Seismic Performance of Multi-Story Buildings with Oblique Columns of Different Shapes

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Abstract - *The design and construction of tall structures which is capable of resisting the adverse effects of earthquake forces is the most important. The stiffness plays governing role in analysis and design of structure in tall buildings when subjected to lateral loads. To carry the lateral loads and control the excessive lateral deflection of buildings, provision of an efficient structural system with a reasonable height limit is a good solution for such issue. Various construction techniques are adopted in order to increase the seismic performance of the building. Here the oblique columns are used instead of normal columns. The oblique columns are slanted or rotated at an angle with the specified line. This work deals with the study on the oblique columns of different shapes in high rise building. In this work high rise buildings with normal columns and with different angles of oblique columns are considered. Response spectrum analysis is executed. The results of the analysis on the story displacements, story drift, story stiffness, story shear and base shear are compared. The analysis is carried out in ETABS version 15.*

Key Words: *Oblique Column, Seismic Performance, Response Spectrum Analysis*

1. INTRODUCTION

The oblique columns can be adopted in high-rise, mid-rise and low-rise building. Oblique restraints cause coupling between the principal axis deflections and rotations, and the flexural buckling mode involves simultaneous bending about both principal axes. The position, arrangement, and angle of the inclined columns are makes different types oblique columns in buildings. The angle may vary and this affects the performance of the building. The lateral loads are resisted by structure with oblique columns, the highest story displacement is incredibly much less in oblique structure as compared to the easy Reinforced Concrete Frame building. The unique compositional characteristics of oblique columns provide lateral stiffness very efficiently and at the same time produce distinguished architectural aesthetics in any existing cityscapes like twisted structures and tilted structures. Today's diverse architectural design directions have produced various non- prismatic building forms such as twisted, tilted, tapered and free forms. In this paper, Response Spectrum Analysis (RSA) is executed combined with a numerical building model by this program. The results of the analysis on the base shear, story drift, story stiffness, story shear and displacements are compared.

1.1 Objectives

- To compare normal and oblique columns of different shapes in high rise building by response spectrum analysis and to determine how the shape of column affect the performance of oblique columns. Provided, both circular and rectangular columns are with equivalent cross sectional area.
- To study the seismic performance of oblique columns with different angles in high-rise buildings.

1.2 Scope

- To study the effect of inclination of oblique column of the building in plan on the behaviour of the structure and to understand the structural behaviour of oblique column with different shapes, under earthquake forces.
- Response Spectrum Analysis is done.
- Study is done in G+12 storied building having circular and rectangular shaped columns with different angles such as 80°, 90° and 100°.
- The modeling and analysis is done by using ETABS 2015 software.

2. Methodology

Only the external columns are provided as circular by keeping the internal columns as rectangular. Both circular and rectangular columns are with equivalent cross sectional area. ETABS software is used for modeling and model analysis. Building configuration and loading data's for models are given. In this project the building models are symmetrical to both axis. Response Spectrum analysis is done.

2.1 Building Configuration

Table -1: Model Description

Type of frame	Special moment resisting RC frame (SMRF) at the base
Seismic zone	IV
Number of story	G+12
Floor height	3m
Depth of slab	150mm
Size of beam	350×650mm
Size of circular column	900mm diameter
Size of rectangular column	750 × 850mm

Spacing between frames in X and Y direction	7.5m
Materials used	M30 concrete, Fe 500 steel
Thickness of walls	230mm

2.2 Loading Consideration and Design Criteria

- Live load : 3kN/m^2
- Floor finish : 1kN/m^2
- Seismic loading (IS : 1893 (Part I) -2002)
- Zone factor : 0.24
- Medium soil
- Response reduction factor– 5

2.1 Models Analysed

Table -2: Model Designation

Designation	Description
Model 1	12 Story Building with 80° circular oblique column
Model 2	12 Story Building with 90° circular normal column
Model 3	12 Story Building with 100° circular oblique column
Model 4	12 Story Building with 80° rectangular oblique column
Model 5	12 Story Building with 90° rectangular normal column
Model 6	12 Story Building with 100° rectangular oblique column

