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EXPERIMENTAL STUDY ON STEEL CONCRETE COMPOSITE SCC COLUMN

N.K. Amudhavalli[*1], R. Uma Mahendra Yadav[2] & A.P. Ravi Chandra[3]

[*1]Professor, Department of Civil Engineering, CMR College of Engineering & Technology, India
[2&3]Assistant Professor, Department of Civil Engineering, CMR College of Engineering & Technology, India

ABSTRACT

The column was made of Hollow Cold Formed Steel as outer skin (stay-in-place form) and Self-Compacting Concrete (SCC) as filler. Compared to concrete-filled composite columns, the Hollow columns can reduce its own weight while having high flexural stiffness. SCC is an innovative concrete that is able to flow under its own weight, completely filling formwork and achieving full compaction, even in the presence of less hollowness ratio. The experimental program was aimed to study the effect of thickness of sheet in the performance of double skinned hollow composite columns using SCC as filler. An attempt was made to study the properties of fresh and hardened concrete. Four trial mixes of SCC were prepared and the mix with the characteristic strength of M30 was ascertained. Later, Nine Hollow composite columns [1.6mm, 2.0mm and 2.5mm] three of each thickness were cast. Testing for each set of specimen are studied and compared with SCC (RCC).

Keywords: *cold formed steel, Hollow composite column, SCC, thickness of sheet.*

I. INTRODUCTION

Cold-formed steel tubular structures are being increasingly used for structural applications. This is due to the aesthetic appearance, high corrosion resistance, ease of maintenance and ease of construction. Hollow columns consisting of two concentric circular thin steel tubes with filler between them have been investigated for different applications. In composite construction, the concrete and steel are combined in such a fashion that the advantages of both the materials are utilized effectively in composite column. The lighter weight and higher strength of steel permit the use of smaller and lighter foundations. The subsequent concrete addition enables the building frame to easily limit the sway and lateral deflections. Hollow column has less self weight and a high flexural stiffness and hence its usage in seismic zone proves promising. It reduces requirements on labor and construction time and maintains the construction quality. There is a need for self compacting concretes since it faster the construction and reduces the site manpower. It has excellent surface quality without blowholes or other surface defects and it is easier for placing with improved durability.SCC reduces the noise level and even in the absence of vibration the concrete flows during casting. Self-compacting concrete (SCC) is an innovative concrete that does not require vibration for placing and compaction. The SCC proves much advantageous to be used in hollow columns due to its self compacting ability. The placing of this concrete is easy and rapid. Fig (1) shows the comparison of mix proportioning between the self compacting concrete and conventional mix.

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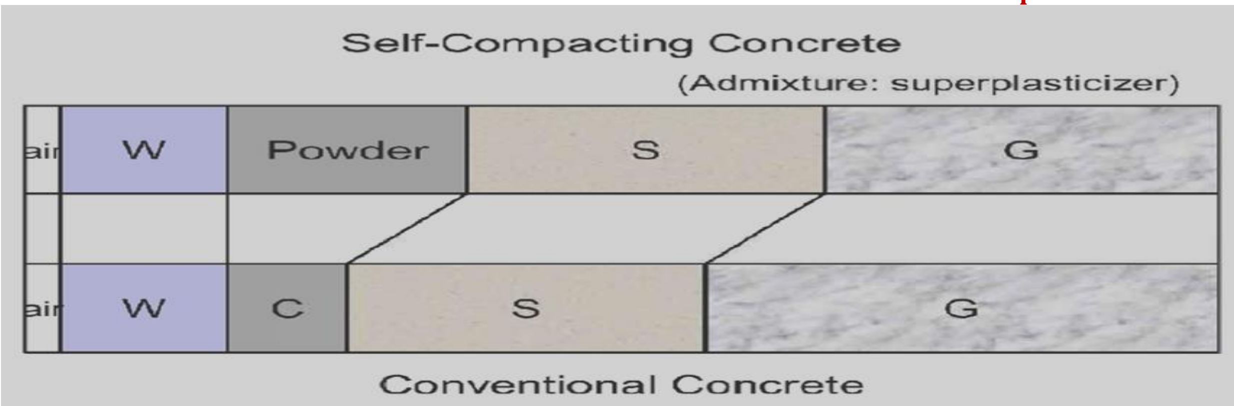

Fig. 1 Comparison of mix proportioning between the self compacting concrete and conventional mix

