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A Comparative Study of Ultimate Strength on Hollow Rectangular Filled Concrete Tube-IN-Tube Section – A Review

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Abstract - This paper briefly discuss about research outcomes of concrete-filled double skin rectangular columns.Hollow structural section (HSS) especially rectangular sections, are commonly used in welded steel frames where members experience loading in multiple directions.Fibre-reinforced plastics are a category of composite plastics that specifically use fibre materials to mechanically enhance the strength and elasticity of plastics.Tubular sections such as Aluminium, Stainless steel, Mild Steel and FRP plays an important role in this study. The most common sectional form consists of a layer of concrete sandwiched between rectangular inner steel tubes and a rectangular outer Aluminumand Stainless steel tube. The topics covered in this paper include comparative study on members subjected to different loading condition, effects of loading and strength. The FRP wrapping plays an important role in experimentation. It is also help to increase the strength and durability of the section.The hollow specimens of size 100mm x 45mm x 2mm and height of 300mm is being prepared and then cured. The parameters examined include the concrete strength, stress, strain and theaxial load ratio. The test result will also show that these ductilityand durability.
Keywords - Tubular columns; Fiber-reinforced polymer (FRP); double-skin columns;Concrete; Steel; Aluminum; Stainless steel.

I. INTRODUCTION

There has been increased use of hollow structural sections (HSS) in recent years. In particular, rectangular hollow sections (RHS), square hollow sections (SHS), and circular hollow sections (CHS) are used for their aesthetic appeal. Modern architecture in Australia is dominated by tubular structures (eg Stadium Australia, Sydney Football Stadium, and Darling Harbour - all in Sydney, Australia). However, the market for steel extends well beyond such famous examples.

In the past few years, concrete-filled steel tubular (CFST) columns have gained popularity for buildings, bridges and other types of structures. CFST columns have also become popular among designers and structural engineers; this is due to the great advantages of CFST columns. CFST columns combine the structural properties and advantages of both steel and concrete materials. They help to accelerate the speed of construction as the steel tube acts as a shoring during the concrete pouring, so this also leads to saving costs in the concrete-pouring process by eliminating the need for formwork. Other advantages are the high strength and the increase of the structural stiffness.

CFST columns have a high load-bearing capacity and high seismic resistance. The steel tube provides confinement to the concrete infill, which in turn acts as a support to the steel tube and prevents local inward buckling of the section; also CFST columns have an attractive appearance and a reduced cross-section.

One of the most important advantages of CFST is its high fire resistance due to the heat sink effect of the concrete infill that delays the rise of temperature in the cross-section, together with the shielding effect of the steel tube that protects the concrete core from direct fire exposure. The steel casing prevents spalling of the concrete, which remains better protected against fire.

The main aim of the project is to improve the strength of concrete under warping condition. The Concrete filled double skin rectangularsectioncombines the advantages of thewell-known concrete-filled steel tube (CFST) and the conventional hollow reinforced concrete (RC) columns. Thus, CFDST columns have a series of advantages, such as high strength and bending stiffness, good seismic and favorable construction ability. The hollow specimen of outer seven Aluminum and sever stainless steel tube is 100mm x 45mm x 2mm and 14 inner steel tubes are 50mm x 20mm x 1.5mm. The entire specimen is of height 300mm.

Thus tubular sections are properly cast and its ultimate strength is calculated. Then the sections are warped using FRP and epoxy resins on other specimen. After that 60%, 70%, 80% of ultimate load is allowed to apply on the Aluminum and Stainless Steel respectively. This should increase the strength and also reduce the buckling.

