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Experimental and Analytical Investigation on Composite Column

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Abstract: *In this project, a study was carried out produce composite column and to study the properties and behavior of composite column experimentally and analytically. Concrete mix designs are prepared using the IS code method for M40 concrete grade. The specimens were produced with different shapes (square, rectangular and circular) and sizes. These tests are conducted to ensure the quality of material and to reduce the cost. Laboratory tests were carried out on the prepared cft column specimens. The compressive strength of the composite column are determined. Then the samples of composite columns are modelled using abaqus software and its behavior is studied analytically. Finally, the results of experimental and abacus modeling is compared.*

Keywords: Composite column, cft columns, steel, tubes, compression

I. INTRODUCTION

The use of composite construction has become more widespread in recent decades. Composite construction combines the advantages of both structural steel and concrete, namely the speed of construction, strength, and light weight of steel, and the inherent mass, stiffness, damping, and economy of concrete. The steel frame serves as the erection frame to complete the construction of the rest of the structure. Composite columns may be structural steel shapes encased in concrete or concrete-filled steel tubes. CFT columns have an advantage over RC columns because the steel tube serves as formwork for placing the concrete and offers some confinement to the cured concrete, thus improving its ductility.

In modern structural constructions, concrete-filled steel tubular CFT columns have gradually become a central element in structural systems like buildings, bridges and so forth. CFT columns have become so widespread owing to their axially compressed nature making them superior to conventional reinforced concrete and steel structural systems in terms of stiffness, strength, ductility, and energy absorption capacity. The steel tube not only takes axial load, but also provides confining pressure to the concrete core, while the concrete core takes axial load and prevents or delays local buckling of the steel tube. Furthermore, concrete filled composite columns also have the advantage of requiring no formwork during construction, thus reducing construction costs.

CFT - CONCRETE FILLED TUBULAR COLUMNS

Concrete-filled tube (CFT) column consists of a steel tube filled with concrete. The concrete fill adds stiffness and compressive strength to the tubular column and reduces the potential for inward local buckling. The steel tube acts as longitudinal and lateral reinforcement for the concrete core to resist tension, bending moment and shear, and to prevent the concrete from spalling. Due to the beneficial composite action of both , the CFT columns provide excellent seismic resistant structural properties such as high strength, high ductility and large energy absorption capacity.In addition, the steel tube acts as both erection steel and forming for the composite column during construction, thus decreasing a considerable amount of the labor and materials and reducing the construction cost. As a result, CFT columns have gained popularity in supporting heavy loads in high-rise buildings, bridges and offshore structures and various experimental and analytical studies have been performed on CFT columns.

ADVANTAGES OF CFT COLUMN

In recent years, CFT structures have become more widely accepted and used in tall buildings as well as arch bridges, particularly in the far-east region, like China and Japan. The concrete filled steel column system has many advantages compared with ordinary steel or reinforced concrete systems. The main advantages
are listed below:

Interaction between steel tube and concrete:

Local buckling of the steel tube is delayed, and the strength deterioration after the local buckling is moderated, both due to the restraining effect of the concrete. On the other hand, the strength of the concrete is increased due to the confining effect provided by the steel tube, and the strength deterioration is not very severe, because concrete spalling is prevented by the tube. Drying shrinkage and creep of the concrete are much smaller than in ordinary reinforced concrete.

Cross-sectional properties:

The steel ratio in the CFT cross section is much larger than in reinforced concrete and concrete-encased steel cross sections. The steel of the CFT section is well plastified under bending because it is located outside the section.

Construction efficiency:

Labour for forms and reinforcing bars is omitted, and concrete casting is done by Tremie tube or the pump-up method. This efficiency leads to a cleaner construction site and a reduction in manpower, construction cost, and project length.

Fire resistance:

Concrete improves fire resistance so that fireproof material can be reduced or omitted.

Cost performance:

Because of the merits listed above, better cost performance is obtained by replacing a steel structure with a CFT structure.

Ecology:

The environmental burden can be reduced by omitting the formwork and by reusing steel tubes and using high-quality concrete with recycled aggregates.

II. REVIEW OF LITERATURES

A detailed review of literature has been carried out and the work done by various researchers in the field of composite columns are presented.

