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Concrete-Filled Steel Tubular (CFST) Columns

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Abstract—*With the advancements in the engineering structures in accordance to the height of the structure the concrete filled steel tubular members are found to be most propitious. This conclusion can be drawn down from ample of researches and structural evidences from all around the globe. Since the year 1961, the engineers of developed countries are monitoring CFST members for their potential application in the structures. Many operations have been performed under CFST columns, worldwide the codes have been arrived for its effective use like the Euro code version "BS EN1994-1-1", the American code version "American Institute for Steel Construction (LRFD) AISC 360-05" and the two Australian codes "Australian Standard of concrete structures AS 3600-2001" and "Australian Standard of steel structures AS 4100-1998".*

Concrete-filled-steel-tube (CFST) columns are the most favourable column type for the construction of high rise buildings due to its consummate strength and ductility performance bestowed by the composite action. However, this beneficial composite action cannot be fully matured at early elastic stage as steel distend more than concrete and thereby causing inoperative interface bonding, which degrades the elastic strength and stiffness.

This paper attempts to provide a detailed comparison of the design considerations and analysis of concrete-filled steel tubular (CFST) columns and its assistance over RCC columns for the practical use.

1. INTRODUCTION

Concrete filled steel tubular (CFST) columns are the vertical members, they are a modern day structural upgrading of columns so as to improvise its ductility, strength and the load bearing capacity, these members utilize both steel and concrete. They incorporate of a steel hollow section which can be of any shape (circular or rectangular) and size according to the need, with plain or reinforced concrete filled at the centre core. The hollow steel tubes that are either fabricated or rolled were firstly formulated to support the construction load of the upper floors. Typically, they are used in composite framed structures; they are widely used in high-rise and multi-storey buildings as vertical members or in the large size structures where efficient formational system is required.

The privilege of using CFST columns in the structural systems not only enhances the structural performance but improvise the construction sequence as well. The functioning of the concrete in-fill is improved due to incarceration exerted by the steel shell. The diffusion of matter in the cross section also makes the network very efficient in term of its structural potential. The steel lies at the outer periphery where it performs efficiently in order to resist the tensile forces. The concrete core gives the substantial contribution to resist the axial compressive forces.

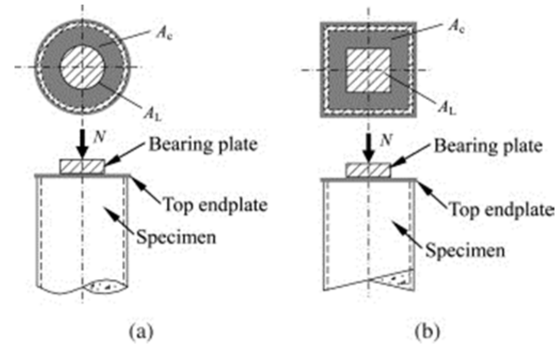

Fig. 1: Plan and Section of CFST Columns

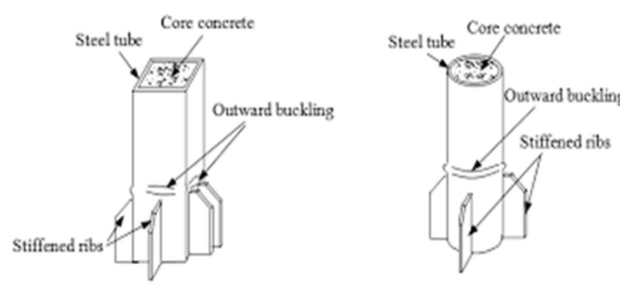

Fig. 2: Rectangular and Circular CFST Columns

2.1 Behaviour of Concrete Filled Steel Tube Columns

2.1.1 Columns under Compression

Some of the betimes research on concrete filled steel tubular columns subjected to concentric compression was accomplished out by Jacobson and Gardner (1967), Park and Knowles (1969). During the analysis of behaviour of CFSTs, they found that the concrete ascendancy results in an amplification of the compressive strength, and also in the evolution of hoop stresses in the steel tube which causes depletion in the effective yield strength of steel, after ample amount of experimental and theoretical studies were performed, and a conclusion was drawn that the measured ultimate load of circular CFSTs is considerable larger than the nominal load.

