# Effect of Shear Wall on Seismic Behaviour of Eccentrically Loaded Buildings

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***Abstract-*** *In this thesis the effect of shear wall and its location on the seismic behaviour of structures with different eccentric loading condition is being studied. The behaviour of eccentrically loaded buildings with and without shear wall is studied using linear static and linear dynamic analysis with the help of a finite element based software. It is observed that providing shear walls to the structure decreases displacement, torsion, storey drift, and increases the performance of the structure significantly by providing lateral stability. The shear wall located at the core as box type provides the best performance among other locations since this location is not much preferable due to architectural point of view the next best location would be to provide shear wall at the outer edges of the structure. Also from the different analysis methods considered in case of displacement, storey drift and base shear the dynamic analysis gives lesser values than static analysis.*

***Keywords***- Shear wall, ETABS, Storey drift, Storey displacement, Storey stiffness, Torsion, Eccentric loading.

## I. INTRODUCTION

The height of a structure assumes a vital job in its seismic performance. In this era of architectural diversity eccentric distribution of load has become a most common problem. At the point when these tall structures have eccentric distribution of mass and stiffness, at that point their structural design turns out to be even more difficult and challenging. Because of asymmetry, there will be eccentricity between the Centre of Mass and Centre of Rigidityin this manner inciting torsion. This torsional conduct of unevenly loaded structure is one of the most common reasons for structural damage and failure amid strong ground motions. Behaviour of the structure during an earthquake basically relies upon mass distribution, strength and stiffness in both horizontal and vertical planes of structure. If such structure is designed without shear wall, the sizes of beam and column become very substantial and there is lot of reinforcement congestion at the joints which makes it hard to pour and vibrate concrete at these spots. In the present work exertion has been made to explore the behaviour of eccentrically loaded buildings with and without shear wall and the impact of Shear Wall positioning by using linear static and linear dynamic analysis. Nine types of G + 15 structural models with eccentric loading conditions and each type in turn has five different shear wall position patterns, totally forty models are considered.All these models are analysed by Equivalent static method and by Response Spectrum method. The results so obtained are compared with respect to displacement, storey drift, torsion, and the best location of shear wall position is determined.

## II. OBJECTIVES OF THE STUDY

The objectives of thesis are as follows.

1. To perform analysis of the considered structure with eccentric loading and with and without shear wall by Equivalent static method and Response spectrum method.
2. To study the behaviour of the structure due to eccentric loading.
3. To study the behaviour of structure when shear wall is located at different positions.
4. To study the parameters namely torsion, storey drift, displacement, base shear.
5. To compare the results obtained by different analysis methods.
6. To govern the best possible position of shear wall considering different parameters.

## III. MODELING

In the present study a RCC bare frame 15 story structure with floor to floor height 3.5m is considered. The plan dimensions of the structure are 32 m in both X and Y direction, for this structure shear wall is adapted at different positions and also different eccentric loading conditions are taken into consideration. The structure is modelled using ETABS software.

Five different positions of shear wall namely SWP-1 (shear wall position-1) to SWP-5 and a BARE condition, i.e. bare frame structure which possess no shear wall, and eight different eccentric loading conditions namely ELC-0 (eccentric loading condition-0) to ELC-8 are considered, among these ELC-0 represents model with no eccentric loading and model with loading conditions ELC-1 to ELC-4 have asymmetric loading about one axis, and that with ELC-5 to ELC-8 have asymmetry about both the axis. All combined together 40 models are taken into consideration. Each one of them has the following specifications.

