component result. Be that as it may, to anticipate any basic conduct in a dependable manner without tests each client of a limited component bundle ought to have a specific foundation about the limited component technique when all is said in done. Moreover, he ought to have principal learning about the connected programming to have the option to pass judgment on the suitability of the picked components and calculations. This paper is planned to demonstrate a synopsis of ANSYS capacities to acquire consequences of limited component examinations as precise as could be expected under the circumstances. Numerous highlights of ANSYS are appeared and where it is conceivable, we show what is as of now executed in ANSYS.16 Workbench.

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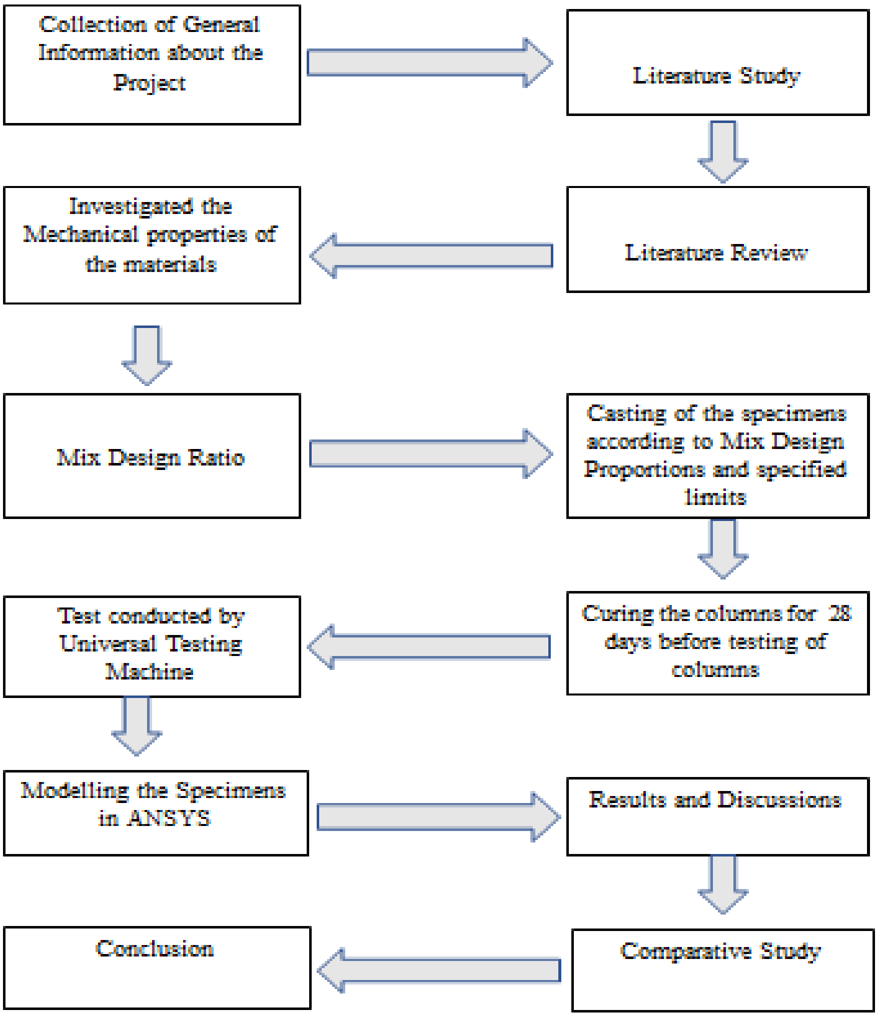

Fig 3. Steps involved in experimental investigation of structural behavior

B. Materials Used

•Hollow steel tubular section (SQUARE 150x150x700mm – 3mm thickness, CIRCULAR 165mm Outer Diameter - 4 mm thickness)
•Cement- Ordinary Portland Cement53grade
•Fine aggregate - This is river sand which is locally available.
•Coarse aggregate -The coarse aggregate used were locally available. The maximum nominal size of aggregate was 20mm. This are major ingredient of concrete.
•Steel bars – Steel bars for providing Reinforcement.
•Water- Any natural water which is fit for drinking and has no taste or colour is generally accepted for concrete. The tap water is used for preparation of concrete.

