Evaluation of effective location and thickness of shear wall on performance of multi-storey building subjected to lateral load

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Abstract. The aim of the present study is to identify the optimum thickness of the shear divider and suitable position of shear divider in the structure. In this present study G+20 storeys building is considered which is positioned in a zone IV with soil type as medium. The linear static analysis method is used for analysis by using etabs 2016 software. We have considered four different thickness of shear wall such as 150mm, 175mm, 200mm and 225mm and again considered the three different position in the buildings such as shear divider at corner, shear divider at mid span of the structure and core divider at center of the structure. The parameters considered are storey dislocation, storey drift, Overturning moment, base shear and modal time period.

1. Introduction

Shear partition might be characterized as auxiliary elements, which gives stability, strength and stiffness against transverse loads determining strength and stiffness mainly in the shape in many instances, elevated structures are planned as a surrounded structure with shear dividers that can successfully resist horizontal forces. Transverse forces generated either because of wind blowing against the structure or because of the latency powers initiated by ground shaking will, in general snap the structure in shear and push it over in twisting. This sort of forces can be opposed by the utilization of a shear divider framework which is one of the most productive techniques for guaranteeing the transverse firmness of tall structures. These dividers for the most parts start at foundation level and are unceasing throughout the structures altitude. Their thickness can be as low as 150mm, or as high as 400mm in tall structures. Shear dividers are typically given along both length and width of structure. Shear dividers resemble vertically-oriented wide beams that convey earthquake heaps downwards to the foundation. Shear dividers in high seismic areas require superior descriptions.

The utilization of shear divider structure has acquired reputation in elevated structure, particularly in the creation of administration apartment or office/ business tower. It has been demonstrated that this frame work gives effective basic framework to multi-story working in the scope of 30-35 story's (MARSONO & SUBEDI, 2000). Previous 3 decades records of the administration history of tall structure containing shear divider component, none has tumbled during solid breezes and tremors (FINTEL, 1995).
2. Objectives of the Present Study

- To study conduct of shear divider with various thickness.
- To study the ideal position of the shear divider.
- To study the variants of displacement with respect to altered thickness and distinct position of shear dividers.
- To get the most effective structure to oppose the lateral weights.
- To assess the varieties of base shear, Lateral story dislodging, story float, overturning moment, Time period concerning distinctive thickness and diverse position of shear dividers.

3. Methodology

3.1 Building Configurations

The current study is an exertion towards analysing of the structure located on a flat ground during the earthquake. An ordinary moment resisting building of G+20 stories located over a medium soil is considered. The number of bays will be kept as 5 along both direction and the bay size will be kept as 5m with the storey height being 3m. The building will be analysed considering zone IV by response spectra method using ETABS 2016 software.

3-D space frame study will be plotted on four distinct building arrangements resting on flat ground under the stroke of seismic load. The configurations include the thickness of shear wall like 150mm, 175mm, 200mm and 225mm on height building of G+20 storeys. The main frame remains same having constant height, constant area and constant exposures in all sides and materials with same properties are considered for all configurations.

The Various building models considered are
- Model 1: Building with shear divider with thickness 150mm
- Model 2: Building with shear divider at Corner with thickness 150mm
- Model 3: Building with shear divider at Core with thickness 150mm
- Model 4: Building with shear divider with thickness 175mm
- Model 5: Building with shear divider at Corner with thickness 175mm
- Model 6: Building with shear divider at Core with thickness 175mm
- Model 7: Building with shear divider with thickness 200mm
- Model 8: Building with shear divider at Corner with thickness 200mm
- Model 9: Building with shear divider at Core with thickness 200mm
Model 10: Building with shear divider with thickness 225mm
Model 11: Building with shear divider at Corner with thickness 225mm
Model 12: Building with shear divider at Core with thickness 225mm

**figure 2.** Shear divider at the corner of structure

**figure 3.** Shear divider at the Middle of structure
4. Result and Discussion

4.1 Storey Displacement

Table 1. Lateral Storey Displacement along X direction for distinct position of shear divider

| Storey Level | SW at Mid | SW at Corner | SW at Core |
|--------------|-----------|--------------|------------|
| 21           | 59.19     | 52.917       | 77.553     |
| 20           | 56.884    | 50.167       | 75.468     |
| 19           | 54.365    | 47.262       | 72.995     |
| 18           | 51.715    | 44.306       | 70.185     |
| 17           | 48.894    | 41.276       | 67.025     |
| 16           | 45.895    | 38.178       | 63.533     |
| 15           | 42.724    | 35.023       | 59.738     |
| 14           | 39.397    | 31.826       | 55.678     |
| 13           | 35.934    | 28.606       | 51.393     |
| 12           | 32.364    | 25.386       | 46.922     |
| 11           | 28.72     | 22.191       | 42.308     |
| 10           | 25.036    | 19.048       | 37.593     |
| 9            | 21.367    | 16.008       | 32.818     |
| 8            | 17.758    | 13.098       | 28.028     |
| 7            | 14.265    | 10.356       | 23.269     |
| 6            | 10.952    | 7.824        | 18.594     |
| 5            | 7.892     | 5.55         | 14.068     |
| 4            | 5.172     | 3.583        | 9.781      |
| 3            | 2.891     | 1.977        | 5.867      |
| 2            | 1.17      | 0.796        | 2.553      |
| 1            | 0.143     | 0.104        | 0.291      |
| 0            | 0         | 0            | 0          |
Figure 5. Lateral Storey Displacement for distinct position of shear divider

