

# Analysis of Framed Structures with Oblique Column using ETABS

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**ABSTRACT:** Nowadays seismic resistant or aseismic structures are designed to protect buildings to some or greater extent from earthquakes. Columns play a vital role in the behaviour of a structure. Oblique columns are the columns that are neither parallel nor right angle to a specific line. Y shaped oblique column are oblique column which have two inclined branches. By adopting Y shaped column it reduces the number of column and increases the space utility. Using ETABS 2016 the seismic resistance of the Y shaped oblique column is analysed with the help of three parameters such as storey displacement, storey drift and storey stiffness. High rise buildings are mostly affected by the seismic forces. The comparative study of structures with Y-shaped oblique column, shear wall and conventional column are done. Shear wall is commonly used vertical wall for the seismic resistance of the building. The analysis result shows that building with Y-shaped oblique column is more seismic resistant than conventional column with respect to these three parameters. But the building with shear wall is far better in the seismic resistance. The increase in percentage of concrete is very high in the case of building with shear wall and negligible for Y-shaped oblique column. So Y shaped oblique column can be used for the seismic resistance of the structure.

**KEYWORDS:** Oblique column, ETABS, displacement, drift, stiffness, shear wall.

## I. INTRODUCTION

Modern architecture and high-rise buildings are important benchmarks of technological development. Constructions of the unique architectural structures are always a challenge to structural engineers. Buildings are subjected to lateral loads like wind and earthquake. Earthquake is the greatest damaging natural hazard to the building, the design and construction of tall structure which is capable of resisting the adverse effects of earthquake forces is the most important. Columns play a vital role in assessing the overall strength of the building against effect of lateral loads. Columns behave differently under static and dynamic loading conditions. The dynamic load consideration is must for places where the seismic activity is high. Therefore when seismic loads are considered the combined approach of ductility and strength must be applied. Some of the complex geometric conditions and building irregularities requires experimental and analytical approaches for different material properties and sectional properties.

Oblique column which is neither parallel nor a right angled to the specific line. There are different types of oblique column which are V shaped, Y shaped and Tree shaped. There are even more varieties of application of different shapes based on the architectural requirement. Also the number of columns are reduced it makes an ease and faster construction which is more beneficial. On the basis on inclination of the oblique column the performance of building has been differed.

## II. METHODOLOGY

### Building Configuration

Here we are considering high-rise (G+18) commercial building. The building is a fixed base building of importance factor 1. The importance factor depends on the occupancy category of the building which is obtained from Table 6 IS 1893-2002. Since it is a commercial building importance factor is 1. Response reduction factor is 5 (Table 7, IS 1893-2002) and is determined by type of lateral load resisting system used. The site class is considering as II (medium).

Earthquake is the seismic loading and the earthquake zone is considered as zone IV according to IS 1893 (part 1) -2002. It is the indicator of maximum risk characterized by Maximum Considered Earthquake (MCE) in the zone in which structure is located. The load cases are live load is 4 kN/m<sup>2</sup> from IS 875 part 2 and floor finish is 1 kN/m<sup>2</sup> from IS 875

part 2 and dead load is assigned by ETABS automatically. The slab thickness of the structure is 150mm and M30 grade of concrete is used. The grade of steel is Fe415. The floor height of buildings are 3m and plinth height are 2m.

#### Y-Shaped Oblique Column

Here we used Y shaped oblique column. Oblique columns are also used for the space utilization, since we can eliminate some columns due to the presence of Y branches. The degree of inclination of the branch will affect the performance of the structure. Here we chose the angle as  $45^\circ$ . Since the plinth height is taken as 2m the maximum angle that we can adopt is  $45^\circ$ . If the angle get increased the branch will overlap. The Y branches start at 1m from the ceiling.

#### Shear Wall

In structural engineering, a shear wall is a vertical element of a seismic force resisting system that is designed to resist in plane lateral forces, typically wind and seismic loads. For slender walls where the bending deformation is more, shear wall resists the load due to cantilever action. It is used generally in high-rise buildings subjected to lateral load. The wall thickness varies from 40mm to 500mm, depending on number of stories, building age and thermal insulation requirements. Here we choose 230mm thick shear wall for high rise building. The best location of the shear walls were chosen from the fig.3.4. The wall is placed internally and externally. The external columns gives better result, so we place shear wall externally and done the comparison. All these shear wall configurations were analyzed and best among them was selected.

