# Strength Performance Of Expansive Concrete Filled CFST Columns Under Axial Loading

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***Abstract-*** *This study investigates the bond strength and axial compressive strength of concrete-filled circular steel tubes (CFST) columns using expansive concrete. Expansive concrete is a type of concrete that can generate internal expansive pressure, leading to improved bond strength and increased compressive strength. The study involves experimental testing of 16 CFST columns filled with expansive concrete and regular concrete as a control. The test results show that the bond strength of the expansive concrete-filled CFST columns is significantly higher than that of the regular concrete-filled columns. The increase in bond strength is attributed to the formation of micro-cracks in the expensive concrete, which enhance the mechanical interlocking between the steel tube and the concrete. The study also found that the axial compressive strength of the expansive concrete-filled columns is higher than that of the regular concrete-filled columns. This is due to the internal expensive pressure generated by the expansive concrete, which leads to denser concrete and higher compressive strength. Additionally, the effect of confinement on the bond strength and axial compressive strength of the columns was also investigated. The results showed that the confinement provided by steel hoops significantly improves both the bond strength and axial compressive strength of the expansive concrete-filled columns*

## I. INTRODUCTION

Structural members made up of two or more different materials are known as composite members. The main advantage of composite members is that the beneficial properties of different materials can be effectively combined to form a single unit that performs better than having members of single material. The most common form of composite member used in structural engineering industry is a steel - concrete composite member. As a material, concrete works well in compression, but it has less resistance in tension; whereas steel is strong in both compression and tension. Steel-concrete composite member utilizes concrete's compressive strength along with steel's resistance to tension resulting in a highly efficient unit that can be most effectively used in construction industry.

## II. CONCRETE FILLED STEEL TUBULAR SECTION

Concrete-Filled Steel Tube (CFST) columns involves of a steel tube filled with plain or reinforced cement concrete. The concrete core enhances stiffness and compressive strength to the steel tubular column and reduces the probability for inward local buckling. On the other hand, the steel tube acts as longitudinal and lateral reinforcement for the concrete core helping it to resist tension, bending moment and shear and providing confinement for the core concrete. CFST column utilizes the advantages of both hollow structural steel and concrete core. The enhancement in behavior of CFST column as a structural system is due to the composite action between the constituent elements. Due to admirable static and earthquake resistant properties of CFST members such as high strength, high ductility and large energy absorption capacity, they are being widely used. Under axial compression, the steel tube confines the concrete core, thereby improving both the axial load resistance and ductility of CFST members. Due to high shear capacity of concrete filled steel tubular members, the failure occurs due of flexure in ductile manner. Moreover, steel tube serves as permanent formwork and also acts like distributed reinforcement located at the most efficient position. This approach is economical and also meaningfully speeds up the erection work. For concrete- filled steel tubes, inward local buckling of steel tube is effectively prevented which is normally observed in bare steel hollow columns (Lin *et al*. 2014).

## III. NEED FOR THE STUDY

The behaviour of CFST columns has been the theme of numerous experimental and theoretical research studies since Kloppel&Godar (1957). Tests have been performed on short and slender columns under an assortment of axial and eccentric load conditions. Detailed experimental studies into the enhanced strength and ductility of short columns have been published by Dutta & Bhattacharyya (1995), O'Shea & Bridge (1995), Ramajeyam&Swamidurai (1997), Schneider (1998), Claeson&Gylltoft (2000), Johansson &Gylltoft (2002), Giakoumelis& Lam (2004) and Chithira&Baskar (2012). Accompanying such investigations, an assembly of design models have been derived empirically or theoretically and are incorporated in several International design standards for the implementation of CFST design provisions. Due to variations in analytical procedures, design philosophy and empirical data used, momentous discrepancies exist with respect to quantifying the ultimate capacity of the composite section. This non-uniformity and the inception of CFST columns in buildings and bridges has emphasised the importance of further research required into the behaviour of CFST by varying the infilled concrete in columns.

## IV. SCOPE OF THE THESIS

The parameters varied to study the behavior of axial compressive strength are the length of column, diameter of column and age of concrete.

ACI-318, AISC-LRFD and Euro Code 4 (EC4) is used in the theoretical investigation on CFST columns.

The commercial software Abaqus 6.14 is used to create the numerical models to validate it with the experimental results and parametric study is carried out by varying the length, diameter, thickness of steel tube and grade of materials.

