# BEHAVIOUR OF PREFABRICATED STEEL REINFORCED CONCRETE COLUMN WITH CORE UNDER MONOTONIC AXIAL LOAD

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**Abstract -** *In this paper Prefabricated Steel Reinforced Concrete (PSRC) system is introduced. PSRC columns, in which, the steel angles are placed at corners of cross section and are connected by transverse reinforcement which provide shear resistance, concrete confinement and bond resistance between concrete and steel angles. The parametric study includes the comparison between the PSRC column with and without core. Specimen with core consists of various shapes. Compression test were performed analytically over 30 specimens to evaluate the axial compression capacity and force deformation behaviour. The analytical results show that the structural performance of PSRC columns with core have better performance than that of specimen without core.*

***Key Words***: Composite columns, Compression test, Concentric axial load, Eccentric axial load, High strength concrete, High strength steel, Prefabricated steel angle, Reinforced concrete, Steel equal angle section, Precast concrete core

## 1. INTRODUCTION

Columns are essential structural members that are vulnerable to the brittle failure, that they carry high axial compressive load and difficult to satisfy their plasticity demand compared to beams. High-strength materials improve structural safety and space efficiency. Thus, the utilization of high strength composite columns is growing within the development of building and long-span structures. Reinforced concrete (RC) has been used within the development of assorted structures for many years. For the development of structures like buildings, parking garages, high-rise structures and bridges, concrete is employed as common material. Concrete is robust in compression but weak in tension, therefore, might finish in cracking and failure under large tensile stresses. Steel has the high tensile capability and should use in areas with high tensile stresses to form up for the low rigidity of cement. Concrete, as a usually modest material with capability to oppose high-compression and steel, as a material with high rigidity, work on providing a mechanism to resist the applied loading has created strengthened cement concrete a typical compound for construction works. samples of such combinations in structural constructions are conventional rebar concrete, steel-concrete composite system and welded wire fabric system. Steel-concrete composite columns like Concrete-Enclosed Steel (CES) and Concrete-Filled Steel Tube (CFST) columns, prefabricated Cage System (PCS) have massive supporting capability because of composite action.

## 2. FINITE ELEMENT ANALYSIS

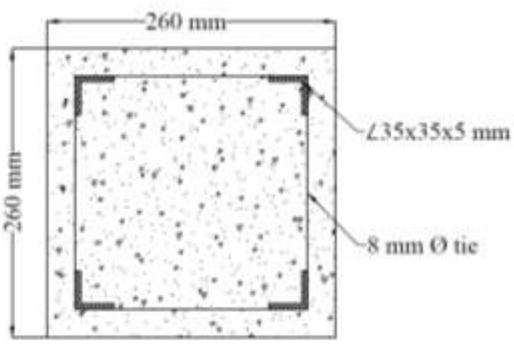
### 2.1 General

Finite Element Analysis has been used in many previous researches to predict the behaviour of Composite column when under load, using commercial finite element software like ANSYS and ABAQUS. In this study, a finite element model is developed to stimulate the behaviour of PSRC short column using ANSYS 16.1 software. The type of analysis used is a non-linear analysis. A number of 30 models were created to simulate the axial capacity and failure modes of these models and to compare them with the conventional reinforcement column. The details of the specimen are described in Table 1.

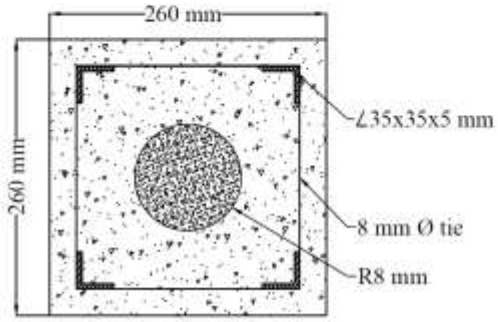
**Table -1:** Details of Specimen

| Classification | Properties | PSRC |
|---|---|---|
| Section | B × D (mm)<br>$A_g$ = BD (mm$^2$) | 260 × 260<br>67,600 |
| Concrete | $f'_c$ (MPa) | 40 |
| Steel | $f_{ys}$ (MPa)<br>Steel shape | 650<br>4L-35x35x5<br>4L-50x30x4 |
| Column length | Net length, L (mm) | 900 |
| Transverse reinforcement | Type<br>$f_{yt}$ (MPa)<br>Spacing (mm) | 8mm Ø ties<br>415<br>100 |

In this study a precast concrete core of high strength with different shapes are enclosed in the PSRC specimen. The area of the core is taken as same in all the specimens analyzed. The shapes modelled are circular, square, criss-cross and scattered square. They are loaded under the eccentricities of 0%, 25%, 50%, 75% and 92%. The cross-sectional details of the specimens analyzed here are shown in Fig. 1. The cores are made with high strength precast concrete of grade M65.