- Number of bays along X axis : 8
- Number of bays along Y axis : 8
- Spacing from one column to another in both directions : 4m
- Each Storey height : 3.5m

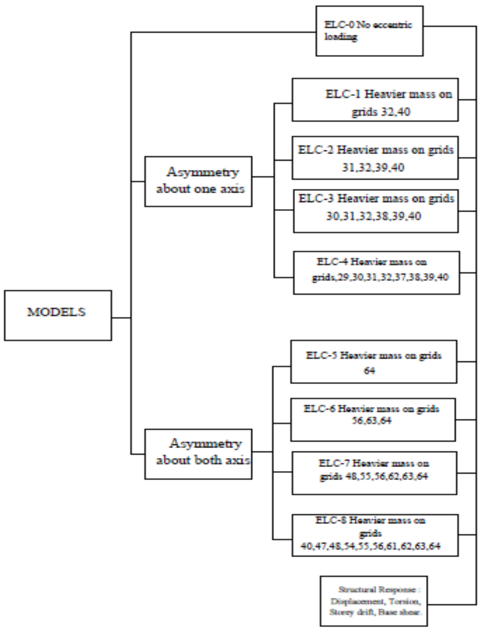


**Fig. 3.1: Flow chart describing the different load arrangements**

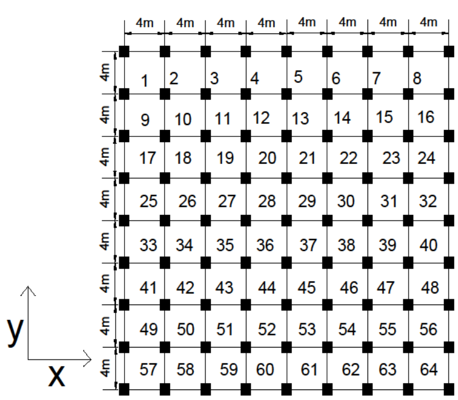


**Fig. 3.2: Plan and grid system (with grid numbering) of the proposed Model**

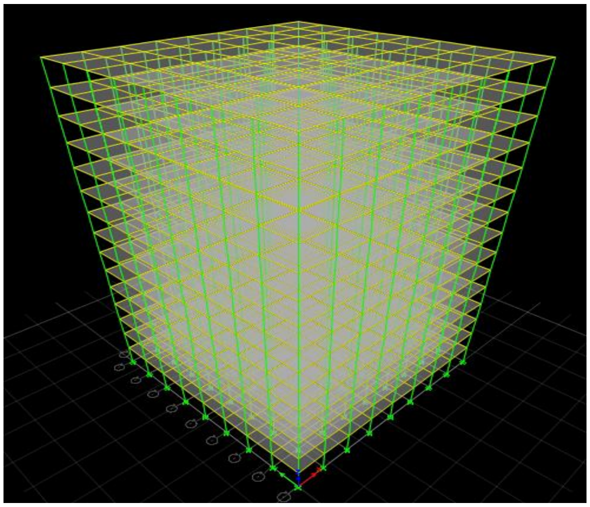

**Fig. 3.3: 3D view of model with no shear wall**

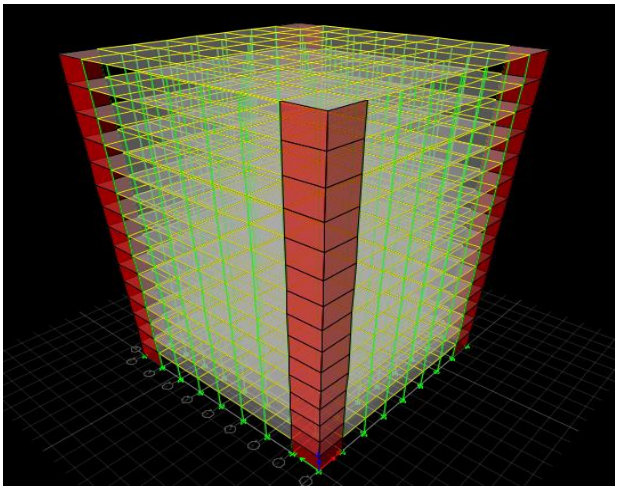

**Fig. 3.4: 3D view of model with Shear Wall Position-1 (SWP-1)**

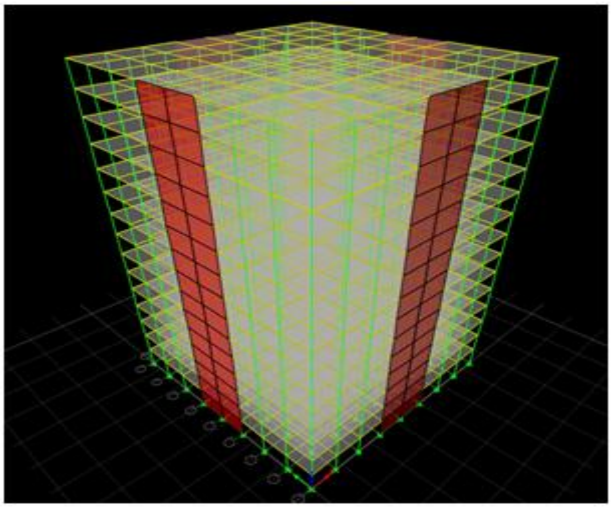

