

Pushover Analysis of RC Frame for effective column design

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Abstract - Earthquake, a natural fury cannot be ignored as far as the stability of a structure is concerned. All structures should be made seismic resistant to prevent loss of life and infrastructural damage. The Pushover Analysis is conducted to find out the seismic response of the structure Here seismic performance of two RC frame structures of G+4 storey consisting of circular shaped column as against equivalent square shaped column is carried out using pushover analysis. The building has an overall plan dimension of 25m x 20m. All the beams are considered as 300 mm x 450 mm in size and columns are of 3.2m height in each floor. The square columns used are of size 300 x 300 mm and the circular columns are of 340 mm diameter. The area of the two columns is kept constant The M25 grade of concrete and Fe 415 grade of steel is considered for design. Pushover analysis is carried out using commercially available software ETABS and behavior of RC frames is studied. The performance levels of the two frames are compared. It is found that the performance levels of RC Frame with circular columns is found to be a bit better than RC frames with square columns.

Key Words: pushover, equivalent, performance levels, seismic, stability

1. INTRODUCTION

Frequent earthquakes have caused immense damage to structures which indicate the need for seismic analysis of structures. Earthquakes cannot be avoided but the extent of damage and loss can be reduced by evaluating the seismic resistance of a structure and adopting safe strengthening measures. Pushover analysis is one such method by which the seismic capacity of a structure is evaluated. The performance levels of the two frames are compared and the effective column is decided. The pushover analysis is conducted using ETABS.

1.1 Pushover Analysis

A non linear static analysis in which the lateral loads are increased until a collapse mechanism develops. A performance based approach method in which the relation between lateral loads and deformation is obtained and measures the successive damage states of a building.

2. METHODOLOGY

2.1 MODELLING

The fundamentals of modeling using ETABS is the generalization that multi storied building are composed of identical floors that repeat in the vertical direction. This makes the modeling and analysis really fast and easy. In this study I have used two bare RC frames for analysis, one with square columns and another with circular columns. The plan and elevation of the models generated using ETABS are shown in Fig 1 and Fig 2 respectively below.

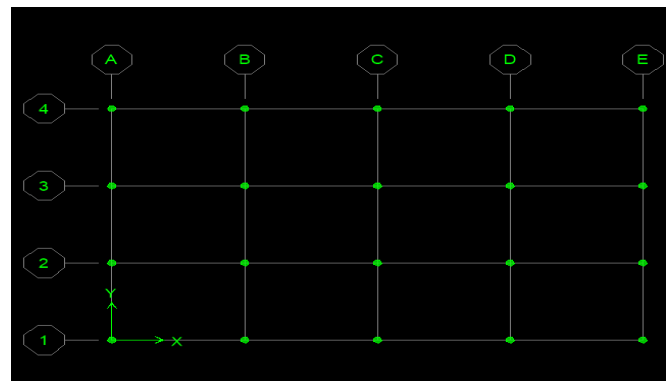


Fig 1: RC Frame Plan (Circular Columns)

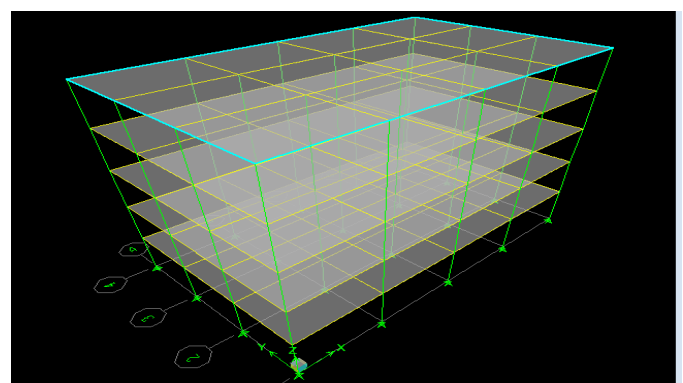


Fig 2: RC Frame (3D View) (Circular Columns)

