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Experimental Behavior of Full Encased Composite Column under Axial Compression

Sagar Patil[1], Dr. Suresh Parekar[2]
[1]M.E. Structures, AISSMS COE, Pune University
[2]H.O.D. Associate Professor, Dept. of Civil Engineering, AISSMSCOE, Pune University

Abstract: This paper presents the experimental behaviour of full encased composite columns (FECC) under axial compression. A composite column is a column in which steel section is embedded into concrete with longitudinal reinforcement as well as lateral reinforcement. In this papers results of full encased composite columns were compared with the conventional reinforced concrete columns and are presented in the form of graphs and tables. From the experimental results it was concluded that FECC can replace conventional reinforced concrete column when subjected to high compressive loads. Failure mode of both FECC and conventional reinforced concrete column were almost same.
Keywords: Full encased composite column, conventional reinforced concrete column, Longitudinal reinforcement, Compressive loads and axial compression.

I. INTRODUCTION

A composite column is a compression member which may either be made up of a structural steel sections encased by concrete or concrete filled in hollow circular/rectangular steel tube. The use of steel-concrete composite columns, such as concrete encased steel (CES) and concrete-filled steel tube (CFT) columns, has increased in the construction of high-rise buildings and long span structures. In particular, the use of high strength materials in composite columns is growing to improve structural safety, economy and to reduce the column size.

It has got a few advantages over the conventional reinforced concrete construction: (1) due to its higher strength and stiffness, cross-sectional area reduces; (2) reduces material consumption and project execution time; (3) inherent ductility resulting in suitability for earthquake loading; and (4) provides good fire resistance.

As a result, it is becoming increasingly popular in the construction industry particularly in foreign countries, those having a definite design guideline based on their individual codes of practice and advanced construction techniques/equipments. In the present study the main objective is to study the behavior of full encased composite column and to prove it is a better alternative to reinforced concrete column when subjected to high compressive loading.

II. FABRICATION OF SPECIMENS

In the present experimental study total 18 specimens of height 600 mm were cast with slenderness ration less than 12. Out of 18 specimens, 6 specimens have circular FECC sections with circular and rectangular encasement i.e. 3 with circular encasement and 3 with rectangular encasement, 6 specimens have rectangular FECC sections with circular and rectangular encasement i.e. 3 with circular encasement and 3 with rectangular encasement and remaining 6 columns were cast using conventional reinforced concrete as a control specimen with varying cross section i.e. rectangular and circular.

The steel pipe section was of 1.6 mm thickness. The size of control specimens considered for circular section is on the bases of least lateral dimension required for reinforced concrete column as specified in IS 456:2000.

In case of rectangular section least lateral dimension is finalised as 180 mm for the same cross sectional area of circular section. As per the recommendation given in IS 456:2000, 6-12 mm Φ bars and 4-12 mm Φ bars are provided minimum longitudinal reinforcement for circular and rectangular section respectively and 6 mm ties at 160 mm spacing are used as lateral reinforcement.

For all specimen steel formwork was fabricated as per the specified sizes i.e. 230 mm x 180 mm rectangular and 230 mm circular. Mixing of concrete was done manually and a uniform quality was obtained. After 24 hours of casting all specimens demoulded kept for 28 days curing.

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TABLE 1: NOMENCLATURE OF COMPOSITE AND CONTROL SPECIMENS

Sr. No.	Specimen Designation	Dimension (mm)	A_g (mm^2)
1	CCC	230	41547.56
2	CCCE		
3	CCRE		
4	CRC	230 x 180	41400
5	RCCE		
6	RCRE		


Fig. 1: Photograph of CCR


Fig. 2: Photograph of CRC


Fig. 3: Photograph of RCCE


Fig. 4: Photograph of RCRE


Fig. 5: Photograph of CCCE


Fig. 6: Photograph of CCRE

III. EXPERIMENTAL SETUP AND TESTING

All control and full encased composite column (FECC) specimens (230 mm diameter and 230 mm x 180 mm circular and rectangular cross sections respectively) were tested using load testing machine of 15000 kN vertical loading capacity. All control and FECC specimens were tested using LTM upto failure at uniform rate of loading under axial compression. The deformation was recorded at a constant interval of 72.6 kN up to failure and recorded observations are given in the Table below. The load deformation behavior was presented in the form of graphs of load versus deformation in next section.

