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Ultimate Strength Analysis of Concrete Filled Single and Double Skin Aluminium Tubular Columns with GFRP Laminates

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***Abstract:** This paper presents the results of rectangular aluminium columns and double skin rectangular columns of inner tube as PVC pipe wrapped with GFRP and the influence of the number of FRP layers are to be studied through experimental. A total of 12 specimens in which 6 are concrete filled hollow section and 6 are double skin filled hollow section wrapped with GFRP are to be investigated. Columns are tested under compressive loading based on the number of GFRP layers, the columns are grouped into three; no-layer (unwrapped), wrapped with two layers, wrapped with four layers. Research results will be compared with software analysis of ANSYS*

I. INTRODUCTION

Composite columns have been widely used in the construction industry for a number of decades. The increase in the use of the concrete filled steel columns throughout the world in recent years is mainly due to the significant advantages that this type of columns which could offer in comparison to more traditional construction methods. Composite columns consist of a combination of concrete and steel, and make use of the best properties of these constituent materials. The use of composite columns can result in significant savings in column size, which ultimately can lead to significant economic savings. The reduction in column size can provide substantial benefits where floor space is at a premium such as in car parks and office blocks.

It is well known that concrete-filled steel composite columns have the advantages of high-bearing capacity and ductility, easy construction and cost saving. Similarly, aluminum tube columns filled with concrete can effectively take advantages of these two materials to provide both high strength and high stiffness. There are many advantages in using aluminium alloy as a structural material, such as appearance, lightness, corrosion resistance and ease of production. Furthermore, the aluminum tubes surrounding the concrete eliminate permanent formwork, and as such, construction time can be reduced.

However, little research has been carried out on concrete-filled aluminium tube composite columns. Hence, there is a need to investigate the structural performance of concrete-filled aluminium tube columns.

II. LITERATURE REVIEW

A. *Balasubramani N et al (2015),* have studied that the Double Skinned Hollow Composite Columns in-filled with SCC - M25, M30 and M35. This paper describes experimental study six are Double Skinned Hollow Concrete Filled steel Tubular (DSHCFT) columns annularly in-filled with Self Compacting Concrete (SCC) of grades M25, M30 and M35 and yield strength of steel tubes 250MPa and Six specimens of RCC (SCC) columns. The effect of grade of in-filled concrete tested for axial load, various factors such as load-deflection, stiffness, failure mode, confinement of concrete, ultimate compressive strength and ductility are experimentally studied and reported. The experimental results of DSHCFT are also compared with European Code 4 and found that the code predicts conservatively. The comparison was also extended over ultimate strengths of DSHCFT columns with their RCC (SCC) counter parts and reported.

B. *Usha Sivashankaran et al (2015),* have studied that the Experimental work on Double skin Concrete Filled tubes (DSCFT) are a variation of CFT (Concrete- filled steel tubular) with a hollow core formed by two concentric steel tubes in – filled with concrete. Six Specimens with three different volume fractions of steel fibres are cast and tested.Experiments on circular steel tubes in – filled with steel fibre reinforced concrete (SFRC) and normal concrete have been performed to investigate the contribution of steel fibres to the load bearing capacity of Short Composite Columns . The main Variable considered in the test study is the percentage of steel fibres added to the in –filled concrete . All the specimens were tested under axial compression until failure state realization. This project presents the percentage Variation in the compression strengths of the 3 types of

Composite members taken under Study. The results show that 1.5% SFRC in filled steel columns exhibit enhanced ultimate load carrying capacity.

C. *Lanhui Guo et al (2013***),** have studied that behavior of thin-walled circular hollow section tubes subjected to bending. This paper describes a series of bending tests to examine the influence of section slenderness on the inelastic and elastic bending properties of thin-walled CHS. With the increase of diameter-to thickness ratio, more buckling ripples appeared, and the local buckling became more pronounced. The stiffeners in the steel tubes increased the load carrying capacity and improved the ductility of the specimens. The experimental results were compared with current design guidelines on thin-walled steel members in AISC-LRFD, AS4100 and European Specification. It was found that the test results agreed well with the results based on AS4100 design code.