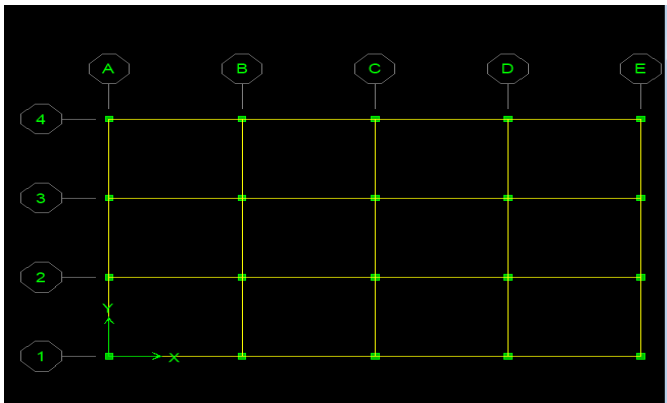


Fig 3: RC Frame Plan (Square Columns)

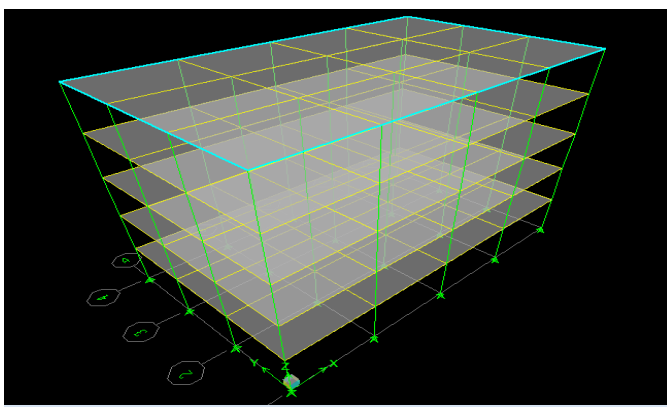


Fig 4: RC Frame (3D View) (Square Columns)

The problem is studied for a building with 15.0 m x 25 m grid having circular columns and another model with square columns. The height of the column in global Z direction is considered as 3.2 m for each floor. The sizes of the columns are selected to satisfy code provisions in both shapes and sizes. The slab is modeled as a shell for the analysis. The columns are considered to be fixed at the foundation level. The M25 grade of concrete and Fe415 grade steel reinforcement is considered.

Table -1: Model Specification

Specifications of RC Frame		
Plan size	12 m x 20 m	
No of floors	G+4	
Storey Height	3.2 m	
Beam Dimension	300 mm x 450 mm	
Columns	Circular	450 mm diameter
	Square	300 mm x 300 mm

Slab	120 mm
Concrete Grade	M 20
Steel	Fe 415
Reinforcement (%)	3

2.2 ANALYSIS

The push over curves and the capacity curves for the two RC frames are generated using pushover analysis. The Pushover curve is the curve which is plotted between the Base force and Roof displacement. This curve shows the overall response of the structure in case of incremental seismic loading. This loading is increased monotonically, in small increments, till there is a failure in the structure at any level. As the loading is increased, a curve between the base force and roof displacement is plotted. This curve is known as the pushover curve.

