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EVALUATION OF SEISMIC RESPONSE OF AN VERTICALLY IRREGULAR BUILDING WITH SOFT STOREY

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Abstract: Due to urbanisation and space occupancy issues, soft storey architecture is a common characteristic in high rise buildings or multi-story buildings. Due to their soft storeys, these measures cause the lateral load resisting system's stiffness to decrease, making a progressive collapse in a powerful earthquake inevitable for such structures. Damage and collapse are frequently seen in soft story buildings during earthquakes because this storey level contains concrete columns that were unable to offer appropriate shear resistance. The current study is primarily concerned with examining how a soft storey affects a structure's behaviour. The current work uses dynamic analysis to examine several positions for a soft storey within a multi-story building. In a multi-story building with lateral loads from an earthquake, the building's performance is assessed at various levels by taking into account the bare frame, bracings, shear walls, and composite column. The response spectrum analysis techniques described in the code practice are used to evaluate the lateral load analysis caused by seismic action. ETABS software is used to carry out these structural analyses. To evaluate the performance of the soft storey in the multi-story building, ETABS software is used to track variables such storey displacement, storey drift, storey shear, and time period. The study is carried out by considering a G+15 RC multistoried building. Ultimately, based on the findings, recommendations are made regarding the suitability of various configuration.

Keywords: ETABS, storey shear, time period, storey displacement, soft storey.

I. INTRODUCTION

One of the primary drivers of tall building development in India's major cities is the country's rapid population increase. Additionally, it is what has led to the nation's progress. In multi-story structures, soft story is offered based on the requirements of the building's inhabitants. For instance, offering parking in the basement or on the floors with commercial uses. If a storey is less rigid than the storey directly above it by 70% or less rigid by 80% than the typical three stories above it, it is said to be a "soft story”. Due to this storey's lower stiffness, columns are required to counteract lateral earthquake stresses. If these columns are insufficient, the structure will sustain significant damage or collapse.

II. METHODOLOGY

The models were modelled using Etabs software. The buildings consist of 4bays of 5m each in both directions. The height of the building is 47.5m. The loads imposed are: Live Load= 3kN/m, Super dead load= 1.5kN/m. Beam size: 230x450mm; Column size:600x600mm, 750x750mm.

The analysis encompassed all 13 models, involving a comprehensive evaluation of software-generated outcomes in terms of parametric values such as Storey Displacement, Storey Drift, Storey Shear and Time Period. A comparison between bare frame and all the soft storey models were also done.

Results for the maximum Storey Displacement, Storey Drift, and Storey Shear were produced using the ETABS software. The codal provisions described below were used to collect the Time Period values.

The response spectrum approach was used to conduct the seismic study in accordance with IS:1893(Part 1):2016. Seismic Zone (V), Zone Factor of 0.36, Importance Factor of 1, 5% dampening, and a Response Reduction Factor of 5.0 were the seismic parameters used. All building layouts were thought to use a unique moment-resisting frame. Following the computation of the member forces resulting from dynamic loading for each contributing mode, the combination of modal responses were calculated using the CQC approach. The buildings were equipped with shear wall, bracing and composite column and their performance was evaluated.

