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A Review on Parametric Performance of CFT Column

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Abstract: This paper gives brief review on research performed in the field of Parametric performance of Concrete Filled Steel Tube (CFST) Columns. The use of concrete filled steel tubes columns is increasing day by day in construction of buildings because it has excellent static and earthquake-resistant properties. Steel and concrete gives good performance and design flexibility due to its Confinement Effect. It also gives excellent result in the field of performance of structure. In Structural Engineering, due to excellence in a variety with principal cross section, Concrete Filled Steel Tubes Columns are being used in high rise building. In CFST Columns, steel tubes works as formwork for concrete. Local buckling is prolonged in CFST because the steel tubes prohibit excessive concrete spalling and composite columns makes column significantly stiff. In Recent Period, use of Concrete Filled Steel Tubes Columns has being significantly increasing day by day due to its simplicity in its construction and superior performance in the field of structures.
Keywords: CFST, design flexibility, earthquake-resistant, excellent performance, superior performance.

I. INTRODUCTION

Composite Columns made of Steel Concrete were used for over a decade. As CFST columns have numerous advantages in both design and construction it is gaining popularity in construction. Due to composite effects of concrete filled steel tubes they are used in high-rise buildings, arch-bridges and other various structures as composite structural element. An efficient structural system is provided by CFST. It is considered as an advantageous system due to its composite structure which is capable of carrying large axial load by interaction between concrete and steel. Concrete Filled Steel Tube (CFST) columns are fortunate for many earthquake resistive buildings, columns of high rise buildings, piers of bridge which are subjected to high strain rate from traffic and railways decks. The Steel tubes in CFST acts as formwork for casting concrete in construction so the structure has better constructability. There is no other reinforcement as a result the tube acts as longitudinal and lateral reinforcement for the concrete core. Concrete filled steel tube about all axes supplies high compressive and torsional resistance about all axes when it is compared with concrete encased steel composite sections. CFST columns have excellent loading capacity, ductility and energy absorption capacity.

II. STUDIES ON GEOMETRICAL EFFECTS

Shams and Saadeghvaziri (1999) demonstrated the nonlinear response of estimated concrete filled steel tubular columns under axial loading for that they created three-dimensional finite element model for CFST columns and compared them with the existing experimental values. They made a conclusion that the geometry of the columns as well as material properties of concrete highly affects the stress-strain properties of the confined concrete and it was found that as compared to square column, circular column has higher confinement effect due to more uniform stress distribution. As compared to high strength concrete, the concrete with a lower unconfined compressive strength exhibited higher confinement ratio. It was concluded that the compressive strength of concrete is D/t ratio, unconfined concrete compressive strength and cross-sectional shape dependent. Maximum Stress-Strain of a column mainly depends on D/t ratio and cross-sectional shape.

Another fascinating investigation was carried out by Zheng et al. (2000) who made a study on rational ductility equation for thin walled steel structure with the help of evaluation procedure. It was based on the empirical ductility equation which was proposed for stub columns which elaborates an elasto-plastic push over analysis and failure criterion. Suggestion was made that push over analysis can be neglected; proposed procedure was demonstrated by some cantilever columns and one storey frame to the ductility evaluation. As a result an extensive parametric analysis were carried out for the investigation of the stub column ductility with respect to various parameters which affects deformation such as the flange width-thickness ratio, axial force, stiffeners slenderness ratio, cross sectional shape, and column aspect ratio. An elasto-plastic large deformation FEM analysis was done in which both residual stresses and initial deflections were taken into consideration and empirical formulae were proposed.

Dalin Liu (2005) has conducted test in which he lined up 22 specimens in four series which were fabricated and were tested in the research programme. The Tensile and Crushing test was done to obtain material properties of steel and concrete. As a result relation between ultimate capacities and axial load shorting of the specimens were recorded for further analysis. For the formation of hollow steel section four components of flat plates were welded together. After 32days of casting of concrete the specimens were tested by applying 5000KN capacity by Universal Testing Machine. To measure overall displacement transducers were placed around the specimen symmetrically between the two platens of the testing machine. To record longitudinal strain on the exterior surfaces of the steel section strain gauges were bonded at the mid-height. The author concluded that circular steel how sections are more effective in terms of offering confinement to the concrete core over other sections. This is due to hoop stress in circular section. High strength of composite columns is favorable by ductility performance of Steel. Cross-Sectional aspect ratio has adverse affect in the improvement of strength. Data produced by experiment was compared with design code data and was concluded that provision in EC4, ACI and AISC conservatively estimate the Ultimate capacities of the specimens by 1, 9 and 11% respectively.