#### ETABS 2016

ETABS means Extended Three-dimensional Analysis of Building Systems is the innovative and revolutionary new ETABS is the ultimate integrated software package for the structural analysis and design of buildings. Incorporating 40 years of continuous research and development. ETABS is an engineering software product that caters to multi-story building analysis and design. Modeling tools and templates, code-based load prescriptions, analysis methods and solution techniques, all coordinate with the grid like geometry unique to this class of structure. It has fast linear and nonlinear analytical power, sophisticated and comprehensive design capabilities for a wide-range of materials. Fundamental to ETABS modeling is the generalization that multi-story buildings typically consist of identical or similar floor plans that repeat in vertical direction. Once modeling is complete, ETABS automatically generates and assigns code-based loading conditions for gravity, seismic, wind, and thermal forces. Provides insightful graphic displays, reports, and schematic drawings that allow users to quickly and easily decipher and understand analysis and design results

#### Time History Analysis

Time history analysis is a step-by-step analysis of a dynamic response of a structure to a specified loading that may vary with time. Time history analysis is used to determine the seismic response of a structure under dynamic loading of representative earthquake. It is a non linear dynamic analysis. Time history is the sequence of values of any time-varying quantity (such as a ground motion measurement) measured at a set of fixed times. Also termed as time series. Time history method gives all possible forces which are generated, and there by displacement of structure, during entire duration of ground motion at equal interval, typically 0.05 to 0.1 sec. In absence of ground motion of given area it is advisable to go for response spectrum method to carry out dynamic analysis.

### III. EXPERIMENT

The beam dimension is 400mmx400mm and column dimension is 600mmx500mm. The plan, elevation and three dimensional view of the building with conventional column is shown in the fig.1 a, b and c respectively.

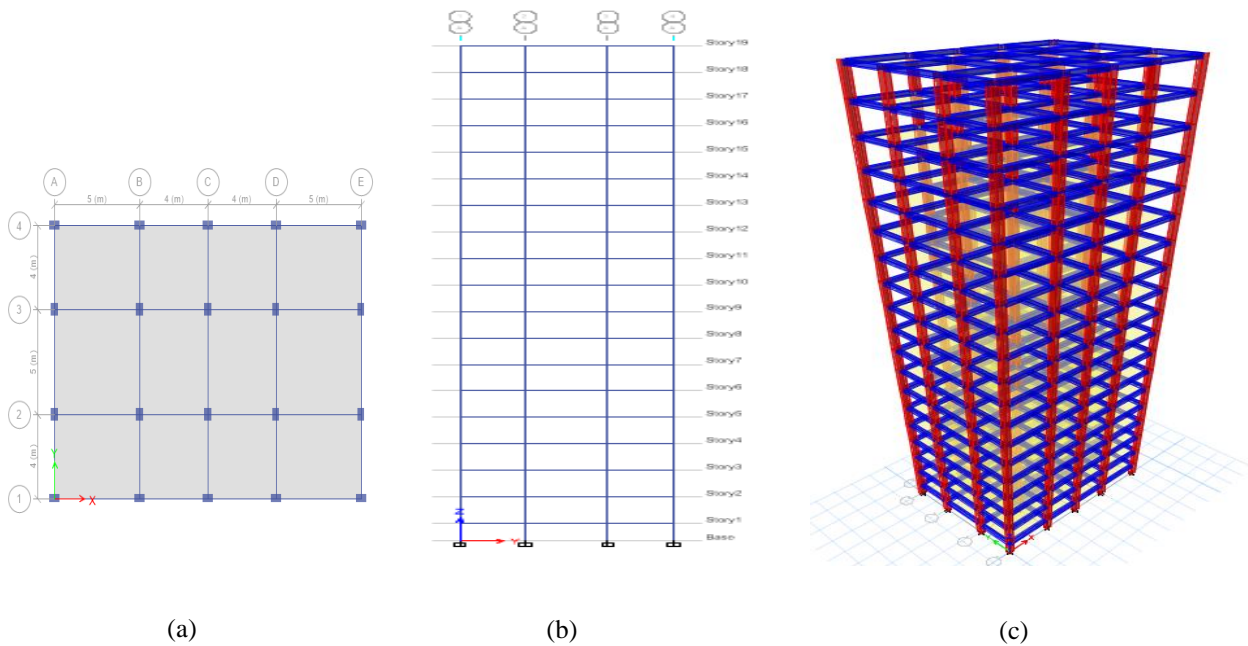


Fig. 1 Plan of high rise building with conventional column(a) Elevation of high rise building with conventional column(b) Three-Dimensional view of high rise building with conventional column(c)

The plan, elevation and three-dimensional view of the building with y shaped oblique column is shown in the fig.2, a, b and c respectively. The two columns are eliminated because the structure stay safe without those columns. It is because of the y shaped oblique column.