Two stages of experimental investigation are carried out. Initially four different types of concrete are considered for the study as concrete infill material and the specimens are tested for bond and axial strengths. Further, the CFST column specimen with infill which influenced the better engineering performance and the conventional CFST column specimen are tested for bond and axial strengths by varying geometric property and age of testing (28 to 365 days).

At some point of time the load values tend to decrease, which is an indication that the CFST column specimen lost its bond between the steel tube and the concrete core. Even after this point, the test is continued until the specimen obtained a concurrent load value or a maximum recordable slip of 50mm. The experimental test readings of the push-out test are recorded.

## V. MATERIAL

### Cement

Cement as an ingredient in concrete is a vital material owing to its characteristics of binding concrete mix together, giving it strength. One of the important criteria for the selection of cement is its ability to produce improved microstructure in concrete. The selection of proper grade and good quality of cement is important for concreting. Few imperative factors, which play a vital role in the selection of the type of cement, are compressive strength at various ages, fineness, heat of hydration, alkali content, Tri calcium silicate (C3S) content, Di calcium silicate (C2S) content and compatibility with admixtures etc., In this project, Ordinary Portland cement of 53 grade is used. The specific gravity of cement is 3.15.

### Fine Aggregate

Fine aggregate which is river sand used for concrete should be free from clay, silt and chloride contamination etc., and properly sieved to give minimum void ratio. The sand with properties such as void ratio, gradation, specific gravity, fineness modulus, free moisture content, specific surface and bulk density have to be assessed to design concrete mix with optimum cement content and reduced mixing water.

### Coarse Aggregate

Coarse aggregate which is gravel that are passed through 10mm size sieve and retained on 12.5 mm and 20mm size IS sieve is used in the project. The aggregate retained on 12.5 mm is taken 40% and those retained on 20 mm are taken as 60%.

### Water

Water to be used in concrete should be Potable. Potable Water is an important ingredient of concrete as it actually participates in the chemical reaction with cement. As it helps to achieve the strength by the formation of cement gel, the quantity and quality of water required is to be looked into very carefully.

### Steel Fibre

Steel fibres are used to improve the loading carrying capacity and tensile strength of concrete. There are different types of steel fibre namely crimpled type, hook type etc.

The steel fibres are chosen on the basis of aspect ratio which is the ratio of length of fibre to the diameter of fibre. In this project, hook type steel fibre of aspect ratio 60 is used in steel fibre reinforced concrete.

### Ground Granulated Blast Furnace Slag (GGBS)

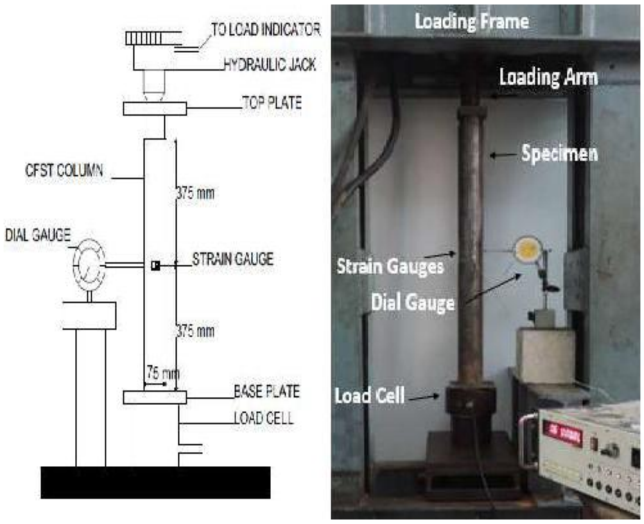
GGBS is a granular product obtained by quenching molten iron slag from blast furnace. GGBS is a pozzolanic material used as a replacement for cement in concrete.

**Alkali Activator Solution**

Alkali activator solution is used in geopolymer concrete to induce polymerization. 5 Molar NaOH together with sodium silicate is used as activator solution for the experimental investigation.

**Expansive Agent**

Shrinkage compensating admixture is added in expansive concrete which allows unrestrained expansion of 4%. One of the best shrinkage compensating admixtures Cebex 100 is used for the experimental investigation.