The hollow composite column increases the strength for a given cross sectional dimension. Since the stiffness increases in hollow composite column it leads to reduce slenderness and increased buckling resistance. Identical cross sections with different load and moment resistances can be produced by varying steel thickness, the concrete strength and reinforcement. This allows the outer dimensions of a column to be held constant over a number of floors in a building, thus simplifying the construction and architectural detailing. Formwork is not required for concrete filled tubular sections. Steel members have the advantages of high tensile strength and ductility, while concrete members may be advantageous in compressive strength and stiffness. Many researchers agree that composite members utilize the advantages of both steel and concrete. They are comprised of a steel hollow section of circular or rectangular shape filled or centrifuged with plain or reinforced concrete. Figure 2. Shows the various types of composite columns (a) Concrete encased steel (CES), (b) CFST, (c) combination of CES and CFST, (d) Hollow CFST sections, (e) Hollow double skin sections.

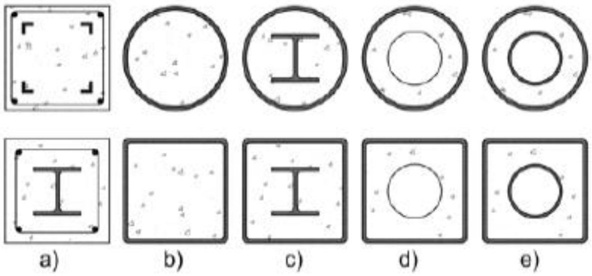

Fig 2 .Various types of composite columns

The main effect of concrete is that it delays the local buckling of the tube wall and the concrete itself, in the restrained state, and is able to sustain higher stresses and strains when unrestrained. These composite columns can be also used for the resisting outside pressure, such as ocean waves, ice; in seismic regions because of excellent earthquake-resistant properties such as high strength, high ductility, and large energy absorption capacity. Concentrically layered hollow CFST elements are more effective than ordinary hollow elements, because of the interaction between surfaces of concrete layers which appears after spinning .This interaction appears independently on the type of loading applied to such hollow CFTS element and on the increased load-bearing capacity of the components.

II. METHODS AND MATERIALS

Through out this investigation, 53-Grade (IS 12269-1987), Ordinary Portland cement is used**.** Locally available hard granite broken stone jelly of maximum size 12.5mm-10mm with specific gravity 2.67 is used in this investigations.

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The aggregates are clean and free from deleterious materials. Clean river sand conformed to zone II of (IS 383-1970) is used with specific gravity 2.64. Portable drinking water is used for mixing of concrete. High Performance Superplasticising Admixture CONPLAST SP430 dosage of 0.7 –2.0 l / 100 kg cement and Viscosity Modifying agent GLENIUM STREAM 2 of dosage 50 to 500 ml/100 kg of cementitious material is used in this investigation. Mixture of water soluble copolymers is absorbed onto the surface of the cement granules, changing the viscosity of the water and influencing the rheological properties of the mix. The strength of the steel used was 250Mpa.

From various trial mixes the mix proportion of M30 are arrived .It satisfies the requirement of both the rheoplastic and the strength aspect and hence is used in the casting of hollow composite column. Columns are cast for varies Diameter to thickness ratio using SCC, R.C.C with SCC. The test methods to assess properties in fresh state are given in table 1. The following test are used to estimate the fresh concrete properties of Self Compacting Concrete namely, Slump flow test, L box test, U box test, V funnel test by adjusting the super plasticizer and VMA content to arrive a mix satisfying rheoplastic characteristic.

Table 1. Lists of Test Methods for Self Compacting

Property	Test methods	Suggested values	Test values
Filling ability	Slump flow	650-800mm	680mmm
	T_{50}cm slump flow	2-7sec	4 sec
	V funnel	8-12sec	9 sec
Passing Ability	L box(H2/H1)	0.8-1.0	*0.*8
	U box(R1-R2)	0-30mm	20 mm
Segregation resistance	V funnel at T5min	+3 sec	+3 sec

The experimental investigations are carried out in 2 phases. In phase I, "Trial mixes" are cast and final mix proportions are arrived. Appropriate w/c ratio for Self Compacting Concrete is determined by slump flow test. The fresh properties and hardened properties are determined for Self Compacting Concrete. The hollow columns of known Diameter to thickness ratio and known hollowness ratio without spacers were cast using SCC as the filler material. Compressive strength test, Split tension strength test and Flexural strength test are used to estimate the hardened concrete properties of Self Compacting Concrete. A steel pipe of diameter 114mm and strength 250Mpa is cut to a height of 500 mm. Similarly a pipe of 40mm diameter and strength 250Mpa is cut to the same height. The two pipes are to be held concentrically. For this purpose a steel plate of 3mm thickness and 16mm width with length equal to the 36mm is cut. This plate is used as spacers, connecting both the pipes. Four spacers are welded at equal interval at both the ends. These are placed on the plain metal sheet for concrete to be cast into them.