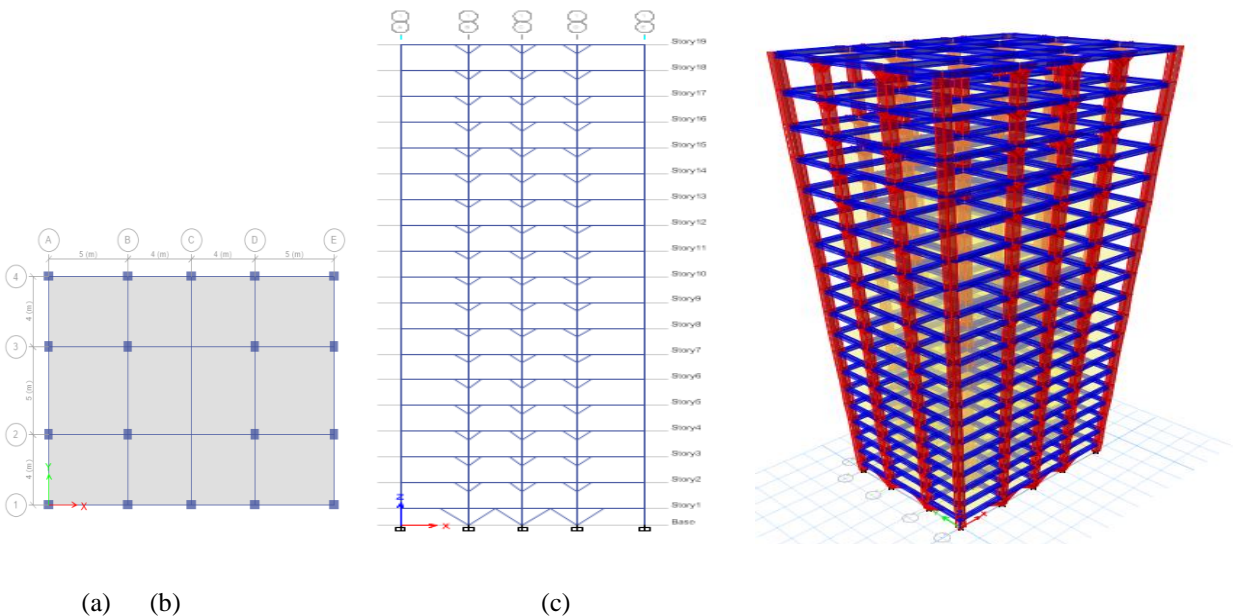


Fig.2 Plan of high rise building with oblique column(a), Elevation of high rise building with oblique column(b), Three Dimensional view of high rise building with oblique column(c)

The plan, elevation and three dimensional view of the building with shear wall is shown in the fig.3, a, b and c respectively.