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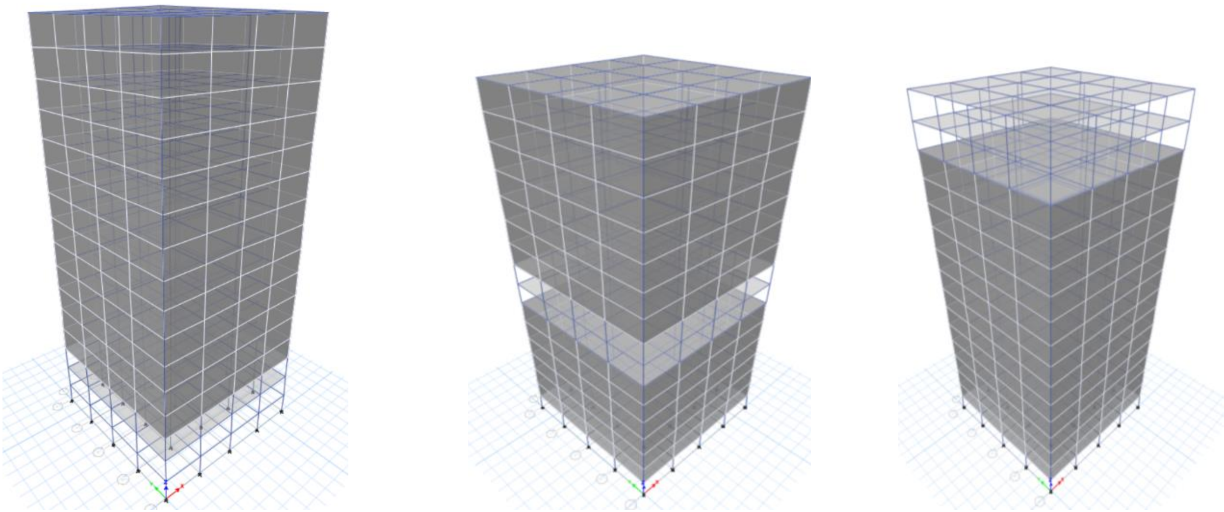

Figure 1: multiple soft storey at bottom(gf and 2nd floor),middle(7th and 8th floor) and top(14th and 15th floor).