Han et al. (2008) has done investigation on the behavior of concrete filled steel tubular stub columns experimentally by subjecting axial compressive load. Testing of 32 specimens was done. The main parameters which were varying in the experiment are (i) Cross Section: circular and square (ii) Local Compressive area ratio (concrete cross sectional area to local compression area) (iii) End Plate thickness. For the analysis of CFST stub columns which were subjected to axial local compression finite element analysis was done. The test results have shown good agreement as FEA modeling was done. Side by side theoretical modeling was also developed and the investigation was made on the basic of mechanism of the composite columns which were subjected to axial local compression Strength Index(SI) and Ductility Index(DI) bigger should be the end plate thickness.

III. STUDIES ON SLENDERNESS EFFECTS

Brain Uy (2000) conducted an experimental study which was based on effect the of steel plate slenderness limits. He developed numerical model and that was augmented and calibrated with these results. For the determination of strength-interaction diagram a simple model was developed by the author and the results were corroborated against both the test results and the numerical model developed. Model which were made by author were based on the rigid plastic method of analysis, genuine in international codes of practice, but did not report for the effects of local buckling, which were found to be momentous with large plate slenderness values, particularly for large values of axial force. Based on the above study, the author suggested for the modification plated columns in design.

Brain Uy (2001) also carried out a comprehensive set of experiments which was based on the strength of short concrete filled high strength steel box columns. In his study a numerical model was presented with these tests. After that comparison was made with the Eurocode4 for composite columns were also endeavored and it was un-conservative in its prediction of axial and combined strengths was concluded at the end. After that a mixed analysis technique was presented in which treated concrete as rigid plastic and steel as linear elastic. As a result these models were compared well with the numerical model presented and both models were found to be conservative for the prediction the test results.

Brain Uy (2003) who also investigated three series of experiments undertaken to determine the combined behaviour under compression and bending for high strength steel box columns filled with concrete. Different slenderness limit was considered for each, as a result consideration was made in terms of restrained local buckling slenderness limits to compact them and thus no reduction due to local buckling of the component plates was expected. Test was conducted to establish the stress-strain behaviour of the steel in both tension and compression with the help of series of tensile coupon and stub column. Testing of columns in both pure compression and under combined bending and compression was done. Columns were cast in plates with plaster at either end to ensure a uniform loading surface. The eccentric load on columns was loaded with the help of knife-edge at both the ends of columns. The test set up comprises of strain gauge and Linear Variable Deformed Transducers (LVDT). Under pure compression maximum loads were obtained from curves of specimens was concluded by author. The maximum axial load that was achieved likely to be reduced as eccentricity increases and this result was concluded for a column under combined actions. The load-strain curves for these columns were useful in determining the one set of yield as well as highlighting local buckling on the compression faces which was in elastic in all the columns and beams tested. It is to be noted, that all with a considerable plastic plateau all columns behaved in a fairly ductile manner and premature fracture of the welds was not visible in any of the columns tested.

Zeghichea and Chaoui (2005) have performed an experimental study by taking 27 concrete filled steel tubular columns. The main parameters which was considered by him was column slenderness, load eccentricity covering axially and eccentrically loaded columns with single or double curvature bending and the compressive strength of the concrete core. The outer diameter of circular steel tube was 160 mm and wall thickness was considered as 5mm. The length of the columns was assumed between 2.0 to 4.0 m in increments of 500 mm and concrete was filled in the vertical position. By applying different loading conditions columns were tested under three groups. In first group columns were tested under axial loads, in second group e/D ratio was varying between 0.05 to 0.20 which were subjected to equal eccentric loads and the third group compresses columns in which testing was done under double curvature bending. For testing columns a maximum load capacity of 10000KN were tested in a compressive testing machine. At ends of each column a set of adapter end plates equipped with half-spherical bearings were manufactured were fixed to both ends to form a simply supported column because the main parameters which were studied was length of the composite column and the concrete strength. Variation of L/D ratio was from 12.5 to 25.0. The conclusion made by author was that the increase of the concrete core strength was effective for shorter columns and decreased with the increase of the composite column length. After reaching the steel yield strain with small lateral mid-length deflections all axially loaded columns likely to be failed.

Gopal and Manoharan (2006) conducted an experimental study in which study was made with the help of 12 slender steel tubular columns of circular sections which were filled with both plain and fibre reinforced concrete. Under eccentric compression the specimens were tested to investigate the effects of fibre reinforced concrete on the strength and behavior of slender composite columns. The main test parameter for this study was slenderness ratio. Similar Specimen of Hollow steel sections were also tested as reference columns. By load-deflection and load-strain curves test results were exemplified. Various peculiarities such as strength, stiffness, ductility, energy absorption capacity and failure mode were point at issue. From the experiment it was concluded that the use of the fibre reinforced concrete as infill material had made a considerable effect on the strength and behavior of slender composite columns. The authors came to the conclusion that the use of FRC filled steel tubular columns gives relatively high stiffness as compared with plain concrete filled columns. The ductility was almost same for both plain and FRC filled columns as a result the use of FRC as a filling material increases the load bearing capacity as compared with that of unfilled columns and reduces the lateral displacements.