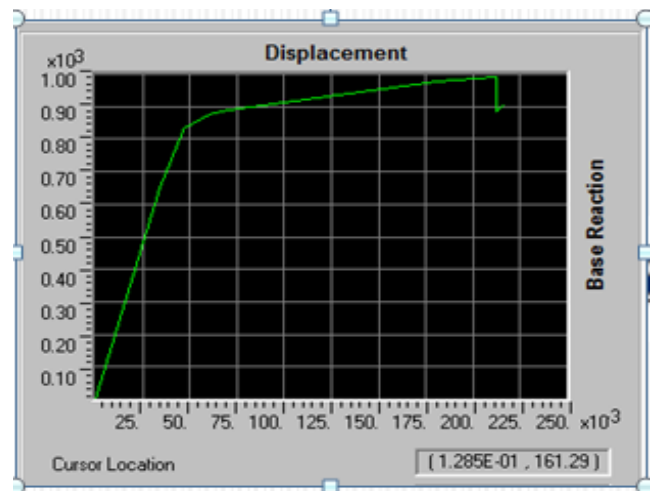


Fig 5: Pushover Curve-Square Column

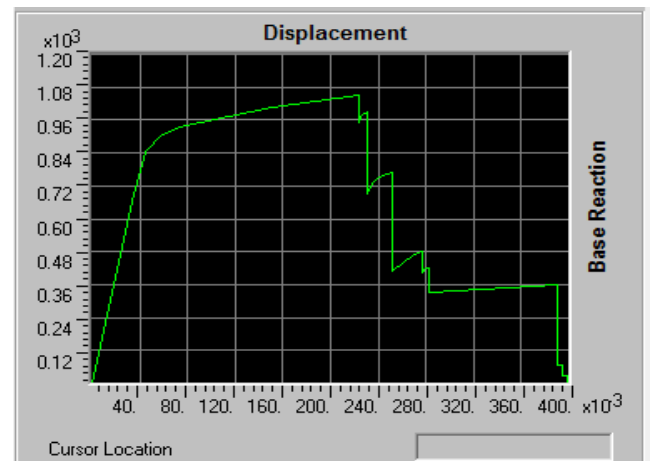


Fig 6: Pushover Curve-Circular Column

The capacity spectrum curve obtained is shown in Fig 7 and Fig 8. The performance point for a given set of values is defined by the intersection of the capacity curve and the single demand spectrum curve

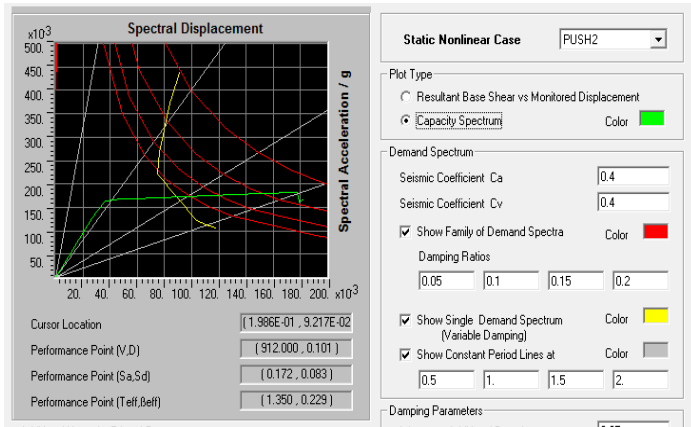


Fig 7: Capacity Curve (RC Frame-Square Columns)

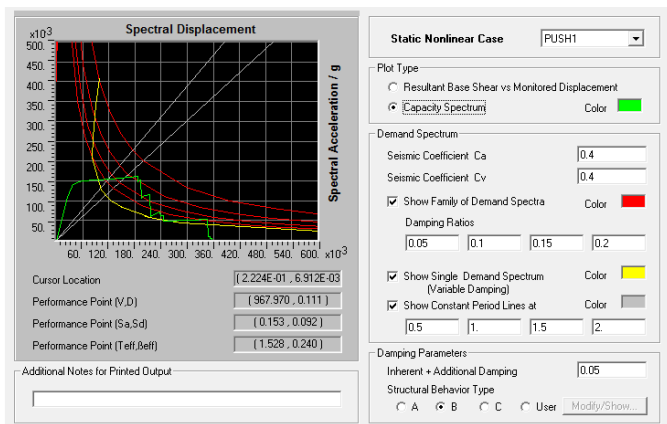


Fig 8: Capacity Curve (RC Frame-Circular Columns)

The pushover displaced shape and sequence of hinge information on a step-by-step basis was obtained and is shown in the figures below

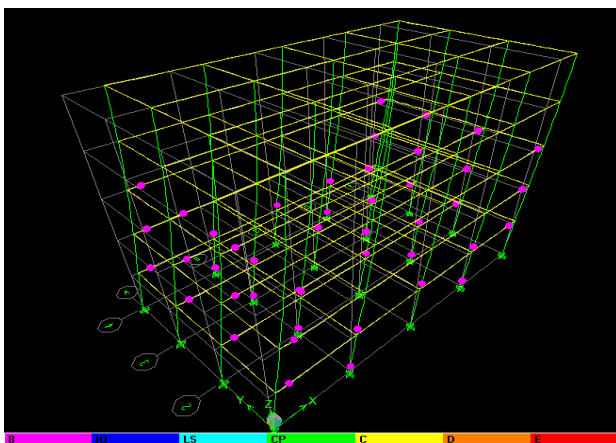


Fig 9: Step 2(RC Frame with Square Columns)