D. *Dong C X et al (2013),* have studied that the Concrete-filled Double-skin Tubular Columns with External Steel Rings. Concrete-filled-steel-tube columns have been adopted widely for column construction of tall buildings due to its excellent confining effect. However, the central part of concrete in CFST columns have relatively small contribution towards bending and torsion resistance, which can be effectively replaced by another hollow steel tube with much smaller area without reducing the load carrying capacity due to composite action. This structural form with the in-between annulus of inner and outer steel tubes filled with concrete is called concrete-filled double-skin tubular (CFDST) columns. Nonetheless, similar to CFST columns, the imperfect steel-concrete interface bonding of the outer tube will take place in the initial elastic stage because steel dilates more than concrete. It consequently reduces the confinement and stiffness of the CFST columns. To resolve the problem, it is proposed in this study to use external steel ring confinement to restrict the dilation of the outer steel tube in CFDST columns. A series of uni-axial compression tests was performed on CFDST columns with and without external steel rings. From the test results, it was found that the external steel rings could effectively restrict the dilation of the outer steel tube, and improve significantly the uni-axial strength, elastic strength and ductility of CFDST columns when compare with those specimens without rings

E. *Feng Zhou et al (2012),* Numerical study on concrete-filled aluminium circular hollow section columns. A numerical study on concrete-filled aluminium circular hollow section columns is presented. A nonlinear finite element model was developed in this study. The model was verified against test results. The finite element model was used for a parametric study and investigated the diameter-to-thickness ratio of the aluminium hollow sections and the concrete strength. The aluminium tubes of high strength material using the nominal concrete cylinder strengths of 70 and 100 MPa were investigated. The results obtained from the numerical study were compared with the design strengths calculated from the American and Australian/New Zealand specifications for aluminium and concrete structures. Design equations for concrete-filled aluminium circular hollow section columns are proposed. It is shown that the proposed design equations accurately predicted the column strengths.

F. *Kadhim Zuboon Nasser (2012),* have studied that the Structural Behavior of Concrete Filled Aluminum Tubular Columns. The paper presents an experimental and theoretical study on the behavior of circular concrete filled aluminum tubular columns. The main purpose of the experimental program was to investigate the structural behavior of aluminum-concrete composite columns under axial compression loading conditions. Twenty four specimens were tested to investigate the effect of diameter, D/t ratio and slenderness ratio of a aluminum tube on the load carrying capacity of the concrete filled tubular columns. Diameter to wall thickness ratio ranged between $11.9 \leq D/t \leq 22.8$, and the length to tube diameter ratios of $3 \leq L/D \leq 10$ were investigated. The main purpose of the theoretical investigation was to predict the strength of aluminum -concrete composite columns subjected to axial compression loading conditions. The empirical equations proposed in the present study are capable of predicting the values of ultimate loads of aluminum -concrete composite columns and were in good agreement with the experimental values. The average values of ratios of experimental to predicted values of ultimate loads are 1.0104 for the proposed empirical equations. The circular hollow section tubes were fabricated by extrusion using 6061-T6 heat-treated aluminum alloy. The column strengths, load-axial shortening relationship and failure modes of columns were presented.

G. *Lin-Hai Han et al(2012),* Behaviour and Calculations of Concrete-Filled Double Skin Steel Tubular (CFDST) Members. The topics covered in this paper include members subjected to static and dynamic loading, effects of longterm loading, fire performance and residual strength after exposure to fire. when the hollow ratio (χ) of a CFDST is within the normal range of 0-0.5, the CFDST generally demonstrates a similar behaviour as that of a CFST, whilst the fire resistance of the CFDST is superior to that of the latter.

H. *Jae-Yoon Kang et al (2012),* have studied that the Flexural Behavior of Concrete-Filled Steel Tube Members and Its Application. A new bridge system described in this paper uses concrete-filled steel tubes as replacement for conventional girders. Proposed a new steel/concrete composite bridge system with steel pipes girders filled with concrete as the main girders. Test results showed that concrete-filled steel tube girders have good ductility and maintain their strength up to the end of the loading. Results of this investigation demonstrated the potential of the concrete-filled tube as a bridge girder.

