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Effective Positioning of Shear Wall in Asymmetrical Building on Sloping Ground

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Abstract: The present study focuses on the effective positioning of shear walls in asymmetrical buildings constructed on sloping ground. A multi-storey reinforced cement concrete (RCC) building (G+7) with a slope angle of 15° is considered for analysis. The structural modelling and analysis are carried out using STAAD Pro software. Different shear wall configurations, namely C-shaped, L-shaped, and T-shaped shear walls, are incorporated into the building model to evaluate their influence on structural performance. The analysis is performed using linear static analysis and response spectrum analysis as per relevant Indian Standard codes. Key structural parameters such as storey displacement, storey drift, base reaction, bending moment, shear force, and axial force are evaluated and compared for all models. The results are presented in tabular and graphical forms for better understanding. The results of the study indicate that the inclusion of shear walls significantly improves the seismic performance of the structure by increasing stiffness and reducing lateral displacement. Among the different configurations, the L-shaped shear wall is found to be the most effective in controlling displacement and drift, while the T-shaped shear wall attracts higher internal forces due to increased stiffness. The C-shaped shear wall shows comparatively lower stiffness and performance. The study concludes that proper selection and positioning of shear walls play a crucial role in enhancing the stability and safety of buildings constructed on sloping ground. The findings of this study can be useful for structural engineers in designing efficient and earthquake-resistant structures in hilly regions.

Keywords: Shear Wall, Sloping Ground, Asymmetrical Building, Seismic Analysis, Storey Drift, Torsion, Earthquake Engineering.

I. INTRODUCTION

Earthquake is one of the most destructive and unpredictable natural phenomena that significantly affects human life, infrastructure, and the overall socio-economic development of a region. It occurs due to sudden release of energy in the Earth's crust, which generates seismic waves that travel through the ground and cause shaking of structures. The intensity and duration of ground motion depend on various factors such as magnitude of earthquake, depth of focus, soil conditions, and distance from epicenter. The impact of earthquakes on structures can be devastating, leading to partial or complete collapse of buildings, damage to bridges, failure of dams, and destruction of lifeline systems such as water supply, electricity, and transportation networks. The failure of structures during earthquakes is not only due to the intensity of seismic forces but also due to deficiencies in structural design, poor construction practices, lack of proper detailing, and absence of adequate lateral load resisting systems. In many cases, buildings fail because they are not designed to withstand lateral forces, which are the primary forces acting during seismic events. One of the most critical aspects of earthquake-resistant design is the ability of a structure to resist lateral forces without undergoing excessive deformation or collapse.

Conventional buildings designed mainly for gravity loads often lack sufficient lateral stiffness and strength, making them vulnerable during earthquakes. Irregularities in building geometry, such as asymmetry in plan or elevation, discontinuity in structural elements, and uneven distribution of mass and stiffness, further increase the vulnerability of structures. In the Indian context, seismic risk is a major concern due to the presence of several earthquake-prone regions. The country is divided into different seismic zones (Zone II to Zone V) as per IS 1893, with Zone V being the most severe. Regions such as the Himalayan belt, North-Eastern states, parts of Gujarat, and Western Ghats are highly susceptible to earthquakes. Historical earthquakes such as Bhuj (2001), Sikkim (2011), and Nepal (2015) have demonstrated the severe damage that can occur due to inadequate structural design and planning. Due to rapid urbanization, population growth, and increasing demand for residential and commercial spaces, construction activities are expanding rapidly in these seismic regions. However, the availability of flat land in such areas is limited, especially in hilly terrains. As a result, buildings are often constructed on sloping ground, which introduces additional challenges in structural design and behavior. Unlike buildings on flat ground, structures on sloping terrain are inherently irregular due to variation in ground levels. Buildings on sloping ground exhibit complex structural behavior because of differences in column heights, foundation levels, and load distribution. The columns located on the uphill side are generally shorter, while those on the downhill side are longer. This variation leads to unequal stiffness distribution, which significantly affects the dynamic response of the structure during an earthquake.