(a)

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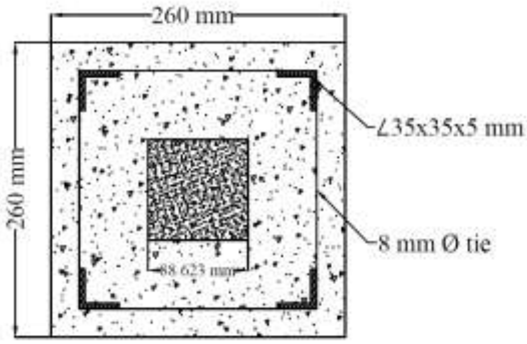


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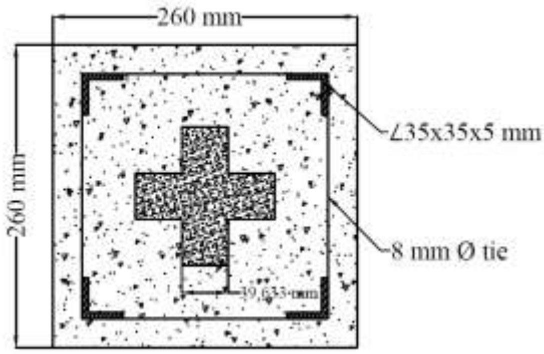


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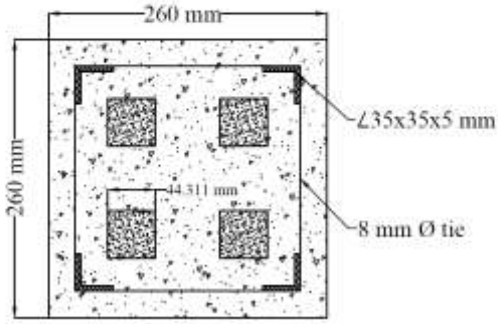



(e)

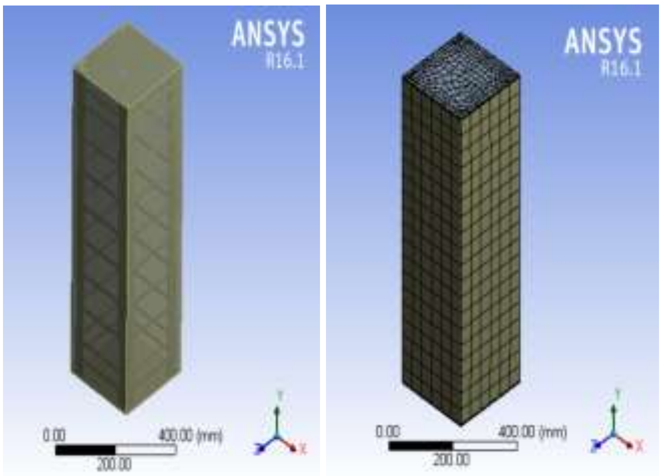
**Fig -1:** Cross – Sectional Details of PSRC Columns: (a) PSRC without core; (b) Circular; (c) Square; (d) Criss – Cross; (e) Scattered Square

### 2.2 Modelling and Meshing

The samples are modelled using the commercial software ANSYS 16.1. After preparing all the input data of material and geometrical properties, the column models were divided into small cubical elements. The fundamental concept of finite element method is dividing the geometry of a structure into finite number of elements, connected at finite number of points called nodes. A nonlinear finite element analysis was done to study the behaviour of composite column. Column specimens were meshed with similar pattern as column in validation shown in Fig. 2.

### 2.3 Boundary Condition and Loading

Following the testing procedures conducted by Kim et al. [5], the top surfaces of the PSRC columns were free and bottom surface were restrained against translation only. A loading plate was installed at the top surface and a base plate at the bottom surface, to simulate the experimental test. The axial load is applied in the form of a point load at eccentricities.




(a) (b)

**Fig -2**: (a)Model of PSRC Specimen; (b) Meshing of PSRC Specimen

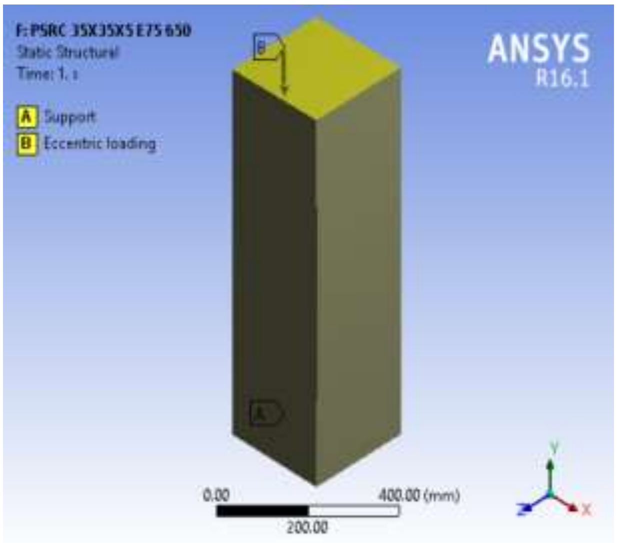



**Fig -4**: PSRC Column with Loading

The properties of materials for analysis are listed in Table 4.2.