Brian Uy (2000) showed that concrete filled steel box columns have recently experienced a renaissance in their use throughout the world. This has occurred due to the significant advantages that the construction method can provide. This paper deals with the strength behavior of short columns under the combined actions of axial compression and bending moment. The paper addresses the effect of steel plate slenderness limits on this behavior. An extensive set of experiments has been carried out and a numerical model developed elsewhere is augmented and calibrated with these results. A simple model for the determination of the strength-interaction diagram is also verified against both the test results and the numerical model developed in this paper. This model, based on the rigid plastic method of analysis, is existent in international codes of practice, but does not account for the effects of local buckling, which are found to be significant with large plate slenderness values, particularly for large values of axial force. Thus some suggested modifications are proposed to allow for the inclusion of slender plated columns in design. A set of detailed experiments has been conducted that included very large plate slenderness limits. The experiments here have shown that local buckling is significant in thinwalled composite columns. Furthermore, the use of the mean compressive stress for maximum compressive stress was found to be valid when the plate slenderness was compact. This may also be due to the good quality of concrete caused by the retention of moisture.

B. Lakshmi et al (2002) showed a semi analytical method to predict the behavior of infilled columns is presented in this paper. Moment- curvature-thrust relationships are generated for column cross sections by an iterative process. Nonlinear equilibrium equations resulting from geometric and material nonlinearities are solved by an incremental-iterative numerical scheme based on the generalized displacement control method. Square, rectangular, and circular cross sections of compact steel tubes filled with concrete are considered in the analysis. The columns are pin- ended and subjected to uniaxial or biaxial loading. The accuracy of the proposed analytical method is established by comparing the results with the corresponding experimental values.

Anil Kumar Patidar (2012) The Concrete Filled Steel Tube (CFST) member has many advantages compared with the conventional concrete structural member made of steel reinforcement. CFSTs are frequently used for columns, caissons and for piers, deep foundations because of their large compressive stiffness. The FEA modeling using ANSYS software is adopted to investigate the load versus lateral deflection behavior of the composite sections. The effects of steel tube thickness and strength of in-filled concrete tubes are examined. The FEM model of hollow and CFST columns are developed using ANSYS software and the load versus behavior of columns is studied. The finite element proposed model shows the resistance to deformation when concrete is used as infill material and deformation decreases when an increase in the grade of concrete. The hollow steel tube column however deform to a greater extent as compared with the column having the in fill material.

Sachin G Tidke, Dinesh W.Gawatre (2013) made an investigation on concrete filled tubular column or CFT column consists of hollow steel tube filled by concrete. Concrete filled steel column is becoming popular for the earthquake resistant structures because of good ductility and high axial strength. It has been observed that structure with concrete filled steel column performs well during strong earthquake. Several codes, namely Eurocode- 4,BS 5400-part-5,AISC-LRFD and Architectural Institute of Japan have their own specifications for concrete filled steel columns. In this paper load carrying capacity of concrete filled steel columns are determined analytically using these code specified formulae. Finally the analytical results are compared with experimental data available from existing literature.

Darshika k. Shah (2014) showed **i**n recent days, due to the expansion of cities it is required to construct the high storey buildings. Composite buildings prove to be promising for multi storey building. As a result, composite columns have recently undergone increased usage throughout the world, which has been influenced by the improvement of high strength concrete enabling these columns to be considerably economized. Columns are designed to resist the majority of axial force by concrete alone can be further economized by the use of thin walled steel tube. The paper discusses about the behavior of the composite column and various codal provisions. It also focuses on the research activities done on the composite column over the last few years, which have impacted the use of composite column.

III. MATERIAL

Cement

Ordinary Portland cement 53 grade brand conforming to Indian Standard is used in the present investigation. The cement is tested for its various properties as per Indian Standard code.

Fine Aggregate

The locally available sand is used as fine aggregate in the present investigation. The sand is free from clayey matter, salt and organic impurities. The sand is tested for various properties like specific gravity, bulk density etc., in accordance with Indian Standard 2386-1963

Coarse Aggregate

Machine crushed angular granite metal from the local source is used as coarse aggregate (confined to Indian Standard: 383-1970). It is free from impurities such as dust, clay particles and organic matter etc. The coarse aggregate is also tested for its various properties.