II. STUDY OF LITERATURE REVIEW

Tao YU & Yu-Bo CAO (2009) has studied that, "Hybrid FRP-Concrete-Steel Double-Skin Tubular Columns" reports the series of cyclic axial compression tests on hybrid DSTCs. Hybrid DSTCs have been shown to be very ductile under cyclic loading and their envelope axial load-strain curves are almost the same as the corresponding monotonic axial stress-strain curve. It has also been shown that repeated unloading/reloading cycles have a cumulative effect on the permanent strain and the stress deterioration of the confined concrete in hybrid DSTCs. Interfacial slips between the steel tube and the concrete may lead to noticeable differences in the axial strain between them when the column is fully unloaded from an axial strain level that significantly exceeds the yield strain of the steel tube.

T. Yu &Y.L. Wong (2007) has studied that, "Structural Behavior of Hybrid FRP-Concrete Steel Double-Skin Tubular Columns"reports the new hybrid structural member possesses good ductility and good energy dissipation capacity. When subjected to concentric compression, the concrete sandwiched between the two tubes may achieve significant enhancement in both strength and ductility over unconfined concrete. Although significant cracks will occur early in the loading process. Longitudinal fibers may be required in the outer GFRP tube if the new hybrid member is to be used to resist bending only. In addition, there may be a need to improve the bond between the concrete and the steel tube, such as through the use of mechanical shear connectors to prevent possible premature slips as observed in one of the beam tests presented in the paper.

Lin-Hai Han &Fei-Yu Liau (2005) has studied that," Behavior and Calculations of Concrete-Filled Double Skin Steel Tubular (CFDST) Members" reports the hollow ratio (χ) of a CFDST is within the normal range of 0-0.5, the CFDST generally demonstrates a similar behavior as that of a CFST, whilst the fire resistance of the CFDST is superior to that of the latter. Apart from the research results reported in this paper, ongoing numerical study is being carried out to analyze the post-fire behavior of CFDST columns. Repair approach will be further recommended. The authors also believe that there is immediate research need to put forward suitable beam-to-column connections for CFDST columns, in which the load can be transferred and shared by the three components simultaneously. Durability is also a key issue need to be studied further
for this type of composite construction.

C.X. Dong1 & J.C.M. Ho (2006) has studied that,"Concrete-filled Double-skin Tubular Columns with External Steel Rings" reports the CFDST columns with external confinement were effective in restricting the lateral dilation of the columns and maintain an intact steel-concrete interface bonding. The performance of ring-confined CFDST columns is better than the unconfined CFDST columns in terms of strength, stiffness and ductility. It is because the steel rings provide a more effective, uniform and continuous confining pressure to the concrete core. The external ring confinement can effectively improve the axial strength of CFDST columns by an average value of 11.5% (9.5%) for CFDST columns with c = 0.56 (c = 0.72). The external ring can effectively improve the stiffness of CFDST columns by an average value of 24.7% (31.2%) for CFDST with c = 0.56 (c = 0.72) respectively.

T. Yu1 & J. G. Teng (2004) has studied that, "Behavior of Hybrid FRP-Concrete-Steel Double-Skin Tubular Columns with a Square Outer Tube and a Circular Inner Tube Subjected to Axial Compression" reports the concrete in square hybrid DSTCs is effectively confined by the two tubes, and local buckling of the inner steel tube is constrained by the surrounding concrete, leading to a very ductile response. The axial stress-strain behavior of concrete in such DSTCs is very similar to that of concrete in square FCSCs. Square DSTCs are superior to square FCHCs. The inner steel tube plays the important role of preventing the concrete near the inner edge from inward spelling. The ultimate axial stress of concrete in a square DSTC is generally similar to that in a corresponding square FCSC. The ultimate axial strain of concrete in a square DSTC depends significantly on the void area ratio and may be considerably higher than that of FCSCs with the same FRP tube and concrete strength. Further research is needed to clarify the effect of stiffness of the steel inner tube on both the ultimate axial stress and ultimate axial strain of concrete in square DSTCs.