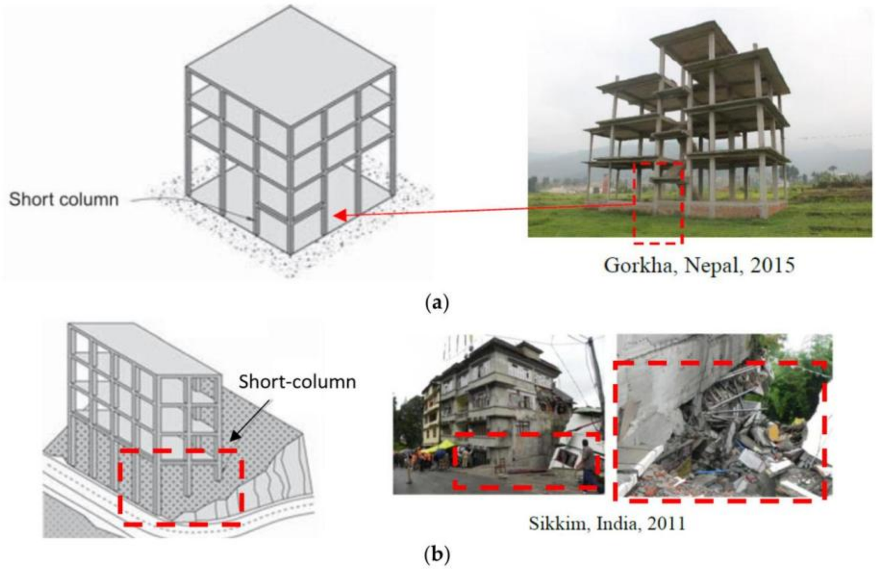


Figure 1.1: Earthquake Effect on Building

Figure 1.2: Earthquake Effect on Building on Sloping Ground

II. METHODOLOGY

Structural Configuration:

Structural configuration refers to the overall arrangement and organization of structural elements such as beams, columns, slabs, and shear walls within a building. It plays a crucial role in determining the strength, stiffness, stability, and overall performance of the structure under various loading conditions. In the present study, special attention is given to the structural configuration, as the building is constructed on sloping ground and exhibits asymmetrical characteristics, which significantly influence its seismic behavior. The structure considered in this study is a multi-storey reinforced cement concrete (RCC) framed building with G+7 storeys, designed as a Special Moment Resisting Frame (SMRF). This type of framing system is selected because of its high ductility and ability to dissipate energy during seismic events, making it suitable for earthquake-prone regions. The structural system consists of a combination of beams, columns, and shear walls, forming a three-dimensional framework capable of resisting both vertical and lateral loads effectively.