III. RESULTS & OBSERVATIONS

A. General

In this chapter the CFST models and RCC conventional models are prepared. The CFST models are tested under UTM. The results are mentioned in later part the validation is done in FEA software ANSYS.

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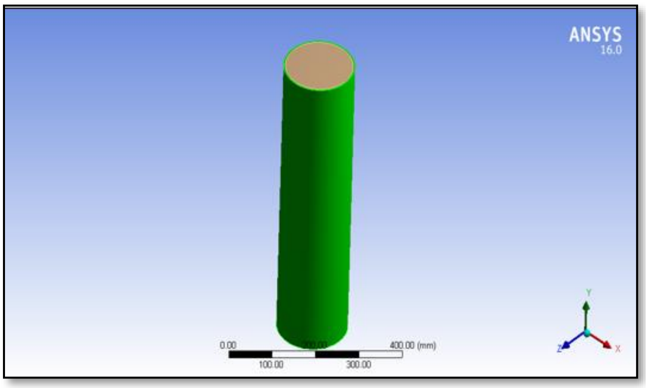

Fig. 4 Modelling of Circular RCC Column

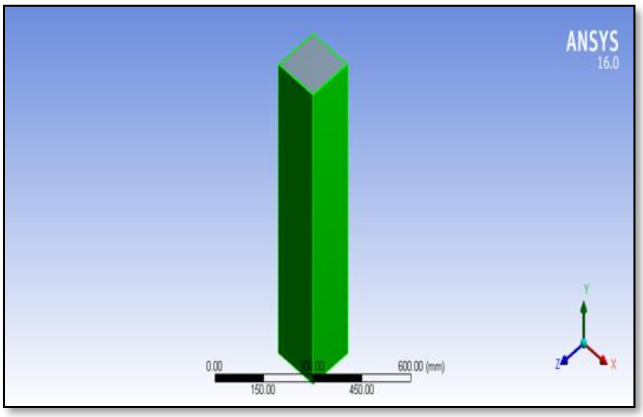

Fig. 5 Modelling of Square Column

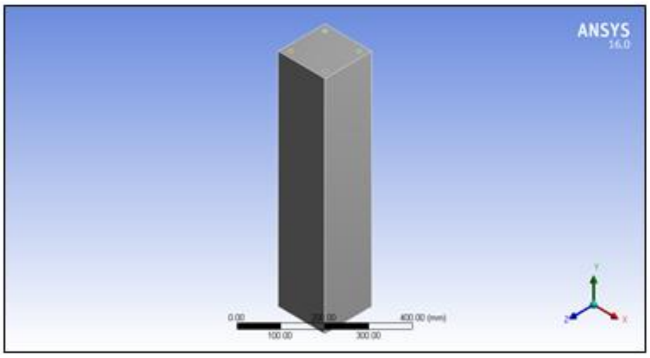

Fig. 6 Modelling of RCC column

B. Experimental Test Results:

1. CIRCULAR CFST (165mm Outer Diameter – 4mm Thickness): -

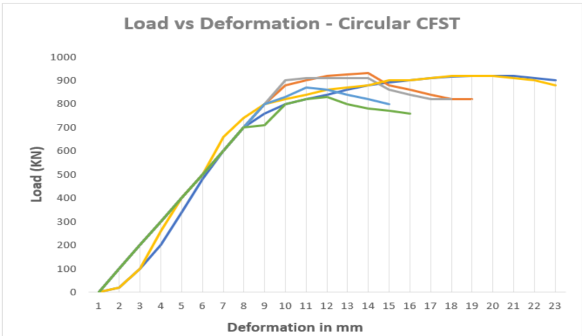

Fig. 7 Load Vs Deformation Curve for Circular CFST

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The above graph shows the load vs deformation curve for the Circular CFST columns as per the experimental data results, which shows that the Circular CFST 2 has maximum load carrying capacity of 931.861 KN with compressive strength of 43.581 N/mm 2 along with deformation of 23.300 mm.

