Structural Analysis of Building using ETABS for Different Plan Configuration

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ABSTRACT

ETABS use for analysis of concrete as well as steel structure. Extended Three-dimensional Analysis of Building System means ETABS also used for analysis and design of high rise building and also skyscrapers. In this study we are going to observe the effect of different plan configurations on performers of building. We will observe the maximum shear force, maximum bending moment, maximum story displacement and story drift for different plan configuration for skyscrapers.

The main objective of the paper is to understand and implement irregularities in structural analysis and design G + 30 storey structure as per code (IS 1893:2016 and IS 875:2016 part III). Also, to study the changes in lateral displacement in structure for different plan configuration. As well as to study the comparative change in lateral drift for different plan configuration. We will also study the effect of overturning moment cause due to earthquake and wind forces on different plan configuration. And study the story shear for different plan configuration.

Keyword: - *Structural analysis, Tall building, ETABS, Plan irregularities.*

1. INTRODUCTIONS

In this study Rectangular, L, C, I and E shape buildings will analyse using ETABS. For these we will take 40m X 24m size of building and G + 15 + Terrace and G + 30 + Terrace, having storey height 3m each. Total height of building 45.45m & 90.45m respectively. Live, earthquake and wind load are applied to structure accordance with IS 875 part II, IS 1893: 2016, IS 875 part II respectively. Wall load are applied accordingly with storey height.

Spectrum analysis will be carried out for the structure. Initially we assume site located in Pune i.e., Earthquake zone III, Soil type II and basic wind speed 39 m/s., terrain category II and class B. Analysis done by ETABS software. ETABS is very useful software to analyse the structure. World tallest building “Buraj Khalifa” was analyse and design using this software. It will provide us nearly actual behaviour of structure.

Because of the nature of earthquakes, a dual design philosophy has been adopted for the design of buildings in earthquake prone regions. The first design criterion is to ensure that little or no damage is suffered during an earthquake that can reasonably be expected to occur during the life-time of the structure. The second is that the building does not collapse during the most severe probable earthquake that could occur at that site. The corollary of this is that if the building is to remain cost effective the second criterion will make it necessary to design the building inelastically.

It is for this reason that all buildings designed in regions where earthquakes pose a serious threat to infrastructure are in some way designed inelastically. At present three main methods are used to analyse buildings subjected to earthquakes. These are:

1. Response history analysis.
2. Response spectrum analysis.
3. Quasi-static method.

Response history analysis is potentially the most accurate but there are two problems associated with it. The first is that it can be difficult to choose an appropriate earthquake to use as the loading, while the second is that it is generally too computer-intensive to be practical especially if inelastic analysis is considered. The computer resources required to perform a response history analysis on a detailed inelastic finite element model are generally considered prohibitive.

The most commonly employed method is the quasistatic method, as it is the simplest, requires only static analysis, and estimates the response of the structure for an ensemble of earthquakes.

The response spectrum method is identical to the quasistatic method except that it considers more than just the fundamental mode of vibration. Most codes require that enough modes of vibration are considered to account for 90% of the modal mass.

For the quasi-static method and the response spectrum method the earthquake forces are divided by a behaviour factor (also known as a structural response factor or response modification coefficient). This factor accounts for the reserve strength of the building after the formation of the first plastic hinge and allows a pseudo inelastic design to be achieved without complicating the analysis. The only extra requirement to account for inelastic behaviour is for the designer to choose an appropriate building behaviour factor. Typically, this is done by choosing a value from a table in a relevant earthquake code. This is simple and reasonably effective but it is overly conservative. The various ductility factors have been arrived at empirically based on past experience of structural behaviour during earthquakes and based on generalised analysis of simple models of various building types.

A recent improvement to this technique, known as modal push-over analysis (which accounts in an approximate way for the effects of yielding) has been developed and evaluated by Chintanapakdee and Chopra. The combination of modal responses remains problematic, and results suggest that significant errors may arise in the analysis of tall and/or reduced-strength frames. The method is evaluated by comparing results with those of (non-linear) response history analysis, which evidently remains our most reliable analytical tool. Other recent developments of the push-over technique include that of Kim et al. where the procedure is enhanced by considering more than just the fundamental mode and recalculating mode shapes whenever yielding occurs.

