

Comparative Analysis of Concrete Filled Steel Tube as a Compression Member

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Abstract

Concrete-filled steel tubes (CFSTs) are used in constructions such as piles, caissons, columns, piers. Relative to conventional structural steel and reinforced concrete and provides huge tensile and compression capacities; the concrete fill prevents buckling of the steel tube and increases the capacity, stiffness and ductility of the section. Sometimes, reinforcement is used to strengthen and facilitate connection to adjoining members. Even though these properties are well favouring, the use of CFST in practice is rare because every design code gives different codal provisions.

A study was carried out to enhance design norms for CFSTs without reinforcement bars under general loading. A model was made to reproduce test results subjected to both axial and combine loading and after validation model was used to study the strength and performance of CFSTs under general loading. The comparisons indicate that present design gives good resemblance of CFST capacity subjected only to bending or axial loads with experimental results by previous researchers but current provisions provide conservative values for the CFSTs under general combine loading.

Keyword- Concrete Filled Steel Tubes (CFST), ABAQUS, Combine Loading, Axial Loading

I. INTRODUCTION

Concrete-filled steel tube (CFST) columns consist of a steel tube and concrete infill. Steel tube confines the concrete in a triaxial state. Composite columns offer considerable improvements over conventional columns reinforced with steel bars and are used in many structural applications. In traditional reinforced concrete columns, solid steel bars are used as longitudinal reinforcement. CFST members have higher strength, larger stiffness and ductility. In this study an attempt is made to study behavioural response of Concrete-filled steel tube CFST members subjected to various combinations of loading using finite element analysis based modelling in ABAQUS and the said results are compared with conventional reinforced cement concrete members.

Concrete-filled tubes CFSTs are composite members that consist of a steel tube and concrete infill. In Asia, they have been used as building columns and bridge piers as an alternative to conventional reinforced concrete construction. A primary benefit of CFSTs is that the concrete fill provides large compressive load capacity and restrains buckling of the steel tube, which results in significant resistance and inelastic deformation capacity.

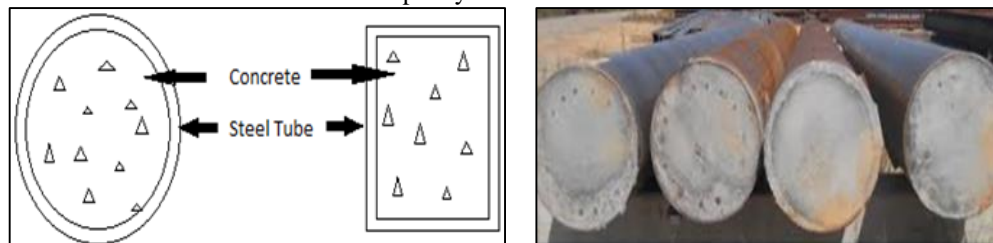


Fig. 1: Concrete filled steel tubes (CFST)

Various literature on Concrete filled steel tubes were studied and it was found that most feasible method for composite section analysis is Finite Element based Method. In the present study, done by Scheinder the non-linear response of concrete filled steel tubular column using FE Modelling under the axial loading has been carried out with the intention to investigate the relative importance of several factors. These include the variation in load displacement graph and the crack patterns of concrete filled steel tubular columns. Finally results from FEM compared with experimental results and comparative study shows the behaviour of concrete filled steel tubular columns under axial loading.

A. Modeling of CFST

Three different types of elements were used to model the concrete fill, steel shell and interface between the steel shell and concrete fill.

1) Concrete Element Modelling

The eight-node solid element (C3D8R) was used to model the concrete, Drucker Prager plasticity model inset in ABAQUS was adopted for specimens to describe the plastic stress strain behavior of the confined concrete. The dilation angle, ψ , of the concrete is an important model parameter, which in part determines the plastic hardening of the concrete. It was approximated as 20° based on the results of prior studies.

B. Steel Element Modelling

The four-node shell element (S4R) was used to model the steel shell. Von-Mises yield criterion is used to define the yield surface for steel. The poisson ratio for steel is taken as 0.3.

C. Friction Surface Modelling

Shear stress transfer between the steel tube and the concrete infill is accomplished through friction, which was introduced to the model through a friction coefficient assigned to the GAP element. Thus, shear stress at the interface is generated with pressure acting through the GAP element with a specified value of friction coefficient. A friction coefficient of 0.47 was used based on validation from a prior study.

The validation of modelling results was done by comparing experimental results of model of Matsui et. al with results based on ABAQUS.

Parameter	Value
Modulus of Elasticity of Steel (E_s)	200000 MPa
Modulus of Elasticity of Concrete (E_c)	25000 MPa
Outer Diameter (D)	140 mm
Tube Thickness (t)	6.5 mm
D/t	39.6
L/D	21
Coefficient of Friction	0.47
Dilation Angle	20
Poisson's Ratio	0.3

