

# Study on Behaviour of Asymmetric Building with Different Column Sections under Seismic Loading

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## Abstract

**Objective:** Objective of this study is to find variation of parameters displacement, story drift, fundamental time period, base shear and column force with respect to geometry of building and of column. **Methods/Statistical Analysis:** Response spectrum analysis was done for all the models using ETABS software and all the above parameters are extracted from all the models including one reference model with rectangular geometry. All the models generated are compared with that of the base or reference models and the results are stated. **Findings:** It was found that the story drift was maximum at the bottom of the structure when compared to the above stories so as the displacement. Circular columns are found to have increased base shear when compared with remaining models. **Improvements:** Masonry in-fills induces stiffness which reduces the stiffness of the structure which decreases the displacement of building so inclusion of masonry in-fills can improve the stability of the building

**Keywords:** Asymmetrical Buildings, Column Orientation, Re-Entrant Corner Irregularity, Response Spectrum Analysis

## 1. Introduction

The effect of shape of column and orientation of column will have a major influence on structure when a structure is subjected to a lateral load such as earthquake load.

In<sup>1</sup> gave an approximate method to estimate the maximum lateral drift demands in multi-story buildings with non-uniform lateral stiffness responding mainly to fundamental mode when subjected to earthquake ground motions.

In<sup>2,3</sup> explained about the seismic behaviour of multi-story RC buildings with different slab systems and compared their results.

In<sup>4-6</sup> explained the effect of seismic loadings to irregular structures. In<sup>7,8</sup> explained the effect of seismic loading in infilled and bare framed multi storied structures by taking displacement, story drift into account. In<sup>9</sup> had done push over analysis of shear walled 19 story structure. In<sup>10</sup> explained the effect of brick masonry infills and openings using ANSYS

## 2. Methodology

In this paper three types of column geometries and two orientations are considered and their effect on the parameters listed above will be studied for a 21(G+20) story building using ETABS 2015 software for different shapes of the buildings. The shapes of the building are taken from IS 1890-2002 (re-entrant corner irregularity) all the shapes are considered and parameters are compared with regular building which is rectangular shaped. Span of each bay is 4mts in both the directions Figures 1-5 are the shapes of the buildings considered for the analysis.

## 3. Building Geometry

The material properties of the building, dimensions of beams and columns, soil type which are used for the analysis are shown in Table 1.

Dead load was taken from IS 875 part I, live load is taken from IS 875 part II and Response spectrum analysis was done for all the models as per<sup>11</sup> and are

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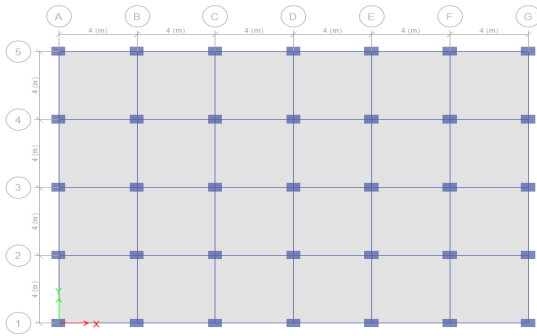


Figure 1. Base model.

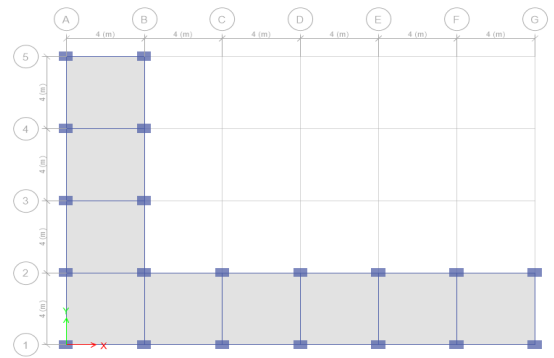


Figure 5. Type 4 model.

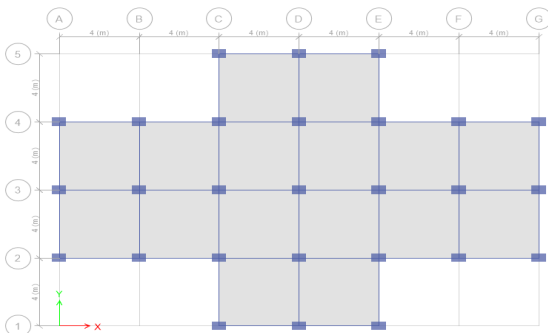


Figure 2. Type 1 model.