Tall buildings, which are usually designed for office or commercial use, are among the most distinguished space definitions in the architectural history of American urbanism in the twentieth century. They are primarily a reaction to the rapid growth of the urban population and the demand by business activities to be as close to each other as possible. Architect’s reinterpretations of the building type, the high cost of land in urban areas, the desire to prevent the disorganized expansion, the need to preserve agricultural production, the concept of skyscraper, influence of cultural significance and prestige, have all contributed to force buildings upward.

2. METHODOLOGY

2.1 Problem statement

- ⦿ Building type: Residential building
- ⦿ No. of storeys: G+15.
- ⦿ Geometrical details
  - Ground floor height: 4.0 M.
  - Typical floor height: 3.0 M.
- ⦿ Material details
  - Concrete grade: M30
  - Grade of steel: FE500 for main and ties (HYSD reinforcement).
- ⦿ Building shape:
  - Rectangular shape
  - O shape
  - L shape
  - E shape
  - C shape
- ⦿ Construction type:
  - R.C.C. Framed structure.
- ⦿ Soil Bearing Capacity:
  - 300 KN/SQM

The above building analyses by using ETABS. Following are the steps to analyze the building:

STEP 1: Prepare model for given type of plan configuration. Using grid system of 24 x 40 m.

STEP 2: Assign frame property to the grid system. Assign horizontal and vertical beams to grid system. Assign column property to joints. Assign slab property in between beams. Finally, this floor plan replicates to all storey for complete model of building.

STEP 3: Assigning loads to the model. As we take floor to floor height 3m for typical floor, wall loads will be as follows,

150 thick regular brick wall – 0.15 x 20 x (3 – 0.6) = 7.2 KN/SQM.
Parapet wall load – 0.15 x 20 x 1 = 1 KN/SQM.
Slab loads for typical floor – Live load – 2 KN/SQM
Floor finish – 1 KN/SQM
Slab load for terrace floor – Live load – 1.5 KN/SQM
Floor finish – 3 KN/SQM

