EXPERIMENTAL STUDY OF STRUCTURAL BEHAVIOUR OF DOUBLE SKIN HOLLOW–CFST UNDER AXIAL COMPRESIVE LOADING AT DIFFERENT HOLLOWNESS RATIOS

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ABSTRACT: The purpose of this experimental study is to investigate the behavior of the double-skinned concrete filled steel tubular (DSCFT) columns on the strength, stiffness and ductility performance. The diameter-thickness (D/t) ratio and the hollowness ratio were chosen as main parameters in designing the specimens. A total of 36 specimens were tested under axial compressive load. Test results concluded that the DSCFT columns can effectively provide strength and deformation capacity even with a large D/t ratio. We have studied the variation in structural properties of Double Skin Hollow CFST at different hollowness ratios. Total 36 no. of specimens were prepared and tested in axial compressive loading with different hollowness ratio.

INTRODUCTION:

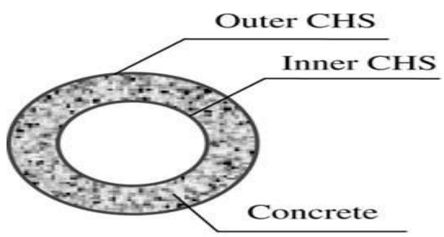
Double-skinned Hollow concrete filled steel tubular (DSH-CFST) columns consisting of two concentric circular thin steel tubes with filler between them have been investigated for different applications the use of fully concrete filled steel tubes (DSH-CFST) has become widespread in the past few decades.

They have Better structural performance than those of bare steel or bare reinforced concrete. The steel hollow section acts as Formwork as well as reinforcement for the concrete. Concrete eliminates or delays the local buckling of steel hollow section, and increases significantly the ductility of the section. DSH-CFST construction has proven to be economic in material as well as providing for rapid construction and thus additional cost savings. In recent years, it was proposed by several researchers that concrete filled double skin steel tubes (DSH-CFST) be studied for their strength as a column or a beam. Advantages of DSH-CFST over CFST include: increase in section modulus; enhancement in stability; lighter weight; good damping characteristics and better cyclic performance. It is expected that the DSH-CFST.

Columns can obtain a higher fire resistance period than the CFST columns, due to the inner tubes of the composite columns being protected by the sandwiched concrete during fire. It is thus expected that concrete filled double skin steel tubes (DSH-CFST) have a potential of being used in building structures Steel members have the advantages of high tensile strength and ductility, while concrete members may be advantageous in compressive strength and stiffness.

A variation of the concrete filled tubular column is the double-skin tubular column (DSH-CFST), consisting of two generally concentric tubes with the space between filled with concrete. To the best knowledge of the authors, such double-skin tubes were first reported in late 1980s (Shakir-Khalil and Illouli 1987). Since then, much research has been conducted on these columns, both on double skin steel tubular columns (Shakir-Khalil 1991; Wei et al. 1995; Yagishita 2000; Zhao et al. 2002; Tao et al. 2003) and double-skin FRP tubular columns (Fam and Rizkalla 2001). The inner void reduces the column weight without significantly affecting the bending rigidity of the section and allows the easy passage of service ducts.

The euro code 4 being a dedicated code for composite construction combined the design approach of both structural steelwork and reinforced concrete columns. All these codes provide a design procedure just for CFST, CES composite columns and any code does not mention hollow CFST elements. Generally, these codes are adopted for hollow section as for solid member.



Double Skin Hollow CFST

In modern structural construction, Double Skin Hollow CFST columns have gradually become a central element in structural systems like buildings, bridges and so forth.

Double Skin Hollow CFST columns have become so widespread owing to their axially compressed nature making them superior to conventional reinforced concrete and steel structural

OBJECTIVES OF THE STUDY

1. The main objective this experimental work is to study structural behavior of double skin hollow CFST in axial compressive loading condition.
2. To compare the structural properties of the two types of Double Skin Hollow CFST and solid CFST.
3. To improve the ductility of Double Skin Hollow CFST to take heavy the earthquake loads.
4. To study the variation in structural properties of Double Skin Hollow CFST at different hollowness ratios

METHODOLOGY

The hollow sections are to be filled with concrete on site. For sections filled under factory conditions, the same basic requirements need to be met; however, the more closely controlled conditions in the factory could have advantages, particularly when high strength concretes are being used. It must be emphasized that the concrete plays an important structural role and it will only do this if a good standard of concrete design, concreting procedure, control and site supervision is used.

In many cases, grout is an acceptable alternative to concrete for filling hollow sections and in most cases the following recommendations also apply to grout filling.

Good control over concrete materials and testing is required, especially for higher strength mixes. The testing of materials for concrete, and of the concrete itself, should be in accordance with the standards and regulations generally accepted or laid down in the country in which the work is to be carried out. General information on concrete and concreting may be found in textbooks on the subject.

In this experimental work we will use the four sizes of steel tubes with following dimensions.