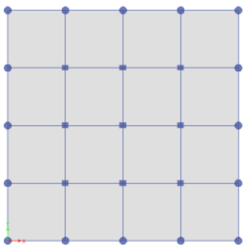


Fig -1: Plan of Model 1, Model 2 and Model 3

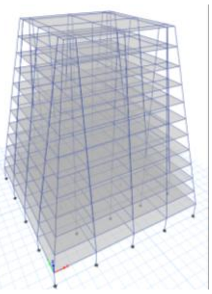


Fig -2: 3 D view of Model 1

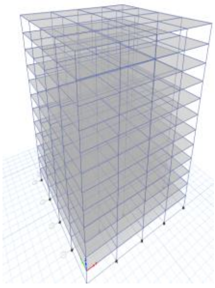


Fig -3: 3 D view of Model 2

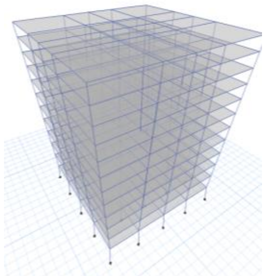


Fig -4: 3 D view of Model 3

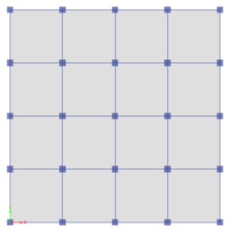


Fig -5: Plan of Model 4, Model 5 and Model 6

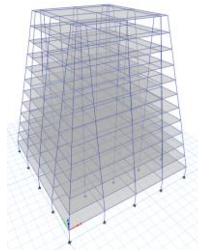


Fig -6: 3 D view of Model 4

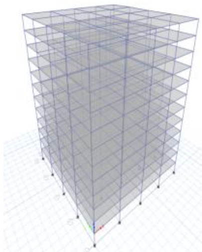


Fig -7: 3 D view of Model 5

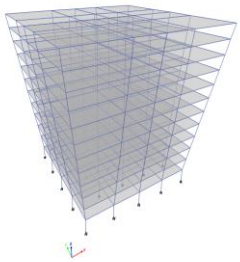


Fig -8: 3 D view of Model 6

3. RESULTS AND DISCUSSIONS

3.1 Results of Model 1

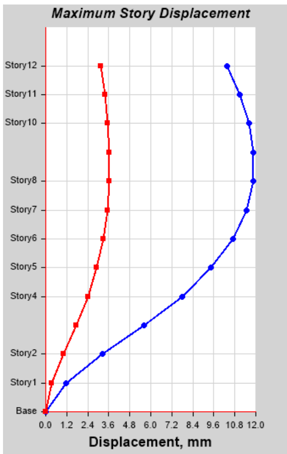