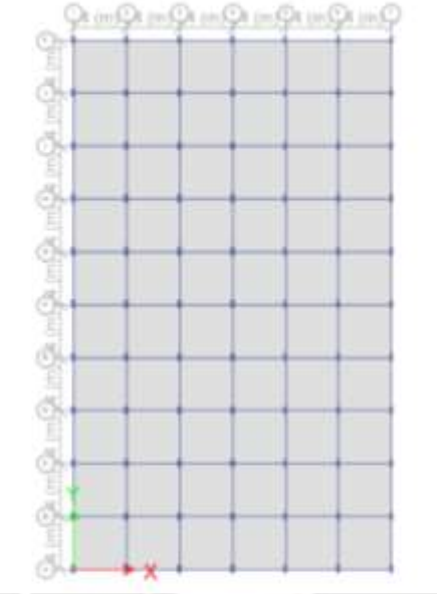

Fig -1 Plan of rectangular shape building

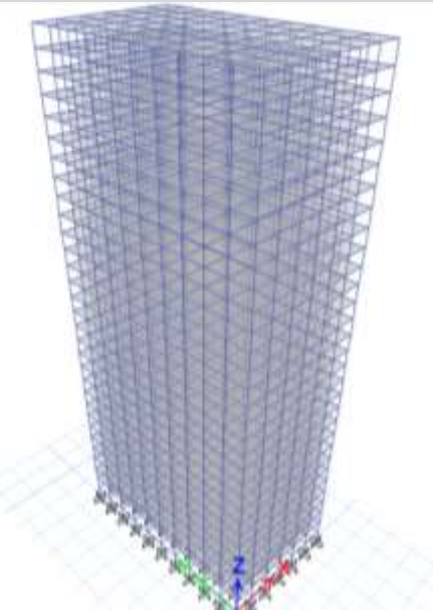

Fig -2 View of rectangular shape building

Fig -3 Wall loads

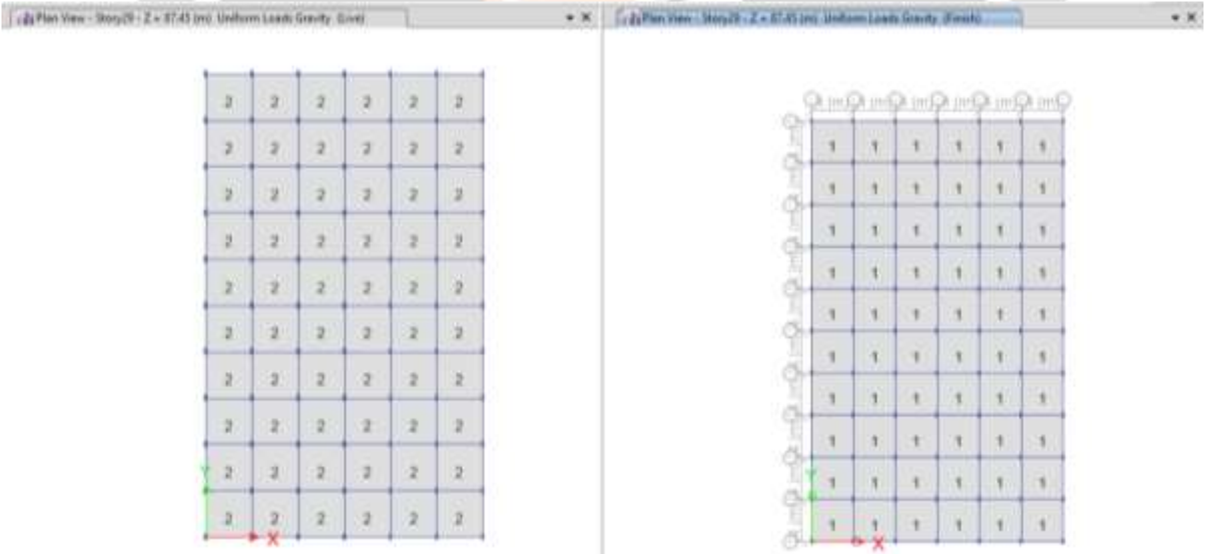

Fig -4 Slab loads

3. RESULTS

3.1 Lateral displacement

It is observed that there was maximum lateral displacement in L- shape building in x- direction, and maximum displacement in y- direction in E- shape building.

