Comparative Study on Buckling Load Capacity of CFST Columns for Cyclic Loading underDifferent Infill ConcretesUsing TauguchiApproach

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Abstract

In the present study, the behavior of Conventional Concrete (CC), Light Weight Concrete (LWC) and Self Compacting Concrete (SCC) Filled Steel Tube (CFST) columns under Monotonic ans Cyclic loading hasbeen tested. The experimental investigations are carried out for 54 specimens that includes 18 specimens filled with Conventional concrete, 18 specimens filled with Light weight concrete and 18 specimens filled with Self-compacting concrete (SCC) of grade M20, M30 and M40 with different L/D ratios using Tauguhi approachdue to monotonic loading and Cyclic loading . It is found that the capacity of buckling load and deformations areobtained from testing under cyclic loading, the buckling or ultimate load for CFST columns in fill as SCC are higher compare to CC infill by2.2% - 4.5% for cyclic loading. Buckling load capacity of SCC infill CFST columns is more than LWC infill CFST columns about 4.7% - 7.0% for Cyclic loading. As per the results Buckling load capacity for CFST column with higher grade infill more effective in Cyclic loading and verified and validated using Finite elementsoftware ABAQUS6.10.1

Keywords - SCC-self compacting concrete, LWC- lightweight concrete, CC- conventional concrete, CFST- concrete filled steel tube, cyclic loading.

Introduction

Experimental investigation conducted to know the behavior of Conventional Concrete Filled Steel Tube columns, Light weight concrete Filled SteelTube columns and Self compaction concrete Filled steel Tube columns subjected toMonotonic and Cyclic loading has been tested[1]. The experimental investigations are carried out for 54 specimens that includes 9 specimens of Conventional Concrete Filled Steel Tube columns , 9 specimens of Light weight Concrete Filled Steel Tube columns and 9 specimens of Self compaction Concrete Filled Steel Tube columnssubjected to cyclic loading with grades M20, M30 and M40 with different L/D ratios (i.e., 6,12 and16)and 9 specimens of Conventional Concrete Filled Steel Tube columns , 9 specimens of Light weight Concrete Filled Steel Tube columns and 9 specimens of Self compaction Concrete Filled Steel Tube columnssubjected to Monotonic loading with grades M20, M30 and M40 with different L/D ratios (i.e., 6,12 and16) and different diameters of hollow steel sections with constant thickness of 3.2 mm (i.e., outer diameter of 33.70mm,42.40 mm and 48.3 mm)[2, 3]. The parameters such as the geometric properties of the column section specimens with different L/D ratios, diameters with constant thickness and different grades of concrete have been considered during the test using Tauguchi approach[4, 5]. It is found that the capacity of buckling load and deformations are obtained from testing under cyclic loading, the buckling or ultimate load for CFST columns are higher compare for higher grades of concrete,also the confinement of infill concrete increases the load carrying capacity[6, 7]. According to Tauguchi approach, the experimental results are tabulated for load and corresponding deformations also variations of deformation and load curves are plotted. Major conclusion drawn from the test results.

Materials

Materials required for concrete collected and tested according to relevant codes for different materials (IS: 12269-1987, IS: 2386-1975, IS383-1970, ACI211.2 -98, IS: 456-2000,..) and super plasticizer used as admixture to improve or to develop workability and about 0.5% by weight of cement for conventional concrete and light weight concrete mix and about 2.0% by weight of cement for Self-compaction concrete mix. (IS: 9103:1999 and IS2645:1975)[8, 9].

Mix Proportions

The mix design for the different types of concretecarried out and used to fill in the prepared specimens is done as per codalprovisions. In case of light weight concrete the coarse aggregates are completely replaced by cinders. The cinders used are in between 6 mm to 10 mm in size because of small diameter of availability of steel tubes[10, 11]. The aim of mix design is to select suitable ingredients and to determine the relative proportions of the ingredients, so that the required workability, durability and strengths are obtained with a less cost, Shown in table1, table2 and table3.

Table.1 Conventional Concrete mix proportion for M 20, M 30 and M 40 grade

Constituents in Kg/ m^3	Concrete Grade (CC)		
	M20	M30	M40
Cement	318	360	402
Fine aggregate	743.0	686.0	680.0
Coarse aggregate	1138.0	1108.0	1076.0
Water	190	192	192
W/C ratio	0.6	0.54	0.48
Mix proportion, Cement: fine aggregates:Coarse aggregates	**1 : 2.336 : 3.578**	**1:1.905:3.077**	**1:1.692:2.677**

Table.2 Light Weight Concrete mix proportion for M20, M30 and M40 grade

Constituents in Kg/m^3	Concrete Grade (LWC)		
	M20	**M30**	**M40**
Cement	336	408	445
Fine Aggregates	940	880	860.5
Coarse Aggregates	674	632	617
Water	168	184	187
W/C ratio	0.50	0.450	0.420
Mix proportion, Cement: fine aggregates:Coarse aggregates	1: 2.798 : 2.006	1: 2.16 : 1.55	1: 1.934 : 1.387

Table.3 Self Compaction Concrete mix proportion for M20, M30 and M40 grade

Constituents in Kg/ m^3	Concrete Grade		
	M20	M30	M40

Cement	326.4	400	440
Fine aggregate	735.4	676.0	664.0
Coarse aggregate	1128.5	1082.0	1062.0
Water	163.2	172	176
W/C ratio	0.5	0.43	0.4
Super plasticizers SP430 (2% of cement weight)	6.528	8.0	8.8
Mix proportion, Cement: fine aggregates:Coarse aggregates	1 : 2.253 : 3.457	1:1.69:2.705	1:1.509:2.413

Experimental Program

Tests are conducted on CFST columns in fill as different grades of concrete, L/D ratios andD/t ratios and tabulated loads and corresponding deformations[12, 13]. The buckling loads and deformations are tabulated for Conventional concrete (CC), Light weight concrete (LWC) and Self-compaction Concrete(SCC) as in fill in CFST columns in table 4.