## VI. ESTIMATION OF QUANTITY OF INGREDIENTS OF CONCRETE

| Type Of Concrete | Cement (Kg) | Fine Aggregate (Kg) | Coarse Aggregate (Kg) | Water (L) | Other Ingredient |
|---|---|---|---|---|---|
| Conventional Concrete | 438.75 | 650.25 | 661.25 441 | 197 | Nil |
| Steel Fibre Reinforced Concrete | 438.75 | 650.25 | 661.25 441 | 197 | Hook Type Steel Fibres 0.75% By Volume Of Concrete |
| Geo Polymer Concrete | Nil | 650.25 | 661.25 441 | Nil | Fa And Ggbs 50% By Weight Of Cement |
| Expansive Concrete | 437.25 | 650.25 | 661.25 441 | 197 | Cebex 100, 0.45% By Weight Of Cement |

## VII. AXIAL LOAD CAPACITY OF CFST COLUMNS USING NUMERICAL SIMULATION

Numerical investigations on CFST column are carried out for boththe phase one and the phase two specimens investigated experimentally. Eventually, parametric study using Finite Element Analysis is conducted on CFST columns filled with expansive concrete to examine the effects of grade of concrete core, grade of steel tube, type of infill concrete core, thickness of steel tube, diameter of column and height of column in CFST column specimen. In this study, test results of axial load (N) axial strain or axial shortening curves reported are collected and used to make reliable comparisons. Appropriate nonlinear vibrant material models for outer steel tubes and confined concrete core are proposed to overcome the challenges related with erstwhile FE analysis of CFST column. The nonlinear finite element program ABAQUS is employed to attain numerical simulations of CFST columns subjected to the axial compression. The proposed material models and the predicted ultimate strengths of CFST columns are substantiated against experimental data of Talha&Baraa (2016), Cheng (1988) and Gaikoumelis& Lam (2004). Further, the model is used to verify the experimental work conducted in this study. The verified material models are used to conduct a parametric study to examine the effects of grade of concrete core, grade of steel tube, type of infill concrete core,thickness of steel tube, diameter of column and height of column in CFST column specimen. Finally, the influence of the said parameters is reported and discussed in detail.

## VIII. PARAMETRIC STUDY ON CFST COLUMNS

The parameters considered in the study are thickness of steel tube, diameter of column, height of column, grade of concrete core and grade of steel tube. For comparison purpose the specimens are selected in such a way that, the parameter considered in the study is varied by keeping all other parameters as constant. For instance, if grade of concrete is the study parameter then the grade of concrete is varied from 30 to 90 MPafor parametric study by keeping the thickness of steel tube, height of column, diameter of column and grade of steel as constant

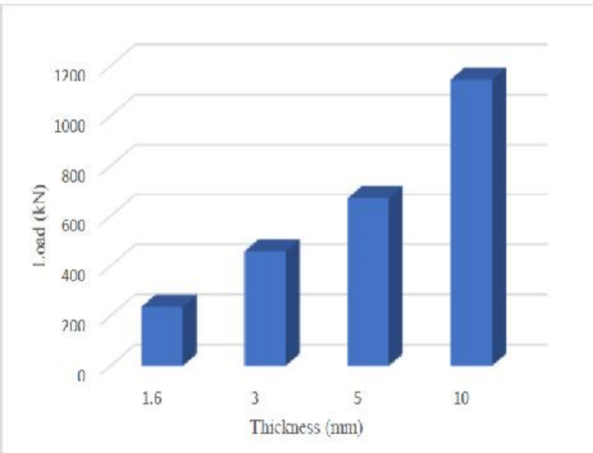
## IX. INFLUENCE OF THICKNESS OF STEEL TUBE

The thickness of steel tube is varied from 1.6 to 10 mm for parametric study by keeping the height of column, diameter of column and grade of concrete and grade of steel tube as constant. The thickness of steel tube considered in the study are 1.6 mm, 3 mm, 5 mm and 10 mm. The axial load carrying capacity for different thickness of steel tubes obtained using the FE model is shown in Figure 6.3. From Table 6.3 the study results show that the thickness of steel tube plays an important role in axial load carrying capacity of CFST column. It is observed that the axial load carrying capacity of CFST column with wall thickness 1.6mm, 3mm, 5mm and 10mm are 235.9 kN, 457.4 kN, 670.3 kN and 1145.2 kN respectively. This drastic increase in axial capacity of CFST column is owing to the confining pressure offered by the steel tube to the concrete core in CFST column. Larger the thickness of steel tube results in higher confining pressure also larger the thickness will delay the local buckling of steel tube which will result in higher load carrying capacity.