Table 2. Lateral Storey Displacement along Y direction for different position of shear wall

| Storey Level | SW at Mid | SW at Corner | SW at Core |
|--------------|-----------|--------------|------------|
| 21           | 66.501    | 57.691       | 64.437     |
| 20           | 63.663    | 54.516       | 61.392     |
| 19           | 60.65     | 51.228       | 58.195     |
| 18           | 57.505    | 47.888       | 54.898     |
| 17           | 54.195    | 44.486       | 51.474     |
| 16           | 50.713    | 41.028       | 47.922     |
| 15           | 47.065    | 37.528       | 44.251     |
| 14           | 43.266    | 34.002       | 40.477     |
| 13           | 39.341    | 30.471       | 36.623     |
| 12           | 35.32     | 26.96        | 32.717     |
| 11           | 31.239    | 23.495       | 28.796     |
| 10           | 27.136    | 20.103       | 24.893     |
| 9            | 23.072    | 16.84        | 21.064     |
| 8            | 19.097    | 13.732       | 17.353     |
| 7            | 15.272    | 10.818       | 13.815     |
| 6            | 11.667    | 8.142        | 10.511     |
| 5            | 8.362     | 5.751        | 7.509      |
| 4            | 5.446     | 3.695        | 4.883      |
| 3            | 3.024     | 2.029        | 2.718      |
| 2            | 1.217     | 0.813        | 1.107      |
| 1            | 0.156     | 0.11         | 0.149      |
| 0            | 0         | 0            | 0          |
It is observed in all the cases that displacement values are higher in shear divider of 150mm thick with contrast to other changing thickness of shear divider. Nevertheless, as the thickness of shear divider is increased the displacement goes on decreases. The displacement Values in the structure goes on increases from lower storey to the higher storey in the structure. In all the considered models the shear divider placing at the corner is showing the ideal results as compared shear divider at mid span and core divider at the center of the structure.

4.2 Modal Time Period

| Modes | SW at Mid | SW at Corner | SW at Core |
|-------|-----------|--------------|------------|
| 1     | 2.394     | 1.938        | 2.636      |
| 2     | 2.168     | 1.801        | 2.262      |
| 3     | 1.674     | 1.205        | 1.941      |
| 4     | 0.649     | 0.452        | 0.853      |
| 5     | 0.602     | 0.436        | 0.588      |
| 6     | 0.437     | 0.26         | 0.531      |
| 7     | 0.296     | 0.195        | 0.486      |
| 8     | 0.282     | 0.191        | 0.33       |
| 9     | 0.193     | 0.116        | 0.263      |
| 10    | 0.174     | 0.114        | 0.257      |
| 11    | 0.167     | 0.111        | 0.244      |
| 12    | 0.118     | 0.082        | 0.19       |
It observed that modal time period is more 150mm shear divider compare to other shear divider. The thickness of shear divider increases time period goes on decrease. By considering ideal position of shear divider among all the building the shear divider at corner is showing the lesser time period when compare the shear wall at different position.

4.3 Base Shear

| SW at Mid | SW at Corner | SW at Core |
|-----------|--------------|------------|
| 1770.1399 | 2254.1187    | 1948.6351  |

![Base Shear in KN](image)

**Figure 8:** Base Shear for distinct position of shear divider
Table 5. Base shear in KN along Y direction for distinct position of shear divider

| SW at Mid  | SW at Corner | SW at Core  |
|-----------|-------------|-------------|
| 1603.357  | 2095.7283   | 1672.1344   |

![Base Shear in Y Direction](image)

**Figure 9.** Base Shear for different position of shear wall

It can be observed that however the thickness of shear divider increases the base shear values also goes on increases. For variation in thickness of shear divider the values increased about 6%. By comparing different position of the shear divider at the corner is showing higher base shear and shear divider at the middle of the building is showing lesser base shear.