Table 4 Buckling loads and deformations according to Taguchi method.

D/t	L/D	Grade	Conventional concrete (CC)				Light weight concrete (LWC)				Self-compaction concrete (SCC)			
			Pb_exp_m	Δ_{mon}	Pb_exp_c	Δ_{cyc}	Pb_exp_m	Δ_{mon}	Pb_exp_c	Δ_{cyc}	Pb_exp_m	Δ_{mon}	Pu_exp_c	Δ_{cyc}
10.5	6	M20	146	2.7	142	2.65	144	2.8	140	2.78	149	2.85	147	2.8
10.5	12	M30	148	2.9	143	2.88	145	2.95	140	2.9	150	3	146	3
10.5	16	M40	145	3.1	140	3	142	3	138	2.95	146	3.15	143	3.1
13.3	6	M30	200	3.01	192	2.95	198	2.9	190	2.88	203	3.1	200	3.05
13.3	12	M40	204	3.15	195	3.1	201	3.1	190	3.05	206	3.2	203	3.15
13.3	16	M20	170	2.9	166	2.8	167	3.05	162	2.95	179	3.05	173	3
15.1	6	M40	249	3.05	239	3	246	3	238	2.96	252	3.1	249	3.05
15.1	12	M20	210	2.85	200	2.8	208	2.85	197	2.82	216	3	210	2.95
15.1	16	M30	206	2.95	199	2.85	203	3.02	194	2.95	212	3.05	208	3

Note: Pb_exp_m= Experimental buckling load subjected Monotonic loading

Pb_exp_c= Experimental buckling load subjected Cyclic loading

Δ_{mon} = Deformation due to Monotonic loading

Δ_{cyc} = Deformation due to Cyclic loading

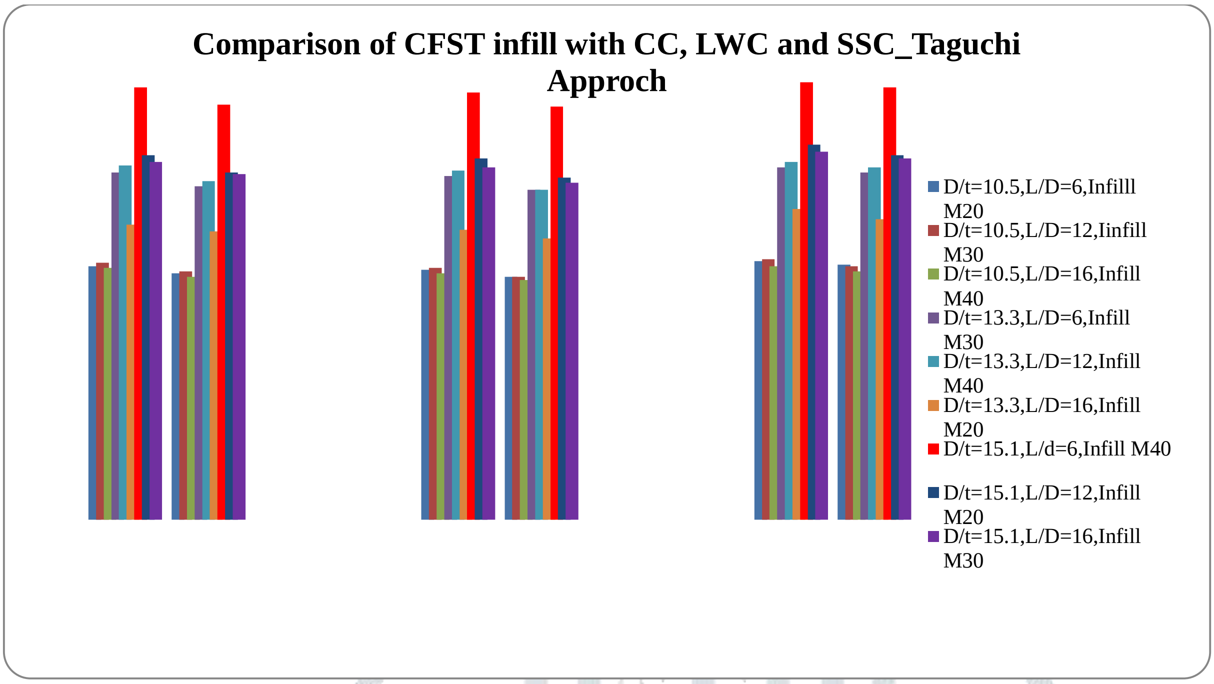

Figure 1 Comparison of Buckling load capacity of CFST column with Differenttypes and different grades of infill concrete for different outer diameters due toMonotonic loading and Cyclic loading.

Discussions and Summary

As per the experimental work Buckling load capacity of CC infill CFST column is more than LWC infill CFST column about 1.5% - 2.0% for monotonic loading and about 1.5% - 2.5% for cyclic loading. Buckling load capacity of SCC infill CFST columns is more than CC infill CFST columns about 2.0% - 3.0% for monotonic loading and about 2.2% - 4.5% for cyclic loading. Buckling load capacity of SCC infill CFST columns is more than LWC infill CFST columns about 2.5% - 6.5% for Monotonic loading and about 4.7% - 7.0% for Cyclic loading. As per the results Buckling load capacity for CFST column with higher grade infill due to Monotonic loading and Cyclic loading, more effective in Cyclic loading.

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