**Fig. 3.5: 3D view of model with Shear Wall Position-2 (SWP-2)**

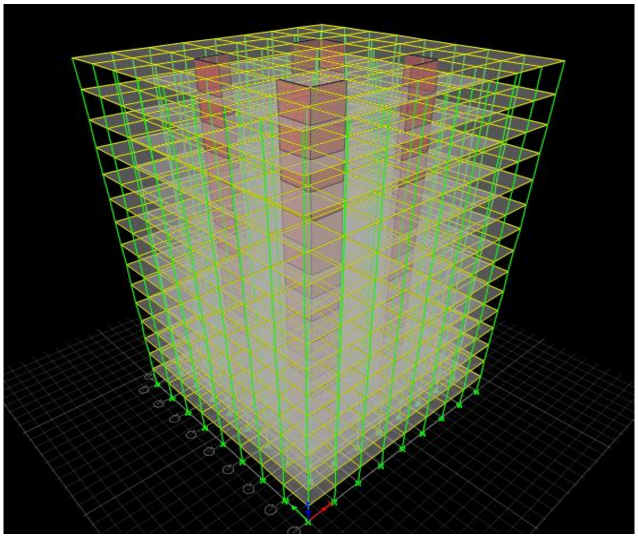

**Fig. 3.6: 3D view of model with Shear Wall Position-3 (SWP-3)**

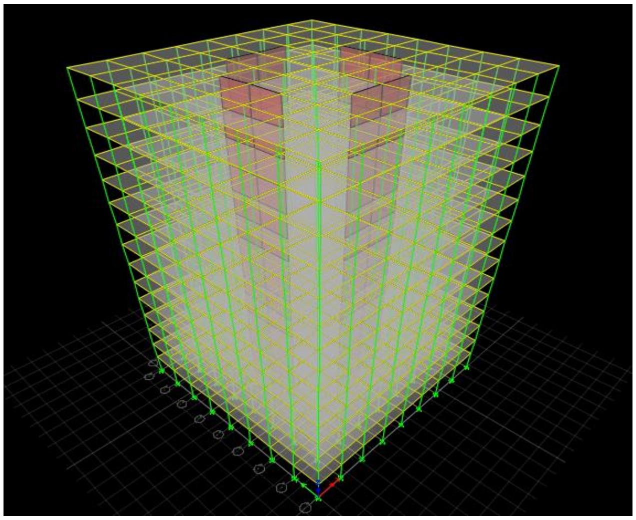

**Fig. 3.7: 3D view of model with Shear Wall Position-4 (SWP-4)**

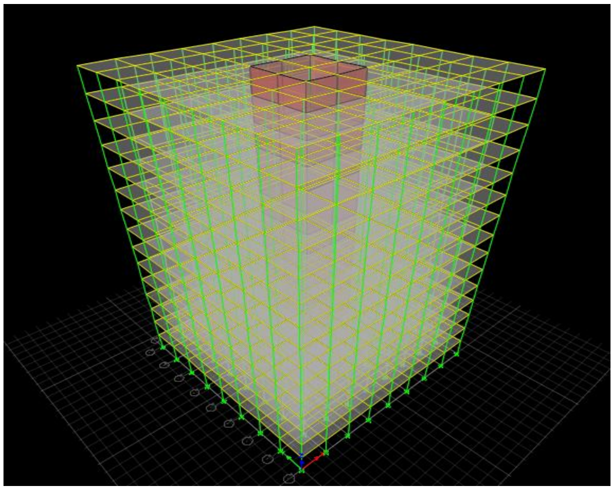

**Fig. 3.8: 3D view of model with Shear Wall Position-5 (SWP-5)**

**Table 3.1 Material property data**

| | |
|---|---|
| Characteristic strength of concrete, fck | 30 Mpa |
| Modulus of elasticity of concrete, Ec | 27386.13 Mpa |
| Yield strength of Rebar Fy | 500 Mpa |
| Modulus of elasticity of Rebar E | 20000 Mpa |