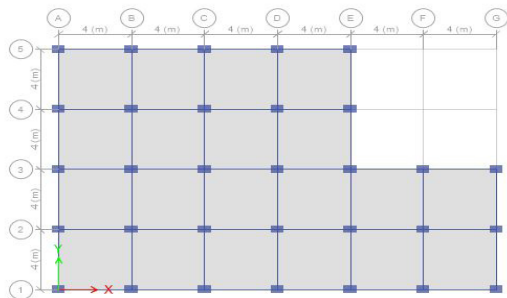


Figure 3. Type 2 model.

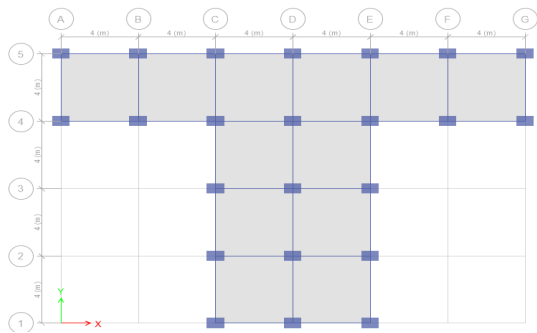


Figure 4. Type 3 model.

Table 1. material, beam, column and soil properties

S.No	Item	Description
1	Type of structure	Multi story rigid jointed RC moment resisting frame
2	Seismic Zone	Zone 4
3	Number of stories	21(G+20)
4	Floor height	3.5m
5	Infill walls	230mm
6	Imposed loads	3/m <sup>2</sup> for floors and 1.5/m <sup>2</sup> for roof
7	Materials	Concrete (M30) Reinforcement(Fe415)
8	Size of columns	500mm × 720mm (Rectangular) 600mm × 600mm (square) 680mm diameter (Circular)
9	Size of beams	230mm × 500mm
10	Slab thickness	150mm
11	Type of soil	Type 1

compared with reference models which is a rectangular model, comparisons are made and conclusions are made depending upon the results obtained.

All the models are generated and using ETABS 2015 and loadings of DL and live loads are given to those

models as per IS 875 part I and part II for dead and live loads respectively. Response spectrum is used as per IS 1892. Load combinations considered are as shown in Table 2 which is shown in below.

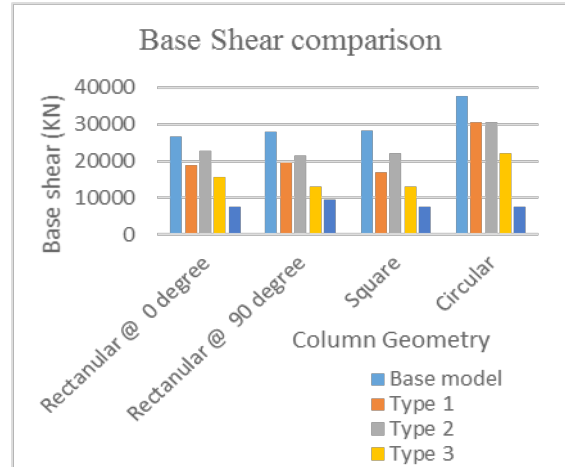
The models are generated with three types of columns and 2 orientations for rectangular column as longer side of the rectangle along X and longer side of the rectangle along Y and shapes as rectangle, square. All the models are generated as bare frames and the results are compared and are tabulated with percentage increase the parameters are calculated and conclusions are drawn.