Fig -9: Story Displacement

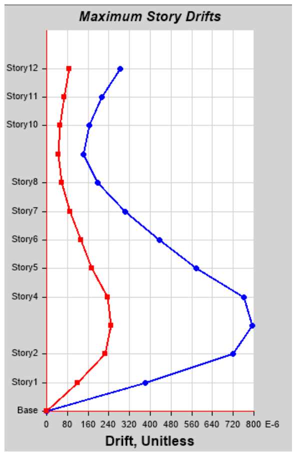


Fig -10 : Story Drift

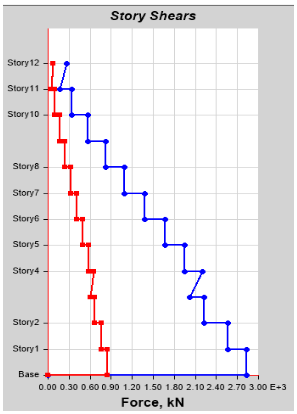


Fig -11: Story Shear

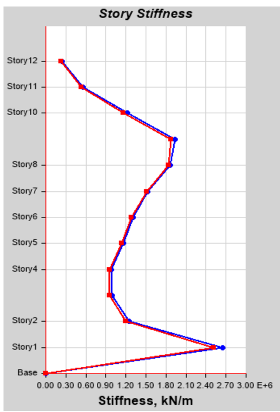


Fig -12 : Story Stiffness

3.2 Results of Model 2

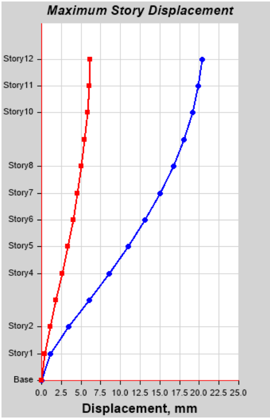


Fig -13: Story Displacement

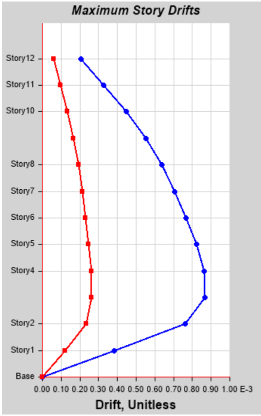


Fig -14 : Story Drift

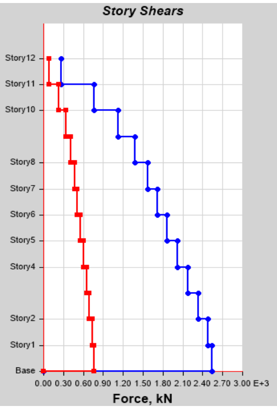


Fig -15: Story Shear

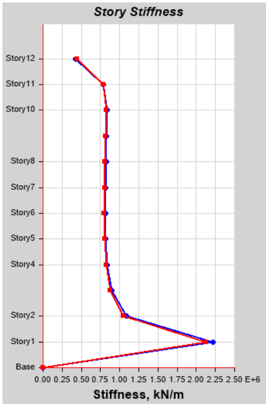


Fig -16 : Story Stiffness

3.3 Results of Model 3

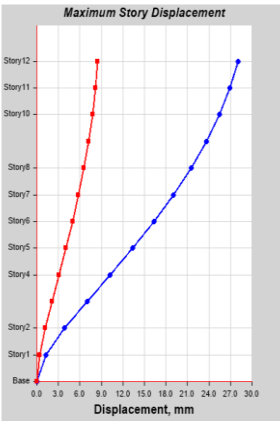


Fig -17: Story Displacement

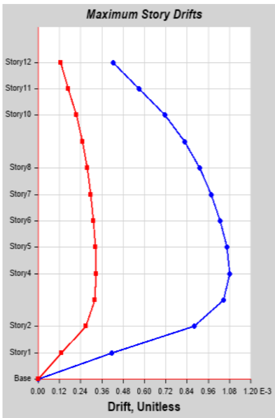


Fig -18 : Story Drift