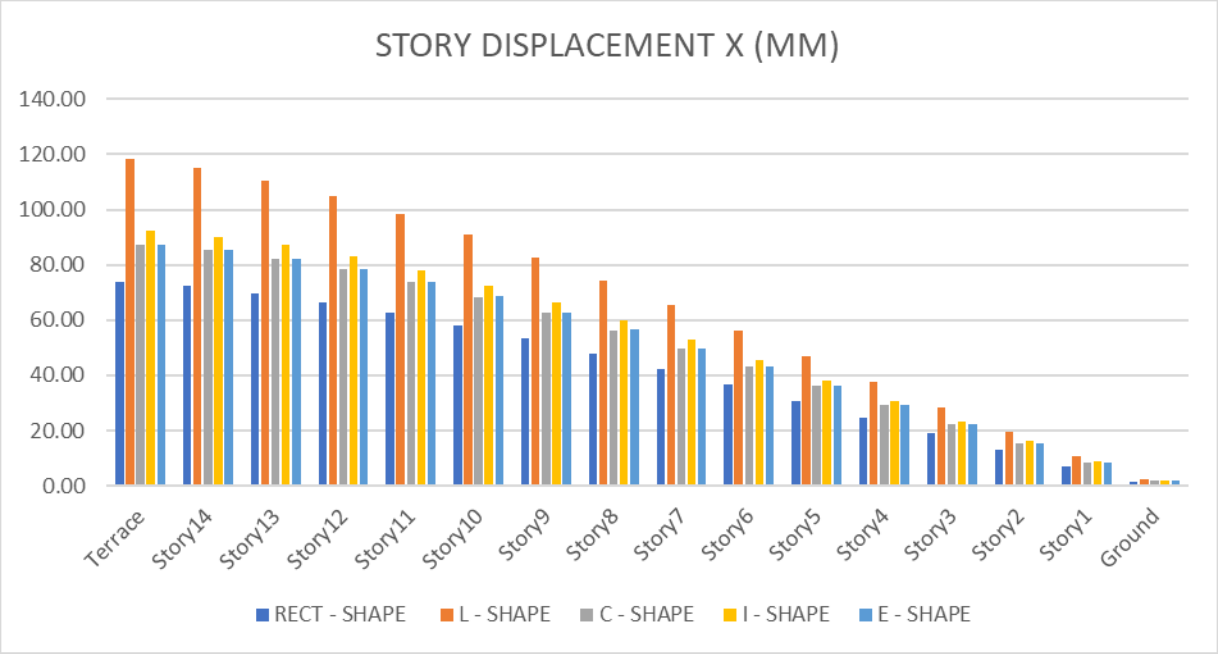

Chart -1 Story displacement in x direction

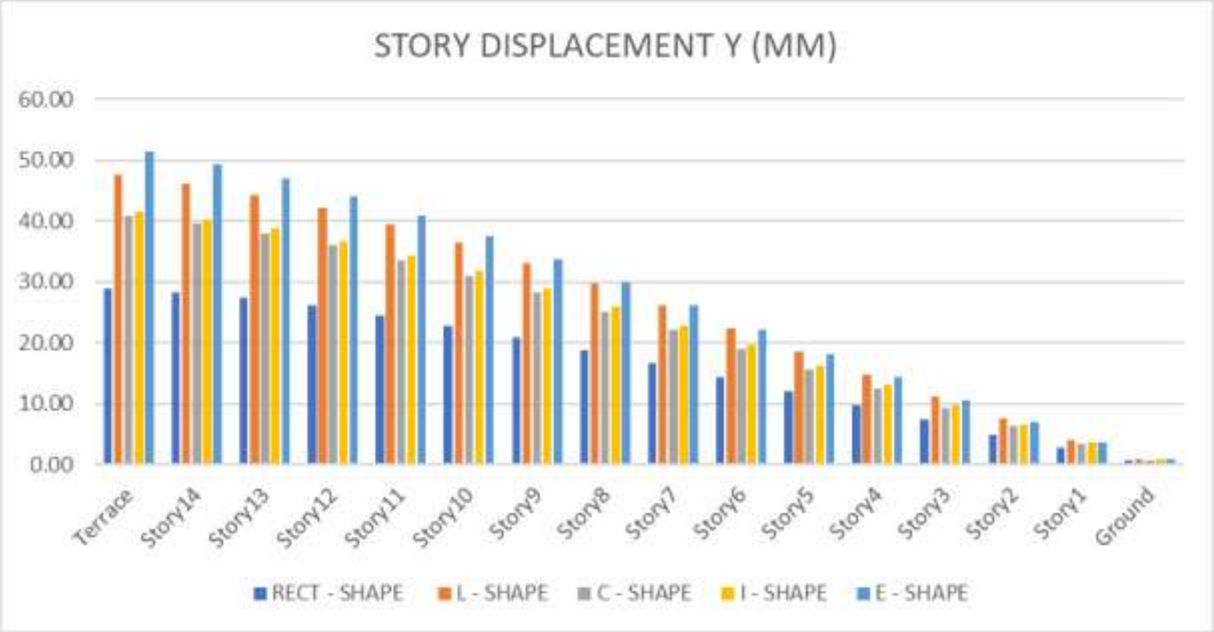

Chart -2 Story displacement in y direction

3.2 Lateral drift

Same as story displacement L- shape and E- shape building shows maximum story drift. Story drift increases up to 5th story and then it will be decreases gradually. Rectangular shape building shows minimum story drift.