Table no. 1 Specimen Grouping

S. no.	Specimen name	Specimen Length	Type of CFST	Outer steel tube		Inner steel tube		No. of Specimen
				D	t	D	t	
1.	D 1-9	300 mm	SSS-CFST	D=150mm	t=3.5mm	nil	nil	9
2.	A 1-9	300 mm	DSH-CFST	D=150mm	t=3.5mm	D=75mm	t=2.5mm	9
3.	B 1-9	300 mm	DSH-CFST	D=150mm	t=3.5mm	d=85mm	t=2.5mm	9
4.	C 1-9	300 mm	DSH-CFST	D=150mm	t=3.5mm	D=95mm	t=2.5mm	9

The concrete should have the following properties*:*

(i) Sufficient workability to ensure proper compaction.
(ii) Sufficient cohesiveness to reduce the likelihood of segregation and bleeding.
(iii) Curing for the specified 28-days

After preparing test specimens we will test them in axial compression testing machine. Then we will draw all the curves on the basis of test results to compare strength of all four types of CFST.

EXPERIMENTAL WORK

The experimental work was carried out in two stages. In first stage, properties of various materials were determined and in second stage cylinder were prepares and tested.

Testing of various materials for parametric study:

1. Cement:

Ordinary Portland cement (Birla uttam OPC-43 grade cement) having average compressive strength (7days) 45.32 N/mm^2 used. Compressive strength of cement was determined as per procedure given in Indian Standard (IS) code.

2 Sand:

The coarse sand obtained from Narmada River, which is normally used in Indore region has been used in this study. The following of sand were determined as per procedure given in IS code.

Course aggregate

Course aggregate (crushed ballast) passing through 40mm sieve and retained on 4.75 sieve were used in this study. Following properties of aggregate were determined as per procedure given in IS code.

Summary of material properties

(1) Cement:

Since, Portland pozzulana cement gives low rate of hydration hence, in present study ordinary Portland cement (Birla uttam OPC-43 grade cement) having average compressive strength (7 days)of 45.32 N/mm^2 is used.

(2) Coarse sand:

Sand used in present study is fineness modulus of 2.75 and specific gravity of 3.45.

(3) Coarse aggregate:

Locally available having fineness modulus of 5.6 and specific gravity.

(4) Water:

Water used for the purpose of mixing and curing.

(5) Mix proportion (M20)

Testing of cube:

Six concrete cubes were prepared mix proportion 1:2.21:4.02 and water-cement ratio 0.51. Cubes were cured in water and 28 days compressive strength was determine by digital compressive strength testing machine.

Table no. 2 Test results Compressive strength of Cube

S.no.	Average Compressive strength (N/mm^2)	7 days	28 days
1.	M-20 grade concrete for trial	14.73	22.06
2.	M-20 grade concrete for filling in tubes	14.25	22.3

Testing of steel:

To determine tensile strength of steel tubes a tensile test has been done on basis of the guide lines given by IS-1977 code for steel testing.

Table 2 Results of tensile test

Serial no.	Specimen no.	Tensile strength in N/mm2	% elongation
1.	S-1	548.57	23.06
2.	S-2	457.12	22.3
3.	Average	502.855	22.68

The average tensile strength is found as 502.855 N/mm2

Testing of Specimen

Table 3 Details of specimens

S. no.	Specimen name	Specimen Length	Type of CFST		Outer steel tube		Inner steel tube		Hollow ness ratio
					D	t	D	t	
1.	D 1-9	300 mm	Single-Skin Solid-CFST	D=150mm	t=3.5mm	nil	nil		Nil
2.	A 1-9	300 mm	Double-Skin Hollow-CFST	D=150mm	t=3.5mm	D=75mm	t=2.5mm		0.25
3.	B 1-9	300 mm	Double-Skin Hollow-CFST	D=150mm	t=3.5mm	d=85mm	t=2.5mm		0.32
4.	C 1-9	300 mm	Double-Skin Hollow-CFST	D=150mm	t=3.5mm	D=95mm	t=2.5mm		0.40

Total 36 no. of specimen has been prepared.

Table 4 (for h/t, d/t, and hollow ness ratios)

S. no.	Specimen name	Specimen Length	Type of CFST	Outer steel tube		Inner steel tube		Hollow ness ratio
				h/t	d/t	h/t	d/t	
1.	D 1-9	300 mm	Single-Skin Solid-CFST	87.14	42.86	nil	nil	Nil
2.	A 1-9	300 mm	Double-Skin Hollow-CFST	87.14	42.86	122	30	0.25
3.	B 1-9	300 mm	Double-Skin Hollow-CFST	87.14	42.86	122	34	0.32
4.	C 1-9	300 mm	Double-Skin Hollow-CFST	87.14	42.86	122	38	0.40

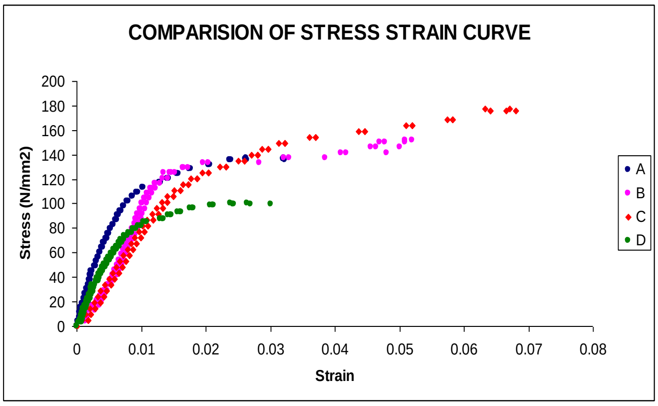
Testing of specimen under axial Compressive loading:

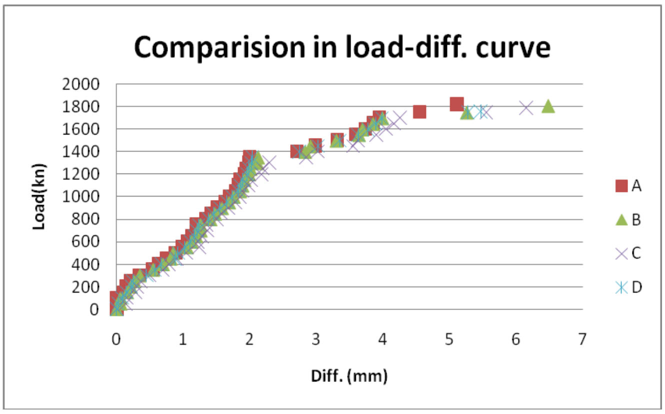
Concrete filled steel tubes under axial loading condition the specimen were casted and tested for axial compression testing machine. Load is applied on both steel and concrete core through thick steel plate. The experimental setup is shown in photograph below, two dial gauge (DL_1 & DL_2) are used to record the axial deformation valve at a particular load and D-Mac gauge is also used to determine axial deformation and to verify the reading of dial gauges.

The test was done by keeping the specimen centrally on the location marks of compression testing machine (2000 KN capacity) and load was applied gradually, uniformly and without jerk. The rate of loading was kept constant and reading was taken for every 50 KN incremental. The load was increased at this rate until the specimen failed

RESULTS AND DISCUSION

Comparison b/w stress strain curve of all four types of CFST (A, B, C, D)
Comparison b/w load-diff. curve of all four types of CFST (A, B, C, D)





Results summary

Table 5 for axial load

S. no.	Specimen name	Specimen details	Hollowness ratio	Load Obtained Experimentally in KN	Load Obtained from K.Kwedaras equation in KN	Percentage deviation
1.	D	Single-Skin Solid-CFST	nil	1770	931	52%
2.	**A**	Double-Skin Hollow-CFST	0.25	1800	959	53%
3.	B	Double-Skin Hollow-CFST	0.32	1810	944	52%
4.	C	Double-Skin Hollow-CFST	0.40	1830	924	50%

Table 6 for Compressive stresses

S. no.	Specimen name	Specimen details	Hollowness ratio	Stress in N/mm2	% increase in stress w.r.t. SSS-CFST
1.	D	Single-Skin Solid-CFST	nil	100	-
2.	**A**	Double-Skin Hollow-CFST	0.25	137	37%
3.	B	Double-Skin Hollow-CFST	0.32	151	51%
4.	C	Double-Skin Hollow-CFST	0.40	177	77%

Table 7 for Ductility

S. no.	Specimen name	Specimen details	Hollowness ratio	Ductility	% increase in Ductility w.r.t. SSS-CFST
1.	D	Single-Skin Solid-CFST	nil	2.42	-
2.	**A**	Double-Skin Hollow-CFST	0.25	3.12	29%
3.	B	Double-Skin Hollow-CFST	0.32	3.56	47%
4.	C	Double-Skin Hollow-CFST	0.40	3.85	59%

CONCLUSIONS:

1. Superposing the concrete and steel strength can predict the ultimate axial strength of DSH-CFST Conservatively. It is illustrated that steel tube can improve the confinement of the concrete, and the In-filled concrete can delay the occurrence of local buckling of the steel tube with a large D/T ratio.

2. The DSCFT columns can have an optimal strength performance if the applied axial load is less than 30%, 38%, 45%, and 36%, the axial capacity for the tube type A, B, C, and D, respectively.

3. It concluded that the inner tube acts as if it stands alone, but can develop its full yielding strength for the presence of the sandwiched concrete; and the outer tube and sandwiched concrete exhibit the same behavior as a fully filled CFST column without the presence of the voids. In other words, the confined state of the concrete is the same as that in the CFST column if the hollow section ratio is not too large.

4. It concluded that on increase hollowness ratio axial compressive stress and ductility is increased in comparison of solid steel tube

5. Performance of CFSTs In linear range in compressive loading can be arranged in decreasing order on the basis of test results as follows A>D>B>C

6. Performance of CFSTs In non linear range in compressive loading can be arranged in decreasing order on the basis of test results as follows C>B>A>D

7. It is concluded that Performance of Double-Skin Hollow-CFST A at hollowness ratio 0.25 is better than all types of CFSTs, on further increasing hollowness ratio Performance of Double-Skin Hollow-CFSTs, B and C is lowers in linear range and increased in non linear range.

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