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ANALYSIS OF G+6 RC FRAME BUILDING RESTING ON SLOPED GROUND USING SEISMIC RESPONSE METHOD

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Abstract: Structural frameworks constructed on hill slopes exhibit distinct structural characteristics compared to those on flat terrain. Due to their inherent asymmetry, these buildings experience significant shear forces and torsional moments. Additionally, the distribution of these forces is uneven due to variations in column lengths. This research involves the modelling and analysis of two different configurations of hillside buildings using the ETABS software. A parametric investigation was conducted, varying the incline of the hill slope (20° and 25°).

The analytical models were subjected to seismic forces employing the Response Spectrum Method. The resulting dynamic parameters were examined, including fundamental natural periods, maximum storey displacements, storey drifts, and storey shear forces. A comparative analysis was performed between the two considered hillside building configurations- Stepback and Stepback-Setback.

Ultimately, based on the findings, recommendations are made regarding the suitability of various hillside building configurations. The buildings in this study are equipped with shear wall, bracing and a combination of both and their overall performance is thoroughly assessed.

Keywords: sloped terrain, step-back configuration, storey shear, time period, top storey displacement.

I. INTRODUCTION

Addressing the unique challenges associated with constructing on steep slopes necessitates meticulous deliberation regarding the design and erection of buildings within hilly regions. The employment of suitable building materials and construction methodologies plays a pivotal role in mitigating the potential for structural compromise, especially during seismic events.

A strategic approach that has found application in hillside areas involves the implementation of step-back and stepback setback configurations. These configurations contribute to the reduction of torsional moments and concentration of stress that can manifest in asymmetric structures. Moreover, the utilization of reinforced concrete (RC) framing presents an opportunity for heightened structural integrity and resilience in the face of seismic disturbances.[1]

The studies conducted so far, have given the idea about structural behavior of hill buildings but their performance in different configurations has not been assessed scrupulously. Hence, in our research, Stepback and stepback setback configurations are compared for two different hill slopes 20° and 25°.

II. METHODOLOGY

The models were modelled using Etabs software. The buildings consist of 5 bays of 5m each in both directions. The height of the building is 22.5m. The loads imposed are: Live Load= 3kN/m, Super dead load= 1.5kN/m. Beam size: 230x450mm; Column size: 300x600mm, 300x750mm.

The analysis encompassed all 16 models, involving a comprehensive evaluation of software-generated outcomes in terms of parametric values such as Top Storey Displacement, Storey Drift, Storey Shear and Time Period.

The ETABS software yielded results for Top Storey Displacement, Storey Drift, and Storey Shear. The Time Period values were acquired following codal provisions outlined below.

In adherence to IS:1893(Part 1):2016, the seismic analysis was conducted using the response spectrum method. The seismic parameters applied included Seismic Zone (V), Zone Factor of 0.36, Importance Factor of 1, 5% damping, and a Response Reduction Factor of 5.0. It was assumed that all building configurations adopted a special moment resisting frame. The member forces due to dynamic loading for each contributing mode were computed, followed by the combination of modal responses using the CQC method. Results were presented based on a comparative analysis of the two configurations. The buildings were equipped with shear wall, bracing and a combination of shear wall and bracing and their performance was evaluated.

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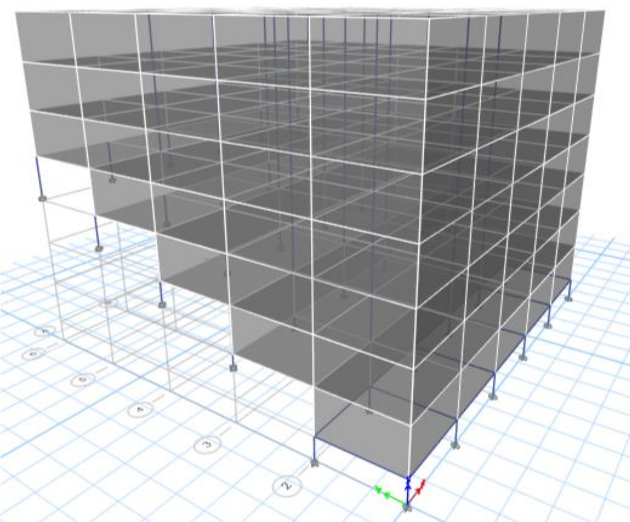