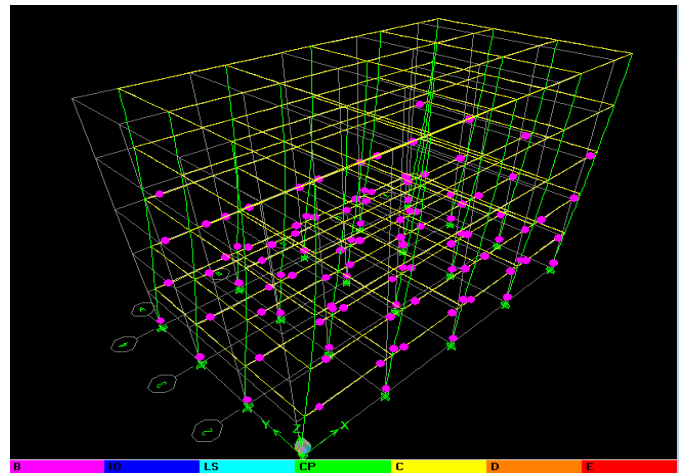


Fig10: Step 4 (RC Frame with Square Columns)

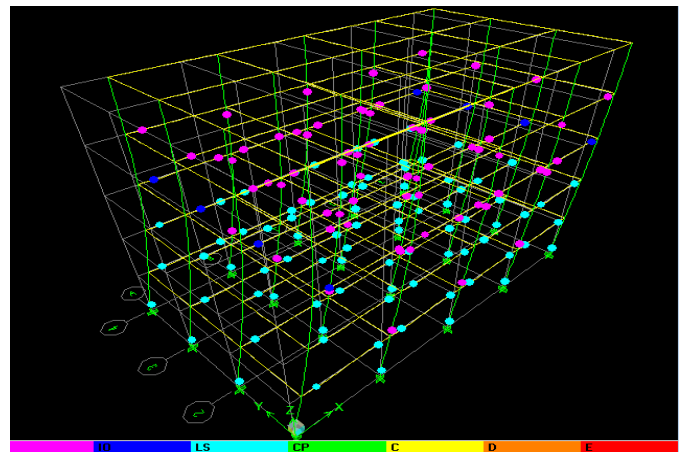


Fig11: Step 6 (RC Frame with Square Columns)

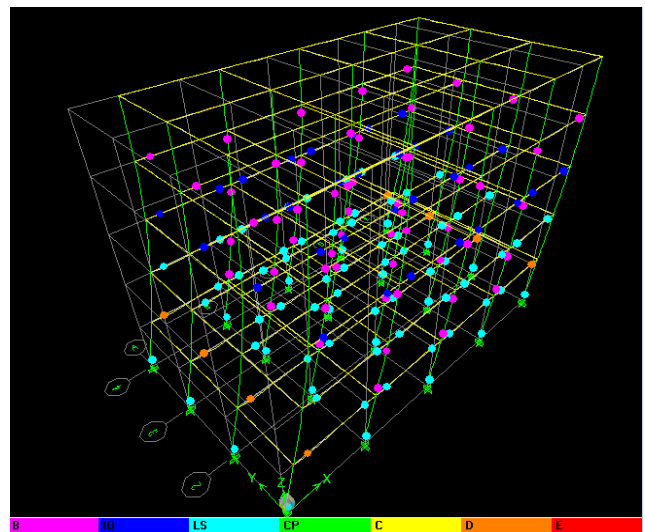


Fig12: Step8 (RC Frame with Square Columns)

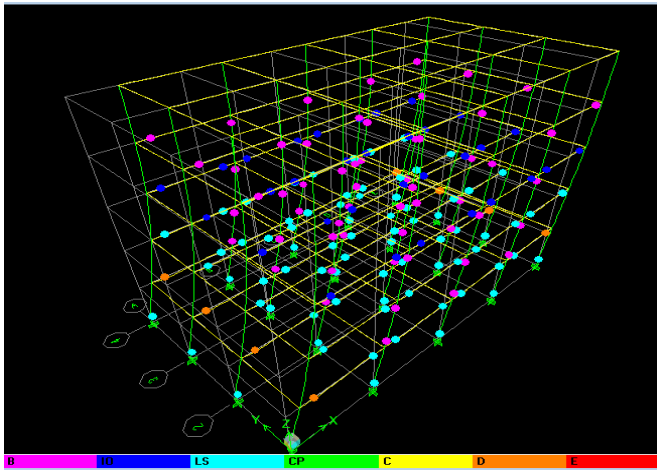


Fig13: Step 10 (RC Frame with Square Columns)