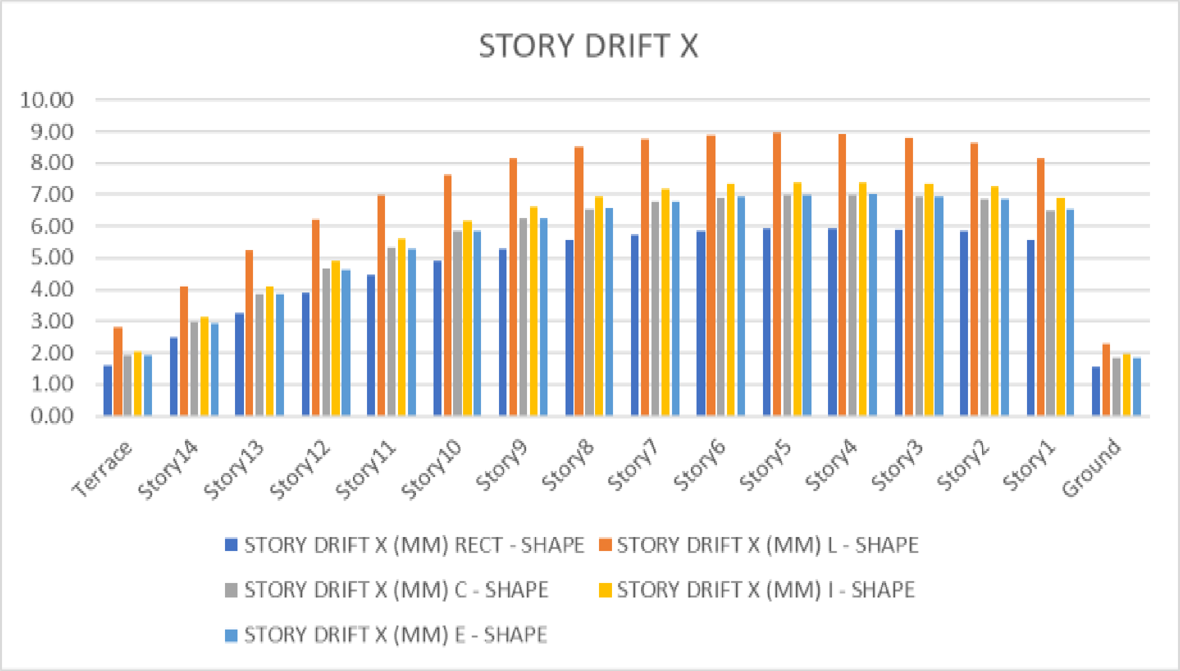

Chart -3 Story drift in x direction

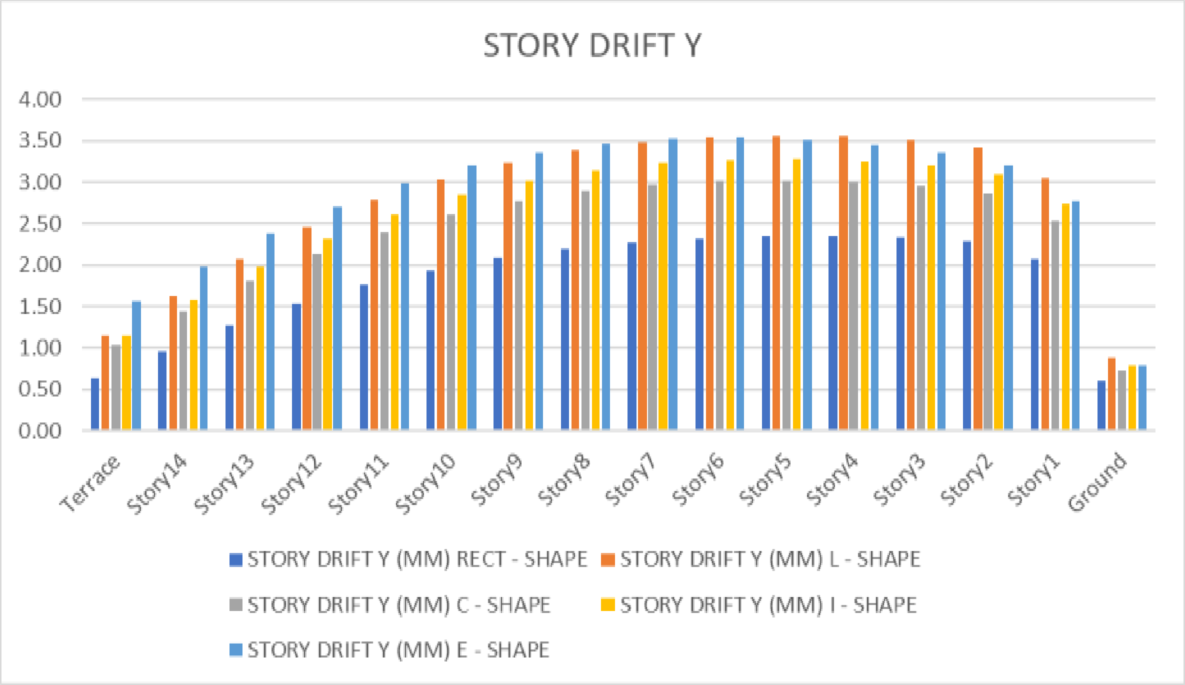

Chart -4 story drift in y direction

3.3 Overturning Moment

All shape building shows almost nearly same pattern for overturning moment. L- shape and E- shape building shows grater overturning moment. Overturning moments are gradually decreases from ground to terrace.

