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Experimental investigation of light-weight concrete-filled stainless steel tube composite long columns

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Cover Page Footnote

This paper has not been previously published and is not currently under consideration by another journal and that all authors have approved of and have agreed to submit the manuscript to this journal. I have full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis as well as the decision to submit for publication.

1. Introduction

Composite long stainless steel columns filled with light-weight concrete provide high strength and ductility with low weight. In addition to these advantages, the steel tubes surrounding the concrete columns eliminate temporary form work which reduces construction time. Stainless steel tube members was important due to the high corrosion resistance, ease of construction and maintenance. Steel tubes assist in carrying axial load and increase the load capacity of the columns. Ultimate loads and behavior of composite columns are influenced by many parameters such as material strength, tube dimension and tube thickness.

Several researchers investigated the behavior of concrete-filled steel tube composite columns construction through experimental tests and numerical models. Tests were done by using a carbon steel tube and high strength steel tube columns using circular, square and rectangular hollow sections. Elsayed S. [9] in 2012 tested and study behavior of short composite stainless steel columns. Kuranovas, A., [1] in 2009 investigated load bearing capacity of concrete filled steel columns. D. Lam and L. Gardner [3] in 2008 introduced structural design of stainless steel concrete filled columns. Gupta, P. K. [6] in 2007 introduced experimental and computational study of concrete filled steel tubular columns under axial loads.

The objective of this study was to investigate the behavior and performance of long composite circular stainless steel columns filled with light-weight concrete. Experimental study aimed to introduce contributions to the field on long composite circular stainless steel columns filled with light-weight concrete under compression load up to failure.

2. Experimental Work

Four composite long and short circular stainless steel columns filled with light-weight and normal concrete were experimented, two of them are long composite circular stainless steel columns with length 1400 mm, diameter 100 mm and thickness of stainless steel tube 2 mm filled with light-weight and normal concrete with strength 12 mpa and 26 mpa respectively, which denoted by C1400/12 and C1400/26. The other two specimens wsa short composite circular stainless steel columns with length 500 mm, diameter 100 mm and thickness of stainless steel tube 2 mm filled with light-weight and normal concrete with strength 12 and 26 mpa respectively, which denoted by C500/12 and C500/26 as shown in Figure (1). The ultimate load, failure mode and axial shortening have been investigated.

The stainless steel tubes that were used to prepare all specimens were available in hot rolled sections. To make sure that there are no imperfections in these tubes, measurements were taken. There were no discernible flaws and the tubes were nearly perfectly straight.

A total of four specimens were prepared. First specimen was long composite column which prepared having light-weight concrete (C1400/12). Second specimen was long composite column which prepared having normal weight concrete(C1400/26). Third specimen was short composite column which prepared having light-weight concrete(C500/12). Final specimen was short composite column which prepared having normal weight concrete(C500/26).

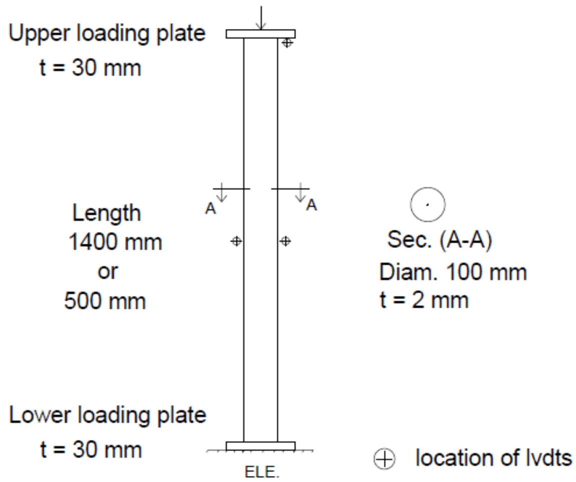

Figure (1) Details of specimens
C1400/12, C1400/26, C500/12 and C500/26

Layers of concrete infill were cast, and the required compaction was achieved. It was crucial to make sure that the load is applied and distributed evenly to the filled concrete and stainless steel tube as shown in Figure (2).

Table (1) list the mechanical characteristics for concrete for each specimen and Table (2) list the dimensions and properties of each specimen

Col. specimen	Cement (Kg)	gravel (Kg)	Sand (Kg)	Foam (Kg)	Water (Kg)	Admixture (Kg)	Density of concrete (Kg/m^3)	Strength of concrete (mpa)
C1400/12	588	-	883	9.3	196	5.9	1447	12
C1400/26	539	809	809	-	186	5.4	2270	26
C500/12	588	-	883	9.3	196	5.9	1447	12
C500/26	539	809	809	-	186	5.4	2270	26

Table (1) Mechanical characteristics of concrete for each specimen (1m3)

Col. specimen	L (mm)	D (mm)	D/t	L/D	Density of concrete (Kg/m3)	Strength of concrete (mpa)
C1400/12	1400	100	50	14	1447	12
C1400/26	1400	100	50	14	2270	26
C500/12	500	100	50	5	1447	12
C500/26	500	100	50	5	2270	26

Table (2) Dimension and prorerties of each specimen

Figure (2) Prepare and casting specimens

The concrete-filled stainless steel tube column tests investigated in this study were excuted using a universal testing equipment in the steel laboratory of Faculty of Engineering of Tanta. The specimens were fitted in the testing device The column specimens were subjected to compressive axial force using a hydraulic testing equipment with a 1000 kN capacity from Mechanics Test System. The supports consisted of a plate 30 mm thickness at both ends of the specimen. Loading rate was set as 5kN/min to gurantee a quasi-static loading state as shown in Figure (3) and Figure (4).

