Experimental Investigation of Cold Formed Steel Long and Short Composite Columns Infilled with M - Sand

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Abstract

The Experimental behavior of cold formed steel hollow, in filled Conventional Concrete and M-Sand replaced concrete in-filled short and long columns subjected to axial load. The experimental investigations are carried out to study the change in strength characteristics obtained for 50% Usage of M-sand. The In-Fill Mix Chosen was M40 for both Conventional and M Sand Mix. The behavior of hollow, CC and in-filled light gauge steel short and long columns and their load carrying capacities are to be studied. Load-Axial shortening and Load-Strain behavior for all the specimens tested are to be drawn. The ultimate loads are determined experimentally.

Keywords: Cold form steel, M-sand, Conventional concrete

I. INTRODUCTION

In modern structural constructions, light weight steel columns have gradually become a central element in structural systems like buildings, bridges. Steel composite columns have become so widespread owing to their axially compressed nature making them superior to conventional reinforced concrete and steel structural systems in terms of stiffness, strength, ductility, and energy absorption capacity. The steel tube not only takes axial load, but also provides confining pressure to the concrete core, while the concrete core takes axial load and prevents or delays local buckling of the steel tube. Furthermore, concrete filled composite columns also have the advantage of requiring no formwork during construction, thus reducing construction costs. After this improved research effort has focused attention on developing techniques for combining steel and concrete most appropriately called as steel-concrete composite structures using light weight gauge.

II. LITERATURE REVIEW

1) Lu, Li and Guojun Sun (2007) investigated the bending moment-axial force- curvature (M-N-Φ) relation of eccentrically compressed square concrete-filled steel tube columns by analytically. A simplified analytical method for predicting the ultimate strength of eccentrically compressed square concrete-filled steel tube columns based on the collapse theory was presented. This method was also calculated the ultimate strength of axially compressed columns with initial imperfection. In this study, the proposed method was compared with experimental results from the work of Furlong, Knowles and Park and Zuo et al. From the comparisons it was seen that the proposed formula predict fairly well for the ultimate strength of the square CFT columns.

2) Ben-Young and Ehab Ellobby (2006) experimentally investigated the behavior of high strength concrete filled high strength stainless cold formed steel tube columns under the effects of shape of the stainless steel tube, plate thickness and concrete strength. The test strength were compared with the design strengths calculated using the American, Australian, New Zealand standards. The test strength and load axial strain relationship shown that the ductility of the column decreased with the increase of the concrete strength. For slender section, the local buckling failure mode was observed. The comparisons of test strength with design strengths predicted by the codes were conservative. Based on the test results, design recommendations were proposed for concrete-filled high strength stain less steel tube columns.

3) Jian CAI and Zhen-Qiang He (2006). The axial load behavior of square concrete-filled steel tubular (S-CFT) stub columns with binding bars were experimentally tested by Ten specimens with the binding wires and 5 specimens without binding bars were tested to examine the effects of width to thickness ratio and binding bars on ultimate strength, stiffness and...
ductility of S-CFT columns. The spacing and diameter of binding bars have an important influence on ultimate strength and plastic deformability of square CFT columns with binding bars. When spacing of binding bars were decreased and the diameter of binding bars were increased, the ultimate strength and the corresponding strain of specimens with binding bars were increased remarkably and the post load-strain curve increased slowly. With the thickness of steel tube increasing, the D/t ratio decreasing, the ultimate strength and the corresponding strain increases and the columns become more ductile.

4) Jane Helena and G.M. Samuelknight (2005), present the experimental behavior and design of axial loaded concrete-filled steel tube circular stub column. The test parameters were in-filled concrete strength and external diameter of the steel tube-to-plate thickness ratio. The column strength and axial load shortening values were evaluated for the various concrete strength and aspect ratios. The experimental results are validated by the design strengths calculated using the American, Australian and European specifications. In the experimental investigation following conclusions were drawn. The column strength increases due to the decreases of the D/t ratio up to 55 and increases for the D/t ratio 55 and 70. It is also arrived the relationship between the column strengths and one concrete cube strength increases approximately linear as the concrete strength increases. It was also described that ductility of the column decreases as the concrete strength increases. Comparing the theoretical ultimate values of column, the American and Australian standards are conservative, while those of the European code are unconservative. In this paper reliability analysis were also performed to evaluate the current composite column design rules.

