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Study about the Behaviour of Concrete Filled Tubular Column with GFRP Wrapping

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Abstract: In this paper, the tubular columns are filled with normal and replacement concrete under M25 grade. The replacement involves 5 % of metakaolin replaced for cement and 25 % of green sand replaced for fine aggregate. The main parameter involved is layer of glass fibre reinforced polymer wrapping. The compression behaviour will be experimentally and analytically studied for the tubular column confined with glass fibre reinforced polymer under single, double, three and four layer.
Keywords: Circular Stainless Steel, Metakaolin, Green Sand, GFRP, Axial Compression.

I. INTRODUCTION

In the past several decades, the concrete filled steel tubular columns have been used in a wide variety of structural engineering applications, particularly in bridges and high rise buildings. This increase in use is largely due to the structural and economic advantages offered by concrete filled tubes over open and empty sections, as well as their aesthetic appeal. Also, circular hollow sections possess many advantages over open sections, including aesthetic appearance and economy in terms of material costs. Stainless steel provides high corrosion resistance, aesthetic appearance, ease of maintenance, ease of construction and high fire resistance compared to traditional carbon steel. Due to the complexity of connections between steel beams and circular hollow sections, their use in structural steelwork is limited. This is because the use of standard bolting is not feasible and costly unpopular welded connections are the normal solution.

Serkan Tokgoz, (2015), showed the experimental behaviour of plain and steel fibre concrete filled stainless steel tubular columns under biaxial bending and axial compression. The parameters such as concrete compressive strength, cross section capacities, load eccentricity, steel fibre material and slenderness was studied, and the ultimate strength capacities, load deflection relations and load axial strain behaviour were investigated. Concluded that the high strength stainless steel tube was very effective on behalf of concrete filled steel tubular column behaviour. Due to the addition of the steel fibre into concrete has improved the ductility and deformation capacity of tested CFSST columns.

Bedage.S.D and Shinde.D.N, (2015), studied the comparison between the experimental results and analytical results obtained by ABAQUS for concrete filled tubular column under axial compression. The analytical results obtained by ABAQUS are in good agreement. Due to the confinement pressure of steel shell concrete exhibits more strength. The confinement pressure is more effective for circular filled steel tube sections than rectangular and square sections. The stresses in steel tubes occur 1.5 to 2.5 times than concrete. The concrete filled steel tubular specimens were failed due to local buckling.

Tian - Yi Song et al., (2015), studied the bond strength between the steel tube and core concrete in full scale concrete filled steel tubes. The parameters such as steel type (stainless steel and carbon steel), concrete type (normal and expansive concretes), age of the concrete (28 days and 3 years) and interface type (normal interface, interface with shear studs and interface with an internal ring). The result shown that the concrete filled stainless steel tubular column have lower bond strength compared with the concrete filled carbon steel tubular column. Meanwhile, the bond strength decreases remarkably with increasing concrete age.

Hui Liu et al., (2015), investigated the strength and ductility performance of concrete filled steel tubular columns after long term service loading. It was found that the post creep mechanical behaviour of concrete filled tubular columns depends on the combined action of enhanced compressive strength of plain concrete and residual creep deformation.

Qing - Xin Ren et al., (2014), conducted test on concrete filled steel tubular columns and beams to explore their performance under compression and bending. The parameters such as shear span to depth ratio for beams, the slenderness ratio and the load eccentricity for columns. The test results showed that the concrete filled steel tubular beams and columns with elliptical sections behaved in ductile manners and were similar to the concrete filled steel circular sections. The shear span (a/B) to depth ratio has a moderate effect on the behaviour of the elliptical concrete filled steel tubular beams, the bending strength is decreased by 12.5% and 22.3% with the increase of (a/B) from 1.56 to 2.60 and to 3.65.

Richard Liew.J.Y et al., (2014), investigated the behaviour of tubular columns in filled with ultrahigh strength concrete at ambient and elevated temperatures. The test were conducted for the basic mechanical properties of the high strength materials and structural behaviour of stub columns under concentric compression, beams under moment and slender beam columns under concentric and eccentric compression. High tensile steel with yield strength up to 780 MPa and ultrahigh strength concrete with compressive cylinder strength up to 180 MPa were used to construct the test specimens. The test values were compared with the predictions using a modified Eurocode 4. At high temperature, strength reduction is less for ultrahigh strength concrete than normal strength concrete, while more strength reduction is expected for high tensile steel compared to mild steel.

Kojiiro Uenaka, (2014), investigated the characteristics of concrete filled elliptical/oval steel tubular columns under centric loading. The parameters such as diameter to thickness and diameters ratios of elliptical/oval steel tube were involved. The result shown that local buckling of the elliptical/oval steel tube associated with shear failure of in filled concrete and also axial loading capacity decreased as diameter to thickness ratio 2a/t and 2b/t increased. The deformities of concrete filled elliptical/oval stainless steel tubular column increased as diameter to thickness ratio decreased due to the increasing of the confined stress being induced by outer tubes.

Ehab Ellobody and Mariam F.Ghazy, (2012), investigated plain and fibre reinforced concrete filled stainless steel circular tubular column under axially and eccentric loading conditions. The column ultimate loads, load axial shortening relationships, load mid height lateral deflection relations and failure modes of the concrete filled stainless steel circular tubular columns were measured. The test ultimate loads were compared with the design ultimate loads calculated using the Eurocode 4 for composite columns. It shown that the Eurocode 4 accurately predicted the ultimate loads of axially loaded concrete filled stainless steel circular tubular columns, but were quite conservative for predicting the ultimate loads of the eccentrically loaded columns. It shown that the Eurocode 4 prediction is increased as the eccentricity is increased. The fibre reinforced concrete filled tubular columns offers a considerable increase in column ductility compared with plain concrete filled tubular columns.

