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A REVIEW PAPER ON INVESTIGATION OF SFRC NFILLED LIGHT GAUGE STEEL BOX COLUMN UNDER AXIAL AND ECCENTRICAL DIFFERENT LOADS

Dudhat Prashantkumar Vasantbhai[1] and Jyoti Yadav[2]
M.Tech. Scholar, Department of Civil Engineering, SRK University, M.P. India[1]
Assis. Professor, Department of Civil Engineering, SRK University, M.P. India[2]

Abstract: *The main objective of the study is to investigate the behaviour of hollow, Plain Cement Concrete (PCC) and Steel Fiber Reinforced Concrete (SFRC) in-filled stub, short and medium columns subjected to axial and eccentric loads and beams subjected to flexure. Investigations have been carried out. investigations were carried out for hollow, PCC and SFRC in filled medium columns using finite element software package ANSYS. In order to simulate the experimental behaviour using the analytical model, actual material non-linearities were incorporated. Non-linear post-buckling analyses were carried out to determine the lateral deflections and micro strains at critical regions under ultimate loads. The numerical model developed using ANSYS was found to simulate the behaviour of the columns very closely to the experimental values.*

Keywords: *Axial ,Eccentrical, Steel Box, ANSYS.*

1. Introduction

The applications of composite members consisting of concrete in- filled steel hollow sections have become increasingly popular in Civil Engineering structures in the last two decades. This is due to their advantages over the conventional structural sections in terms of strength, ductility, stiffness, energy absorption capacity, easy construction procedure and the overall economy. The steel and the concrete in a composite member complement each other ideally. While the steel confines the concrete laterally, allowing it to develop the optimum compressive strength and ductility, the concrete in turn supports the steel shell laterally to prevent elastic local buckling. As erection of building progresses, concrete is filled from lower level of columns to form the composite system that will resist the total gravity and lateral loads, thus considerable amount of labour, materials and construction cost can be reduced. The steel box as a part of a composite column completely encases the concrete core so that the ductility of the encased concrete core is highly improved and enhances the seismic resistant property of the column. The enhancement in the structural properties of concrete filled steel columns is due to the composite action between the constituent elements. The local buckling of the box sections is reduced by the concrete in-fill when compared to hollow box-sections. For hollow sections, the walls are hinged along the corners and the local buckling may involve the corners too. For concrete- filled sections, the walls are fixed along the corners and they remain straight. This effect allows the use of an increased wall slenderness and higher steel quality. In addition, the presence of the steel box-section produces an increase in concrete strength due to the confinement effect. Such members are susceptible to local buckling at relatively low compressive, shear, bending or bearing stress. However a considerable reserve of post- buckling strength exits due to the possibility of membrane actions after local buckling. The use of light gauge steel structures has become increasingly popular in different fields of building construction.filled steel columns is due to the composite action between the constituent elements. The local buckling of the box sections is reduced by the concrete in-fill when compared to hollow box-sections. For hollow sections, the walls are hinged along the corners and the local buckling may involve the corners too. For concrete- filled sections, the walls are fixed along the corners and they remain straight. This effect allows the use of an increased wall slenderness and higher steel quality. In addition, the presence of the steel box-section produces an increase in concrete strength due to the confinement effect. Such members are susceptible to local buckling at relatively low compressive, shear, bending or bearing stress. However a considerable reserve of post- buckling strength exits due to the possibility of membrane actions after local buckling. The use of light gauge steel structures has become increasingly popular in different fields of building construction.

2. Objectives of the Investigation

- To study the material properties of steel, PCC and SFRC and its bond slip characteristics when it is used as in-fills for the composite columns.
- To study the behaviour of light gauge steel hollow and in- filled columns under hinged end conditions subjected to axial loads, uni-axial eccentric loads and bi-axial eccentric loads.
- To study the effect of flat width to thickness ratio of light gauge steel member on load carrying capacity with and without in-fills condition.
- To study the flexural behaviour of light gauge steel hollow, PCC and SFRC in-filled beams under simply supported conditions subjected to pure moment.
- To study the stiffness and ductility characteristics of beams from load-axial shortening, load-lateral deflection and load- longitudinal strain plots for all the specimens.
- To review and compare the various design provisions in the Indian, European, British, Japanese, and American standards.
- To develop a non-linear finite element model incorporating, the geometrical properties and the effect of in-fill on the ultimate load carrying capacities.
- To compare the ultimate load carrying capacities of the stub, short, medium column and beams by experimental, theoretical and numerical means under different loading conditions.

