ISSN (Print) : 0974-6846
ISSN (Online) : 0974-5645
Indian Journal of Science and Technology, *Vol 9(5), DOI: 10.17485/ijst/2016/v9i5/87273, February 2016*

Behaviour of Cold Formed Columns under Axial Loading with Quartz and Silica In-Filled Concrete

M. Shanmugapriya[1*] and M. Helen Santhi[2]

[1]Department of Civil Engineering, Sathyabama University, Chennai - 600119, Tamil Nadu, India; priyasekar25@yahoo.com
[2]School of Mechanical and Building Sciences, VIT University, Chennai - 600127, Tamil Nadu, India; helensanthi.m@vit.ac.in

Abstract

The experimental investigation was carried out to study and investigate the behaviour of hollow, Plain Cement Concrete (PCC) and Silica; Quartz replaced concrete in-filled medium light gauge columns subjected to axial loads. The cold formed sheets were continuously welded at the middle along its length. The basic study for the in-fill materials were carried out initially. For PCC in-fill M40 grade concrete was chosen. A total of 4 columns of 1.50m length were tested, without in-fill, with plain concrete in-fill and with Quartz and Silica in-fill having a cross section of 100 × 50 × 2 mm. All the specimens were tested to failure. Ultimate load, Load-Axial shortening and Load-Strain for all the specimens tested were plotted. With the comparison of hollow columns the Quartz concrete in-filled columns take around 50% more ultimate loads when loaded axially. The in-filled column with Quartz withstands the maximum load; this is due to the fineness modulus property of the material. The Euro Code 4 predicted the ultimate loads closer to that of the experimental loads. Thus Quartz sand can be used as an alternate filler material.

Keywords: Aggregate, Cold Formed, Concrete, In-Filled, Quartz, Silica

1. Introduction

The study of lightweight Cold-Formed Steel (CFS) structural systems is increasing since the CFS members offer one of the highest load capacity-to-weight ratio. The use of in-filled columns is a new trend in composite construction industry. Steel-concrete composite columns are used extensively in modern buildings. Extensive research on composite columns in which structural steel section are encased in concrete have been carried out. The in-fill concrete columns offer high classes of fire protection and for seismic-resistant structures. In-filled composite columns, however have received limited attention compared to encased columns[1]. The strength and deformation of the short and slender concrete-filled steel tubular column under the combined action of axial compression and bending moment was experimentally studied[2]. A numerical model was also developed to study the behaviour of column incorporating material and geometrical non-linearity[3]. Due to the decrease in the availability of river sand a sustainable alternate can be used. Study on concrete using waste materials by partial replacement of aggregates was carried out[4]. Tests on steel tubular columns of rectangular and circular sections filled with normal and lightweight concrete were performed to investigate the behaviour of such columns under axial loadings[5]. The Silica sand and Quartz sand are found as an alternate for river sand.

2. Experimental Investigations

2.1 General

The specimens were fabricated from cold-formed tubes with a measured size of 100 × 50 × 2 mm and 1.474 m long to keep the slenderness ratio as 70 respectively. Tensile coupons test were carried out to measure the material properties of steel. Two types of concrete Silica and Quartz along with Conventional Concrete were used to fill the hollow sections.The mix design was carried out according to IS: 10262-1982.

*Author for correspondence

2.2 Concrete Properties

A nominal mix was designed according to IS: 10262-1982 for M40 grade of concrete. The specimens were casted and the strength development was monitored for a period of 28 days, from which the optimum percent of the Silica and Quartz mix was found and used for the in-fill along with conventional mix.

2.3 Steel Properties

Coupon test was carried out to in order to determine the actual material properties of steel, three coupons were cut from the sections and tested for failure under tension as per ASTM A 370[6] specification. The Figure 1 shows the details of specimen for Coupon Test. The properties of steel such as Yield stress f_y = 270 N/mm^2; Ultimate stress f_u = 312 N/mm^2; Percentage of elongation = 13%; Modulus of Elasticity = 2.1 x 10^{5}N/mm^2 were found. The Figure 2 describes the stress strain behaviour of the steel used.

2.4 Push out Tests

To study the bond strength between the steel sections and the in-fill, push out tests were carried out. The test specimen of 550 mm in length and the concrete was filled up to 500 mm length leaving a 50 mm gap. The load was directly applied on concrete through a steel plate and the slip between concrete and steel was observed using a deflectometer. The Figure 3 shows the Load vs. Slip Characteristics for the in-filled specimens. The slip was very minimal indicating high bond– strength up to the ultimate load. The Quartz in-filled concrete showed

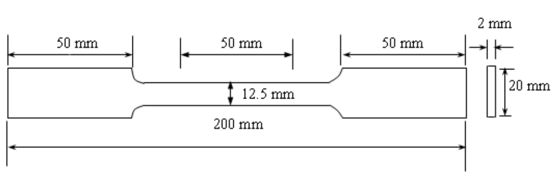

Figure 1. Details of specimen for coupon test.

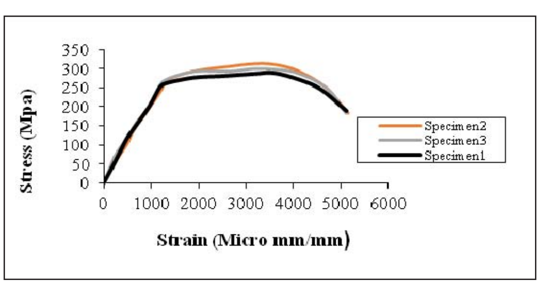

Figure 2. Stress strain behaviour for the steel specimens.