**Table 3.2 Sectional property data**

| | |
|---|---|
| Dimension of Column | 400 x 400 mm |
| Dimension of Beam | 300 x 400 mm |
| Slab thickness | 120 mm |
| Shear wall thickness | 200 mm |

**Table 3.3 Seismic load data**

| | |
|---|---|
| **Seismic zone** | **IV** |
| **Zone factor** | **0.24** |
| **Importance factor** | **1** |
| **Soil type** | **Medium (Type-II)** |
| **Response reduction factor** | **5** |

**Table 4.5.2 Other load data**

| | |
|---|---|
| Live load on floors | 3 kN/m$^2$ |
| Floor finishes | 1kN/m$^2$ |
| In case of eccentric loading, ratio of load variation | 1: 3 |

## IV. RESULTS & DISCUSSION

### 4.1Torsion

In a structure, moments cannot be avoided, however torsional moments should be eliminated as they cause undesirable responses in the structure. Eccentricity in seismic loading induces torsion. Here the torsion induced in columns is observed and the maximum value of the induced torsion for every model is considered.

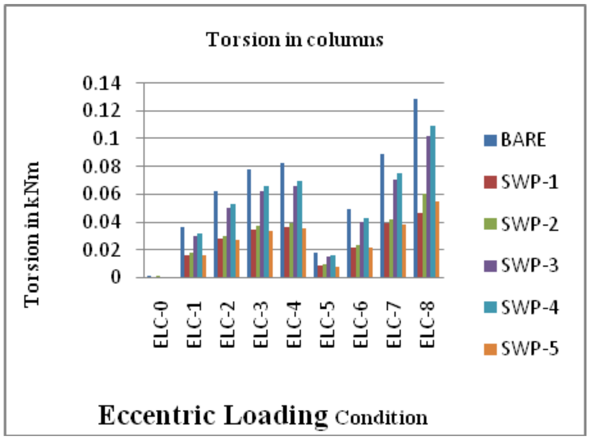


**Fig.4.1.1: Average Torsion in Column along Y direction by equivalent static method**

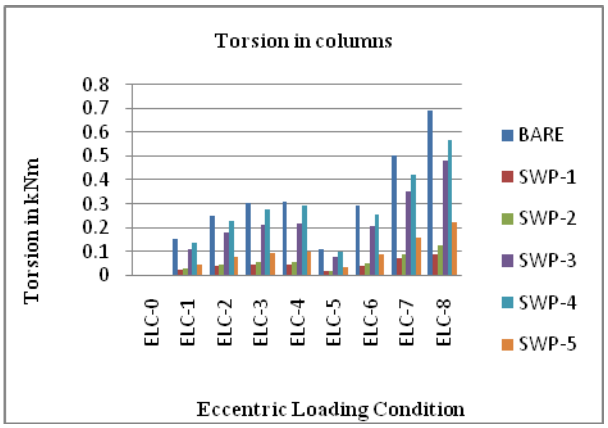


**Fig. 4.1.2: Average Torsion in Column along Y direction by response spectrum method**

**4.2 Top storey displacement**

The movement of storeys from their original position in lateral directions with respect to its base is termed as storey displacement, here the displacement values of the top most storeys are considered, the value of displacement goes on increasing as we go to the higher storeys therefore the top most storey has the maximum value of displacement.