I. *Amir Fam et al(2012),* have studied hat the Concrete-Filled Steel Tubes Subjected to Axial Compression and Lateral Cyclic Loads. The objective of the study is to evaluate the strength and ductility of CFST short columns and beam-column members under different bond and end loading conditions. The behavior of short CFST columns after cracking of concrete is very ductile. The load dropped to a sustained residual strength, approximately equal to the strength of composite section based on unconfined concrete strength, and at least 6 percent axial strain was reached. Test results were compared with the available design specifications, which were found to be conservative. The paper also presents an analytical model capable of predicting the flexural and axial load strength of CFST members. Experimental results were found to be in good agreement with the predicted values.

J. *Aritra Mandal (2008),* have studied that the Concrete filled steel tube under Axial compression. An experimental study was conducted to understand the behavior of Short Concrete Filled Steel Tubular Columns (CSFT) under axial compression to failure. An analytical study was also done to compare with the experimental results. A total of 69 specimens (63 specimens were filled with concrete , 3 specimens were kept hollow and 3 specimens were only concrete) having different cross-sections were tested to investigate the load carrying capacity in particular and behavior as a whole. The length-to-diameter ratios of these test specimens were between 5.17 and 5.9. The diameter-to-thickness ratio were between 18.5 to 58.The steel pipes are made up of mild steel of grade 250 . Thickness of tube wall varied from 1 mm to 3 mm. The sizes of circular pipes are 50.8 mm diameter and 300-mm long. Dimensions of rectangular tubes are 36.1 mm x 76.2 mm and 300-mm long. Tests were carried out on the said steel tubes under axial compression . The objective of this study was to evaluate the accuracy of codal design approach for prediction of load carrying capacity under axial compression and to appreciate the behavior of the tube including its failure pattern. Plain concrete specimens of same dimension as inside dimension of steel tube were also tested under axial compression for comparison. The inside surface of some steel tube were made rough by providing small plates (welded to inner surface of steel tube) to achieve better bond between steel and concrete. Again, the inside surface of some steel tube are provided with grease to reduce bond between steel and concrete. Test results were compared with the theoretical results obtained using ACI , LFRD and EC4 code of practices. Linear analysis was made by FEM model using ABAQUS software to get stress distribution and deflection pattern. Ultimate load carrying capacity was obtained and compared with experimental results. The test results are also compared with other published test results also. Some broad conclusion were made and areas of future research were indicated.

K. *Dennis Lam et al (2008),* have studied that the Structural design of stainless steel concrete filled columns. This paper presents the behaviour and design of axially loaded concrete filled stainless steel circular and square hollow sections. The Continuous Strength Method provided the most accurate and consistent prediction of test capacity, due largely to the more precise assessment of the contribution of the stainless steel tube to the composite resistance. A continuous strength method is proposed and it is found to provide the most accurate and consistent prediction of the axial capacity of the composite concrete filled stainless steel hollow sections due largely to the more precise assessment of the contribution of the stainless steel tube to the composite resistance.

L. *Artiomas Kuranovas et al (2007),* have studied that the behaviour of hollow concrete-filled steel tubular composite elements. Behaviour of composite steel-concrete elements in various loading stages is quite well analysed by theoretical investigations and experiments. Concrete-Filled Steel Tube (CFST) is one of many composite elements used at present in civil engineering. Different approaches and design philosophies were adopted in different design codes for it. But for hollow CFST elements, which are more effective than ordinary CFST, any code does not provide information about how to design these elements. Further investigations of hollow composite CFST elements are needed. In loading stage, when a particular level of stresses exists, an interaction between steel tube and concrete core appears and therefore a complex stress state of element takes place, which increases the load-bearing capacity of the whole composite element. This interaction between components of CFST elements is reached because of different material properties, such as Poisson's ratio, elasticity modulus etc. In this article reasons of the above-mentioned complex stress state appearance and behaviour of hollow CFST element components in different load stages of compressed stub structural member are analysed. The test results are presented in diagrams, tables.

Previous researches of other investigators are summarised. Differences and similarities in behaviour of solid concrete and composite elements and hollow members with different number of concrete core layers are discussed.