III. RESULTS AND DISCUSSIONS

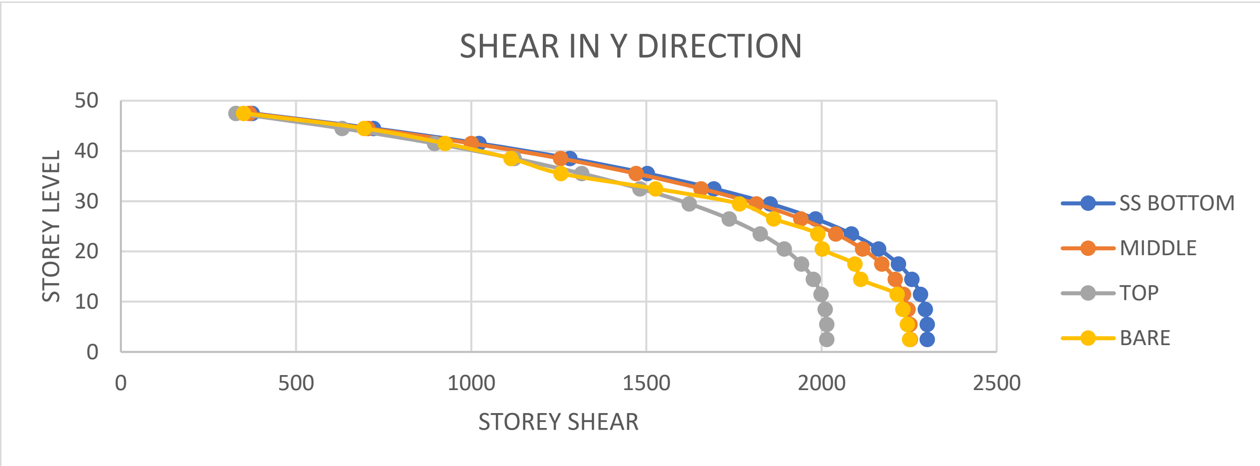

Figure 2: Storey shear comparison

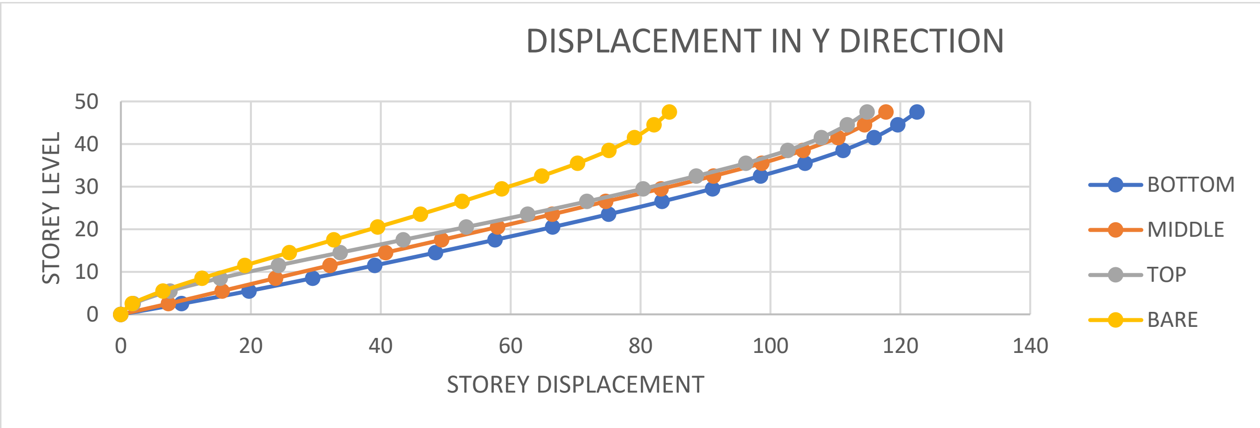

Figure 3: Storey displacement comparison

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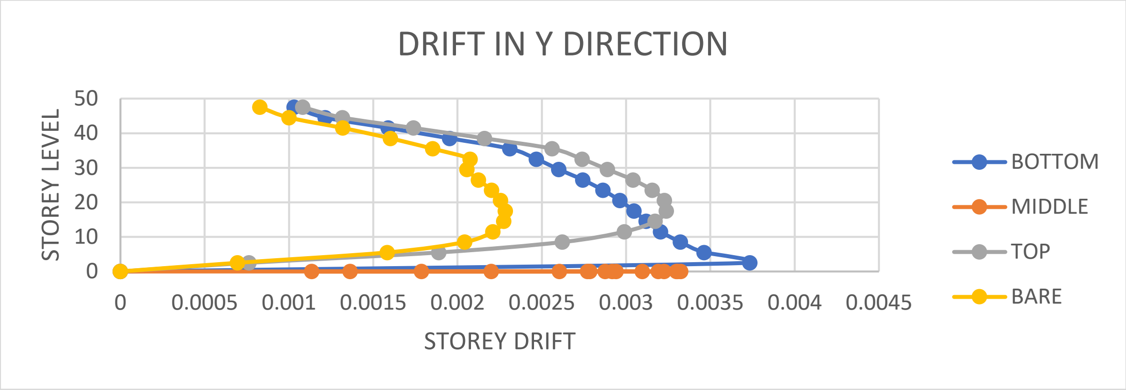

