Structural Performance of Partially Precast Steel Reinforced Green Concrete Columns

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***Abstract*— Steel reinforced concrete (SRC) column has been used because of its good structural performance and have high stiffness high load bearing capacity etc. This project includes study of behavior of partially precast steel reinforced concrete (PPSRC) column subjected to axial loading with demolished concrete lumps (DCL) . The objective is to investigate the performance (PPSRC) columns with green concrete (demolished concrete) and by varying the cross-section of core steel and core concrete. Factors like axial load - deflection curves ,failure modes, the strains of the steel section and the concrete were investigated using ANSYS.**

Keywords- partially precast column, green concrete, demolished concrete lumps

I. INTRODUCTION

Steel reinforced concrete (SRC) column has received much attention of structural engineers and researches because of its good structural behavior. The main advantages of this composite column are high load bearing capacity, great stiffness and inherent ductility. The concrete encasement not only improves the stability of the structural steel but also prevents the steel section from chemical corrosion and fire damage. Therefore, SRC column has been widely employed in the high-rise buildings and long-span bridges in recent years. However, it is generally admitted that the construction procedure is complex, particularly in assembling reinforcement and pouring concrete at beamcolumn connections. The PPSRC column is composed of a precast outer part and a cast-in-place part; precast outer-part consists of the steel shape, longitudinal reinforcement, stirrups and high performance concrete, which are prefabricated in the precast shop. After transporting the outer-part to the construction site, the inner concrete is simultaneously cast with the concrete in beam and slab. Here the inner concrete in PPSRC column can be cast by the normal concrete, lightweight aggregate concrete or recycled concrete. For hollow precast steel reinforced concrete (HPSRC) column, the inner part can be kept hollow to reduce the self-weight or filled with the fire resistive material to improve the fire resistance.

This study includes the behavior of partially precast steel reinforced concrete (PPSRC) column subjected to axial loading The main objective is to study the performance (PPSRC) columns with green concrete (demolished concrete) and by varying the cross-section of core steel and core concrete. Parameters like the failure modes, axial load versus deflection curves as well as the strains of the steel section and the concrete were investigated using ANSYS.

II . OBJECTIVES

- Study the performance of PPSRC with green concrete (demolished concrete) under axial loading
- Study the following parametric changes by varying cross sections of steel and
- Study the following parametric changes by varying infill DCL material

III. SUMMARY OF LITERATURE REVIEW

PSRC specimen with core shows a better deformation capacity under axial load. Partially precast members reduces transportation time and weight problems. Compared to traditional concrete, it produces less carbon dioxide, and is considered cheap and more durable. Green concrete has reduced environmental impact with reduction of the concrete industries CO_2 commissions by 30%.Green concrete is having good thermal and fire resistant

IV .FINITE ELEMENT MODELLING

The model is a 350*350 mm column of 1800 mm length. The modeling is done using Ansys software. Three demolished lumps of different compressive strength is used and analysed. The DCL having higher ultimate load is used for further study by varying the core section as octagonal, circular and square.

A. SECTIONAL PROPERTIES

The sectional properties are cross shaped structural steel of total height 200mm and width of steel shape are 200 mm and 100 mm, respectively, and the thickness of the web and flange are 5.5 mm and 8 mm, respectively. Four pattern plates are used .The stirrups of diameter of 8 mm spaced at 50 mm, arranged at the middle height of the column, and stirrups of diameter 8 mm spaced at 25mm were arranged at both ends of the column. Four longitudinal reinforcements, steel bars with diameter of 20 mm were also placed in the specimens. Shear studs of shank diameter 10mm and 30mm height is used

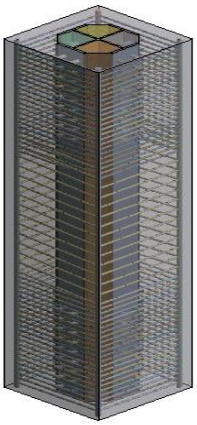

Fig.1. Geometry of PPSRC Column

B. MATERIAL PROPERTIES

As per ACI 318, the material properties of the finite element model are tabulated in table 1.