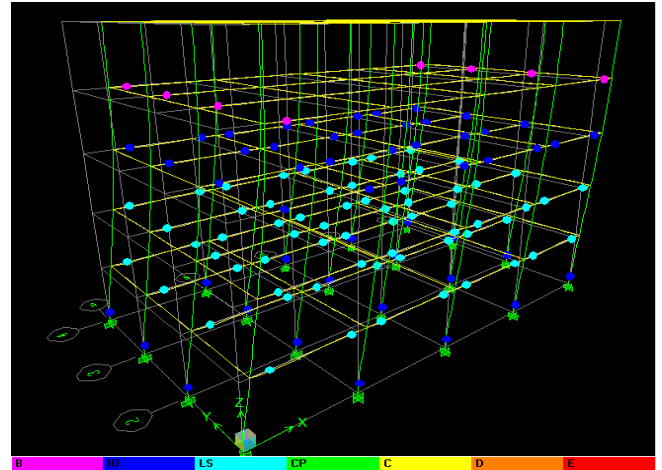


Fig16: Step 6 (RC Frame with Circular Columns)

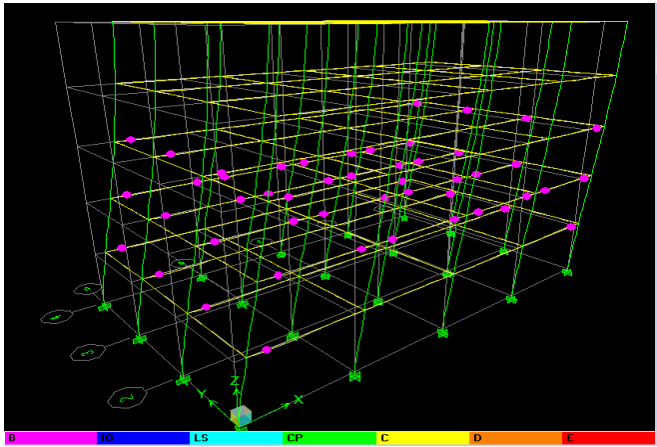


Fig14: Step 2 (RC Frame with Circular Columns)

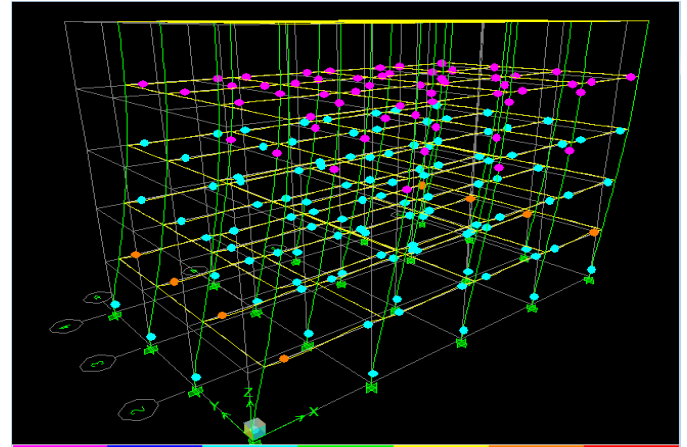


Fig17: Step 8 (RC Frame with Circular Columns)

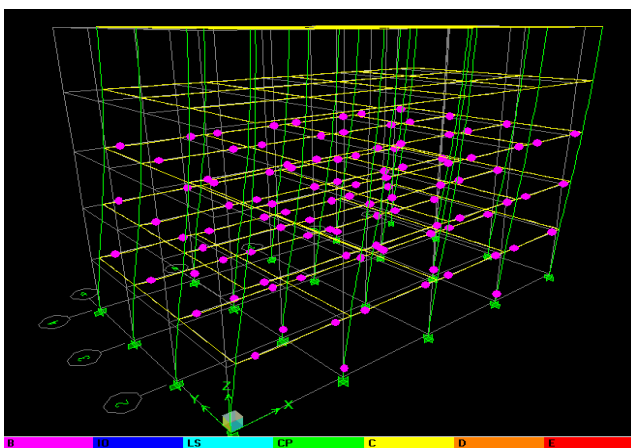


Fig15: Step 4 (RC Frame with Circular Columns)