Figure 4: Storey drift comparison

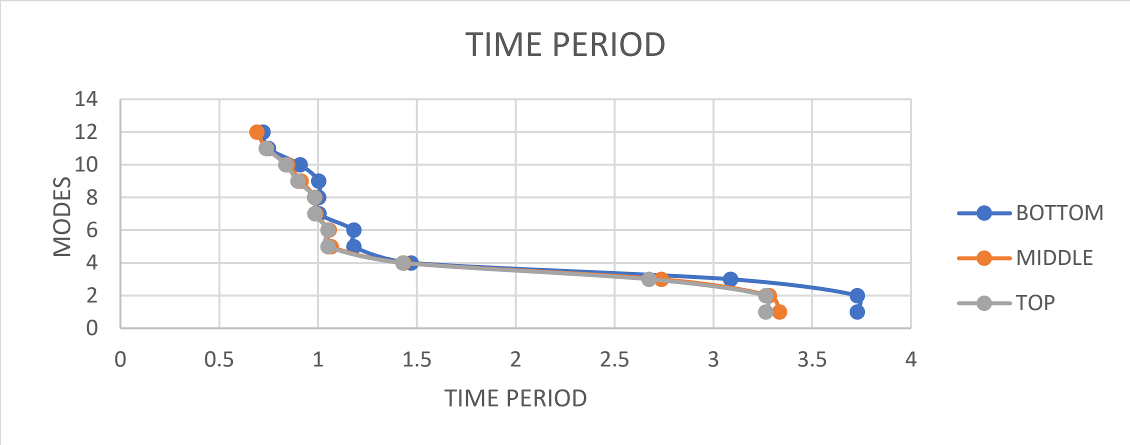

Figure 5: time period comparison

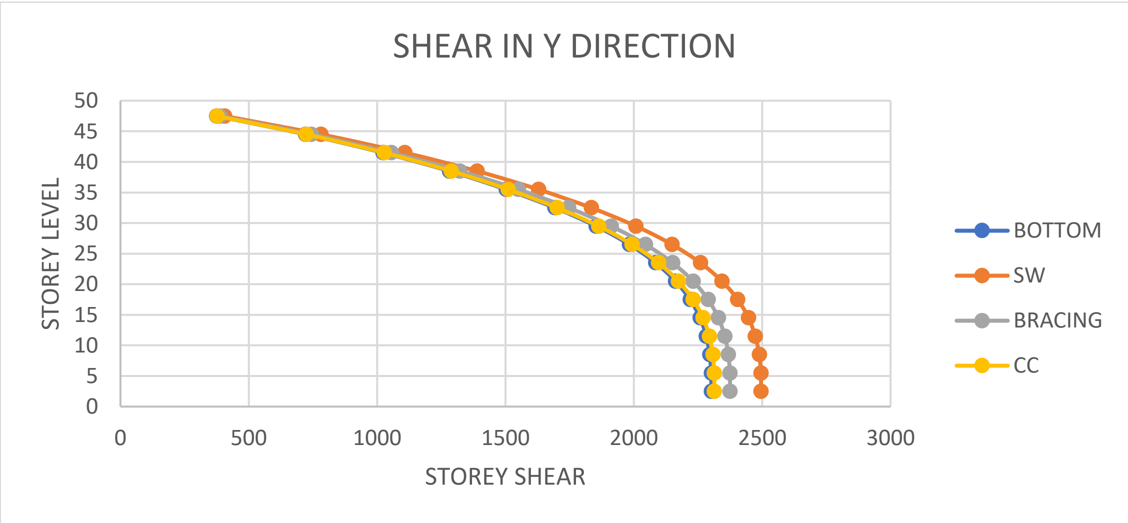

Figure 6: shear comparison when bottom soft stories are equipped with bracing, shear wall and composite column.

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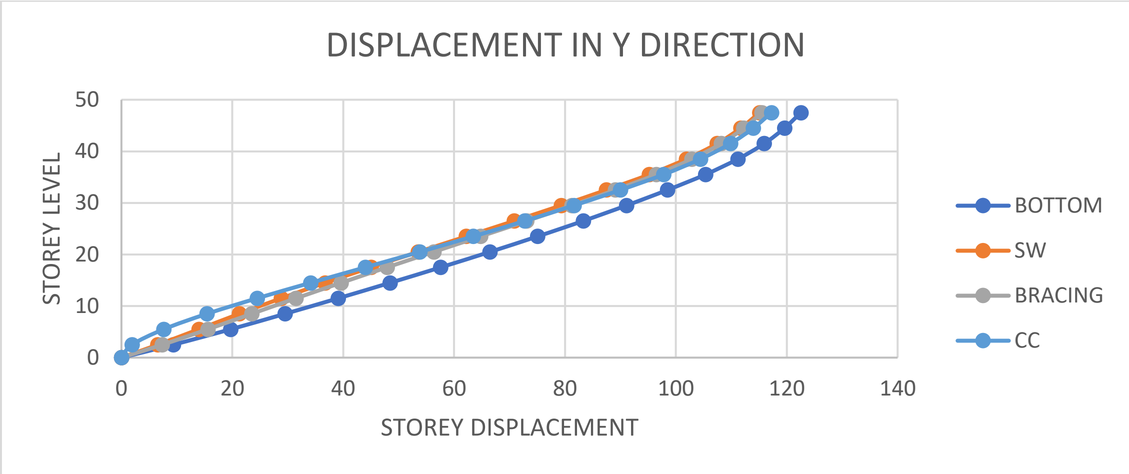

Figure 7: displacement comparison when bottom soft stories are equipped with bracing, shear wall and composite column.