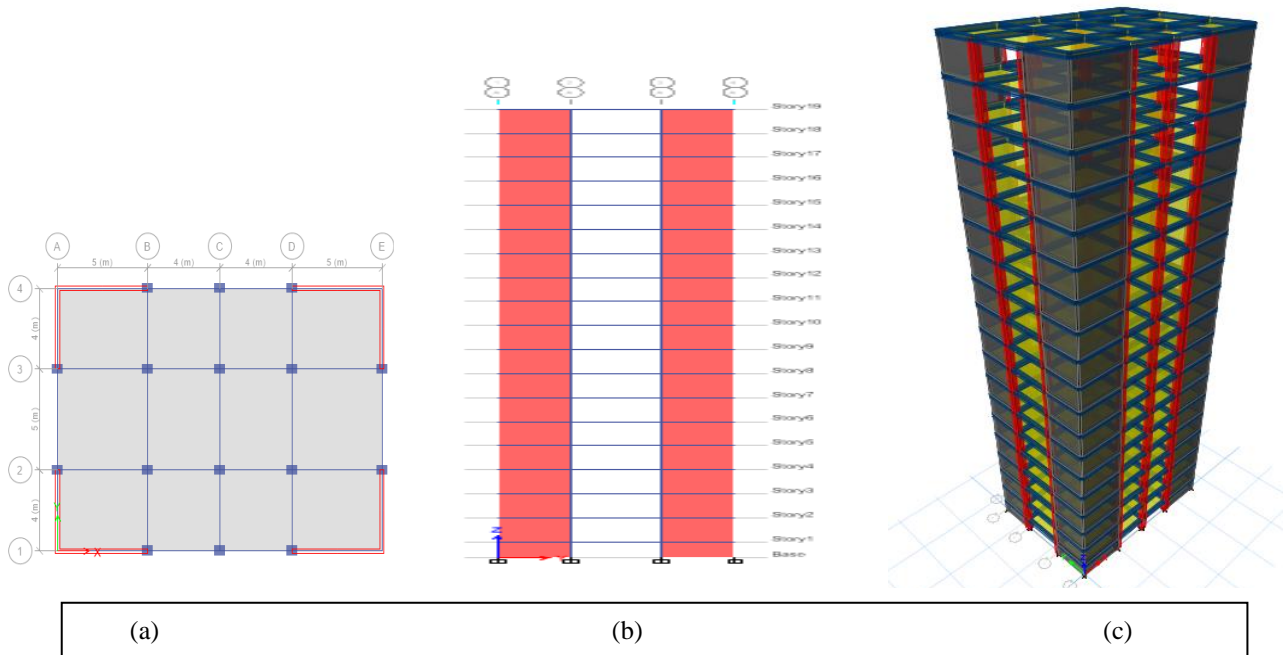


Fig.3 Plan of high rise building with shear wall(a), Elevation of high rise building with shear wall(b), Three dimensional view of high rise building with shear wall(c)

The modeled structures are then subjected to time history analysis. The time history analysis done using El Centro earthquake data. It had a moment magnitude of 6.9 and maximum perceived intensity on the Mercalli intensity scale. It was the first major earthquake to be recorded by a strong-motion seismograph located next to a fault rupture. The magnitude of the earthquake is 6.9. Fig.4 shows acceleration versus time graph of El Centro earthquake data and the time interval is 0.01 seconds.

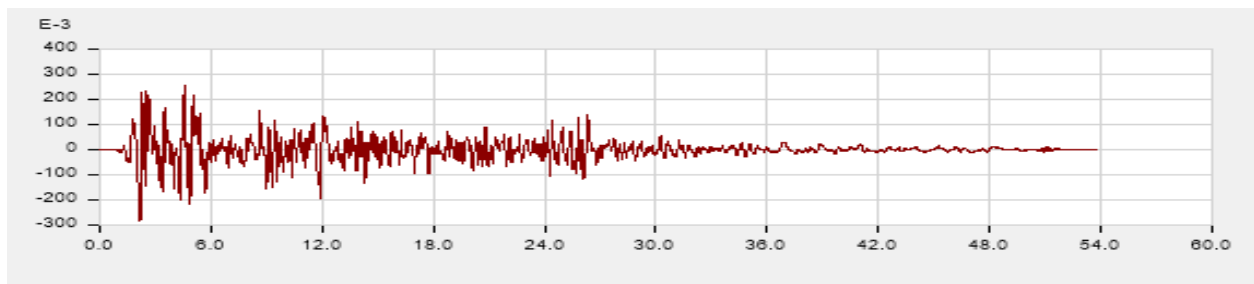


Fig.4 Function graph of El Centro earthquake data

The parameters such as storey displacement, storey drift and storey stiffness are measured. Storey displacement is the absolute value of the displacement of the storey under action of lateral force. It is the displacement of storey with respect to base of the structure. Storey drift can be defined as the displacement of one storey with respect to other storey. The storey drift ratio is the relative difference of design displacement between the top and bottom storey divided by storey height. Stiffness refers to the rigidity of a structural element. It means the extent to which element is able to resist deformation or deflection under the action of an applied force. Storey stiffness is generally defined as the ratio of storey shear to storey drift.

#### IV. EXPERIMENTAL RESULTS

##### Storey Displacement

The comparison graph of storey displacement of high rise building with conventional column, Y column and building with shear wall is shown in the fig.5 a and b. The maximum storey displacement is at top storey. The building with shear wall has less displacement than building with Y column and conventional column. The maximum storey displacement is 24.267mm in X direction and 25.593mm in Y direction for conventional column. For Y column it is

22.362mm in X direction and 23.262mm in Y direction and for building with shear wall 20.226mm in Y direction and 21.264mm in y direction. Due to shear wall the displacement is reduced about 16 to 17%. Because of Y column the displacement is reduced about 7 to 9%.