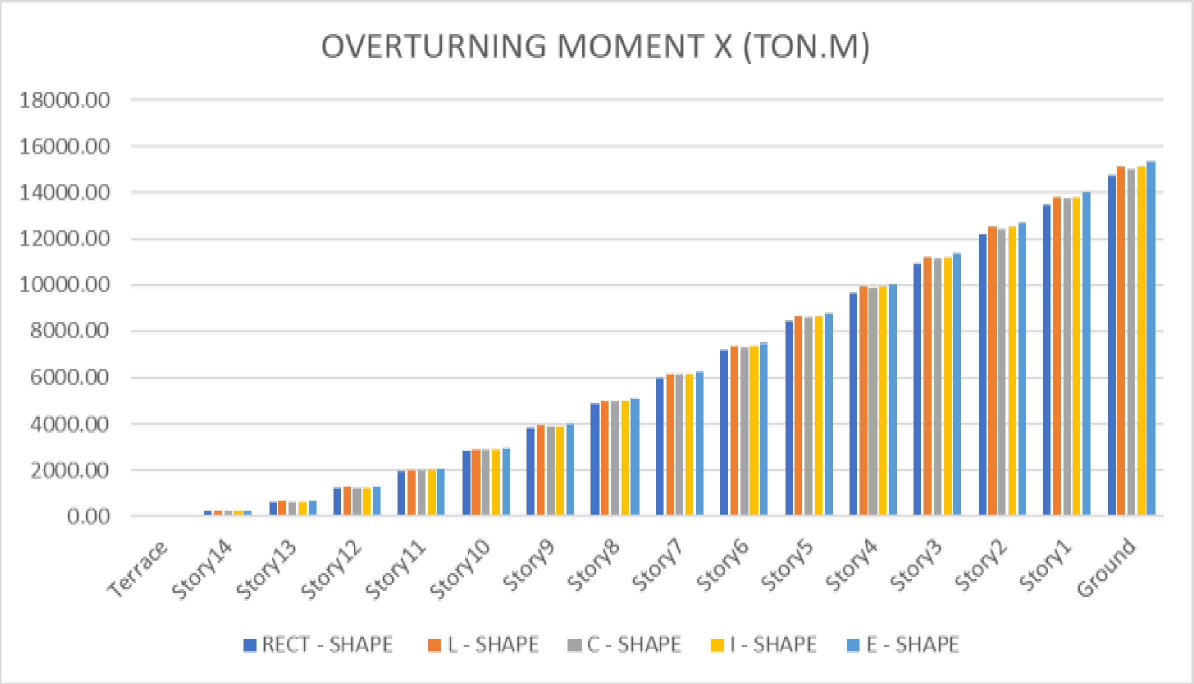

Chart -5 Overturning moment in x direction

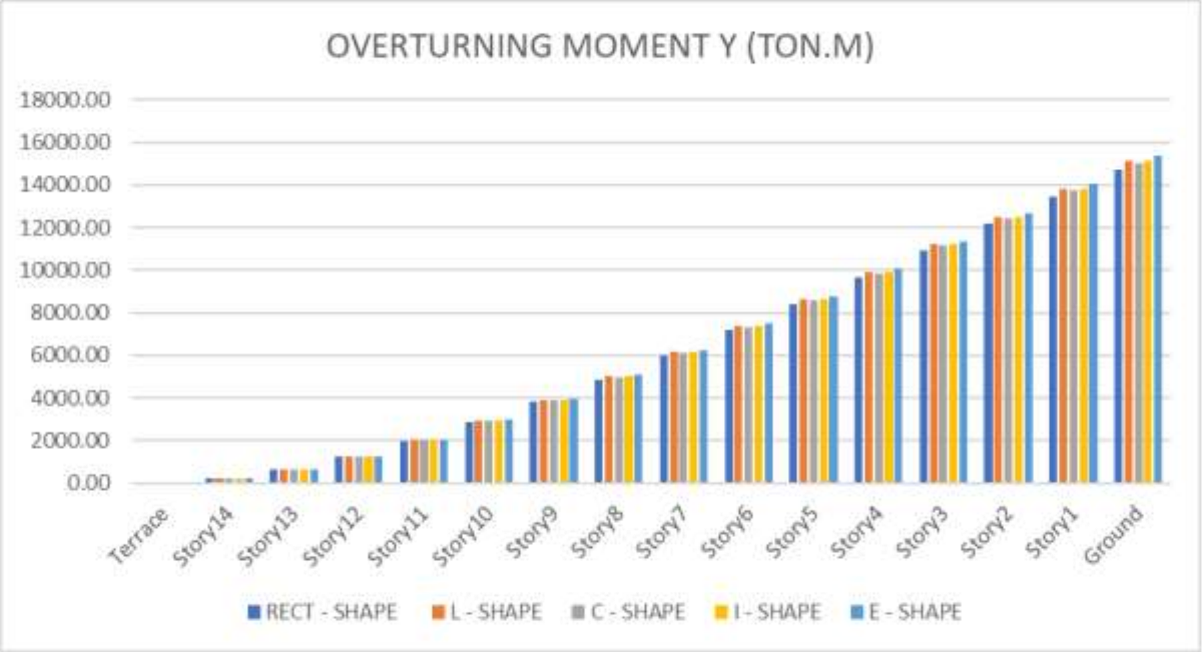

Chart -6 Overturning moment in y direction

3.4 Base shear

It is observed that E- shape building shows grater base shear compare to remaining shape building. Rectangular shape building shows less base shear. I- shape building also shows effective results in base shear.