5) Sumei Zhang et al. (2005) examined the behavior of steel tube and confined high strength concrete for concrete-filled RHS tubes. 50 specimens were tested to study the steel ratio, section height to breadth ratio, concrete strength on the ultimate strength of columns. A numerical separation method was used to separate the compressive load carried by the steel tube and core concrete. To determine the overall behavior of the high strength concrete-filled RHS tubes an equivalent one dimensional linear stress strain model of the steel and the confine concrete were developed. In this experimental result, the concrete strength influenced the failure pattern of concrete-filled RHS columns. The core concrete with lower strength failed by splitting and the high strength failed by shrinking. Ductility was increased with increase in height to breadth ratio. It was also noted that, the load bearing capacity of high strength concrete-filled RHS tubes under axial load was greater than the summation of the load bearing capacity of steel.

6) Hatzigeorgiou and Beskos (2005) studied the optimum design of Fiber Reinforced Concrete filled (FRC) steel tube columns. The study taken into account the effects of confinement of concrete and its steel fiber reinforcement. The design variables of the problem were the dimension of the column and percentage of steel fibers and the constraints were prescribed by the strength and stability requirements. An optimum methodology was prescribed and by this method the FRC filled steel tube columns designed both economically and effectively.

III. MATERIALS USED

- Cold-formed steel
- M-sand

A. Cold-Formed Steel

Light gauge steel framing members, sometime called as cold-formed steel, cold form steel is most prevalently used to describe construction materials and are made from structural quality steel sheet that’s formed into shapes either through press-breaking blanks sheared from sheets or coils, or more commonly, by roll-forming the steel through a series of dies. Unlike hot-formed structural I-Beams, neither process requires heat to form the shape, thus the name “cold-formed” steel. Light gauge steel products are usually thinner, faster to produce, and cost less than their hot-formed counterparts.

B. Sand

When rock is crushed and sized in a quarry the main aim has generally been to produce coarse aggregates and road construction materials meeting certain specifications. Generally, this process has left over a proportion of excess fines of variable properties, generally finer than 5-mm size. The left over river material from the crushing process is commonly known as manufactured sand. In this project work this type of manufactured sand will be used as fine aggregate material for making concrete.

IV. MATERIAL PROPERTIES

A. Properties of Light Weight Gauge Steel Sections

Substantial elimination of delays due to weather, High strength and stiffness, Ease of prefabrication and mass production, Fast and easy erection and installation, More accurate detailing, No formwork needed, Termite-proof and rot proof, Uniform quality, Lightness in weight, Economy in transportation and handling, Non combustibility, Recyclable material, Non shrinking and non-creeping at ambient temperatures.
Table – 1
Properties of Manufactured Sand
<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific gravity</td>
<td>2.67</td>
</tr>
<tr>
<td>Water absorption</td>
<td>1.0%</td>
</tr>
<tr>
<td>Free moisture content</td>
<td>0.2%</td>
</tr>
<tr>
<td>Fine modulus</td>
<td>3.71</td>
</tr>
</tbody>
</table>

V. DESIGN MIX: CONVENTIONAL CONCRETE

The concrete mix was designed for cube compression strength of 40 MPa at 28 days. The design mix was 1:2.4:2.5 with w/c ratio of 0.40 using coarse aggregate of size 12.5mm (70%) and another size 10mm (30%). Then the size of fine aggregate is 2.36mm. These are as per ACI committee 211.1.1991 recommendations. The concrete mix (CC and M-SAND) for the composite columns was mixed in two separate batches. The concrete cubes are casted for the values of cube compressive strength for both the conventional concrete mix.

A. M-Sand In-Filled Concrete

To prepare the cubes for mix proportion 50% of M-Sand with replacement of fine aggregate. In this cube test the compressive strength is found out. Then after column casting load bearing capacity of the column is found out.

VI. COMPRRESSIVE STRENGTH TEST (TEST ON SHORT COLUMNS)

Short columns tests were conducted in the Testing Frame. The Rectangular hollow, CC in-filled and M-Sand In-filled were tested. The columns were tested under axial load condition. The test specimens were the test specimens were placed centrally on the bending bench of the machine. The verticality of the Short column was ensured with the help of a plumb line. Deflectometer was placed to measure the axial shortening and strain gauges are fixed at the longer face of the specimen. The axial load was increased slowly till the ultimate load was reached. Prior to the actual test, a load level of 10 kN was applied so that the platens of the testing machine were firmly attached to both ends of the specimen. The axial load was then applied at a loading rate of 0.30mm/min. The axial shortening and longitudinal strain of the specimen were recorded at a load increment of 25kN.