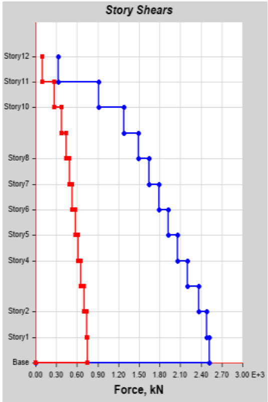


Fig -19: Story Shear

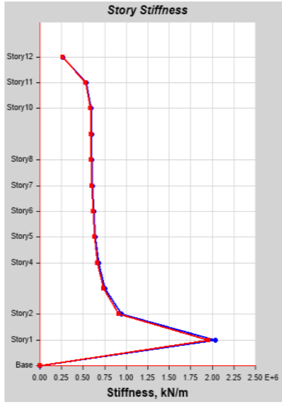


Fig -20 : Story Stiffness

3.4 Results of Model 4

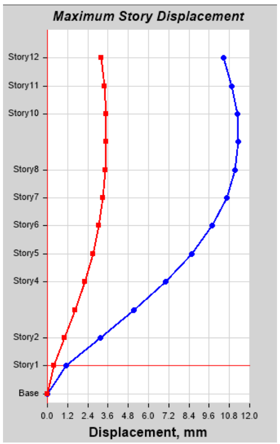


Fig -21: Story Displacement

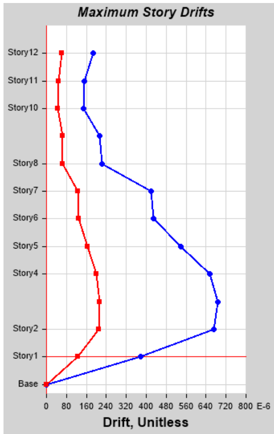


Fig -22 : Story Drift

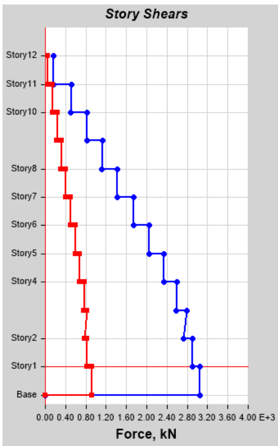


Fig -23: Story Shear

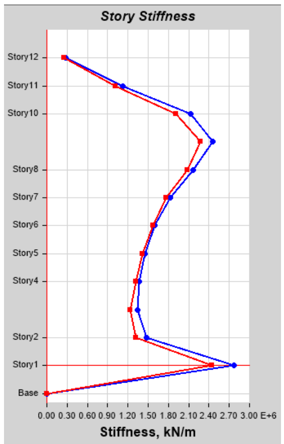
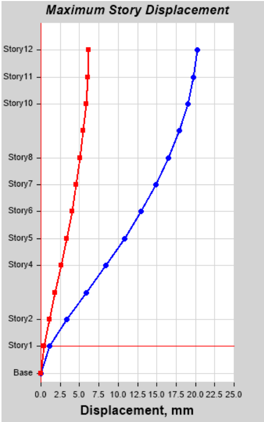


Fig -24 : Story Stiffness

3.5 Results of Model 5



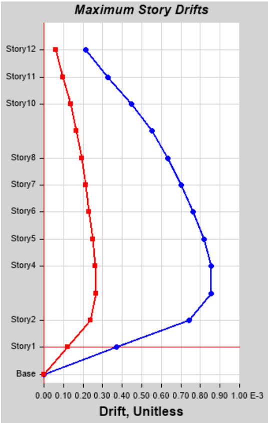
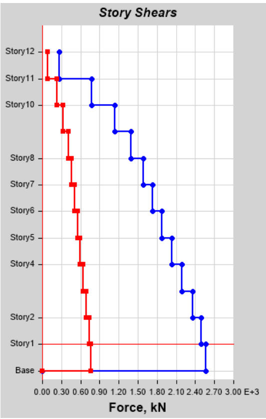


Fig -25: Story Displacement **Fig -26 :** Story Drift



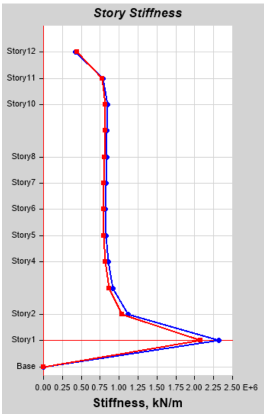
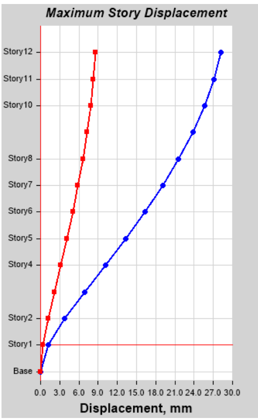