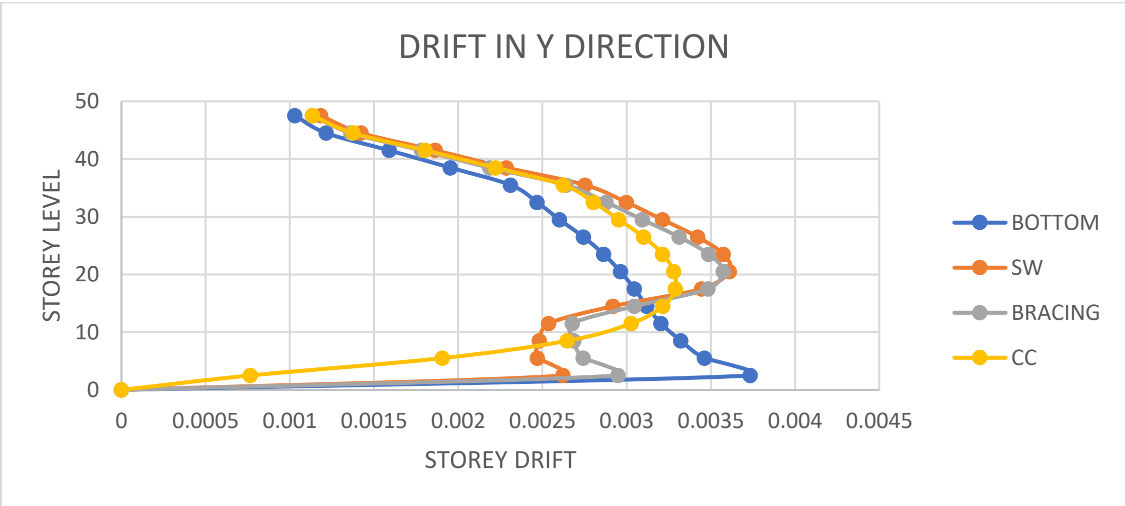

Figure 8: storey drift comparison when bottom soft stories are equipped with bracing, shear wall and composite column.

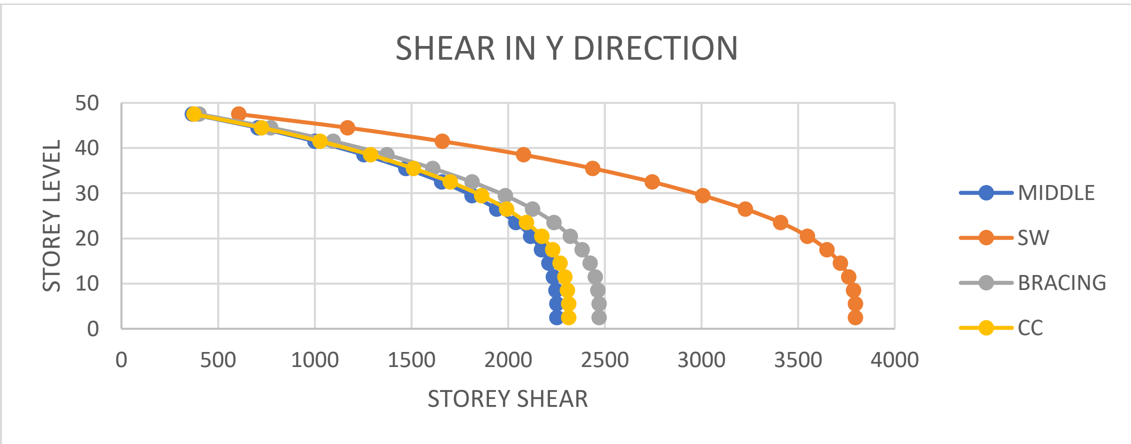

Figure 9: storey shear comparison when middle soft stories are equipped with bracing, shear wall and composite column.