Figure 1: Stepback Building

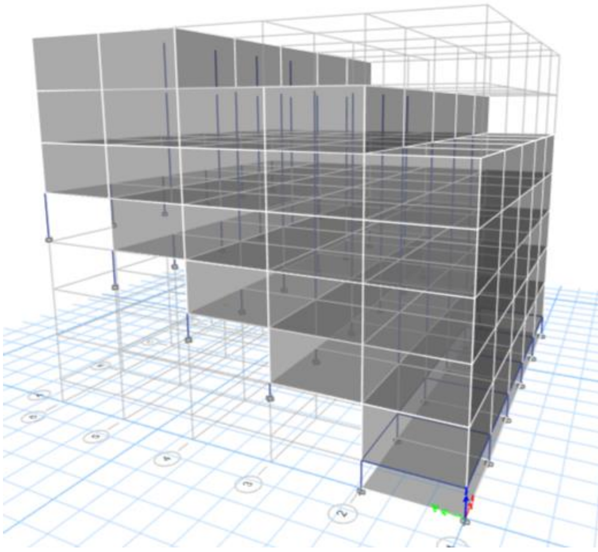

Figure 2: Stepback Setback Building

III. RESULTS AND DISCUSSIONS

Stepback vs Stepback setback: 20°:

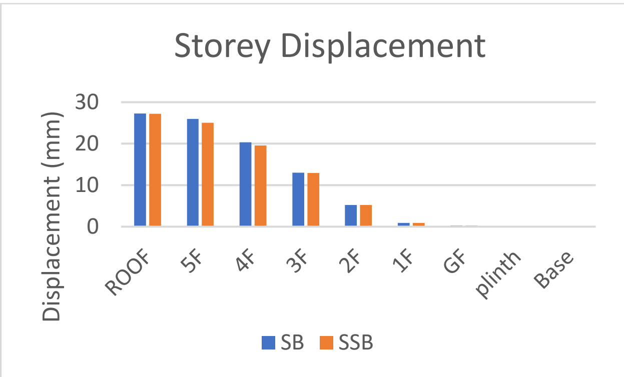

Figure 3: Storey Displacement SB vs SSB 20°

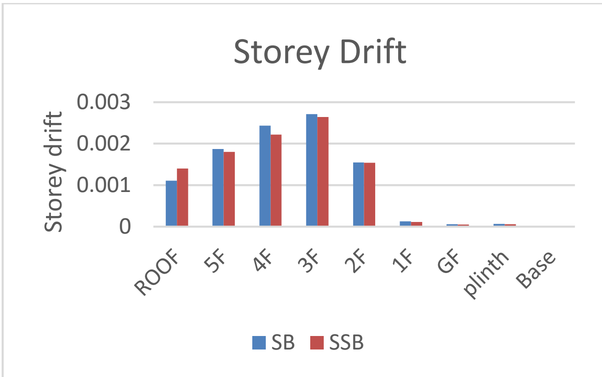

Figure 4: Storey Drift SB vs SSB 20°

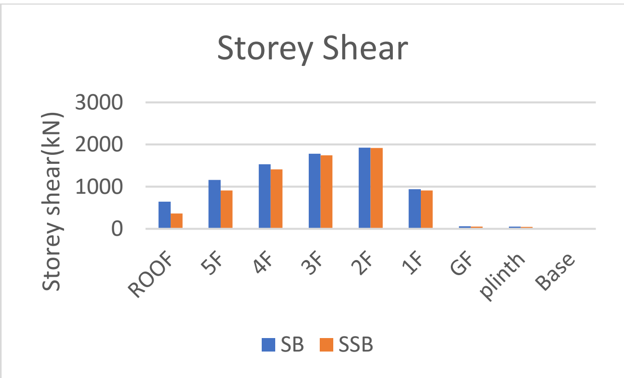

Figure 5: Storey Shear SB vs SSB 20°

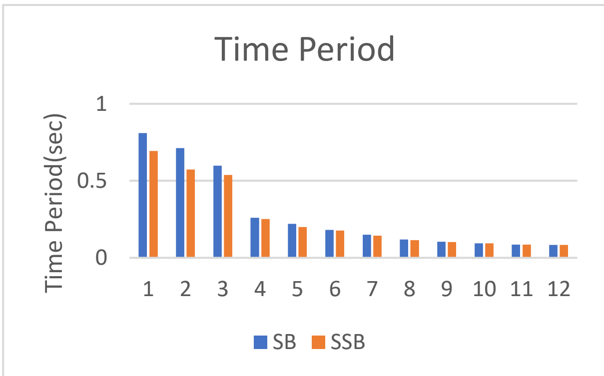

Figure 6: Time Period SB vs SSB 20°

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Stepback vs Stepback Setback 25°:

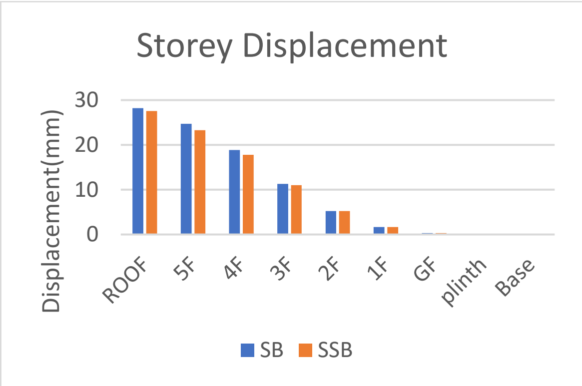

Figure 7: Storey Displacement SB vs SSB 25°

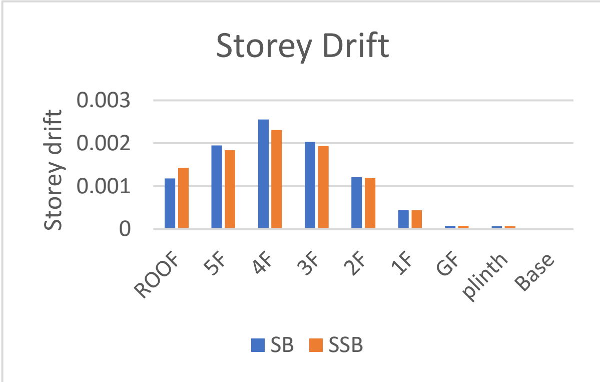

Figure 8: Storey Drift SB vs SSB 20°

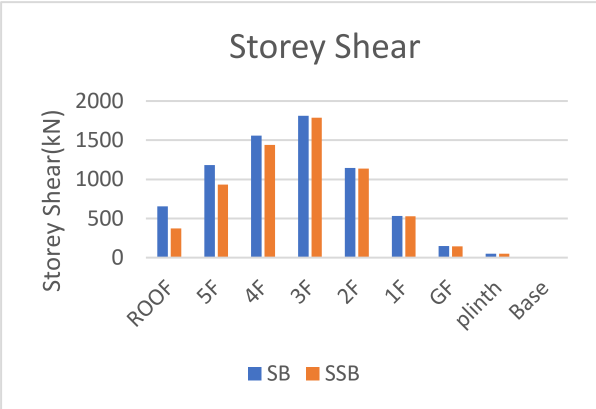

Figure 9: Storey Shear SB vs SSB 25°

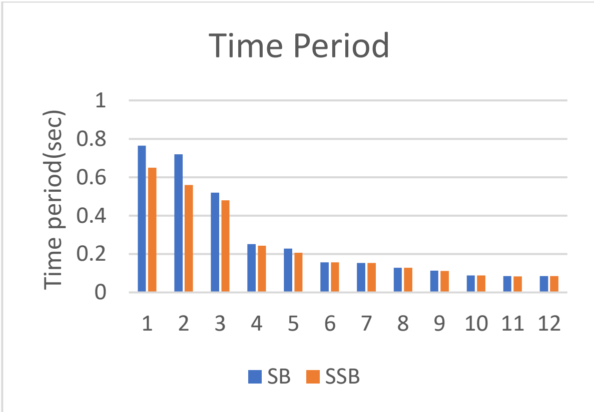

Figure 10: Time Period SB vs SSB 25°

From the above graphs, it can be noted that stepback configuration shows greater storey displacement, drift, storey shear and time period as compared to stepback setback configuration.