TABLE I EXPERIMENTAL TEST RESULTS FOR CIRCULAR CFST

CFST No.	Maximum load carrying capacity	Compressive strength	Deformation
1	923.430 KN	43.186 N/mm 2	19.01 mm
2	931.861 KN	43.581 N/mm 2	23.300 mm
3	911.490 KN	42.628 N/mm 2	30.170 mm
4	860.320 KN	40.235 N/mm 2	20.970 mm
5	847.50 KN	39.361 N/mm 2	29.170 mm
6	932.38 KN	43.605 N/mm 2	21.39 mm

Fig. 8 Testing of Circular CFST

The testing of the Circular CFST columns was done on the universal testing machine with 1200KN maximum load carrying capacity. The failure of columns was seen at the Top, Bottom and Middle portion of columns due to buckling of columns due to application of load. The maximum load carried by Circular CFST column was 931.160 KN.

2. SQUARE CFST (150x150x700mm- 3mm Thickness): -

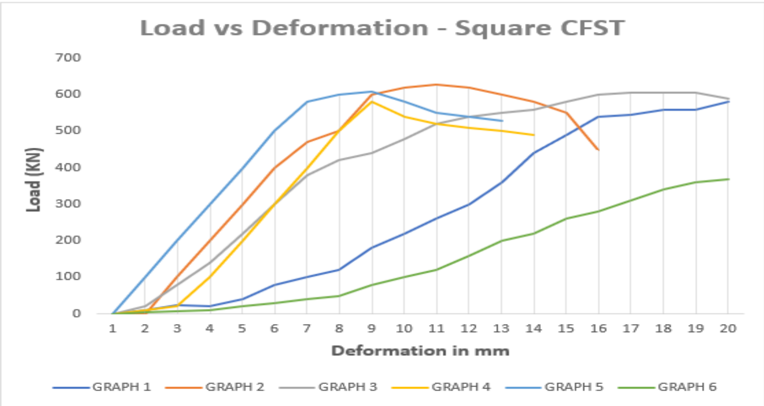

Fig. 9 Load Vs Deformation Curve for Square CFST

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The above graph shows the load vs deformation curve for the square CFST columns as per the experimental data results, which shows that the Square CFST 2 has maximum load carrying capacity of 626.810 KN with compressive strength of 27.858 N/mm 2 along with deformation of 7.810 mm.

TABLE II EXPERIMENTAL TEST RESULTS FOR SQUARE CFST

CFST No.	Maximum load carrying capacity	Compressive strength	Deformation
1	575.950 KN	25.59 N/mm 2	9.930 mm
2	626.810 KN	27.858 N/mm 2	7.810 mm.
3	605.020 KN	26.89 N/mm 2	9.050 mm.
4	579.37 KN	25.749 N/mm 2	9.945 mm
5	602.460 KN	26.776 N/mm 2	9.770 mm
6	397.186 KN	17.650 N/mm 2	6.112 mm

Fig. 10 Testing of Square CFST

The testing of the Circular CFST columns was done on the universal testing machine with 1200KN maximum load carrying capacity. The failure of columns was seen at the Top, Bottom portion of columns due to buckling of columns due to application of load. The maximum load carried by Circular CFST column was 626.810 KN.