2.1.2 Concrete Filled Steel Tube Beam (Bending)

For the calculation of ultimate moment capacity of the CFST sections, the reinforced concrete theory was reviewed by most of the researchers. According to the codes of practices [ACI 318, 1995; AS3600, 1994], it is marked that the concrete failure will occur at 0.3% of limiting concrete strain and has no strength in tension zone, in CFST the tensile force is resisted by the steel tubes only. Therefore, moment resistance has a high stature in the steel tube.

According to the tests performed by Bridge a conclusion was drawn that in a member under pure bending condition concrete provide only 7.5 % of capacity.

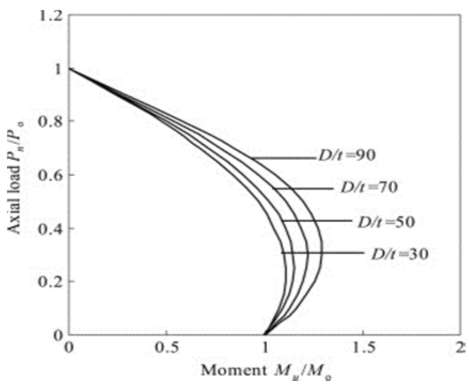

Fig. 3

2.2 Inelastic Connection Behaviour

In a study by Schneider were only circular tubes were considered, The tubes were named as the Type I and Type II, circular tubes were considered as the connection of the girder to the tube wall tends to be cumbersome when compared to the square tube .The connection that was attached to the skin of the steel tube only was named as Type 1, this appeared to be the easiest to construct. The Type II connection had a CFST continued by a girder section.

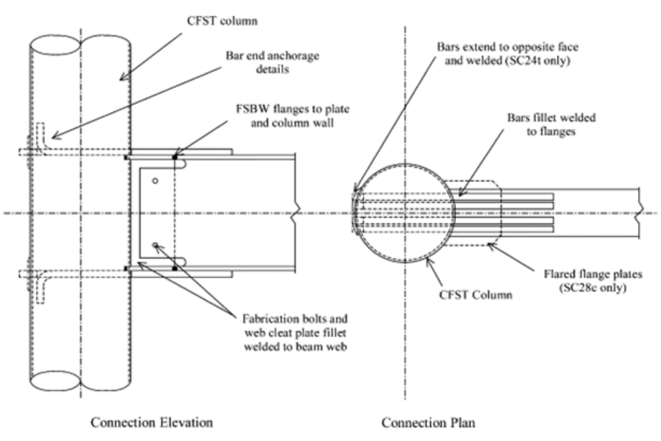

Fig. 4

2.3 Load Transfer Mechanism

It has been perceived that the sum of uncoupled steel and concrete at failure loads is less than ultimate axial capacity of CFST. The confining effect of steel tube on the concrete is one of the major causes of failure. The structural behaviour of CFT sections is highly affected by the contrast between the Poisson's ratios of concrete and steel tube. Initially while loading, the Poisson's ratio for the steel is higher than that of concrete. Thus the steel tube has no impound effect on the concrete. With the increase in longitudinal strain, the lateral expansion of concrete gradually enhances the expansion of the steel tube. At this stage the steel tube bi-axially stressed and concrete becomes tri-axially loaded.

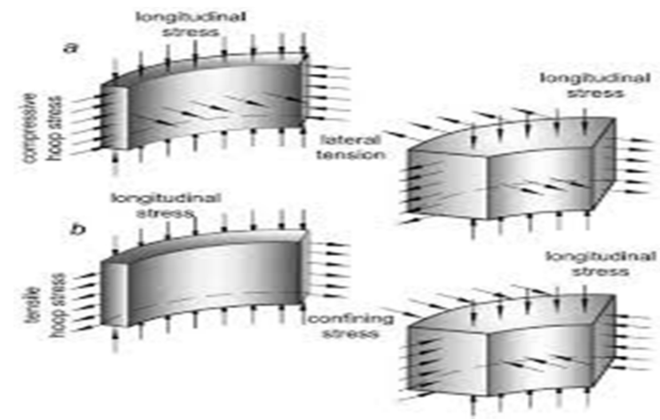

Fig. 5

3.1 Advantages of CFST Column System

Benefits of CFST in resident buildings over steel columns.