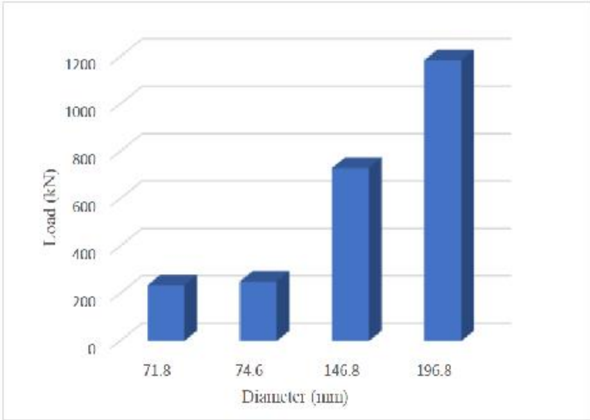
## X. CONCLUSION

1. The chapter of the thesis presents the details and test results of the experimental investigation carried out on CSFT column specimens.
2. The chapter of the thesis presents axial load capacity of CFST Columns using various codes of practice, discusses about the various codal recommendations for concrete in-filled sections under axial compression. The experimental and the calculated values of axial load carrying capacity of the tested CFST column specimens are compared and presented.
3. The chapter of the thesis presents axial load capacity of CFST columns using numerical simulation, presents the details of finite element modelling carried out using the finite element software ABAQUS.
4. The chapter of the thesis documents the results and discussions of all the analyses carried out viz., experimental, theoretical and numerical investigations and comparison of results are presented. This chapter summarizes the conclusions drawn from the present work, contributions and scope for further work.

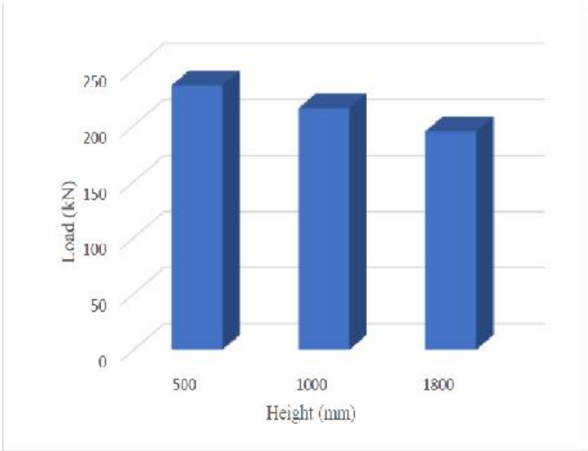
**Axial load carrying capacity of CFST columns vs thickness of steel tube**



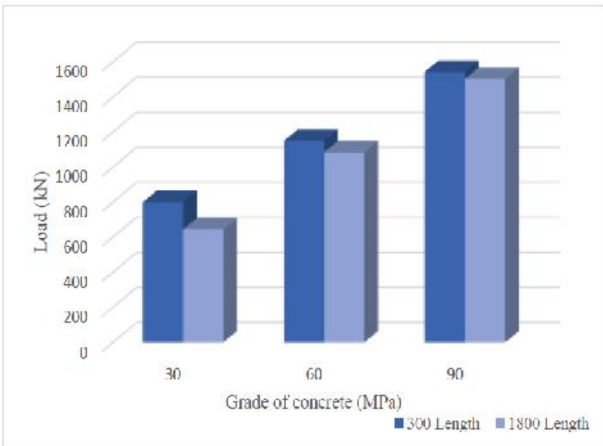

**Axial load carrying capacity of CFST columns vs diameter ofColumns**



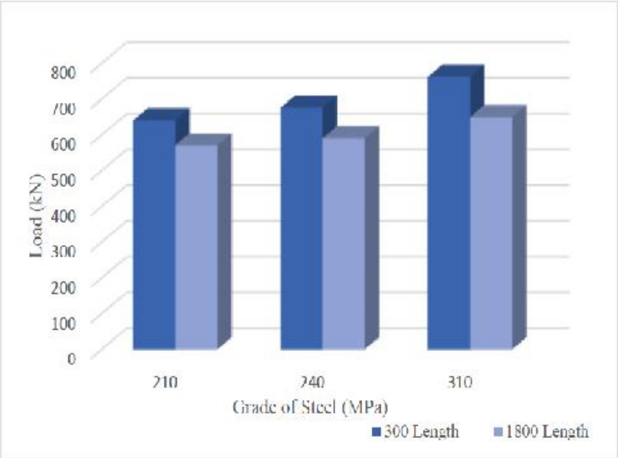

**Axial load carrying capacity of CFST columns vs height ofColumns**




**Axial load carrying capacity of CFST columns vs grade ofConcrete**




**Axial load carrying capacity of CFST columns vs grade of steel**




**Axial load carrying capacity of CFST columns vs l/d ratio**