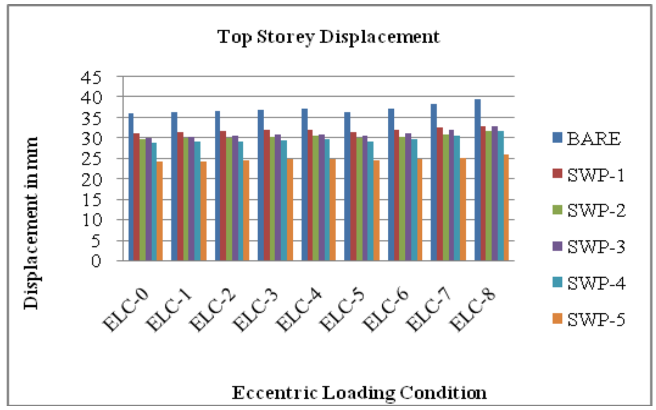


**Fig. 4.2.1: Top Storey Displacement along Y direction by equivalent static method**

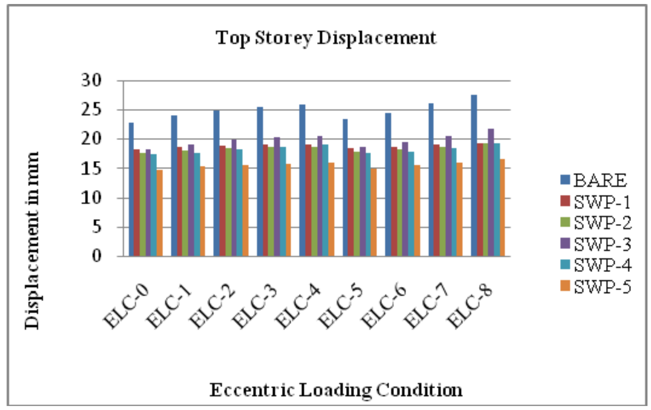


**Fig. 4.2.2: Top Storey Displacement along Y direction by response spectrum method**

**4.3 Storey Drift**

It is the displacement of one storey level relative to the other storey level above or below, the drift in a storey is computed as the difference of deflections of the floors at the top and bottom of the story under consideration. The storey drift increases as the height of the building increases and the value of drift reduces for the top most storey.

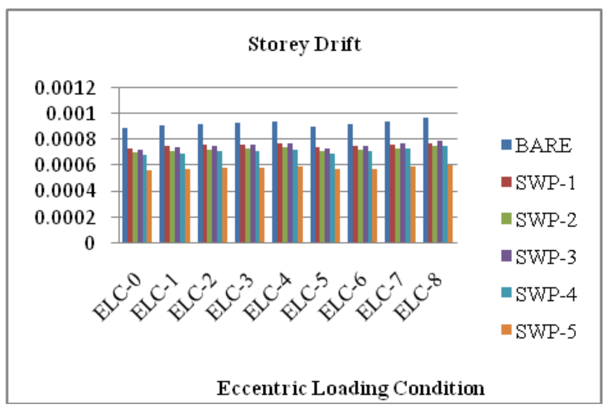


**Fig. 4.3.1: Max Storey Drift along Y direction by equivalent static method**

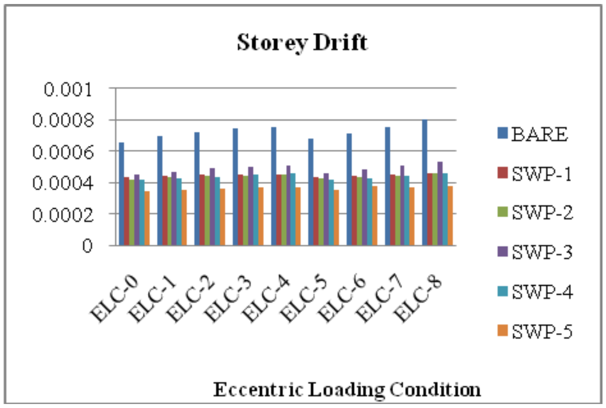


**Fig. 4.3.2: Max Storey Drift values along Y direction by response spectrum method**

### 4.4 Base Shear

Base shear is the estimated maximum expected lateral force which occurs during seismic ground motion at the base of the structure. The design base shear is computed based on the estimated fundamental period of vibration of the structure, here the maximum base shear is considered for all the models and compared with respect to the bare frame model in order to know the percentage increase in base shear after provision of shear wall.