### 4. Results and Discussion

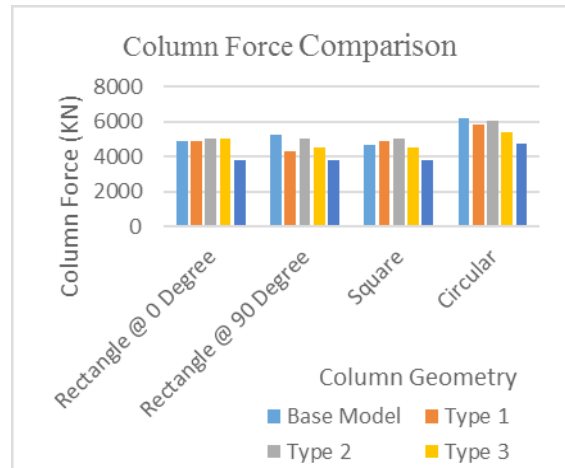
1. From Figure 7 we can say that base shear of the model increases with increase in the gravity loading (Dead load + Live load) of the structure.
2. Displacement (from Figure 6), story drift (from Figure 10, Figure 11, Figure 12 and Figure 13) and fundamental time period (from Figure 9) are maximum for type 4 structure whereas the column force (from Figure 8) is less when compared to any other structure.
3. Displacement (from Figure 6) of type 4 model is high in all cases with all column geometries which

**Table 2.** Load combinations

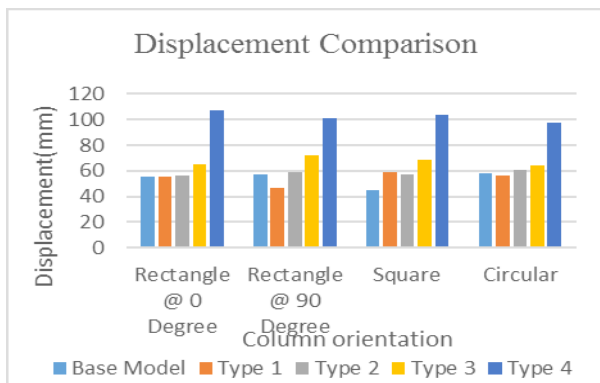
Type of analysis	Load combination
Static analysis	1.5(DL+LL)
Response spectrum	1.2(DL+LL ± EQX) 1.2(DL+ LL ± EQY) 1.5(DL±EQX) 1.5(DL±EQY) 0.9DL ± EQX 0.9DL ± EQY



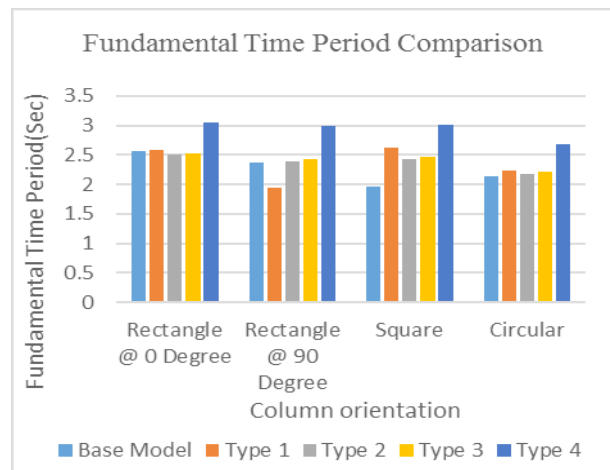
**Figure 7.** Base shear comparison.



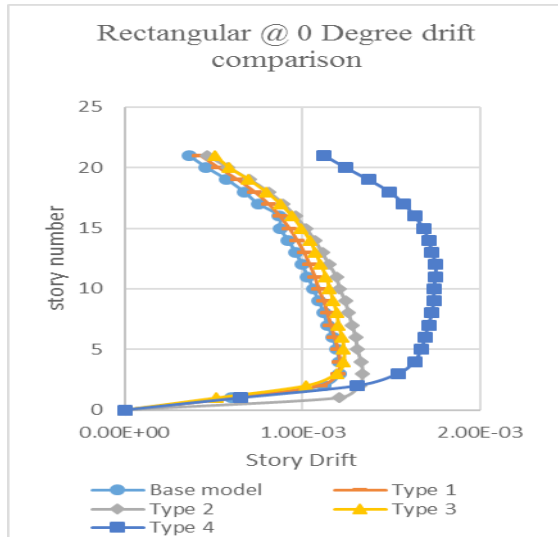
**Figure 8.** Column force comparison.