1. If the frame-tube system is embraced, the RC elevators can be employed as structure to resist the lateral loads. For official buildings the shear-walls or braces set on the symmetrical positions of plan can be used.
2. Column's net can be deployed; two rooms or even more can comprise in a span of the column. Hence, the economical benefit will be more.
3. The frame beam's span can be large the span of frame beam can be reached about 7~8m even more. Hence, steel beams should be utilize.
4. Story structure system
5. As mentioned above, the span of story beams is 7~8m always, even reaches to 10m. Hence, the story structure system may be as following kinds.
   - Composite steel story system
   - Pre-stressed RC plate can be on the steel beam, and then surge RC deck with ~100mm thickness on it.
   - In two direction dense ribs story structure, SRC beams are utilized, this type of story structure system is cheap and convenient for construction.

- The space consumed by CFST columns cannot be more than that of steel column. As the dimension of the column is equivalent to the periphery of the steel tube. Only 10% of the total volume of the CFST is concentrated by the core concrete.
- Aspects like corrosion, fire resistant and seismic effect are improvised in the CFST column as compared to the typical steel column.

Fig. 6: A schematic of unfilled CFST Column.

3.2 Limitations

1. A supreme disincentive to widespread use of CFSTs is the restricted knowledge regarding their nature, due to various anonymous factors complicates the study and analysis of CFST.
2. Primarily the CFT contains only 2 materials steel and concrete which are of different statures, the basic but conflicting properties of the two materials creates a chaos in determination properties such as moment of inertia and modulus of elasticity combine.
3. The failure contraption depends largely on the physical parameters such as volume, thickness, mass etc., which are large in number, which creates a problem in justifying the failure mechanism.

CFST beam-column, are been studied worldwide, researchers are still monitoring various properties such as the effect of bond, confinement, local buckling, scale effect, and fire on CFT member strength, load transfer mechanism and categorization of response in CFTs at all levels of loading so as to facilitate the development of performance-based design provisions.

2. INTRODUCTORY APPLICATION OF CFST COLUMN

Ever since the CFST was introduced, it was first adopted in the subway no. 1 of Beijing. The main aim of using the CFST column was to increase the usable area, the CFST columns introduced were economically feasible.

There are over 200 constructed engineering structures impounded of CFST columns in China. Some typical engineering are introduced as follows.

1. The steel ingot work- shop of Benxi steel company, the span is 24m, interval of column is 6m, which the heavy cranes Q=20t/200t and 10t/50t are equipped. The length of column is 15.8m. Four limbs column was used, steel is Q235 and concrete is C40. It was the first industry building adopted CFST columns. It completed in 1972.

2. Completed in 1999. Shenzhen SEG Plaza is the highest one in China and abroad, it comprises of many new technologies including the CFST columns. It also promotes the development of CFST structures in our country to a higher level.

Fig. 7: SEG Plaza under construction

3. The first CFST Arch Bridge was constructed in china, of the span 115m over the china's wangchang river, concrete filled steel tube (CFST) the concrete in the tube improvises the stability of the thin-walled steel tube in compression.

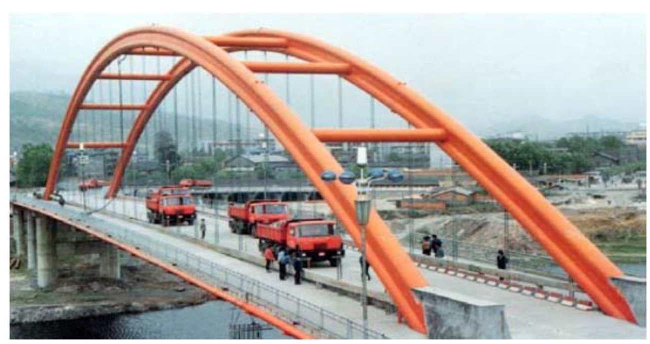

Fig. 8: First CFST Arch Bridge in China: Wangchang East River Bridge (Span 115 m)

3. CONCLUSION

The paper deals with the knowledge regarding the CFST columns, the comparison of CFST columns and typical RCC columns, also provides theoretical information about the practical short term and long term behaviour of the column in loaded conditions and the change in behaviour of the column with respect to its height and span.

The paper also includes the load transfer mechanism in the CFST columns and the first few examples where the CFST columns are been introduced in projects, all around the globe.

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