Table1: Properties of materials used for modelling

II. RESULT AND ANALYSIS IN ABAQUS

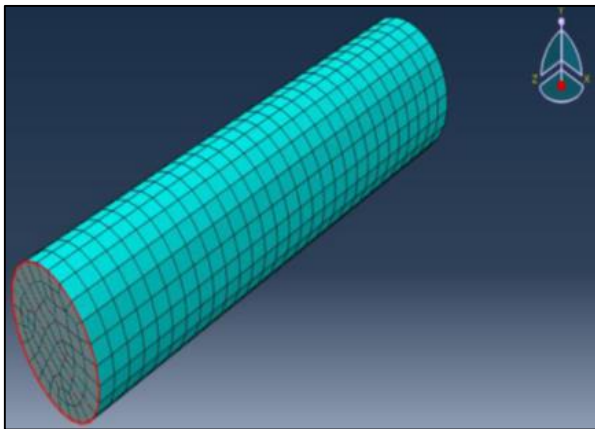


Fig. 2: CFST model in ABAQUS

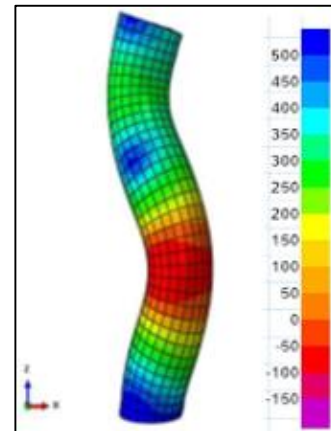


Fig. 3: Deflected shape

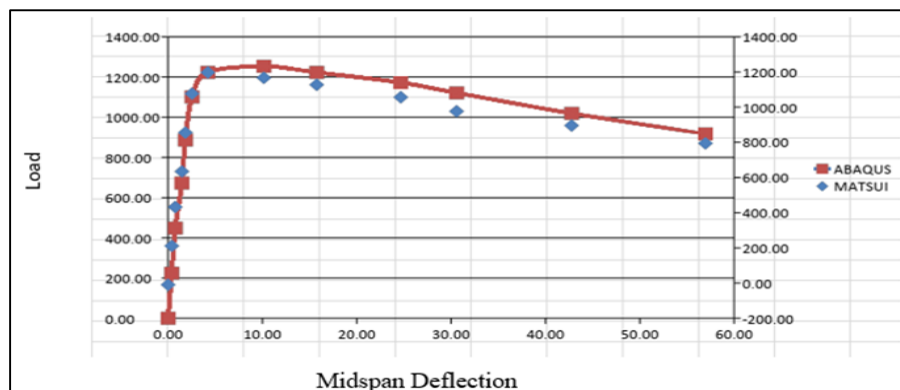


Fig. 4: Validation of results in ABAQUS with experimental data

Comparison of both graphs shows results obtained from experiment by Matsui et.al and ABAQUS are in accordance with each other. This implies modelling is correct.

A. Study of CFST under Combine Loading

The validated models in ABAQUS were studied for various parameters such as D/t ratio, axial load ratio. Graphs below compares the moment vs drift relationship where the drift is defined as lateral displacement at the top divided by the column length. The models provide good simulation of the measured stiffness, yield, and maximum strengths.

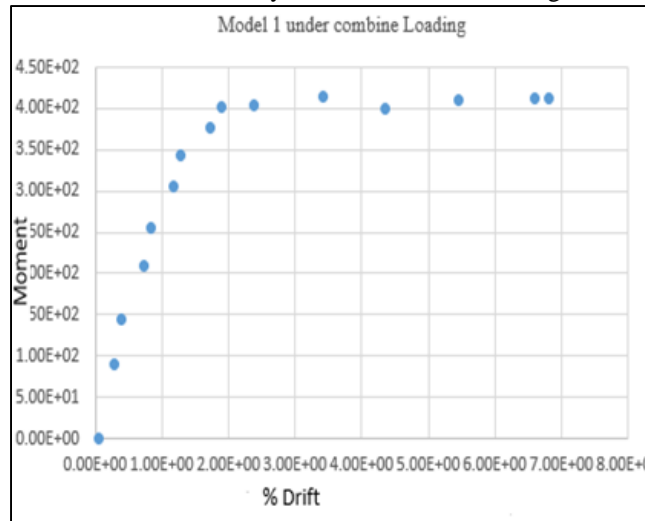


Fig. 5: Moment – Drift graph for 1st model in ABAQUS

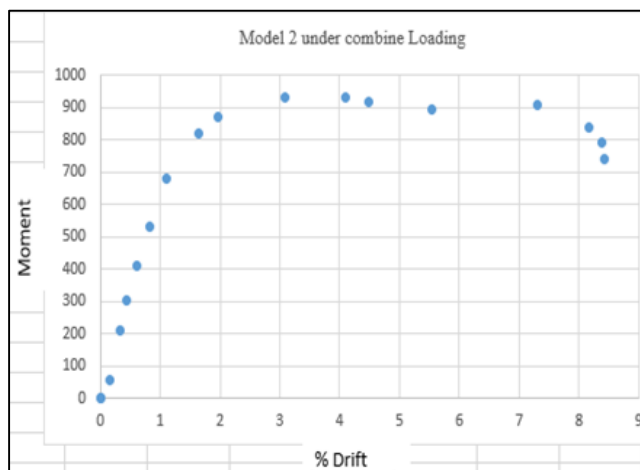


Fig. 6: Moment – Drift graph for 2nd model in ABAQUS

III. CONCLUSIONS

In this study, the strength and behavior of CFSTs without internal reinforcement under general combined loading was studied. The research was as follows. A finite-element model of simulating generalized conditions, including the impact of slip and axial load, was developed. The model was verified using previous tests for CFSTs by researchers under various loading conditions and the accuracy of the finite-element models was verified.

- 1) From Load vs Midspan deflection relationship it was concluded that ABAQUS shows good accordance with actual behavior of CFST model under uniaxial loading and gives result on safer side.
- 2) From analytical study of CFST under biaxial loading it was concluded that as Moment at fix end increases % drift first increases and then decreases showing sudden increase in ductility of specimen when subjected to higher load. Thereafter decrease of moment as % drift increases shows section has yielded and behaving as a plastic member.

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