TABLE 1. Material properties of DCL and outer concrete

	Compressive strength (fc) MPa	Young's modulus (Ec)	Poisson's ratio	Uniaxial tensile strength (MPa)	Dilatan-cy angle
DCL	38.6	28180	0.2	3.86	10
	39.4	26200	0.2	3.9	10
	26	18700	0.2	3.17	10
Outer concrete	45.78	32012.69	0.2	4.2	10

C. STEEL SHAPE PROPERTIES

TABLE .2. . Material properties of steel shape

properties	Young's modulus (MPa)	Yield strength (MPa)	Poisson's ratio
Flange	$2.05* 10^5$	284	0.3
Web	$2.05* 10^5$	284	0.3
Reinforcement	$2.05* 10^5$	410	0.3
Stirrup	$2.05* 10^5$	380	0.3

D. MODELS OF PARTIALLY PRECAST STEEL REINFORCED COLUMNS

To analyze the performance of partially precast steel reinforced concrete column using demolished concrete lumps of different compressive strength. Also to study the performance by varying core section, that is, octagonal, circular, square. The specimens are modeled in ANSYS Workbench 2021 software.

Fig.2 Octagonal core PPSRC

Fig.3.Circular core PPSRC

Fig.4. Square core PPSRC

V. VALIDATION

To validate the finite element model, the model from the base journal [1] was selected and analysed.. For validation, specimen PPSRC-30-0.2: PPSRC denotes partially prefabricated steel reinforced concrete column, 30 denotes the characteristic value of cubic inner concrete compression strength, 0.2 denotes the eccentricity ratio, i.e. e/h = 0.2. The validation results and experimental results are similar. Good agreement between the numerical and test results indicates the validity of the finite element model.

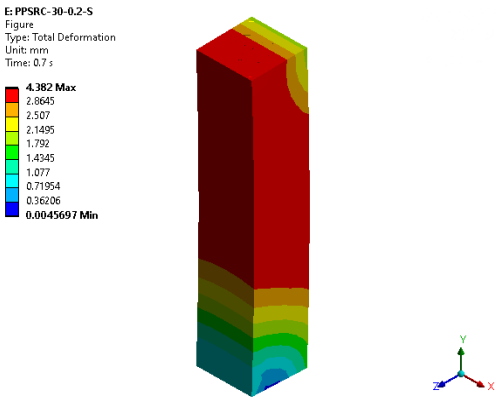

Fig.5. Total deformation

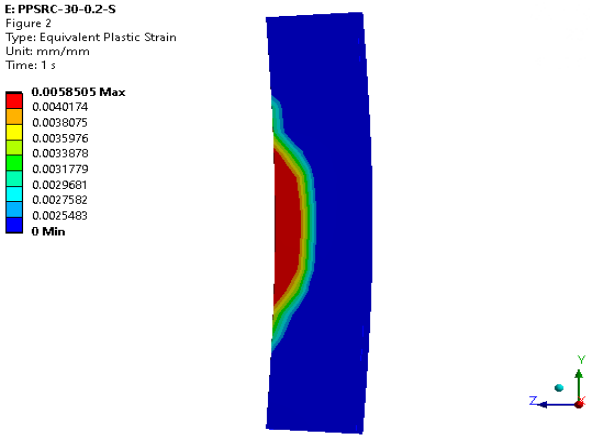

Fig.6. Plastic strain in concrete

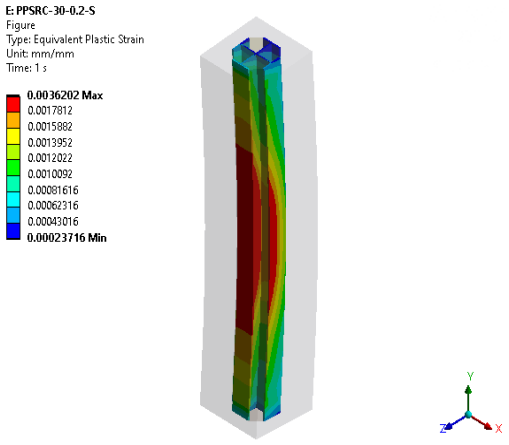

Fig.7. Plastic strain in steel column

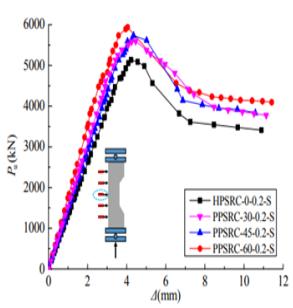

Fig. Load deflection curve in journal

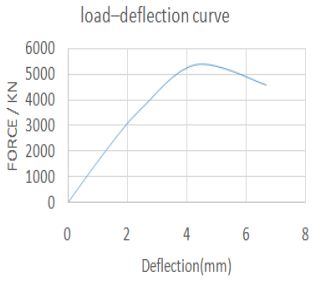

Fig. Load deflection curve obtained in validation

Fig.8. Load- deflection curve

Fig.12. Crushing of concrete (journal)