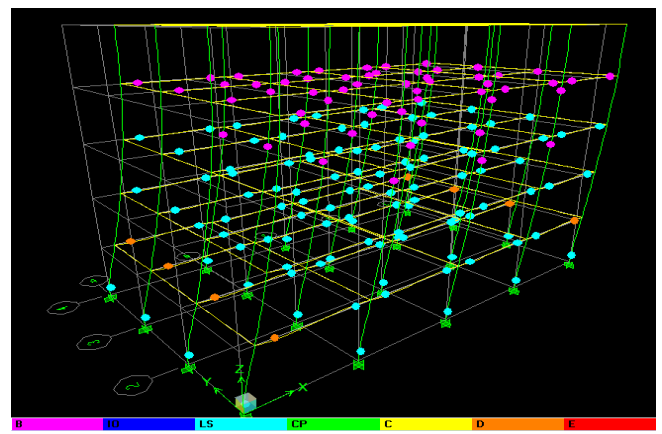


Fig18: Step 10 (RC Frame with Circular Columns)

Storey Displacement curves

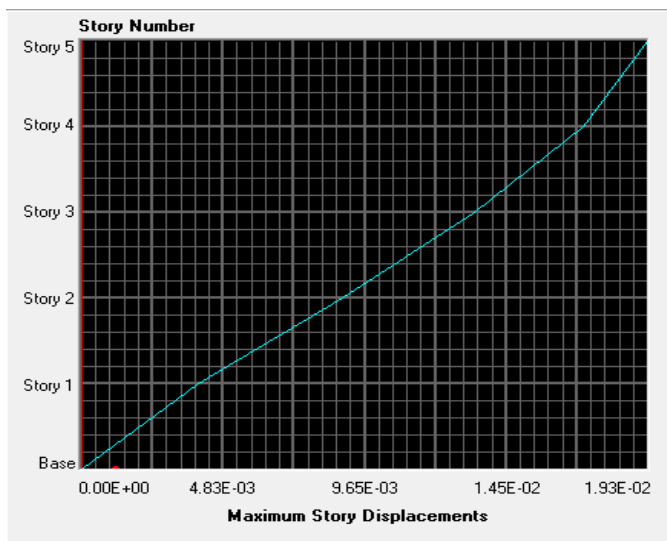


Fig19: Storey Displacement (RC Frame-Square Columns)

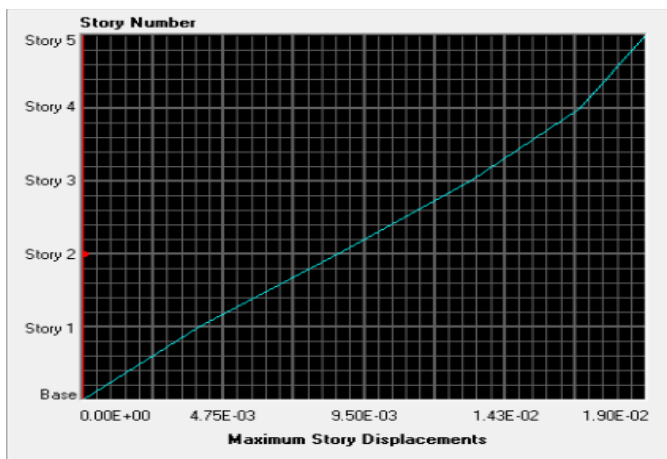


Fig 20: Storey Displacement (RC Frame-Circular Columns)

3. RESULTS AND DISCUSSIONS

The pushover curves prove that the roof displacement is maximum for square column when compared to circular columns. For the same loading the displacement is found to be more in square for all the similar loading patterns.

The performance points of the capacity curves show that circular columns perform better than square columns with regards to the values given.

The storey displacement curves indicate that the story displacements are a just a bit more for square columns. Not much significant variation was found.

Both the frames are found to lie in the D zone of seismic analysis, which show that no significant conclusions can be made from the plastic moment points.

4. CONCLUSIONS

1. The effect of the column shape on the stability of the structure is studied. The efficiency of circular and square columns can be compared since the cross sectional area of the two columns is kept constant. The % reinforcement is also to be maintained in both columns.
2. The effect of confinement on the stability can also be checked. The spiral ties give a better performance.
3. Storey drift are found to be more in the square columns than the frames having circular columns.
4. The behavior of circular column is a little better than square column when the comparison is in terms of storey drift, base shear and roof displacement.
5. The performance of circular column RC frame is also found to be better than the square column RC frame.

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