**Table 4.4.1: Percentage increase in Base Shear along Y direction by equivalent static method**

| % INCREASE IN BASE SHEAR | | | | | |
|---|---|---|---|---|---|
| MODEL | SWP-1 | SWP-2 | SWP-3 | SWP-4 | SWP-5 |
| ELC-0 | 143.716 | 145.9054 | 139.4715 | 149.563 | 187.283 |
| ELC-1 | 143.5991 | 145.8108 | 139.3853 | 149.4642 | 187.1349 |
| ELC-2 | 143.4835 | 145.719 | 139.2998 | 149.3662 | 186.9881 |
| ELC-3 | 143.3703 | 145.6267 | 139.2158 | 149.2678 | 186.8437 |
| ELC-4 | 143.2591 | 145.5362 | 139.1331 | 149.1751 | 186.7013 |
| ELC-5 | 143.6986 | 145.9005 | 139.4226 | 149.5643 | 187.246 |
| ELC-6 | 143.4914 | 145.7093 | 135.7061 | 149.4138 | 186.8748 |
| ELC-7 | 143.2146 | 145.4322 | 139.2109 | 149.2651 | 186.2738 |
| ELC-8 | 141.8599 | 144.949 | 139.0698 | 149.1014 | 186.5796 |

**Table 4.4.2: Percentage increase in Base Shear along Y direction by response spectrum method**

| % INCREASE IN BASE SHEAR | | | | | |
|---|---|---|---|---|---|
| MODEL | SWP-1 | SWP-2 | SWP-3 | SWP-4 | SWP-5 |
| ELC-0 | 143.9164 | 146.3136 | 139.7986 | 150.0491 | 188.3798 |
| ELC-1 | 143.4365 | 145.8503 | 139.7423 | 149.5668 | 188.0015 |
| ELC-2 | 142.7043 | 145.1603 | 142.009 | 149.6482 | 187.4792 |
| ELC-3 | 142.1899 | 144.6736 | 139.6867 | 150.0506 | 187.1738 |
| ELC-4 | 142.0354 | 144.5423 | 139.6021 | 150.3919 | 187.1203 |
| ELC-5 | 143.8565 | 146.24 | 139.7571 | 149.9957 | 188.3036 |
| ELC-6 | 143.7281 | 146.1532 | 139.6697 | 149.8999 | 188.1616 |
| ELC-7 | 143.5398 | 144.7583 | 139.5367 | 149.7393 | 187.9513 |
| ELC-8 | 142.2356 | 145.8081 | 139.3756 | 149.5423 | 187.6924 |

## V. CONCLUSION

In the present study the model is analysed by linear static and linear dynamic method and considering the parameters such as torsion, top storey displacement, storey drift, base shear. The following conclusions are drawn.

- From the results considered from various models it is observed that providing shear walls to the structure increases the performance of the structure significantly, and provides lateral stability.
- It is observed that with increase in intensity of eccentric loading the torsion in the columns increases significantly, when shear wall is provided at SWP-5 the torsion is reduced to great extent also SWP-1 and SWP-2 are proven to give good results.
- The displacement is maximum for top storey in all the structures and it is seen to be maximum for structures without shear wall, considering results from equivalent static method and response spectrum method the effective shear wall position is SWP-5.
- The storey drift values are also seen to be maximum for bare frame structures and the values are least when shear wall is provided at SWP-5.
- Base shear increases significantly when the shear wall is provided at SWP-5.
- The models with SWP-4 and SWP-2 also provide results with reduced displacement, storey drift, and significant increase in base shear values.
- As in SWP-5 the shear wall is located at the core as box type, which is not much preferable the next best option would be to place shear wall at SWP-4 or SWP-2 both have little variation in there results.
- Considering results of both equivalent static method and response spectrum method of analysis the results

obtained from response spectrum method are less in values as compared to equivalent static method of analysis except for torsional values.

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