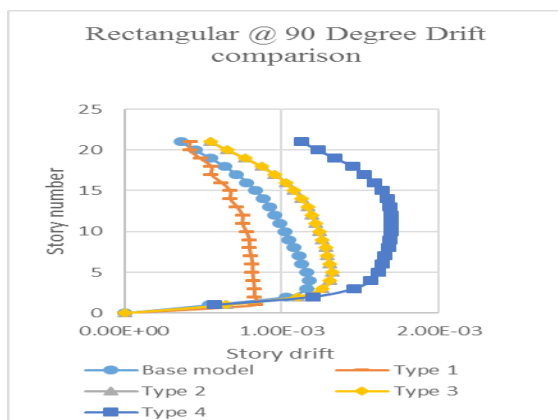
**Figure 6.** top story displacement comparison.



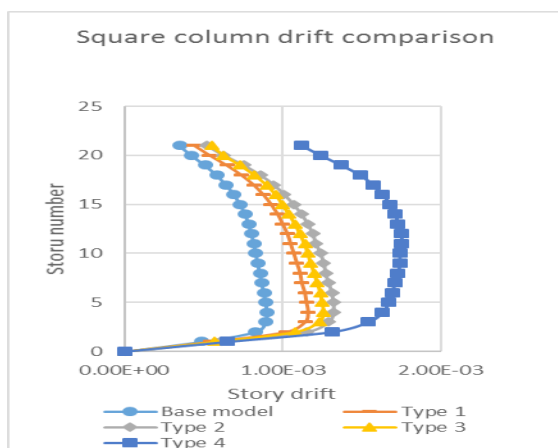
**Figure 9.** Fundamental time period comparison.



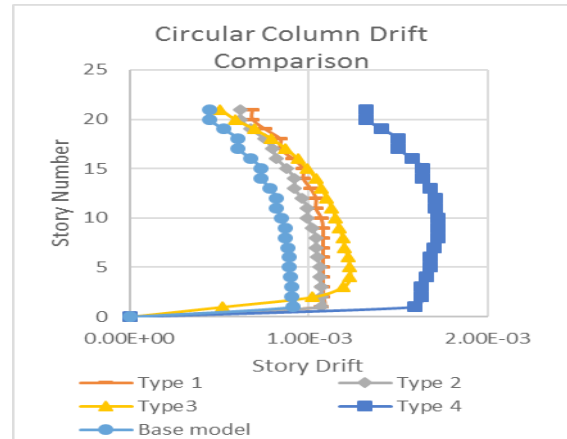
**Figure 10.** Story drift comparison for rectangular column @ 0 degree.



**Figure 11.** Story drift comparison for Rectangular column @ 90 degree.



**Figure 12.** Story drift comparison for Square column.



**Figure 13.** Story drift comparison for Circular columns.

is approximately up to 135% for square columns and minimum being 67.35% for circular columns when compared with their respective base models.

4. Displacement (from Figure 6) are found to be maximum only up to 2 or 3 stories from the base of the structure while the remaining part of the building is less displaced this phenomena can be clearly observed in story drift from Figure 10, Figure 11, Figure 12 and Figure 13 where the drift of the structure is maximum at the bottom stories where for remaining stories these values remain closer.
5. The load combination  $0.9DL \pm 1.5EQX$ ,  $0.9DL \pm 1.5EQY$  gives maximum values for displacement, story drift and can be taken as the worst load combination or combinations giving maximum responses for earthquake loading.
6. The maximum story drift is found for Type 4 structures in all the cases (from Figure 10, Figure 11, Figure 12 and Figure 13) but this value lies within limit for response spectrum for type 1 soils, as per IS 1893-2002.
7. Circular column geometry has higher values of displacement (From Figure 6) and story drift.
8. Rectangular columns show less displacement when the longer side of the rectangle is placed in the direction of the earthquake.

## 5. Conclusions

1. Usage of type 4 structures are to be reduced, as the top story displacement values of this type of structure (from Figure 6) and the story drift values (from Figure 9, Figure 10, Figure 11) of these structures are much

- higher when compared with remaining structures irrespective of the column geometry.
2. Usage of circular columns for the building is also not recommended as it is having higher base shear (from Figure 7) and is having less fundamental time period (from Figure 9)
  3. Maximum story drift is found up to 2-5 stories from the bottom and so is the displacement so we have to reduce this displacement by using bracings so that we may have the chance of reducing the overall displacement.

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