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Fig. 7: Experimental Setup

IV. EXPERIMENTAL RESULTS

All the specimens were tested at a uniform rate of loading up to failure and deformation was recorded at regular interval of loads. The mode of failure was observed for all specimens. Test results for all the specimens are presented in **Table 1**. From the test results it was observed that the encasement of steel pipes in concrete proves to be more effective in load carrying capacity. The failure modes of the tested columns with and without the encased steel section were almost the same. Ultimate deformations recorded at ultimate load of FECC were not much more than the control specimens.

TABLE 2: EXPERIMENTAL RESULTS

Sr. No.	Column Designation	Ultimate Load (kN)	Ultimate Deformation (mm)	Remark
1	CCC	931.70	6.01	Concrete spall off at top and then crushing
2	CCCE	1064.80	6.43	Spalling of concrete and bulging at top
3	CCRE	1137.40	6.83	Spalling of concrete and bulging at top
4	CRC	1089.00	6.42	Concrete spalling and then crushing
5	RCCE	1282.60	6.54	Spalling of concrete and then crushing
6	RCRE	1294.70	6.87	Spalling of concrete and then crushing

V. MODES OF FAILURE

The failure modes of the concrete columns with and without the encased steel section were almost the same. Ultimate deformations of both FECC and recorded at ultimate load of FECC were not much more than the control specimens. The failure of control specimens and failure of FECC specimens was due to vertical cracks occurred at the column surface and with increasing of the applied load cracks become wider and the cover started to spall off.

Fig. 9: Failure of Control Specimen and FECC

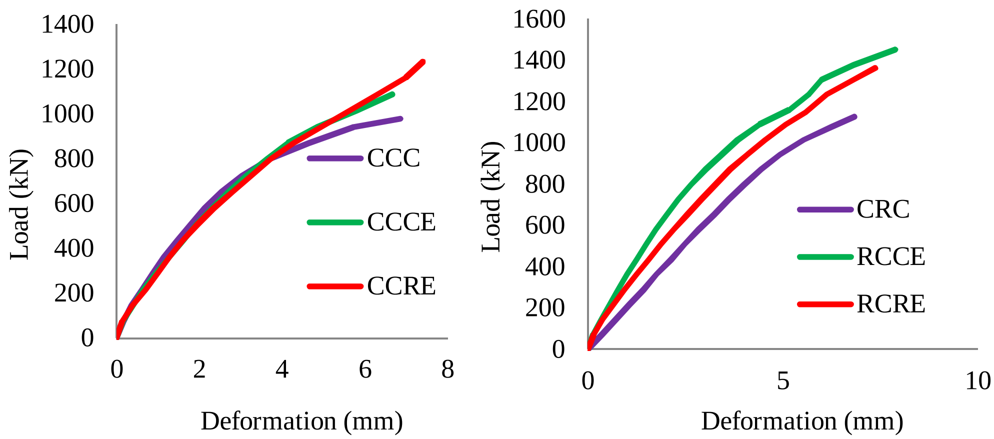

Fig. 10: Load vs deformation graph of control and composite columns

VI. CONCLUSIONS

From the experimental results it was observed that percentage increase in ultimate load carrying capacity of rectangular composite column by 17.78 % than the control rectangular column and rectangular composite column by 18.89 % than the control rectangular column.

From the experimental results it can be concluded that FECC can replace conventional reinforced concrete column when subjected to high compressive loads.

From load vs deformation behavior it can be concluded that the composite column provides more resistance to deformation at higher compressive load than the conventional reinforced concrete column due to encasement.

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