Hernandez - Figueirido.D et al., (2011), conducted test on rectangular and square tubular column filled with normal and high strength concrete and subjected to axial load and single or variable curvature. The test parameters such as the nominal strength of concrete, the cross-section of the column, thickness of the section and eccentricities ratio were involved. It shown that on reducing the b/t ratio, the improvement in force is similar for both normal and high strength concrete. When the eccentricity ratio (r) decreases, there is lower area working under tension and the composite section works better than for equal eccentricity. The improvement occurs in the higher strength concrete compared to hollow section if r = - 0.5. Confinement increases only for the cases where all the transversal strains have the same sign (r = 0 or r = -0.5).

Shehdeh Ghannam et al., (2011), investigated the behaviour of light weight concrete filled steel columns under axial columns. The comparison between normal and light weight concrete filled steel columns for different cross sections using Eurocode 4 and BS 5400 was also conducted. The test results showed that both types of filled columns failed due to overall buckling, while hollow steel columns failed due to local buckling at the ends. The steel tubes filled with lightweight aggregate concrete show acceptable strength under the applied load when compared to design calculations. The behaviours of both lightweight concrete filled steel tubular columns and normal concrete filled steel tubular columns show a similar trend.

Brian Uy et al., (2010), carried out the performance of the short and slender concrete filled stainless steel tubular columns under axial compression or combined actions of axial force and bending moment. The parameters considered in this study are section type (circular and square), cross section slenderness (D/t or B/t), concrete filled sections or hollow sections and concrete cylinder strength. Finally concluded that the smaller cross section slenderness, higher in the deformation capacity and the compressive strength. Concrete filled section has a much higher deformation capacity than the empty sections. The circular section shows more ductile behaviour. The stub columns with smaller D/t or B/t ratio is more effective to exert confinement on concrete.

Wang Zhanfei et al., (2010), investigated the structural properties of concrete filled steel tubular short columns. Parametric study is conducted on the effect of radius thickness ratio, axial load ratio and ductility of concrete filled steel tubular short column. Finally the design formulas for the ultimate strength and ductility of concrete filled steel tubular column subjected to compression and to combined compression and bending moment were evaluated.

Dennis Lam and Leroy Gardner, (2008), studied the behaviour and design of axially loaded concrete filled stainless steel circular and square sections. The column strengths and load axial shortening curves were evaluated. This study is limited to cross section capacity and has not been validated at member level. The results were compared with the existing design methods for composite carbon steel sections - Eurocode 4. It was found that existing design guidance may generally be safely applied to concrete filled stainless steel tubes, though overly conservative results were apparent, particularly for circular hollow section.

Artiomas Kuranovas and Audronis Kazimieras Kvedaras (2007), studied the behaviour of composite steel concrete elements in various loading stages and analysed by investigations and experiments. Theoretical and experimental investigations show that behaviour of hollow concrete filled steel tubular elements was more complicated than that of solid ones, because of complex stress states that none of stresses in hollow concrete core are evenly distributed through the thickness of its cross sections. For single-layered concrete filled steel tubular elements the triaxial stress state is achieved only at the contact surface between the concrete core and steel shell. An internal hollow concrete core of double-layered concrete filled steel tubular elements is in the same stress state as of single-layered members, but an external layer is analysed as being in 3D stress state.

Muhammad Naseem et al., (2006), investigated the behaviour of concrete filled steel tubular columns axially loaded in compression in failure. They carried totally 28 specimens with different cross – sections. In that specimen 16 columns were filled with the concrete and 12 columns were kept as hollow. The parameters such as length to diameter, tube shape and diameter to thickness ratio were involved. Finally concluded that the strength increases in circular columns more than in the square columns. Increasing strength of the circular columns was more than 60 %. Local wall buckling was recorded in the square columns in both the hollow and concrete filled sections.

Zeghiche.J and Chaoui.K, (2004), carried 27 concrete filled steel tubular column specimens. The test parameters such as column slenderness, axially and eccentrically loaded columns with single or double curvature bending and the compressive strength of concrete which was filled in the tubular section. Total specimens were grouped into three categories under different loading conditions. Finally concluded that Eurocode 4 predictions for the columns which was loaded with axially and eccentrically with single curvature bending were on the safe side and in good agreement with the experimental and numerical failure loads. The columns which was tested under double curvature bending are on the unsafe side.

II. RESULTS AND DISCUSSION

Several researchers have been conducted on the concrete filled tubular columns under various loading conditions and also using different concrete types regarding the load carrying capacity, failure mode of columns and other related parameters. The reviewed literature shows that the concrete filled tubular column depends upon the concrete type, loading condition, stress-strain relationship, width to thickness ratio, slenderness limits, confinement effect, local buckling etc. When high strength concrete is used, then the cost will be increased.

Stainless steel are used in the tubular column section due to their main advantages such as corrosion resistance, high durability, high strength, high stiffness and etc.

To reduce the cost of the construction, there is a requirement of usage from the environmental wastages. Therefore usage of metakaolin and green sand were involved as a replacement in the conventional concrete.

For the high level construction purpose such as Bridge construction, high rise building construction, etc. the tubular columns are tested with the confined effect with the GFRP wrapping.

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