IV. REVIEWS ON FINITE ELEMENT ANALYSIS

Chou et al. (2000) analyzed post-buckling behavior of stub columns under axial compression by adopting finite element analysis method. With the help of FEA numerical predictions on the load versus end-shortening characteristics and ultimate load capacity of the structures was obtained as a result procedures for Standard design were developed for post-buckling analysis for stub columns with the finite element analysis method. By this study conclusion was made that the ultimate load obtained using the design procedure consistently under estimated the experimental results and analytical predictions using BS 5950.

Some more studies was conducted by Liang et al. (2000), study was made for the analysis of post-local buckling behavior of steel plates in thin walled CFST welded box columns with the help of finite element method. For post-local buckling characteristic investigations were done for various geometric imperfections, residual stresses and B/t ratios. For evaluating of initial local buckling loads a new method was developed with the help of theoretical analysis. For checking the accuracy of the design models they were verified by a classical solution and experimental results. The results signified that the predictions for the ultimate strength of steel plates and CFST box columns using the proposed design models acquiesce very well with the experimental data. As a result, the authors were able to propose an effective width formula which can use in the ultimate strength calculation of short thin walled CFST box columns which were subjected to an axial load.

Huang et al. (2002) conducted an experimental study in which investigation was made on concrete filled tubular (CFT) columns when axial load was applied over it and behavior of columns with the width-to-thickness ratios between 40 and 150 was analyzed and an effective stiffening scheme was proposed for improving the mechanical properties of CFT columns with square cross-section. Future for examining the effects of cross-sectional shapes, width-to-thickness ratios, and stiffening arrangements on the ultimate strength, stiffness, and ductility of CFT columns seventeen specimens were tested. For more investigation, nonlinear finite element analysis was also conducted for the investigation of columns with different cross-sectional area and axial stress distribution at the ultimate strength level of the specimens was calculated, five were of B/t (or D/t) = 40, eight were of B/t = 70, and four were for B/t = 150. Out of this three specimens were for circular cross section and other were for square cross section. The square tubes with the help of seam welding were fabricated in two U-shaped cold-formed steel plates. When stiffening was specified, the tie bars were fillet welded to the U-shaped cold-formed steel plates before making the seam complete penetration groove welds. With the help of Universal Testing Machine compression test were conducted by applying a load of 4900KN. Axial loads were applied slowly and measured by the test machine load cell and result was concluded that the compression tests stopped at a strain level of 5 %. Results in this study concluded that the stiffening scheme which was proposed has substantially enhanced the ultimate strength and ductility of square CFT columns.

Hu et al. (2003) with the help of ABAQUS, non-linear finite element program has made investigation on the behavior of CFST columns which were subjected to axial loads. He made numerical analysis of various columns which were categorized o the basic of cross section into three groups; circular section, square section, and square section stiffened by reinforcement ties. Based on the results for circular CFST columns, the steel tube provided a large confining effect due to the concrete core, especially when the D/t ratio were small (D/t<40), which indicated that local buckling of the steel tube was unlikely to occur. The results was concluded that the square CFST columns did not provide a large confining effect particularly when the ratio of width-to-thickness was large (B/t>30). The results marked in steel tube that local buckling of was very likely to occur. On the basis of analysis results of square CFST columns which were stiffened by reinforcement ties, it was found that the confinement effect was enhanced especially when the spacing between tie was small and the tie number or diameter was large. The results showed that hindrance in local buckling of the steel tube was delayed by the reinforcement tie. Furthermore, it was concluded that the non-linear finite element analysis indicates the lateral confining pressure decreases with an increase in the B/t ratio because the decrease in the lateral support for the steel tube.

V. CONCLUSION

This paper mainly focuses on the advancement in construction, study and design research done on concrete filled steel tube. In recent time, research is going on designing aspects of CFST and their behavior under different load condition. To know behavior of CFST wide range of research has been done and is going on. Many experimental works has been done on CFST still to check the parameters which affect the ultimate strength need to be carried out. From the literature reviewed, it is clear that considerable progress over the last years has been made in the investigation of CFST. From the research works it is well understood the fundamental knowledge on ultimate strength of the composite construction system conducted so far. Equivalent Stress for various slenderness ratios also need to calculate. As CFST columns saves cost for construction, time and labor, it has turned out that the CFST columns are very much useful and effective when applicable to high rise and long span structures due to its efficiency. According to the reports of earlier research work widely varying and often antithetical assumptions were made on composite columns. Enhanced load carrying capacity is one of the reasons for the large deviations between theoretical and experimental strengths as reported by researchers. The excellent structural behavior of CFST columns and its superiority over the existing conventional construction system has now achieved more prominence and has fascinated the attentions of researches all over the world. As there is no codal provision for any specification about composite column in India future research in this field is needed.

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