<table>
<thead>
<tr>
<th>Sl.No</th>
<th>Specimen Type</th>
<th>Experimental Load (kN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Hollow</td>
<td>168</td>
</tr>
<tr>
<td>2</td>
<td>Conventional Concrete</td>
<td>276.80</td>
</tr>
<tr>
<td>3</td>
<td>M-Sand</td>
<td>298.70</td>
</tr>
</tbody>
</table>

It was observed that the CC in-filled columns were taking 64% more load than the hollow columns and M-Sand in-filled columns were taking 53% more load than the hollow columns. This is because the M-Sand Sand showed some brittle Characteristics.

![Fig. 1: Load Vs Axial Shortening](image-url)

Load versus axial shortening behavior of the Short columns is shown. In the initial stage the load versus axial shortening of the test specimens showed a linear curve. After attaining the peak value (max load capacity) the curve drops slowly for hollow columns and the sudden drop for in-filled columns showing the reduction in capacity of column with small increment in axial shortening.
A. **Load Vs Micro Strain**

The loads versus micro strain for all the types of Short Columns were shown. The strain hardening portion is longer one for the SFRC in-filled columns compared to CC in-filled columns exhibiting the ductile nature of the in-fill.

![Load Vs Micro Strain](image.png)

**Fig. 2: Load Vs Micro Strain**

**VII. Compressive Strength Test (Test on Long Columns)**

Long columns tests were conducted in the Testing Frame. The Rectangular hollow, CC in-filled and M-Sand In-filled were tested. The columns were tested under axial load condition. The test specimens were the test specimens were placed centrally on the bending bench of the machine. The verticality of the Long column was ensured with the help of a plumb line. Deflectometer was placed to measure the axial shortening and strain gauges are fixed at the longer face of the specimen. The axial load was increased slowly till the ultimate load was reached. Prior to the actual test, a load level of 10 kN was applied so that the platens of the testing machine were firmly attached to both ends of the specimen. The axial load was then applied at a loading rate of 0.30mm/min. The axial shortening and longitudinal strain of the specimen were recorded at a load increment of 25kN. It was observed that the CC in-filled columns were taking 64% more load than the hollow columns and M-Sand in-filled columns were taking 53% more load than the hollow columns. This is because the M-Sand Sand showed some brittle Characteristics.

**Table – 3**

<table>
<thead>
<tr>
<th>Sl.No</th>
<th>Specimen Type</th>
<th>Experimental Load (kN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Hollow</td>
<td>245.20</td>
</tr>
<tr>
<td>2</td>
<td>Conventional concrete</td>
<td>294.50</td>
</tr>
<tr>
<td>3</td>
<td>M-Sand</td>
<td>343.60</td>
</tr>
</tbody>
</table>

**A. Load Vs Axial Shortening**

Load versus axial shortening behavior of the Long columns is shown. In the initial stage the load versus axial shortening of the test specimens showed a linear curve. After attaining the peak value (max load capacity) the curve drops slowly for hollow columns and the sudden drop for in-filled columns showing the reduction in capacity of column with small increment in axial shortening.

![Load Vs Axial Shortening](image.png)

**Fig. 3: Load Vs Axial Shortening**
B. Load Vs Axial Micro Strain

The loads versus micro strain for all the types of Long columns were shown. The strain hardening portion is longer one for the SFRC in-filled columns compared to CC in-filled columns exhibiting the ductile nature of the in-fill.

![Load Vs Micro Strain](image)

Fig. 4: Load Vs Micro Strain

VIII. SUMMARY AND CONCLUSION

- From this study it is concluded that conventional concrete column has lesser strength with when compared to M-Sand infill concrete.
- The lateral behavior of conventional concrete is less when compared to M-Sand infill.
- Comparing both long and short column, the results which obtained from long columns gives better results in strength basis than shorter columns.
- Hence the infill concrete is suggested for non-load bearing structures where load is considered.

REFERENCES