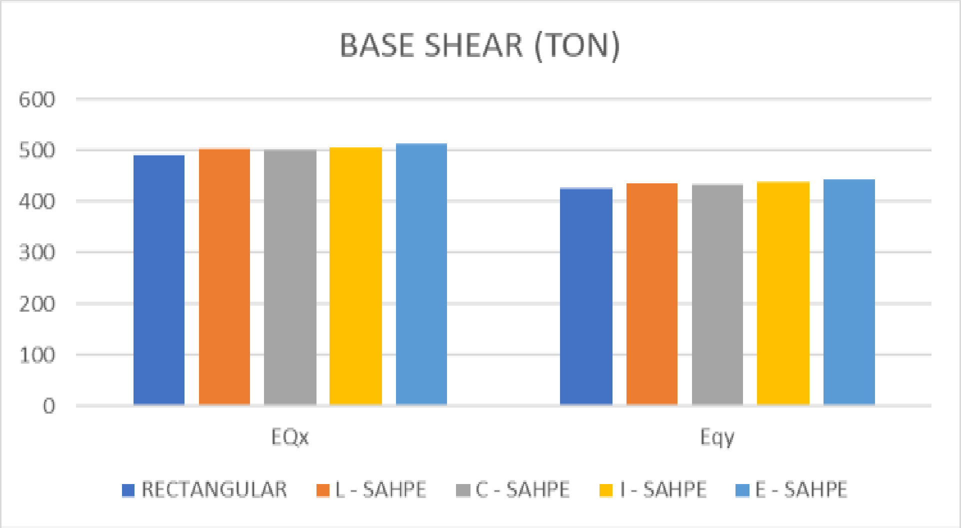

Chart -7 Base shear

3.5 Story shear

There is gradual increase in story shear 5th story and then it is decreasing. L- shape building shows maximum story shear at all story compare to remaining building. Rectangular and I- shape building shows almost same results, it is minimum of all shape of building. C- shape building also shows effective results in story shear.