Storey Drift

The comparison graph of storey drift of high rise building with conventional column, Y column and building with shear wall is shown in the fig.6 a and b. The building with shear wall has less drift than building with Y column and conventional column. The maximum storey drift is 0.000675 in x-direction and 0.000651 in y-direction for conventional column, for Y column 0.000554 in x-direction and 0.000548 in y-direction, for building with shear wall 0.00046 in x-direction and 0.000446 in y-direction. Due to shear wall the displacement is reduced about 31%. Because of Y column the displacement is reduced about 15 to 18%.

Storey Stiffness

For high rise building with conventional column has stiffness 181153 kN/m in xdirection and 184283 kN/m in y-direction, building with Y column has 1223195 kN/m in x direction and 920373 kN/m in y direction and building with shear wall has 12951925.1 kN/m in x-direction and 9318173.045 kN/m in y-direction.

Concrete

The building with shear wall need high amount of concrete compared to building with Y column and with conventional column. The building with conventional column requires 32578.88 kN of concrete, building with Y column requires 34504.94kN concrete and building with shear wall requires 44251.036 kN of concrete.

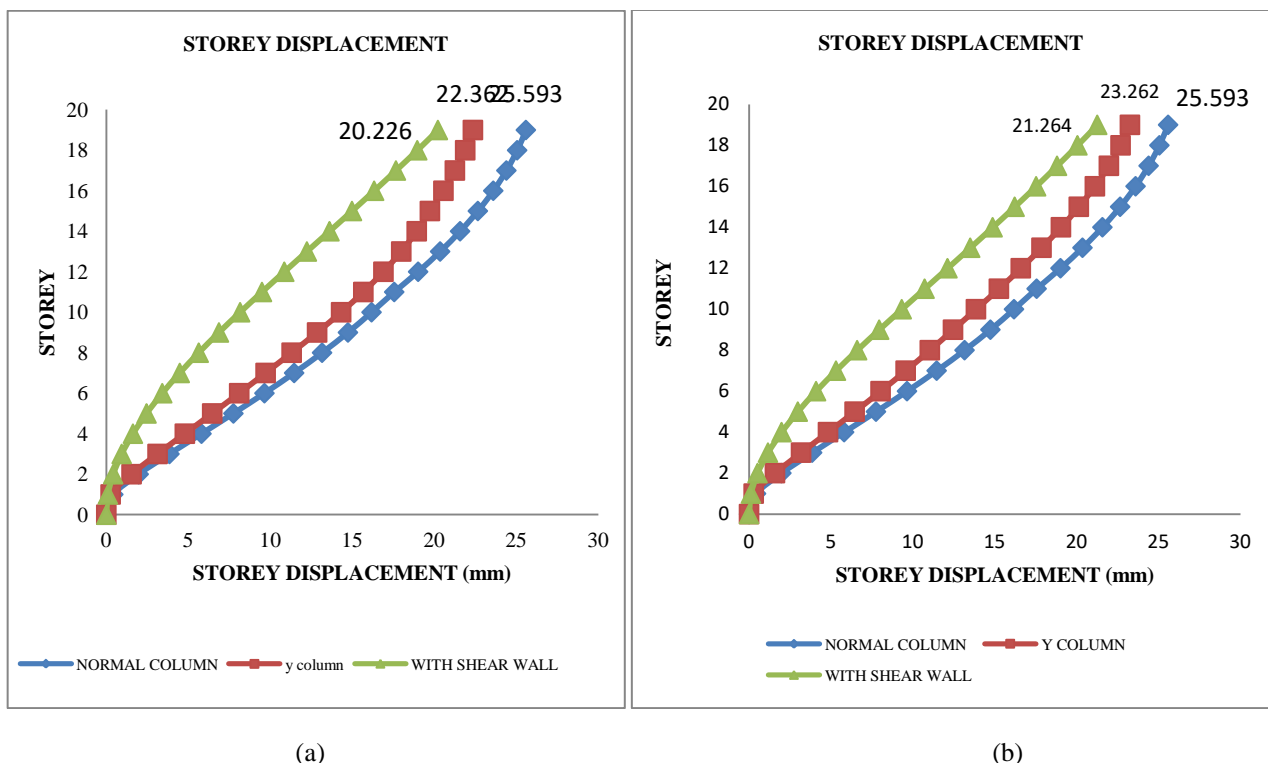
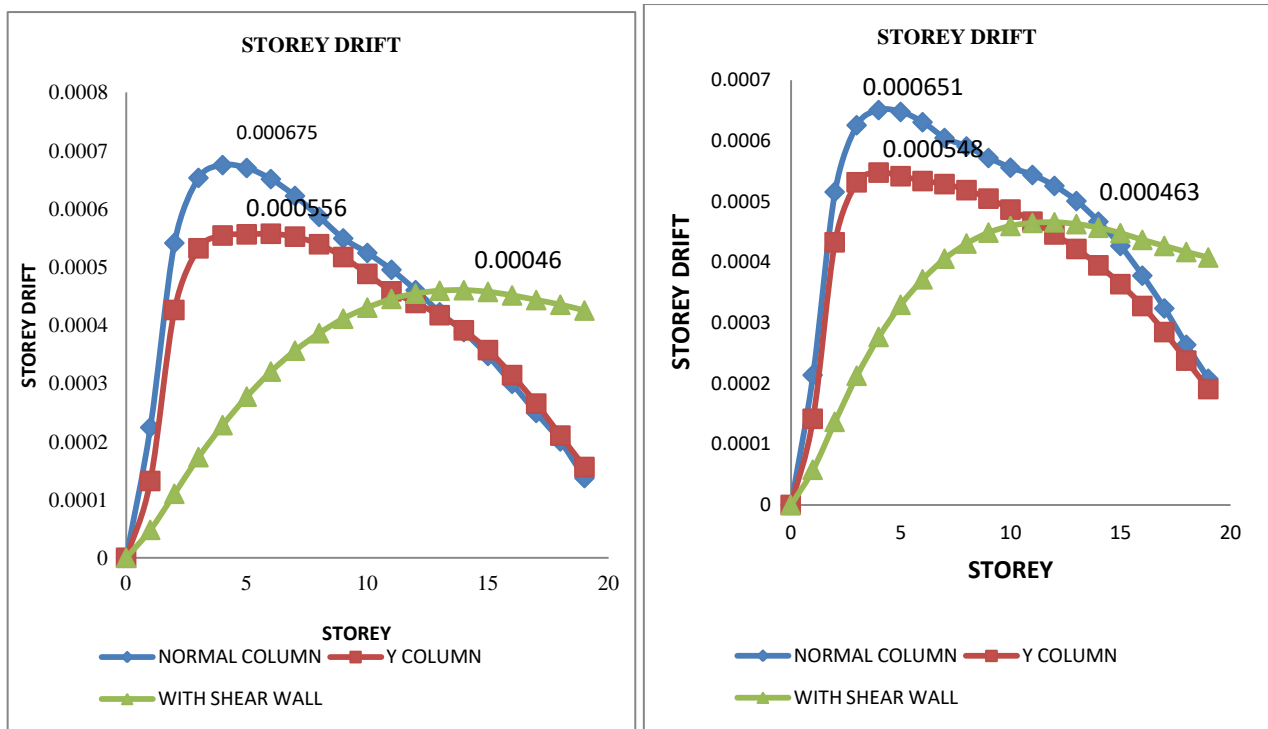


Fig.5 Storey displacement in X direction of high rise building(a), Storey displacement in Y direction of high rise building(b)



(a)

(b)

Fig.5 Storey displacement in X direction of high rise building(a), Storey displacement in Y direction of high rise building(b)

### V. CONCLUSION

1. From these analyses we came to know that high rise buildings are more vulnerable to lateral loads. Therefore, more displacement occurred in high rise building.
2. Y shaped oblique columns when compared with conventional columns, increase the aesthetic appearance of the structure.
3. Y shaped oblique column when compared with conventional column, generates less storey displacement, less storey drift and higher stiffness.
4. Y shaped oblique column when compared with conventional column, has only less than 10% increase in concrete.
5. Y shaped oblique columns helps to reduce the number of columns. Thus, more column free area is obtained.
6. Even though high rise building with shear wall is better in terms of storey displacement, the percentage increase in concrete is about 35.83% when compared with conventional columned high-rise building.
7. So we can use Y-shaped oblique column for seismic resistance. By introducing the inclined support members which will be supported at some intermediate level of the vertical portion of the column causes higher moments. If they are not properly balanced along both sides of the column, it makes design complex and then we have to use balanced cantilever ideology in dissertation work. The position of inclined support members from both the faces should be balanced considering loads.

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