3. Literature Review

Lam and Willams (2005) conducted series of tests on short composite columns and axial compressive loadings. The test parameters considered were the grade of steel section and variation in the concrete strength. Eighteen specimens were tested to derive the interaction between steel and the concrete component. The steel concrete composite columns were tested with and without applying grease inside the steel sections. The test results exhibited that peak load was achieved at small shortening for columns with low constrains factor and for high constraining factored column, the ultimate load was obtained with large displacement.

Ramanagopal and Manoharan (2006). Sixteen circular columns were tested to study the influence of SFRC on their strength under axial and eccentric loads. The fiber reinforced concrete in-fill had moderate improvement on the load carrying capacity of columns under eccentric loading. At large slenderness ratios and eccentricity ratios FRC filled specimens showed 5 to 8% increase in the ultimate loads than the PCC in-filled specimen. The ductility of the SFRC in- filled columns had been slightly better than PCC in-filled specimens. PCC in- filled columns showed increased load carrying capacity than the hollow columns and sustained large strains and deformations.

Mursi and Uy (2014) presented the strength of short and slender concrete in filled high strength steel box columns. A numerical model was also developed to study the behaviour of column incorporating material and geometrical non-linearity. The local buckling effects depend on the slenderness of the component plates of the column and this plays larger role in considering the confinement effect of the concrete core. The full load deflection response of the columns before and after the peak were in extremely good agreement with the experimental results. In the theoretical approach EC4 has not provided any recommendations for the design of slender columns with the slender cross section.

Ghannann et al. (2016) examined the failure modes of steel tubular columns of square, rectangular and circular section filled with normal and light weight aggregate concrete. Thirty six full scale columns were tested under axial loads. The test results were illustrated with load-deflection and axial deformation curves. The hollow column failed by local buckling and in- filled columns failure by overall buckling. The columns with normal concrete in fill exhibited over all buckling with no signs of local buckling prior to failures. The columns with light weight aggregate concrete in fill showed more lateral and axial deformations than the hollow steel columns. Due to low specific gravity and thermal conductivity of light weight aggregate, it was found to be worth to replace the normal aggregate concrete by light weight concrete.

Motto et al. (2016) studied the behaviour of 33 circular and 32 square CFT columns under the eccentric loading. The test parameters for the circular section were D/t ratio, concrete strength and yield strength of steel, where as in the square specimens, the test parameters were B/t ratio, in-filled concrete strength and yield strength of steel. It was found that the high strength concrete filling caused reduction in the ductility of the circular CFT columns. A fiber analysis was also conducted to calculate the scale effect and confinement effect of concrete. By the fiber analysis it was reported that the bending behaviour of eccentrically loaded CFT columns had reasonable level of accuracy compared to the experiment results and the estimated ultimate strengths from the analysis coincided with the experimental results.

KavehAIlchi&Ghazaan (2015) introduced a new method of minimizing the cost of the skeletal structure by using two different techniques such as Colliding bodies optimization and enhanced Colliding bodies optimization which are developed from the basics of Physics. The result obtained from Colliding bodies optimization was much accurate than the enhanced Colliding bodies optimization and had an efficiently proposed algorithm.

Liu and Gho (2017) conducted experimental investigations on 26 high-strength rectangular CFT columns subjected to axial compression. The test parameters were the material strength and the aspect ratios of the cross section. The authors also examined the test results with the design code provisions for ACI, AISC and EC4. A fiber model was also constructed to evaluate the non-linear axial load behaviour of the specimens. The studies showed that EC4 is not safe to predict the ultimate capacity, where as, ACI, AISC and the proposed fiber model conservatively estimated the failure loads by 7,8 and 2% respectively

Mossahebi et al. (2005). This study described the new bridge system using the steel tubular in filled concrete as a replacement for the conventional girder. The CFT girder was the main load carrying element of the bridge. In the experimental results, it was found that the CFT exhibited good behaviour up to the ultimate load level. The in-fill precluded the local buckling of steel while the closed shape of the tube provided the torsional rigidly. The failure of the specimen was due to yielding of the steel tube followed by crushing of the slab deck. It was concluded that the proposed bridge system is suitable for shorter spans of less than 30m.