Figure (3) Specimen testing configuration of long column

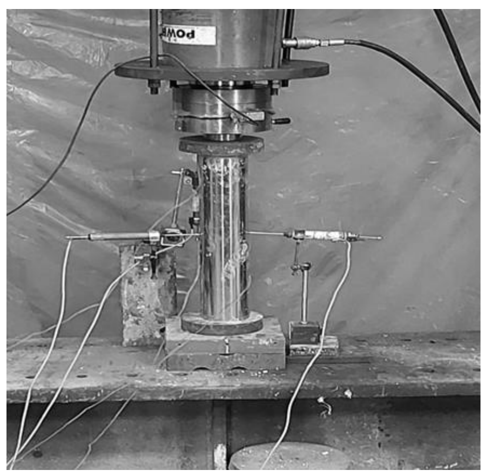

Figure (4) Specimen testing configuration of short column

The axial shortening of the columns was measured using a single transducer (LVDT). The applied loads and readings from LVDT were recorded regularly during the testing using a data capture system.

3. Results and discussion

The deformed shape at failure for specimens C1400/12 and C500/12 were shown in Figures (5). It is shown that overall buckling in specimen C1400/12 and local buckling at middle and beside the loading plates in specimen C500/12.

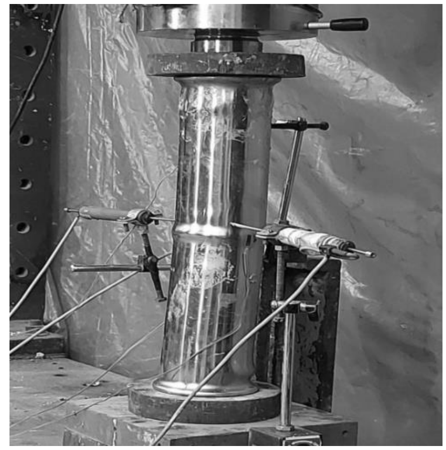

Figure (5): Experimental failure mode for column specimen C1400/12 and C500/12

Experimental results of load-axial shortening relationship for column specimens C1400/12 C1400/26 shown in Figure (6) and Figure (7).

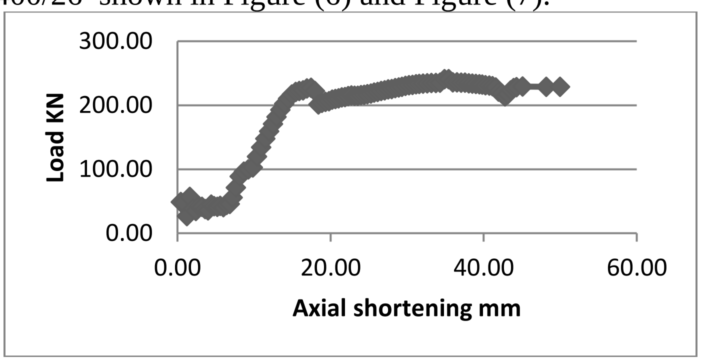

Figure (6): load-axial shortening for column specimens C1400/12

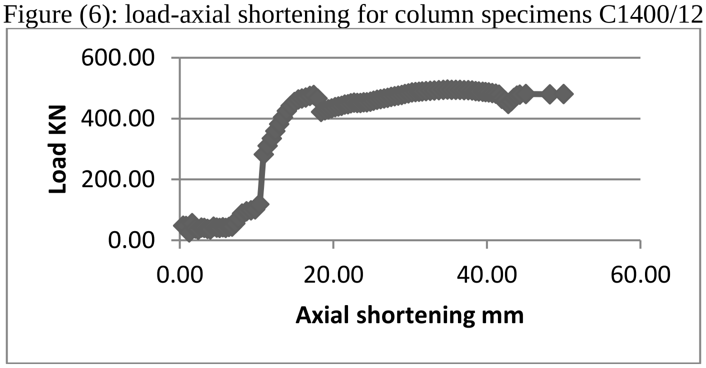

Figure (7): load-axial shortening for column specimens C1400/26

Experimental results of load-axial shortening relationship for column specimens C500/12 C500/26 shown in Figure (8) and Figure (9).