3. R.C.C COLUMNS (150x150x700mm)- (4 Main Bars -12mm), (8mm Stirrups @ 150mm C/C)

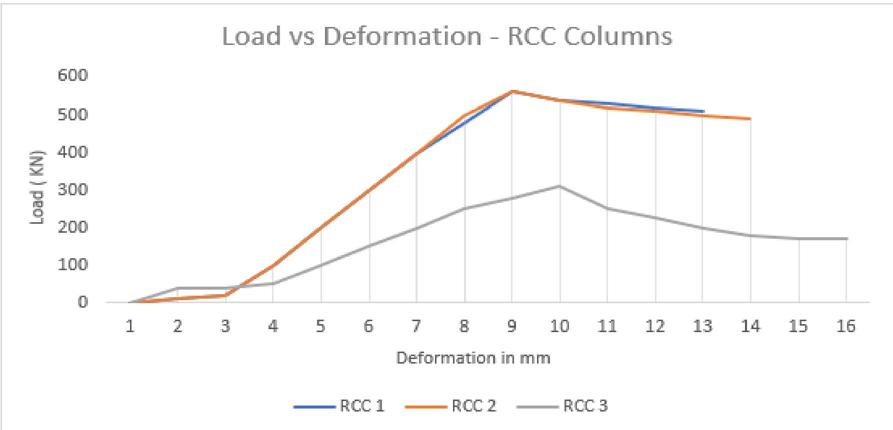

Fig. 11 Load Vs Deformation Curve for RCC Columns.

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The above graph shows the load vs deformation curve for the RCC Columns as per the experimental data results, which shows that the Circular CFST 2 has maximum load carrying capacity of 564.127 KN with compressive strength of 25.072 N/mm 2 along with deformation of 9.763 mm.

TABLE III EXPERIMENTAL TEST RESULTS FOR SQUARE CFST

CFST No.	Maximum load carrying capacity	Compressive strength	Deformation
1	551.179 KN	24.496 N/mm 2	8.681 mm
2	564.127 KN	25.072 N/mm 2	9.763 mm
3	320.146 KN	14.228 N/mm 2	5.113 mm.

Fig. 12 Testing Of R.C.C Columns

The testing of the Circular CFST columns was done on the universal testing machine with 1200KN maximum load carrying capacity. The failure of columns was mainly seen at the Top, Bottom & Middle portion of columns due to formation of cracks and crushing of columns due to application of load The maximum load carried by Circular CFST column was 564.127 KN.

TABLE IV AVERAGE COMPRESSIVE STRENGTH

Type of Column	Circular CFST	Square CFST	RCC
Average Compressive strength	41.8526 N/mm2	26.780 N/mm2	24.784 N/mm2

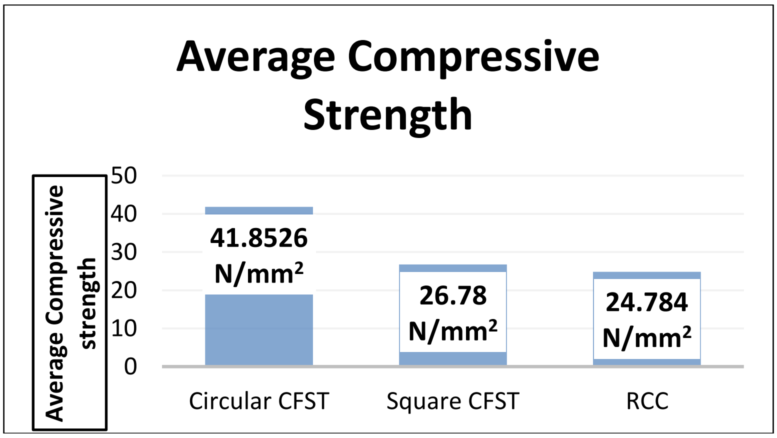

Fig. 13 Average Compressive Strength

The average compressive strength for RCC column is 24.784 N/mm2, for CFST square column with 3 mm thickness is 26.780 N/mm2 and for CFST circular column with 4mm thickness is 41.8526 N/mm2.also it is observed that the compressive strength of RCC Column is 17.09% less than circular CFST and 1.996% less than square CFST.

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IV. CONCLUSION

1. Circular CFST columns have the greatest load carrying capacity. 1.57 times more load than Square CFST and 1.7 times more than RCC columns evaluated experimentally.
2. RCC columns can carry 1.105 times less load than that of Square CFST Columns.
3. RCC Columns can carry 1.7 times less load than that of Circular CFST Column.
4. CFST Columns helps in reduction in size of column sections compared to RCC column by 59.75% for Square CFST and by 73.29% for Circular CFST which helps to make use of more space available.
5. CFST Columns enables the reduction in the cost of construction by 11.994% for Square CFST and by 16.25% for Circular CFST.

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