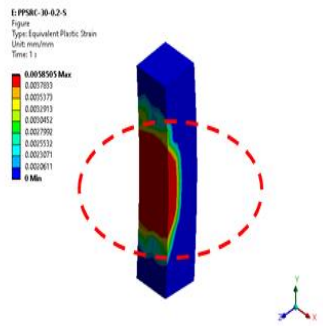

Fig.13.Crushing of concrete (FEA)

Fig.9. Crushing of concrete

Table.4. Load- deflection values of journal and FEA

	Load(kN)	Deflection (mm)
EXP	5150.00	4.00
FEA	5354.00	4.30
%	3.96	7.50

VI. PARAMETRIC STUDY

Here, demolished concrete lumps of three different compressive strength is used in the core of partially precast steel reinforced concrete column and it is analysed using ANSYS software. From the above result, the demolished concrete lump having higher ultimate load,that is 39.4 MPa, is used for the further study by varying the core sections, that is, octagonal, circular, and square. the octagonal core section have thickness of 7.92mm, the circular core section have diameter of 200 mm and thickness of 8.65 mm and the square core have dimension of 200*200mm with thickness of 6.73 mm. All the column is have boundary conditions of top and bottom hinged. Meshing is carried out automatically by ANSYS. The axial loading is applied in displacementcontrolled method.

Fig.10.PPSRC with octagonal core section

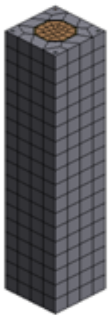

Fig.11. Meshing of PPSRC in ANSYS

Fig.12. Boundary conditions of column

VII. RESULTS AND DISCUSSION

The partially precast steel reinforced column having demolished concrete lumps of different compressive strength and also the study using core sections like octagonal circular, square having demolished concrete lumps in the core are analysed using ANSYS software. All columns are analysed under axial loading.

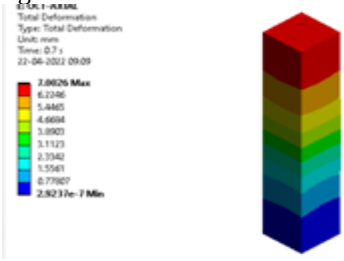

Fig.13. Total deformation of PPSRC column with octagonal core section

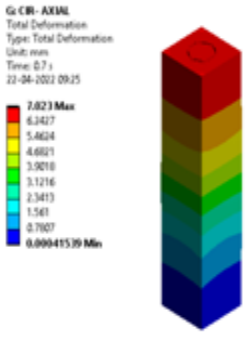

Fig.14. Total deformation of PPSRC column with circular core section

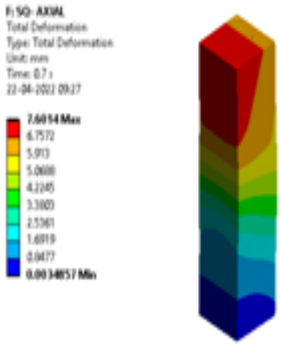

Fig.15. Total deformation of PPSRC column with square core section

The obtained values and load and deflection of partially precast steel reinforced concrete column of core section octagonal, circular, square are copied in excel sheet and the ultimate load and ultimate deflection are noted down . The load deflection curve of three columns are plotted

Table.5.Ultimate Load and Ultimate deflection value

MODELS	Ultimate Load (kN)	Ultimate deflection (mm)
Octagonal core section	9419.8	6.0011
Circular core section	9370.6	6.0039
Square core section	8912	5.0583

From the table it is seen that h partially precast steel reinforced concrete column having octagonal core section have the higher ultimate load of 9419.8 kN, column having circular core section has value of ultimate load of 9370.6 Kn, and the column having square core section have least value of ultimate load of 8912 kN .

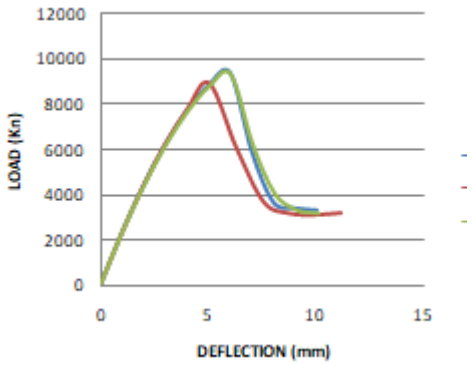

Fig.16. Load deflection curve

VIII .CONCLUSION

Structural performance of partially precast steel reinforced concrete column using demolished concrete lumps is investigated. Three models of demolished concrete lumps of different compressive strength are designed and compared. Based on the result, the model having the higher value of ultimate load and ultimate deflection is selected .Three models having steel sections like octagonal, square and circular were created and analysed . The values of ultimate load and ultimate deflection and obtained from and load and deflection values.

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