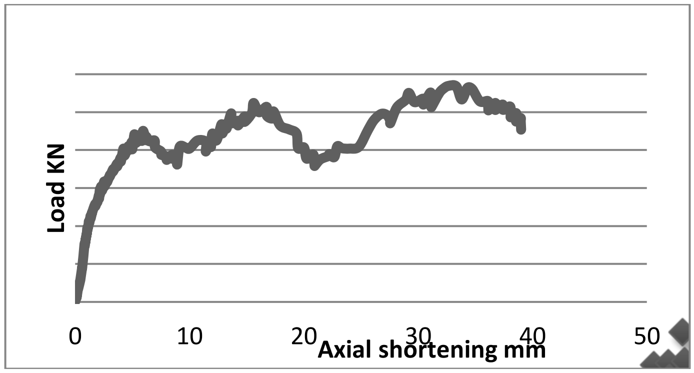

Figure (8): load-axial shortening for column specimens C500/12

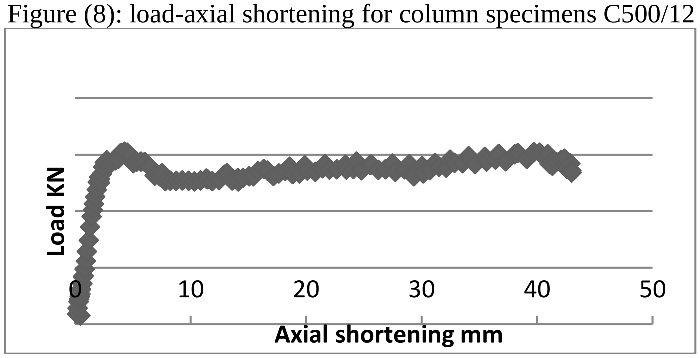

Figure (9): load-axial shortening for column specimens C500/26

It can be seen that from experimental relationships the load-axial shortening behavior was approximate linear in the initial stage and started to be nonlinear after buckling of stainless steel tubes. As expected the ultimate load carried by normal-weight concrete-filled stainless steel tube was considerably greater than that of light-weight concrete due to higher increase in strength.

Comparison between relationship of load-axial shortening for specimens C1400/12 and C1400/26 shown in Figure (10) and for specimens C1400/12 and C500/12 shown in Figure (11).

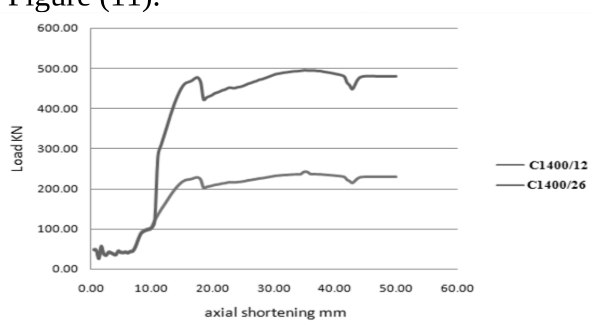

Figure (10): load-axial shortening for column specimens C1400/12 and C1400/26

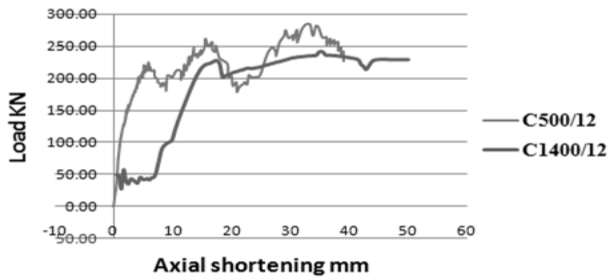

Figure (11): load-axial shortening for column specimens C1400/12 and C500/12

Table (3) list the experimental load capacity for each specimen.

Col. specimen	L/D	Experimental capacity of column (KN)	% cap. Of C1400/12
C1400/12	14	241	100
C1400/26	14	513	46.98
C500/12	5	283	85.16
C500/26	5	609	39.57

Table (3) Experimental load capacity for each specimen

From results of experimental capacity of columns for L/D was 14 it can be shown that using light weight concrete instead of normal concrete in stainless steel composite long columns decrease the capacity of the column to nearly 47%. Capacity of long composite column (L/D=14) with light weight concrete is nearly 85% of short composite column (L/D=5) with light weight concrete.

4. Conclusion

1- This study was reported experimental tests on light-weight concrete-filled stainless steel long columns. Tests were on long columns having L/D = 14 with D/t ratio of 50 and the concrete strengths 12 MPa for light weight and 26 for normal weight concrete. Capacity of columns, load- axial shortening and failure modes were observed and reported in this study.

2- Failure of long column was due to flexural buckling of stainless steel tube which clear that in middle of specimen and due to local buckling of stainless steel tube for short columns which clear that in middle and near ends of specimen.

3- From results of experimental capacity of columns for L/D was 14 it can be shown that using light weight concrete instead of normal concrete in stainless steel composite long columns decrease the capacity of the column to nearly 47%.

4- Capacity of long composite column (L/D=14) with light weight concrete is nearly 85% of short composite column (L/D=5)with light weight concrete.

5- Capacity of long composite column with light weight concrete is less than short column with light weight concrete.

5. References

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