Hollow Steel Sections

A hollow steel section (HSS) is a type of metal profile with a hollow tubular cross section. HSS members can be circular, square, or rectangular sections, although other shapes are available, such as elliptical. HSS is only composed of structural steel per code. The corners of HSS are heavily rounded, having a radius which is approximately twice the wall thickness. The wall thickness is uniform around the section. The three basic shapes of hollow steel sections are referenced as CHS, SHS, and RHS, being circular, square, and rectangular hollow sections.The major properties of the constituent materials of concrete were given in Table 1. (a) and (b)

Table 1(a)

MATERIALS	**PROPERTIES**
CEMENT (OPC)	SPECIFIC GRAVITY = 3.15
WATER	DENSITY = 1000 kg/m^3

Table 1(b)

PROPERTIES	**COARSE AGGREGATE**	**FINE AGGREGATE**
SPECIFIC GRAVITY	2.60	2.67
BULK DENSITY	1630 Kg/m^3	1754 Kg/m^3
FINENESS MODULUS	6.95	3.02
WATER ABSORBTION	0.21%	1.7%

IV. EXPERIMENTAL INVESTIGATION

GENERAL:

An experimental study is conducted to find out the compressive strength of composite column at 28days. M40 grade of concrete is designed according to IS 10262-1987. The specimens were produced with different shapes(square, rectangular and circular) and sizes. The mix proportion of concrete mix is shown in Table 2.

Table 2: Mix proportion for control mix concrete

Cement kg/m^3	Fine aggregate kg/m^3	Coarse aggregate kg/m^3	Water l/m^3
515	398.135	1163.178	206

WORKING PLAN:

The present experimental programme includes casting and testing of specimens for Compression strength. Specimens are prepared for M40 grade of concrete. Total of 6 specimens of different shapes (square, rectangular and circular) and sizes are casted.

CASTING:

The sections of different shape and size of composite columns are casted for M40 concrete grade. The specimen dimensions are given in Table 3.

Table 3:Specimen dimensions

TYPES	**DIMENSIONS (MM)**
Rectangle	100 x 50 x 2.5 80 x 40 x2.5
Square	75 x 75 x 2.5 50 x 50 x 2.5
Circle	90 x 2.5 75 x 2.5

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CURING THE SPECIMENS

After casting, the specimens are stored in the laboratory free from vibration, in moist air and at room temperature for 24 hours. After this period, the specimens are immediately submerged in the clean fresh water of curing tank. The curing water is renewed after every 5 days. The specimens are cured for 28 days in present work.

TESTING OF SPECIMEN

After removal from the curing tank. The specimens are allowed to dry under shade.

The specimens are tested at 28 days respectively and the compressive strengths of six specimens are determined. Testing were done in the UTM machine.

V. ANALYTICAL INVESTIGATION

The different specimens of composite columns are modelled using abaqus software and its behavior is studied analytically.

VI. RESULTS AND DISCUSSION

Table 4:Analytical Results

SECTIONS	DIMENSIONS (MM)	M40 (KN)
Rectangle	100 x 50 x 2.5	375
Rectangle	80 x 40 x2.5	300
Square	75 x 75 x2.5	420
Square	50 x 50 2.5	250
Circle	90 x 2.5	420
Circle	75 x 2.5	320

Fig 1 Deformed sections analysis using abaqus

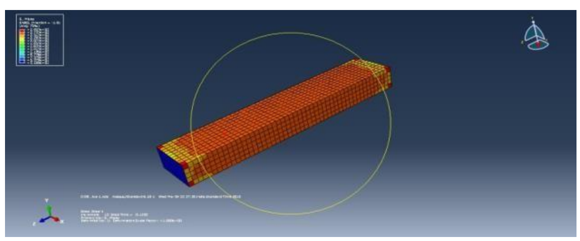
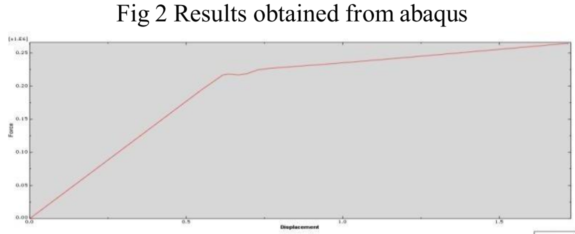


Fig 2 Results obtained from abaqus



SUMMARY

From the literatures, it is clear that investigation were made on concrete filled tubular column consists of hollow steel tube filled by concrete. It is shown that load carrying capacity of concrete filled steel columns are determined experimentally and analytically using abaqus software. Finally the analytical results are compared with experimental data and it shows good agreement with the test results

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