4.4 Storey Drift

Table 6. Storey Drift along X direction for distinct position of shear divider

| Storey Level | SW at Mid | SW at Corner | SW at Core |
|--------------|----------|--------------|------------|
| 21           | 0.000784 | 0.000937     | 0.00089    |
| 20           | 0.00084  | 0.000968     | 0.00094    |
| 19           | 0.000884 | 0.000985     | 0.00094    |
| 18           | 0.00094  | 0.00101      | 0.001053   |
| 17           | 0.001    | 0.001033     | 0.001164   |
| 16           | 0.001057 | 0.001052     | 0.001265   |
| 15           | 0.001109 | 0.001066     | 0.001353   |
| 14           | 0.001154 | 0.001073     | 0.001429   |
| 13           | 0.00119  | 0.001073     | 0.00149    |
| 12           | 0.001215 | 0.001065     | 0.001538   |
| 11           | 0.001228 | 0.001048     | 0.001572   |
| 10           | 0.001223 | 0.001013     | 0.001591   |
| 9            | 0.001203 | 0.00097      | 0.001597   |
| 8            | 0.001164 | 0.000914     | 0.001586   |
| 7            | 0.001104 | 0.000844     | 0.001558   |
| 6            | 0.00102  | 0.000758     | 0.001509   |
### Table 7. Storey Drift along Y direction for distinct position of shear wall

| Storey Level | SW at Mid | SW at Corner | SW at Core |
|--------------|-----------|--------------|------------|
| 21           | 0.000784  | 0.000937     | 0.00089    |
| 20           | 0.00084   | 0.000968     | 0.00094    |
| 19           | 0.000884  | 0.000985     | 0.00094    |
| 18           | 0.00094   | 0.00101      | 0.001053   |
| 17           | 0.001     | 0.001033     | 0.001164   |
| 16           | 0.001057  | 0.001052     | 0.001265   |
| 15           | 0.001109  | 0.001066     | 0.001353   |
| 14           | 0.001154  | 0.001073     | 0.001429   |
| 13           | 0.00119   | 0.001073     | 0.00149    |
| 12           | 0.001215  | 0.001065     | 0.001538   |
| 11           | 0.001228  | 0.001048     | 0.001572   |
| 10           | 0.001223  | 0.001013     | 0.001591   |
| 9            | 0.001203  | 0.00097      | 0.001597   |
| 8            | 0.001164  | 0.000914     | 0.001586   |
| 7            | 0.001104  | 0.000844     | 0.001558   |
| 6            | 0.00102   | 0.000758     | 0.001509   |
| 5            | 0.000907  | 0.000656     | 0.001429   |
| 4            | 0.00076   | 0.000535     | 0.001304   |
| 3            | 0.000574  | 0.000394     | 0.001105   |
| 2            | 0.000342  | 0.000231     | 0.000754   |
| 1            | 0.000119  | 8.70E-05     | 0.000243   |
| 0            | 0         | 0            | 0          |

**Figure 10.** Storey Drift along X direction for distinct position of shear wall
It can be observed that drift values are more or less similar in all the models. In G+20 storied building storeys drift is gradually increasing from base to storey 11 and decreases higher storeys. By considering the distinct position of shear divider the shear divider at the corner is showing the lesser value when compare to the other two position of shear divider and the core wall at the center of the building is showing higher inert storey drift.

4.5 Overturning Moment

### Table 8. Overturning in KN for different position of shear wall

| Storey Level | SW at Mid | SW at Corner | SW at Core |
|--------------|-----------|--------------|------------|
| 21           | 0         | 0            | 0          |
| 20           | 666.5848  | 830.0159     | 738.16     |
| 19           | 1998.9321 | 2510.5213    | 2208.5908  |
| 18           | 3930.1756 | 4956.0966    | 4337.7461  |
| 17           | 6396.9868 | 8085.842     | 7055.9712  |
| 16           | 9339.575  | 11823.3769   | 10297.5026 |
| 15           | 12701.6878| 16096.8404   | 14000.468  |
| 14           | 16430.6103| 20838.8913   | 18106.8867 |
| 13           | 20477.1657| 25986.7076   | 22562.6692 |
| 12           | 24795.7151| 31481.9871   | 27317.6172 |
| 11           | 29344.1574| 37270.9473   | 32325.4239 |
| 10           | 34083.9294| 43304.3249   | 37543.6738 |
| 9            | 38980.006 | 49537.3764   | 42933.8428 |
| 8            | 44000.8997| 55929.8777   | 48461.2979 |
| 7            | 49118.6613| 62446.1243   | 54095.2977 |
| 6            | 54308.8791| 69054.9315   | 59808.992  |
| Layer | Moment in KN.m |
|-------|---------------|
| 5     | 59550.6795    |
| 4     | 64826.7268    |
| 3     | 70123.2232    |
| 2     | 75429.9087    |
| 1     | 80740.0614    |
| 0     | 82864.2292    |

5. Conclusion

Conclusion

- It can be presumed that 150mm shear divider thickness will be adequate in the event of the low ascent to medium ascent building, which offers great cost benefit.
- In instance of Zone-V just 150mm thickness offers more safety and cost-effective thickness.
- It can be presumed that as thickness of shear divider increases the displacement diminishes.
- It can infer that, increasing the shear divider thickness the timeframe goes on diminishes.
- It can presume that increasing the thickness of shear results in increased base shear.
- In all the considered models the shear divider setting at the corner is indicating ideal situation for the shear divider in all the boundaries of the investigation.
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