Comparison between Regular building vs Shear wall vs Bracing vs Shear wall-bracing combination:

Stepback building at 20°:

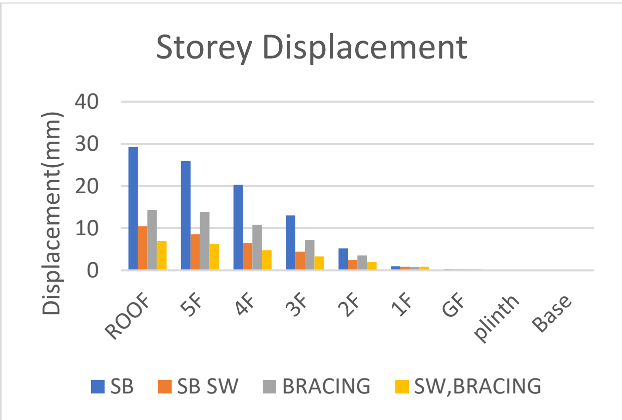

Figure 2: Storey Displacement SB 20°

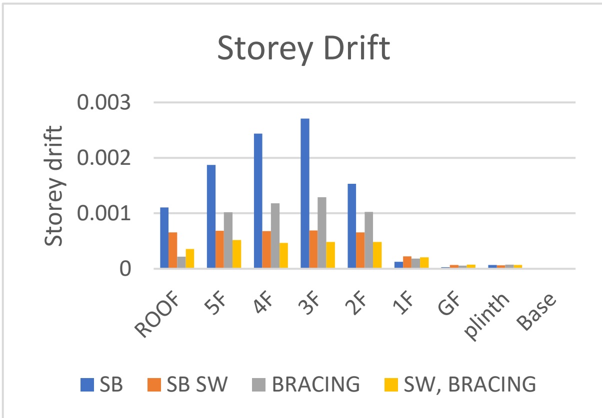

Figure12: Storey Displacement SB 20°

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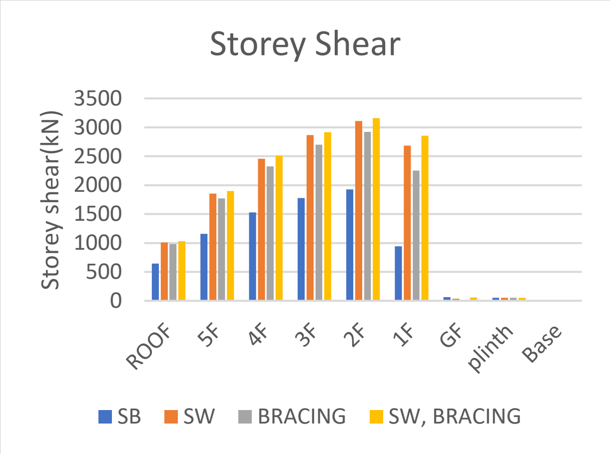

Figure 13: Storey Shear SB 20°

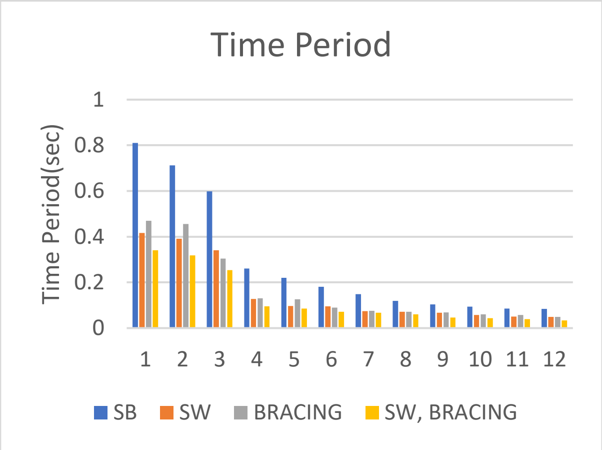

Figure 14: Time Period SB 20°

Stepback Setback building at 20°:

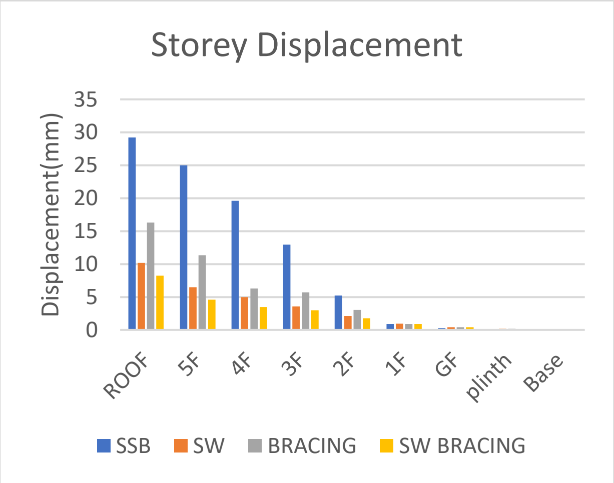

Figure 15: Storey Displacement SSB 20°

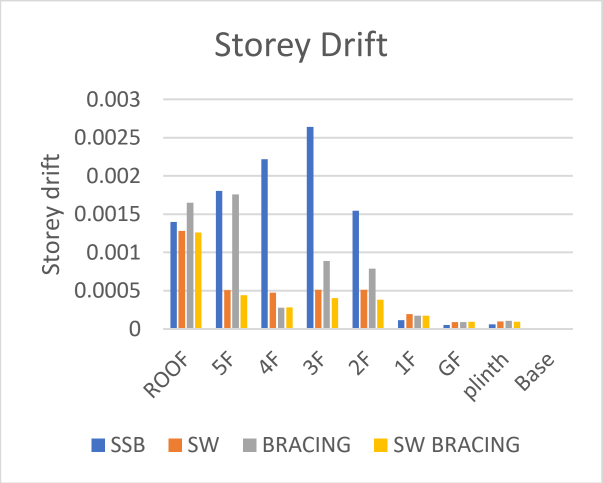

Figure 16: Storey Displacement SSB 20°

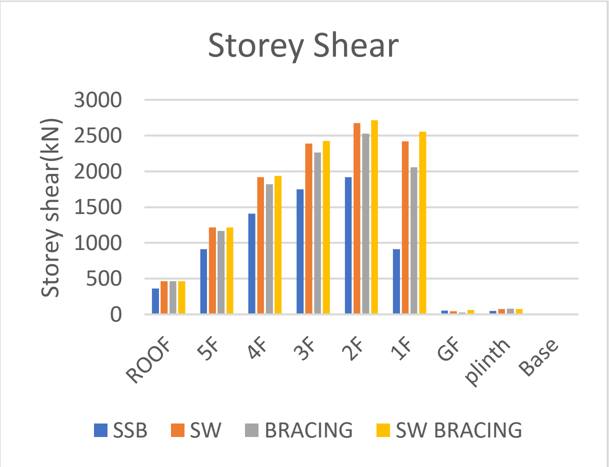

Figure 17: Storey Shear SSB 20°

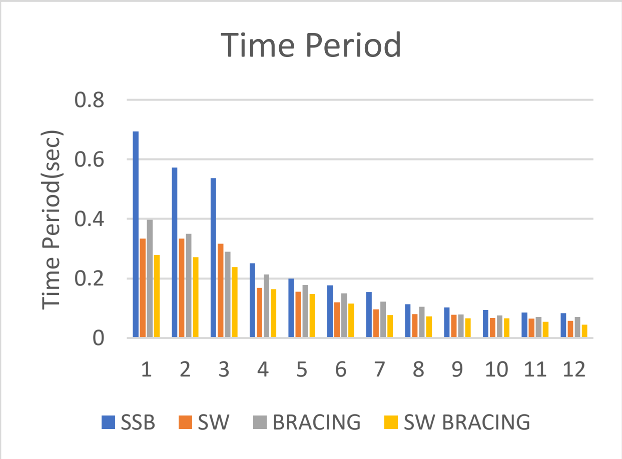

Figure 18: Time Period SSB 20°

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Stepback building at 25°:

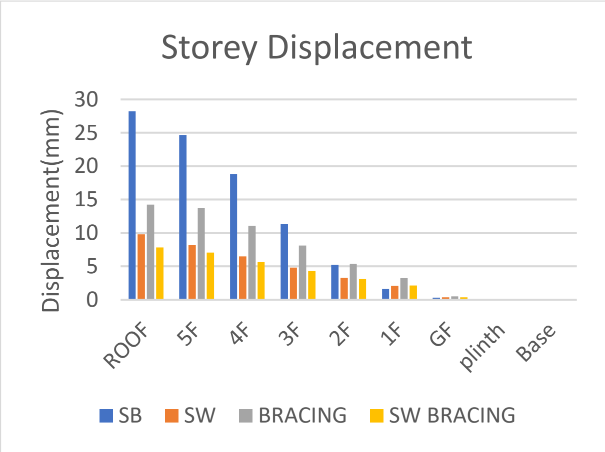

Figure 19: Storey Displacement SB 25°

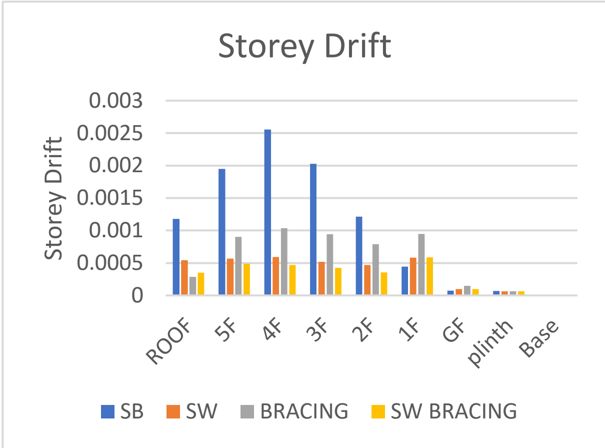

Figure 20: Storey Displacement SB 25°

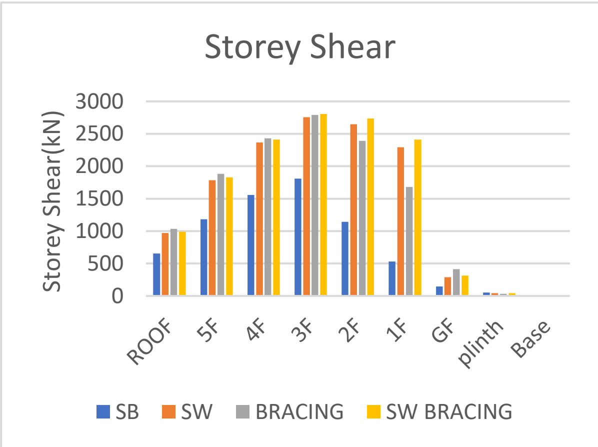

Figure 21: Storey Shear SB 25°

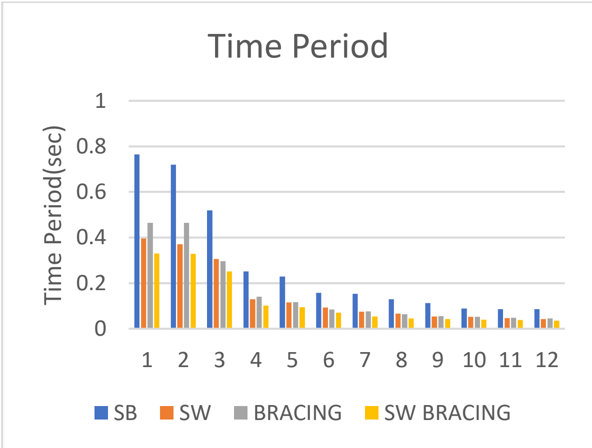

Figure 22: Time Period SB 25°

Stepback Setback building at 25°:

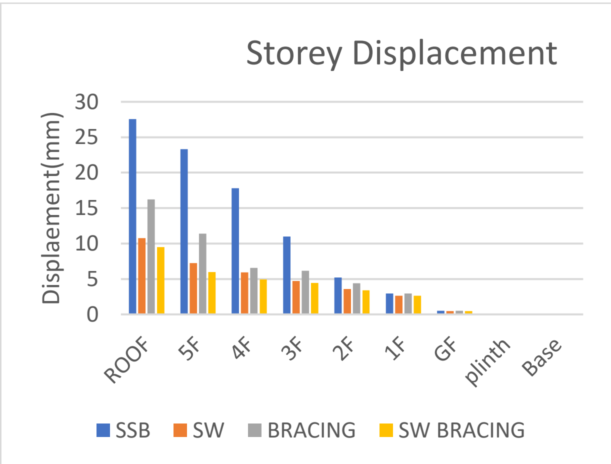

Figure 23: Storey Displacement SSB 25°

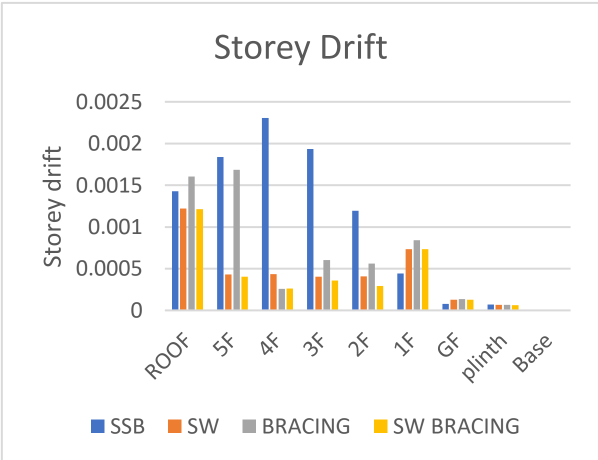

Figure 24: Storey Displacement SSB 25°

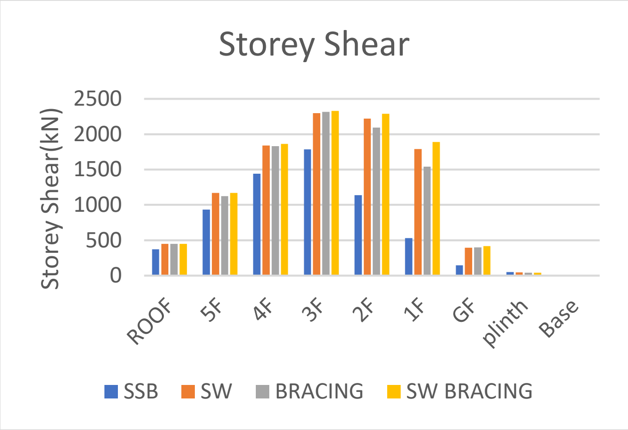

Figure 25: Storey Shear SSB 25°

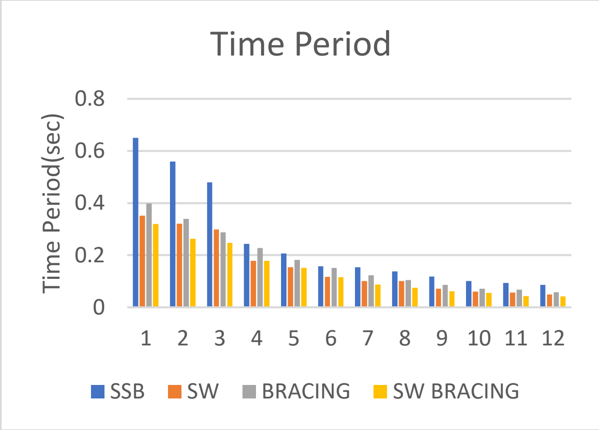

Figure 26: Time Period SSB 25°

From the above graphs, it can be noted that the buildings equipped with a combination of shear wall and bracing perform better than other building configurations.

IV. CONCLUSION

The growing population has resulted in a diminished availability of level ground suitable for construction purposes. Constructing buildings on uneven terrains poses unique challenges, particularly due to their asymmetrical nature. These structures are considerably more susceptible to seismic forces, making them more vulnerable to earthquake damage. Consequently, it is imperative to implement appropriate building configurations tailored to sloped terrains.

In response to this issue, innovative strategies such as the Step-back and Step-back Setback building configurations have been developed. To comprehensively address these considerations, a thorough analysis is conducted using the ETABS software. The results are correlated between both configurations and their performance with provision of shear wall, bracing and a combination of shear wall and bracing is evaluated.

With two angles under consideration- 20° and 25°, the following conclusions can be drawn:

1. The Step-back framework results in increased storey displacement and storey drift values in contrast to the Step-back Setback framework.
2. Step-back approach yields higher storey Shear and time period compared to the Step-back Setback configuration.
3. With increase in the slope the maximum displacement and time period in both configurations increase.
4. For both the Step-back and Step-back Setback frameworks, it's notable that shorter columns experience more pronounced effects. Consequently, designing these short columns demands particular attention.
5. For both the Step-back and Step-back Setback frameworks, it can be noted that the lateral force resisting systems have improved their performance with combination of shear wall and bracing giving the most optimum results.
6. In both configurations around 60% reduction of storey displacement can be observed with provision of shear wall; around 50% reduction with provision of bracing and around 70% reduction with provision of combination of shear wall and bracing.
7. In both configurations around 50% reduction of time period can be observed with provision of shear wall; around 40% reduction with provision of bracing and around 60% reduction with provision of combination of shear wall and bracing.
8. However, in both configurations, the storey shear increases with provision of lateral force resisting systems. This could be due to increase in dead weight of the structure.
9. In conclusion, Stepback setback building configuration performs better on a sloping terrain as compared to stepback building configuration.
10. Lateral force resisting system consisting of both shear wall and bracing gives better performance overall.

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