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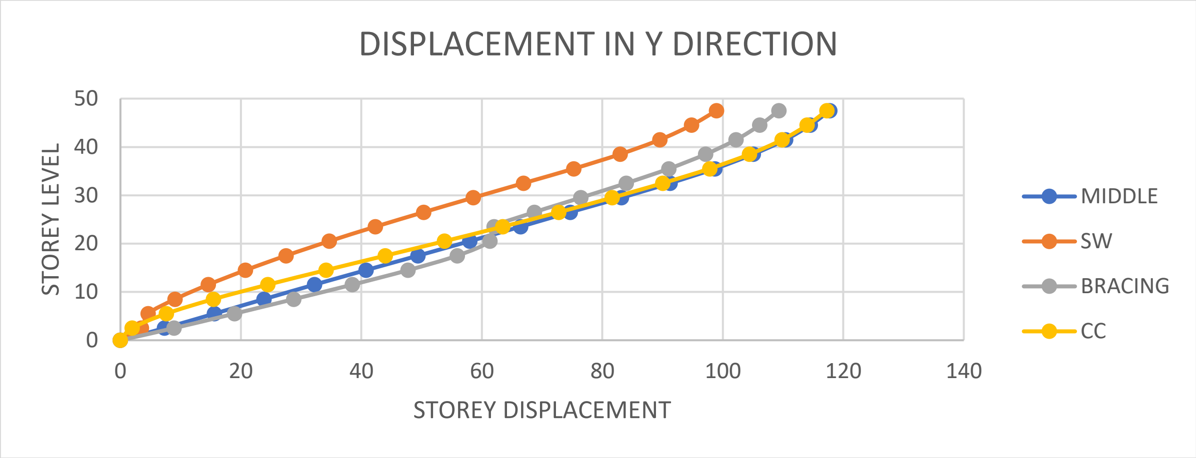

Figure 10: displacement comparison when middle soft stories are equipped with bracing, shear wall and composite column.

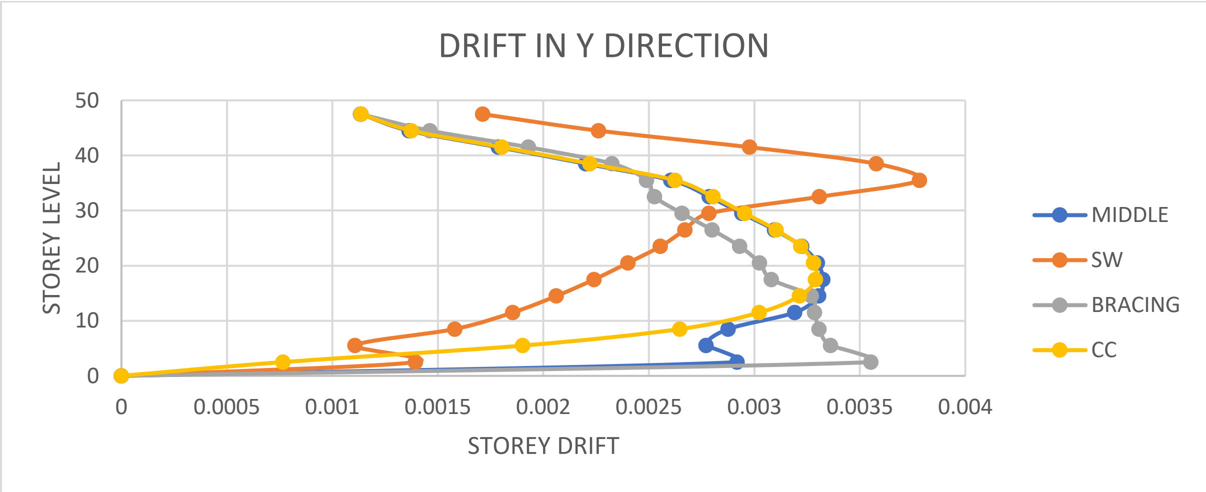

Figure 11: storey drift comparison when middle soft stories are equipped with bracing, shear wall and composite column.