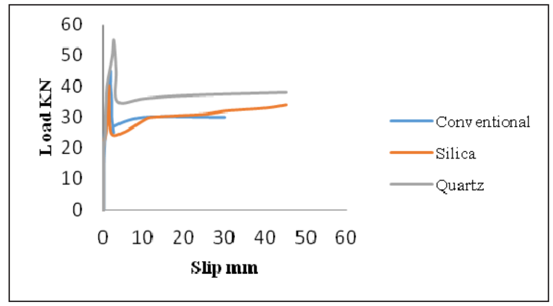

Figure 3. Load vs. slip characteristics for the in-filled specimens.

higher bond strength properties when compared to other in-filled concrete and this is due to the bonding nature of quartz material.

3. Test on Medium Columns

The height of column not less than three times the largest dimension of the section and not more than twenty times the least radius of gyration as prescribed in the IS: 801-1975[7] is called medium column. The column tests were conducted on specimens to get their ultimate strength.

3.1 Test Procedure

The rectangular hollow, Conventional in-filled concrete, Silica in-filled Concrete and Quartz in-filled concrete were tested. The columns were tested under axial load condition. A load level of 10 kN was applied so that the platens of the testing machine were fixed to both ends of the specimen. The axial load was then applied at a loading rate of 0.30 mm/min. Deflectometer are placed at mid height on all the sides to measure the lateral deflection. A 30 mm thick plate was welded directly to the ends of the specimen to create the simply supported end conditions. The axial shortening and longitudinal strain of the specimen were recorded at a load increment of 10 kN.

3.1.1 Load vs. Axial Shortening

Load versus axial shortening behaviour of the short columns with the various in-fill are shown in Figure 4. The test specimens showed a linear curve in the initial stage. After attaining the maximum load capacity, the curve drops gradually for the hollow columns and a sudden drop for the in-filled columns showing the reduction in capacity of column. The in-filled column with Quartz withstands the maximum load; this is due to the fineness modulus property of the material. The Euro Code 4 predicted the ultimate loads closer to that of the experimental loads is shown if Table 1.

3.1.2 Load vs. Micro Strain

The loads versus micro strain for all the columns are shown in Figure 5. For the hollow column the strain is very less. The strain is very less for the in-filled columns

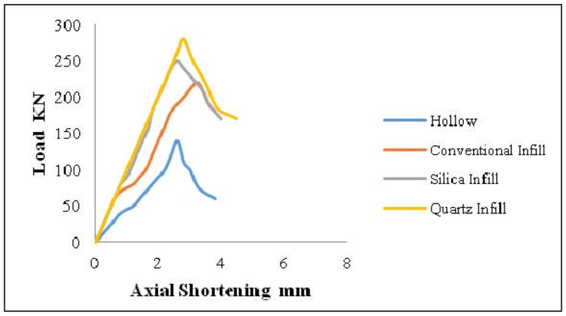

Figure 4. Load vs. axial shortening.

Table 1. Experimental and theoretical load comparison

Sl. No.	Specimen Type	Experimental Load (P_{exp}) (kN)	Theoretical Load (P_{the}) (Eurocode4) (kN)
1	Hollow	140	138.2
2	Conventional Concrete	220	222.6
3	Silica	250	258.4
4	Quartz	280	275.6

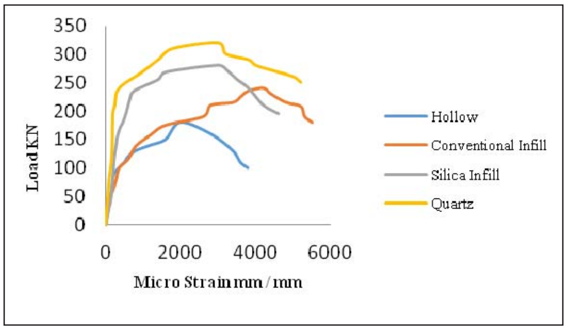

Figure 5. Load vs. micro strain.

but the corresponding load is high when compared to hollow column. The strain hardening portion is greater for the Quartz in-filled columns compared to the other in-filled columns. This condition prevails due to the ductile behaviour of the Quartz material.

4. Conclusion

With the comparison of hollow columns the Quartz concrete in-filled columns take around 50% more ultimate loads when loaded axially. The Quartz in-filled columns take around more ultimate loads when the loads act axially in comparison with other in-filled columns. The Quartz in-fill column can withstand maximum failure when compared to other columns. The experimental loads show closer results in comparison with Euro code 4[8].

5. References

1. Shanmugam NE, Lakshmi B. State of the art report on steel–concrete. Journal of Constructional Steel Research. 2001 Oct; 57(10):1041–80.
2. Ramanagopal SR, Devadas Manoharan P. Test on fiber reinforced concrete filled steel tubular columns. Journal of Steel and Composite Structures. 2004 Feb; 4(1):37–48.
3. Rajeshkumar B, Patidar AK, Helen Santhi M. FE analysis of concrete filled cold formed steel sections using Ansys. International Journal of Advances on Civil Engineering. 2013 Jan-Jun; 3(1):11-18.
4. Mohanraj EK, Kandasamy S, Rajkumar N. Study on concrete using waste materials by partial replacement of aggregates to reduce global warming gases. Indian Journal of Science and Technology. 2011 Mar; 4(3):159–63.
5. Ghannam S, Al-Rawi O, El-Khatieb M. Experimental study on light weight concrete-filled steel tubes. Jordan Journal of Civil Engineering. 2011; 5(4):521–9.
6. Standard Test Methods and Definitions for Mechanical Testing of Steel Products. ASTM: 370–92. 1996.
7. Code of Practice for use of Cold-formed light gauge steel structural members in general building construction. Bureau of Indian Standards. IS: 801-1975.
8. Euro code 4. Design of Composite steel and Concrete Structures. Part 1.1: General rules and rules for buildings (together with United Kingdom National Application Document). London; British Standard Institution: 1994.