Zhang et al. (2005) examined the behaviour of steel tube and confined high strength concrete for concrete-filled RHS tubes. Fifty specimens were tested to study the steel ratio, the section height to breadth ratio and the concrete strength on the ultimate strength of the columns. A numerical separation method was used to separate the compressive load carried by the steel tube and the core concrete. To determine the overall behaviour of the high strength concrete-filled RHS tubes an equivalent one dimensional non-linear stress strain model of the steel and the confined concrete were developed. In theses tests, the concrete strength influenced the failure pattern of concrete-filled RHS columns. The core concrete with lower strength failed by splitting, while the concrete with higher strength failed by shrinking. Ductility had increased with the increase in height to breadth ratio. It was also noted that, the load bearing capacity of high strength concrete- filled RHS tubes under axial loads was greater than the sum of the load bearing capacities of the steel tube and the core concrete. The models developed to analyse the behaviour of high strength concrete filled RHS tubes were in agreement with the experimental results.

Twenty seven concrete-filled steel tubular columns were tested by Zeghiche and Chaoui (2005). The test parameters were slenderness of the columns, eccentricity of the loads and the compressive strength of the concrete core. The results were compared with the method described in EC4. The test results showed that the increase in column slenderness decreased the load carrying capacity of the columns. The load-slenderness ratio decreased at a higher rate for the high strength concrete in-fill compared to the column with normal strength concrete in-fill. The EC4 code predicted the strength on the safer side for columns with single curvature bending. For columns with double curvature bending EC4 predictions were not found to be safe.

The behaviour of stiffened concrete-filled thin walled hollow steel structural (HSS) stub column under axial compression was presented by Tao et al. (2005). Nineteen specimens were tested. Four types of steel tubes were fabricated; stiffened square tubes, inner stiffened square tubes, outer stiffened square tubes and inner stiffened rectangular tubes. In the experimental results it was observed that the sectional capacities increased when stiffeners were provided. The longitudinal stiffeners, not only delayed the local buckling of the plate, but also improved the lateral confinement on the concrete core. It was also observed that there was no improvement in the ductility for the stiffened CFT columns. The outer stiffened columns showed almost the same behaviour as that of the inner stiffened columns. The experimental results were compared with the existing design codes such as ACI, AIJ, AISC, BS5400, EC4 and PBJ1351-2003. Among these codes EC4 and DBJ 1351- 2003 gave best results.

Young and Ellobody (2006) investigated the behaviour of high strength concrete filled high strength stainless cold formed steel tubular columns under the effects of shape of the stainless steel tube, plate thickness and concrete strength. The strengths obtained were compared with the design strengths calculated using the American, Australian, New Zealand standards. The strength to the axial strain relationship showed that the ductility of the columns decreases with the increase in the strength of concrete. Slender sections failed by local buckling. Compared to the strengths obtained experimentally, the strengths predicted by the codes were conservative. Based on the test results, recommendations were proposed for the design of concrete in filled high strength stain less steel tubular columns.

The behaviour of eccentrically loaded high strength rectangular concrete in filled steel tubular columns was presented by Liu (2016). In this study an analytical and experimental investigations were made on 16 slender columns. The test parameters were the strength of steel, cross sectional aspect ratio, slenderness ratio and the eccentricity of loads. The failure loads were compared with the values obtained using the codes of practice EC4, ACI and AISC. The ultimate load carrying capacity of CFT columns was found to be adversely affected by the load eccentricity ratio. Favourable ductility performance was observed for all columns during the tests. By comparing the test results with the theoretical values, the ACI and AISC conservatively predicted the failure loads where as the EC4 provided an un-safe estimate. The proposed numerical model closely predicted the design strength of the columns; hence this model was suggested for the design of high strength rectangular CFT columns subjected to eccentric loadings.

Ellobody et al. (2006) presented the experimental behaviour and design of axially loaded circular concrete-filled steel tube stub columns. The test parameters were the strength of in-filled concrete and the external diameter of the steel tube-to-plate thickness ratio. The column strength and axial load shortening values were evaluated for the various concrete strengths and aspect ratios. The experimental results were validated by the design strengths calculated using the American, Australian and European specifications. From these experimental investigations, following conclusions were drawn.

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