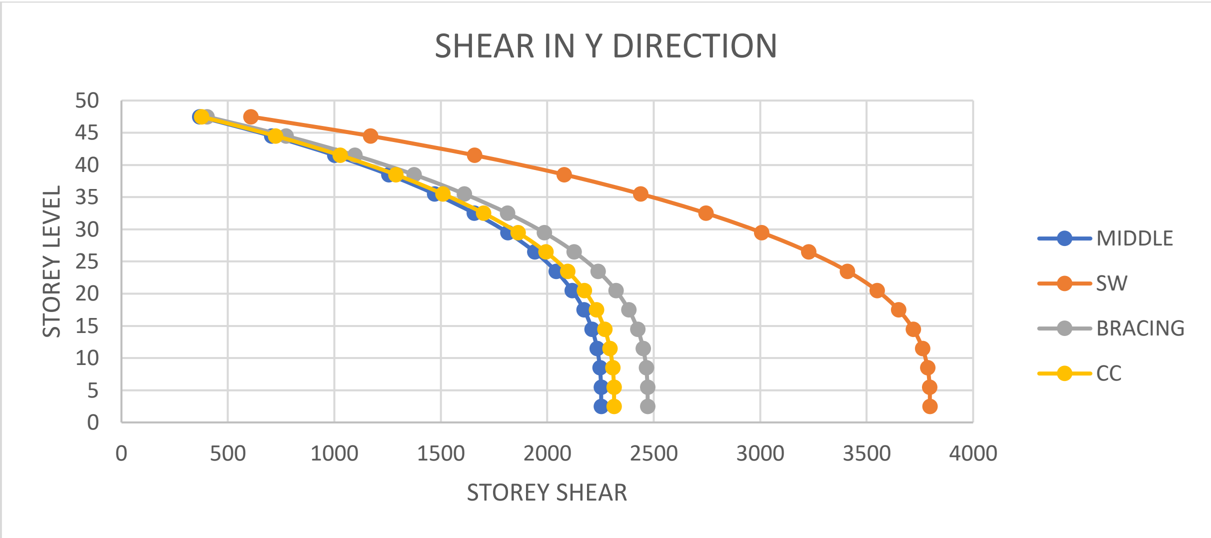

Figure 12: storey shear comparison when top soft stories are equipped with bracing, shear wall and composite column.

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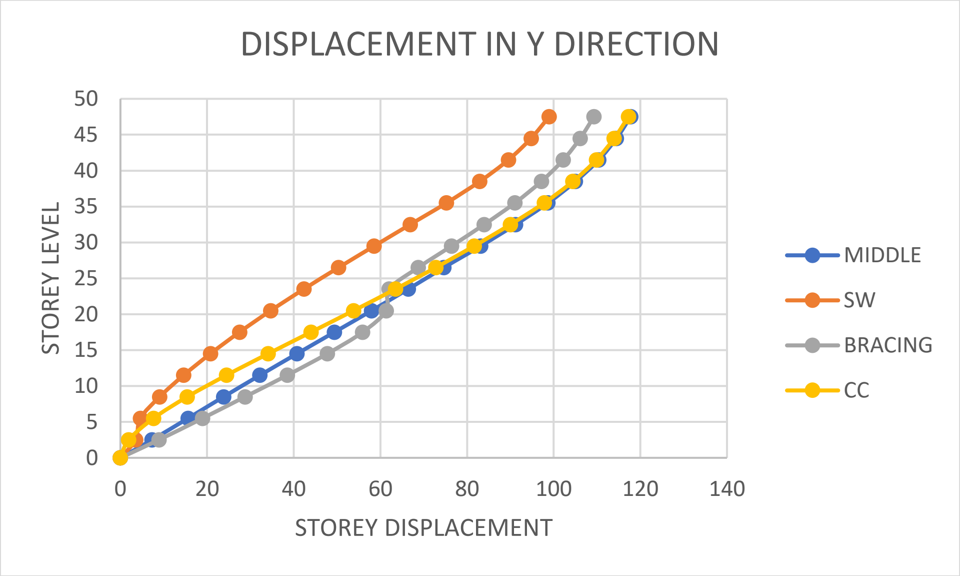

Figure 13: displacement comparison when top soft stories are equipped with bracing, shear wall and composite column.