Fig (3) Inner and outer tubes of hollow column

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Table 2. Dimensions of the hollow column specimen

Sl.no	Details	Outer Tube	Inner Tube
1.	Height(l)	500	500
2.	Diameter	139.7	40mm
3.	Thickness	1.6mm	1.6mm
		2.0mm	
		2.5mm	
4.	Diameter / thickness Ratio	a)87 b)70 c) 56	
5.	Grade of Concrete	M30	

Columns are cast for each thickness of the outer sheet as shown in fig 4. and the specimen is cured for 28 days. After curing cleaning and painting of specimen are done and tested. The hollow column to be tested is placed in between the top and bottom faces of the UTM. The ends are hinged supported with the help of ball and socket arrangement and the load is applied axially under manual control and the deflection for each load increment is noted in the center, top and bottom plates with the help of deflecto meter. Columns having slenderness of 6 are tested in Universal Testing Machine(UTM) of capacity 100 KN. End condition at both ends of columns are hinged. Base plates are used at both ends for uniform loading in columns. Three dial gauges are fixed at left side of top plate, at mid span and at right side of bottom plate to note the deflections. Loads are applied gradually. In UTM loads applied are control automatically but in case of loading frame its control by manual only. Deflections are noted for varying loads. The tested specimen are shown in fig 5.

Fig. 4 Cast Specimen for different D/t ratio

Fig.5 Tested Specimen

III. RESULTS AND DISCUSSION

Experimental Ultimate load for Hollow and RC column for different D/t ratio are given in Table 4. The thickness of plates used to cast the specimens are 1.6mm, 2.0mm and 2.5mm.Thickness of Inner steel tubes are kept constant and outer thickness are varied for all the specimen .

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Table 4. Experimental Ultimate load for Hollow and RC column for different D/t ratio

Hollow Column of Different D/t Ratio	Average experimental ultimate load(KN)		Difference between HCC and RC column	Increased % of load of HCC compared with RC column
	HCC column	RCC column		
D/t=87	456	310	146	32.01
D/t=70	498	310	188	37.75
D/t=56	540	310	230	42.59

Whenever the thickness of the outer tube increased, the load carrying capacity of the composite columns also increased. Fig.6 shows the experimental ultimate load of hollow composite and RCC columns for different D/t ratio. From the fig it is observed the failure mode of concrete filled hollow steel tubes depends on the thickness of outer sheet. Failure of the specimen occurs due to the local or lateral buckling.

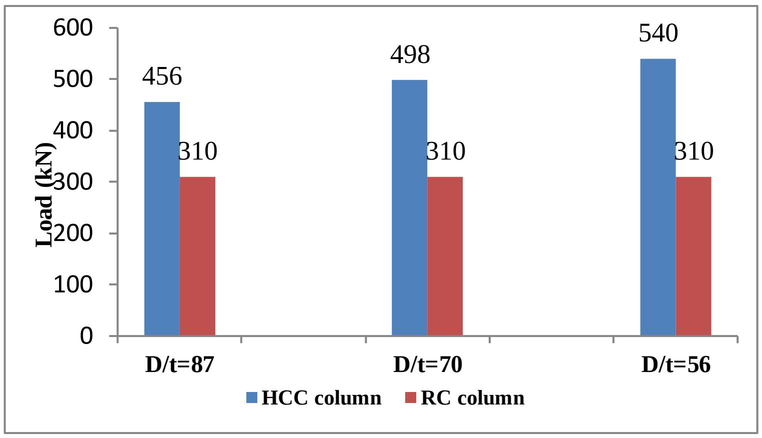

Fig.6 Experimental Ultimate Load of Hollow Composite, and RCC Columns For Different D/t Ratio

IV. CONCLUSIONS

The following conclusions are arrived from the experimental investigations:

1. Addition of the super plasticizer should be made after 60% addition of mixing water to fulfill its purpose.
2. Usage of the super plasticizer increases the early strength of concrete
3. W/P ratio should be less to sustain the strength and rheoplastic properties of the concrete.
4. Usage of graded coarse aggregate helps in achieving the characteristics strength of SCC to a great extent.
5. Generally, when the thickness of sheet was increased, the load carrying capacity of the composite columns was increased.
6. Comparing the results of composite columns with the ordinary reinforced columns, the load carrying capacity is higher. This is due to confinement effect of the steel shell
7. The presence of steel confinement prevents the crushing of the concrete.

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