III. MOTIVATION STUDY FROM THE REVIEWED LITERTURE

The reviewed literatures showed that concrete-filled steel tube girders have good ductility and maintain their strength up to the end of the loading. It also shows that the main purpose of the theoretical investigation was to predict the strength of aluminum -concrete composite columns subjected to axial compression loading conditions.

IV. CONCLUSION

The primary aim of this project is to determine the axial load capacity of the double skin aluminium tubes and aluminium filled hollow tubes.

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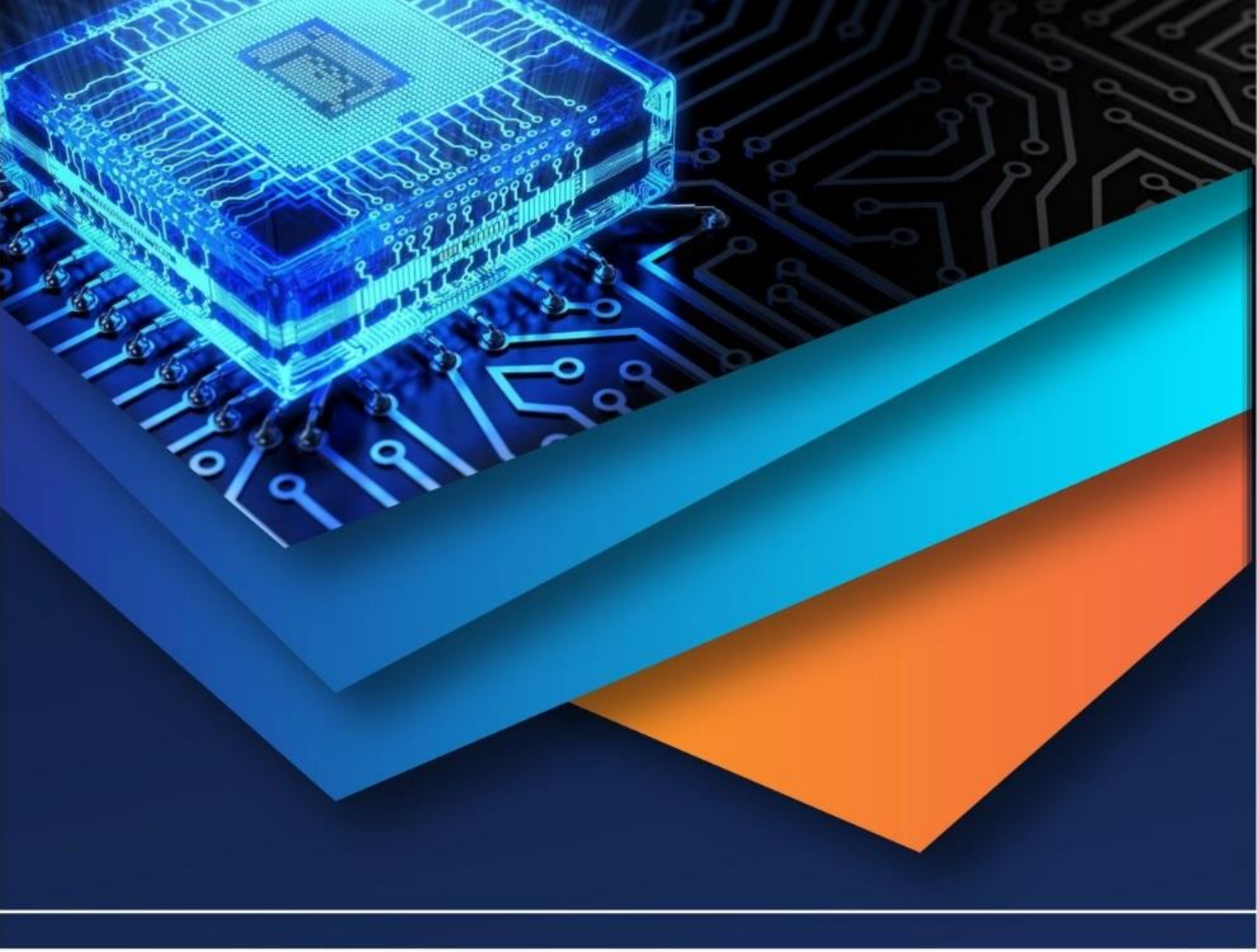

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