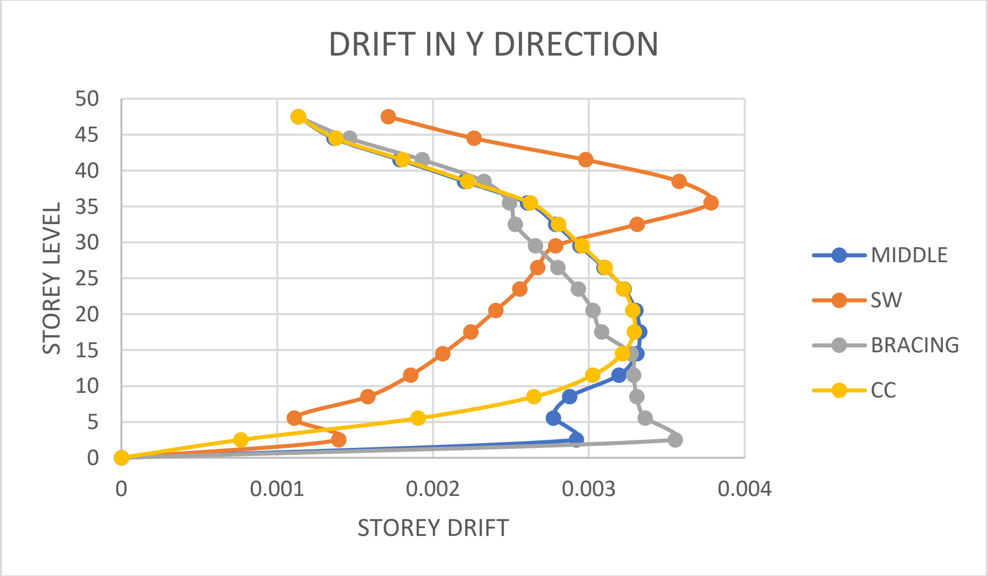

Figure 14: storey drift comparison when top soft stories are equipped with bracing, shear wall and composite column.

From the above graphs the following can be conclusion drawn:

1. Figure 2: Plots of storey shear versus height are made for 4 models. It is observed that model with soft storey at bottom floors (gf and 1st floor) is having more shear when compared to other models. The model with soft stories in the top floor has least shear.

2. Figure 3: Plots of storey displacement versus height are made for 4 models. It is observed that the maximum displacement is at the 15th floor in all the models. For model having soft stories at bottom level the displacement is 19.36% more when compared to soft stories at middle level and 48.18% more when compared to soft stories at top level.

3. Figure 4: The drifts in all model decrease when we go to 15th floor. The model with soft storey at bottom level has more drift when compared to other models. The floor where the soft storey is placed will have more drift indicating that particular storey is more flexible.

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4. Figure 5: The building having soft storey at bottom level has higher time period compared to other models. The time period decreases as we go to upper floors.

5. Figure 6, 7, 8: It is observed that provision of composite column to the bottom soft stories will reduce the storey displacement and storey drift when compared to bracing and shear wall. All 3 mitigation strategy has no effect on storey shear.

6. Figure 9: It is observed that provision of composite column, bracing and shear wall to middle soft stories will not reduce storey shear.

7. Figure 10 and 11: It is observed that provision of shear wall to the middle soft storey will reduce the storey displacement and storey drift when compared to bracing and composite column.

8. Figure12: It is seen that provision of shear wall, bracing and composite column will have no effect on the building.

9. Figure13: It is seen that provision of shear wall will reduce storey displacement. the effect of bracing and composite column is very similar to building having just the soft storey.

10. Figure14: It is observed that all 3 mitigation criteria will have no effect on the building.

IV. CONCLUSIONS

1. Provision of soft storey changes the behaviour of the building with respect to parameters like displacement, drift stiffness and so on compared to conventional buildings.
2. Composite column can be provided to the bottom soft stories as it reduces storey shear, storey displacement and storey drift.
3. The deflection of the building increases by the influence of soft story.
4. RC frame buildings with open first stories are known to perform poorly during strong earthquake.
5. The earthquake reaction is determined to be maximal in the model with soft storey at the ground level and least in the model with soft storey at the top floor in a comparison of single soft storey at various locations in the building. This indicates that the building's ability to respond to earthquakes will be reduced because the top soft story will absorb more energy.
6. The maximum lateral drift value reduces as the soft storey moves to higher floors. To lessen the impact of soft-stories in cases where they are unavoidable, upper floor levels above middle floor heights should be given.

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