Bing Zhang &J G. Teng (2001) has studied that, "Behavior of hybrid double-skin tubular columns subjected to combined axial compression and cyclic lateral loading" reports that results of 6 large-scale hybrid DSTCs with HSC tested under axial compression in combination with cyclic lateral loading. These test results suggest that hybrid DSTCs can still show excellent ductility and seismic resistance even when high strength concrete with a cylinder compressive strength of around 120 MPa is used. More detailed analysis of the test results will be conducted soon to gain further understanding of the behavior of these hybrid columns.

Manoj Singla1 &VikasChawla(1998) has studied that, "Mechanical Properties of Epoxy Resin – Fly Ash Composite" reports the addition of fly-ash in epoxy resin –fly-ash composite the compressive strength has been found to increase with increase in fly ash particles. This increase is attributed to hollowness of fly-ash particles & strong interfacial energy between resin & fly-ash. After reinforcing glass fiber both compressive & impact strength has been increased due to energy absorbed in fiber pull out. In SEM analysis it has been found that fly-ash particles has been uniformly segregated.

Yoosuf ESSOPJEE & Morgan DUNDU(1997) has studied that, "Concrete filled double skin circular tubes" reports the stub columns are intended to give guidance for the design of long columns. Important aspects of each paper are covered, which include the specimen dimensions and properties, failure modes, effects of confinement, test results and the proposed design formulations. As expected, the mode of failure of the outer tubes was outward local buckling. All authors reviewed also found that the inner tubes of some CSDSCT failed by inward local buckling and shear of the concrete infill. This was common in inner tubes with larger diameter-to-thickness ratio.

Gregory J. Hancock &Kim J.R. Rasmussen (1996) has studied that, "Stainless steel tubular columns - tests and design" reports. The stub column tests provided the stress-stain curves of the full cross-section from which the 0.2 % Proof Stresses and the tangent modulus versus stress curves could be deduced. The long column tests provided the reduction of column strength with increasing column length. The proposed design procedure was compared with the tests using a factor of safety equal to unity. Generally, the design curves agreed well with the test strengths of the concentrically loaded columns, although the strengths were conservatively predicted in the short column length range. It was demonstrated that the proposed design procedure provided column strengths which were much closer to the test strengths than would have been the case if the CES 88-1 predictions, (based on the annealed properties), were used without modification.

III. NEED FOR THE STUDY

A. To know the effect in hybrid DSTCs, the repeated unloading/reloading cycles on the permanent strain and the stress deterioration of the confined concrete.
B. To know the axial stress-strain behavior of concrete.
C. To know the CFDST columns show substantial increase in axial load carrying capacity with less axial shortening.
D. To learn the effectiveness of composite action of the steel tubes and concrete whether increases the strength of the CFDST columns.
E. To study the external ring confinement can effectively improve the axial strength of CFDST columns.
F. To learn the lateral load capacity of the CFDST (concrete filled double skinned tubular columns) tested at 28 days.
G. To know the Ductility ratio of the concrete filled double skinned light gauge (CFDST) column sections tested at 28days.
H. When FRP is subjected to concentric compression, the concrete sandwiched between the two tubes may achieve significant enhancement in both strength and ductility over unconfined concrete.
I. The addition of fly-ash in epoxy resin –fly-ash composite the compressive strength has been found to increase with increase in fly ash particles.

IV. CONCLUSION

As a part of preliminary work, the various material needed to be used for the further study, were obtained and their physical properties were determined. A study on hollow tubular section and FRP were done which are proposed to be used in this experimental work. A review of literature was done which was helpful in getting a better idea on the topic. The properties of the material and testing methods has been discussed in phase I project.

The hollow specimen of outer Aluminum and stainless steel tube is 100mm x 45mm x 2mm and inner steel tubes are 50mm x 20mm x 1.5mm of height 300mm are properly cast and its ultimate strength is calculated. Then the sections are warped using FRP and epoxy resins on other specimen. After that 60%, 70%, 80% of ultimate load is allowed to apply on the Aluminum and Stainless Steel respectively. This should increase the strength and also reduce the buckling. The parameters like strength, stress, strain and theaxial load ratio are determined.

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