Fig -27: Story Shear **Fig -28 :** Story Stiffness

3.6 Results of Model 6



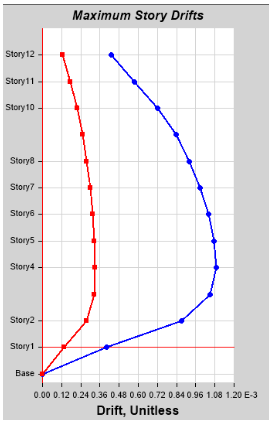
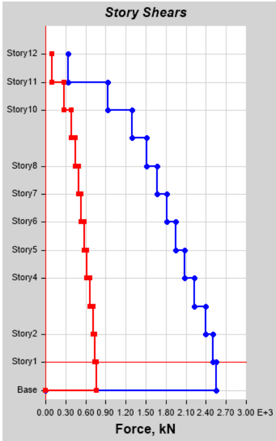


Fig -29: Story Displacement **Fig -30** Story Drift



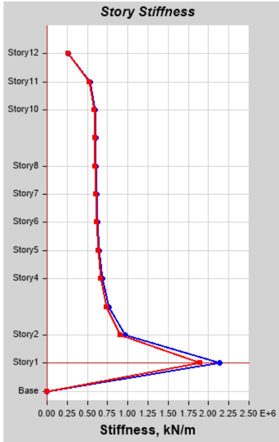


Fig -31: Story Shear **Fig -32 :** Story Stiffness

Table-3: Results of all circular models

Models	Model 1	Model 2	Model 3
Maximum story displacement (mm)	11.878	20.352	28.053
Maximum story drift	0.00079	0.00087	0.00108
Maximum story shear (kN)	2833.20	2542.80	2522.78
Maximum story stiffness (kN/m)	2651752	2212708	2033258
Base Reaction (kN)	2775.05	2444.66	2364.87

Table-4: Results of all rectangular models

Models	Model 4	Model 5	Model 6
Maximum story displacement (mm)	11.326	20.225	28.208
Maximum story drift	0.000687	0.000855	0.001089
Maximum story shear (kN)	3047.38	2561.88	2550.49
Maximum story stiffness (kN/m)	2770804	2315765	2137878
Base Reaction (kN)	2988.56	2465.27	2390.55

4. CONCLUSIONS

This project is attempted to improve the seismic performance of multi story building with oblique columns of different shape. Response spectrum analysis is performed for several models. A successful result was obtained from the response spectrum analysis. It is clearly shown that structure provides more resistance in the oblique column building which makes the structural system more effective. Comparing multistoried buildings having circular normal and oblique columns

- Oblique columns of 80 degrees show around 42 % lesser top story displacement and 9% lesser story drift than normal column.
- Oblique columns of 100 degrees have 38% more top story displacement and 24% more story drift than conventional column.
- Multi story building having oblique columns of 80 degrees have greater story stiffness and story shear than conventional column. But normal columns have greater story stiffness and story shear than the oblique columns of 100 degrees.

Comparing multistoried buildings with rectangular normal columns and rectangular oblique columns

- Oblique columns of 80 degrees show around 44 % lesser top story displacement and 20% lesser story drift than normal column.
- Oblique columns of 100 degrees have 39% more top story displacement and 27% more story drift than conventional column.
- Multi story building having oblique columns of 80 degrees have greater story stiffness and story shear than conventional column. But normal columns have greater story stiffness and story shear than the oblique columns of 100 degrees.
- Base shear increases with increase in the stiffness in both rectangular and circular columns.
  - In all cases, the story displacement decreases when the angle of column decreases.
  - The story drift increases when the angle of oblique column increases.
  - As the lateral loads are resisted by structure with oblique columns, the top story displacement is very much less in oblique structure as compared to the simple RC Frame building.
  - Hence the oblique column of below 90 degrees is more seismic resistant than conventional columns.

By comparing the circular and rectangular oblique column, it is evident that rectangular column performs better than circular columns under seismic forces, even though circular columns give high strength and ductility in all directions.

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