Table 4.2 Material Properties

| Properties | Concrete | Longitudinal Reinforcement | Transverse Reinforcement |
|---|---|---|---|
| Density | 2300 kg/m$^3$ | 7850 kg/m$^3$ | 7850 kg/m$^3$ |
| Modulus of elasticity | 31623 MPa | 2x10$^5$ MPa | 2x10$^5$ MPa |
| Poisson's ratio | 0.15 | 0.30 | 0.30 |
| Compressive Strength | 4.427 MPa | - | - |
| Yield Strength | - | 345 MPa<br>650 MPa | 415 MPa |

## 2.3 Results and Discussion

By doing analysis of these the help of ANSYS 16.1 software following results was determined. The load – deformation details of the specimens are shown in table 3.

**Table -3:** Results from Analysis

| Specimen | Eccentricity (%) | Load (kN) | Deformation (mm) |
|---|---|---|---|
| PSRC 650 without core | E-0 | 3484.3 | 6.389 |
| | E-25 | 2834.6 | 15.486 |
| | E-50 | 2270.9 | 18.717 |
| | E-75 | 1880.5 | 15.671 |
| | E-92 | 1613.8 | 12.580 |
| PSRC 650 Circle | E-0 | 3955.7 | 4.897 |
| | E-25 | 2900 | 8.558 |
| | E-50 | 2337.4 | 18.003 |
| | E-75 | 1935 | 18.491 |
| | E-92 | 2027.1 | 17.718 |
| PSRC 650 Square | E-0 | 3795.9 | 8.062 |
| | E-25 | 2869.9 | 11.147 |
| | E-50 | 2289.7 | 14.423 |
| | E-75 | 1878.5 | 15.212 |
| | E-92 | 1722 | 17.504 |
| PSRC 650 Criss - Cross | E-0 | 3932.2 | 8.589 |
| | E-25 | 2894.6 | 14.867 |
| | E-50 | 2291.8 | 15.406 |
| | E-75 | 1967.4 | 15.918 |
| | E-92 | 1642 | 14.711 |
| PSRC 650 scattered | E-0 | 4065.2 | 10.08 |
| | E-25 | 3017.1 | 7.614 |
| | E-50 | 2419 | 16.674 |
| | E-75 | 2037 | 15.268 |
| | E-92 | 1690.9 | 12.809 |

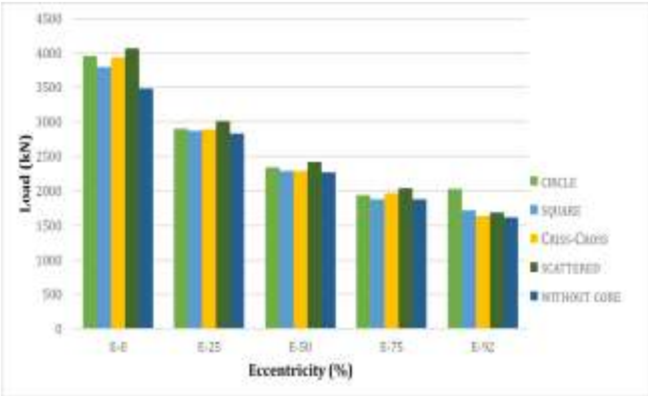



**Chart -1:** Load – Eccentricity values of PSRC 650 with and without core

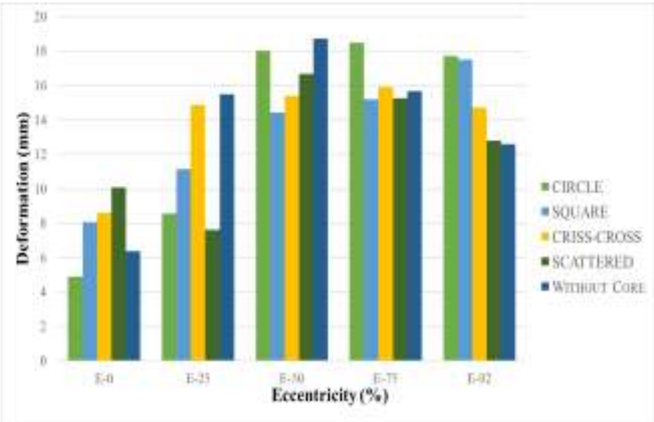



**Chart -2:** Deformation – Eccentricity values of PSRC 650 with and without core

From the above results we can analyze that, at eccentricities the PSRC specimen without core shows better deformation capacity.

## 3. CONCLUSIONS

- PSRC specimen with core shows a better deformation capacity under axial load PSRC specimen without core shows higher load carrying capacity at eccentricities.

- The specimens with core shoes high load carrying capacity than that of specimen without core

- Scattered core specimen shows 5.1% more load carrying capacity. This is due to the uniform distribution of area of moment of inertia.

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