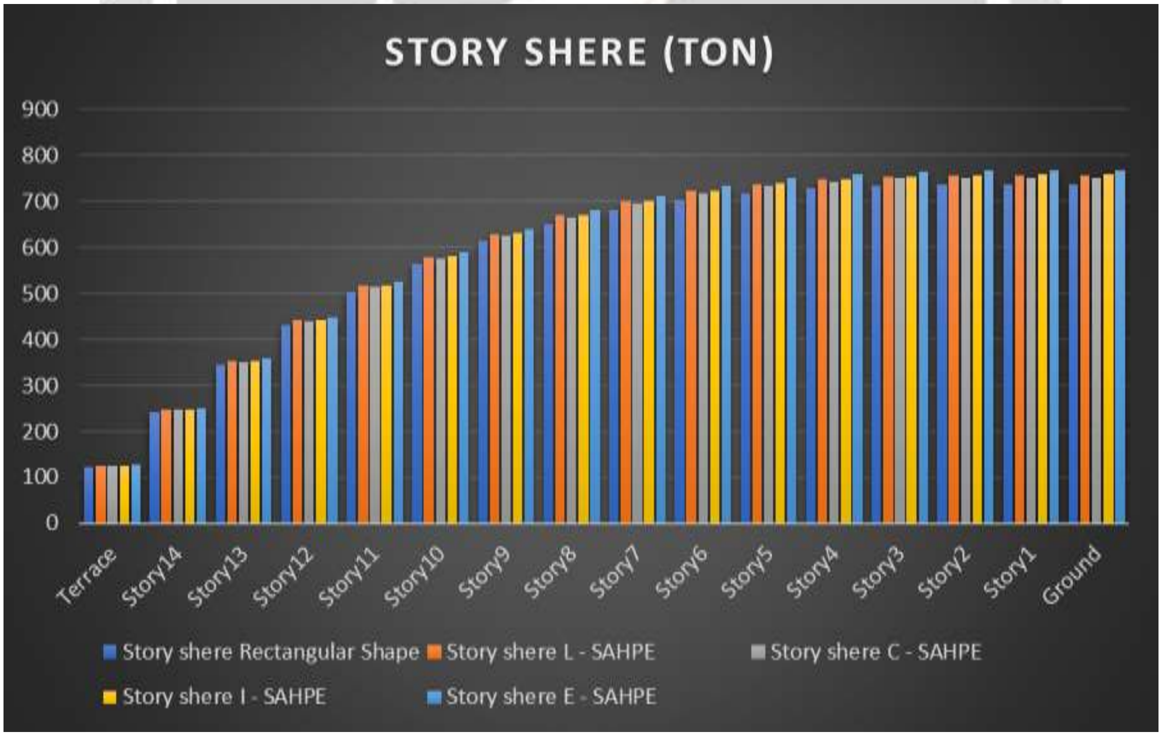

Chart -8 Story shear

4. CONCLUSION

1. It is observed that there was maximum lateral displacement in L- shape building in x- direction, and maximum displacement in y- direction in E- shape building.
2. Same as story displacement L- shape and E- shape building shows maximum story drift. Story drift increases up to 5th story and then it will be decreases gradually. Rectangular shape building shows minimum story drift.
3. All shape building shows almost nearly same pattern for overturning moment. L- shape and E- shape building shows grater overturning moment. Overturning moments are gradually decreases from ground to terrace.
4. It is observed that E- shape building shows grater base shear compare to remaining shape building. Rectangular shape building shows less base shear.
5. There is gradual increase in story shear 5th story and then it is decreasing. L- shape building shows maximum story shear at all story compare to remaining building. Rectangular and I- shape building shows almost same results, it is minimum of all shape of building.

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