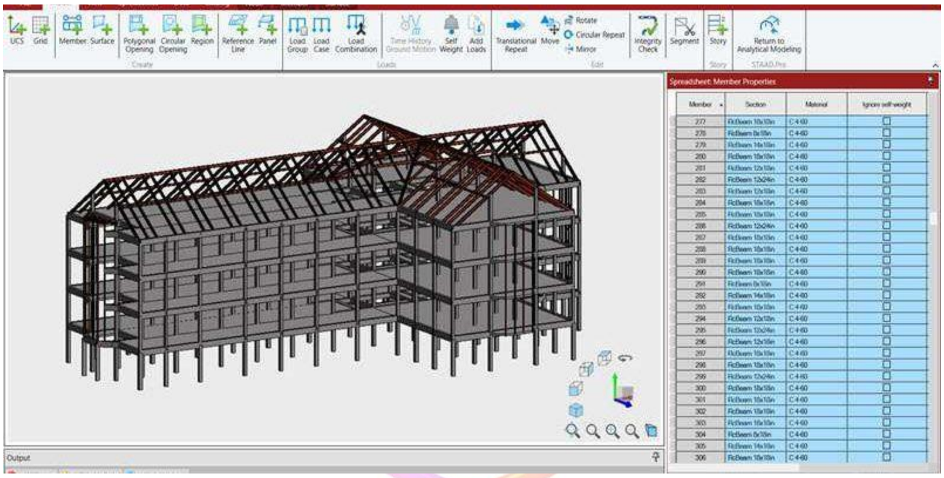


Figure 2.1: Building on Sloping Ground

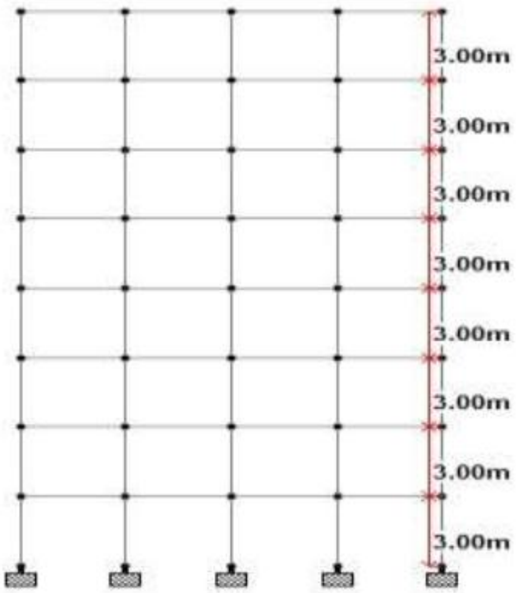


Figure 2.2: Plan of Bare Frame Building

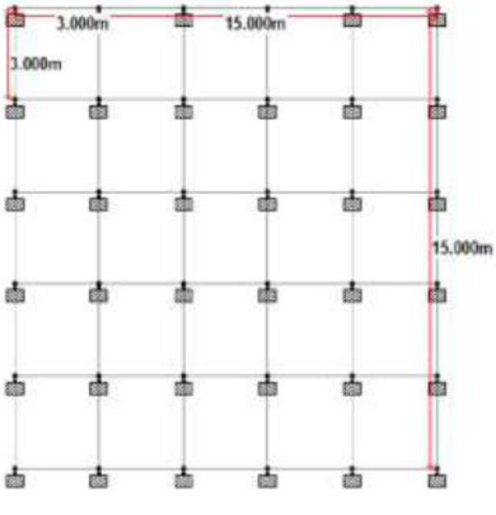


Figure 2.3: Elevation of the building

Shear Wall Configuration:

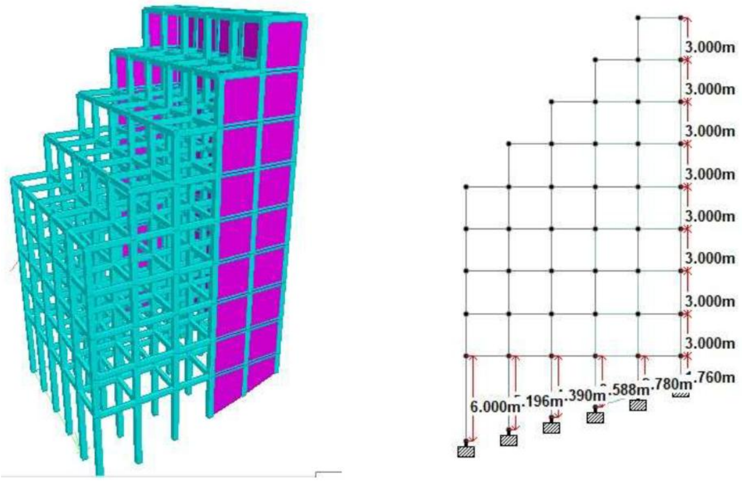


Figure 2.4: Elevation of C Shape Shear Wall with 15° Slope

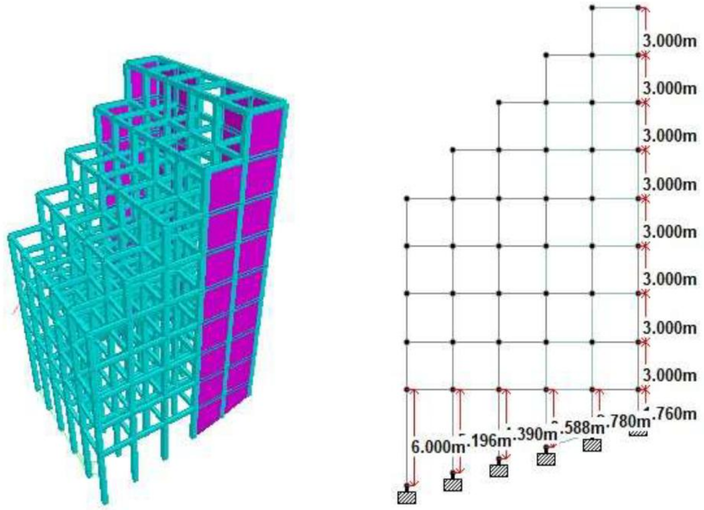


Figure 2.5: Elevation of L Shape Shear Wall with 15° Slope

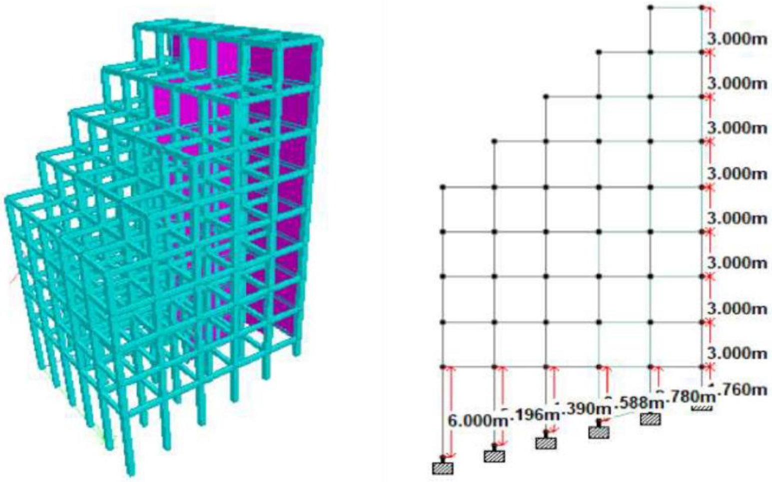


Figure 2.6: Elevation of T Shape Shear Wall with 15° Slope

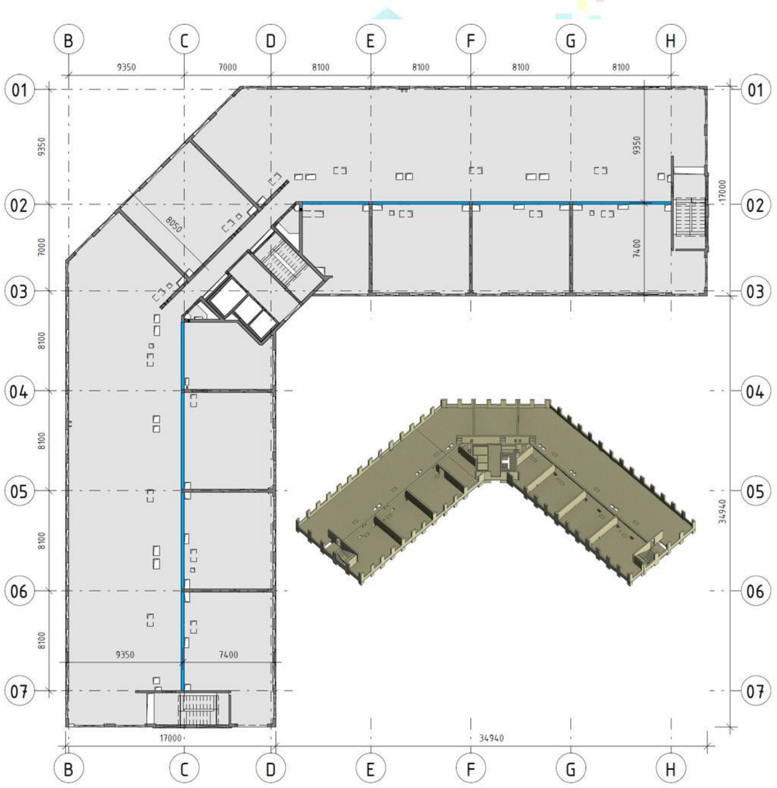


Figure 2.7: Shear Wall Configurations

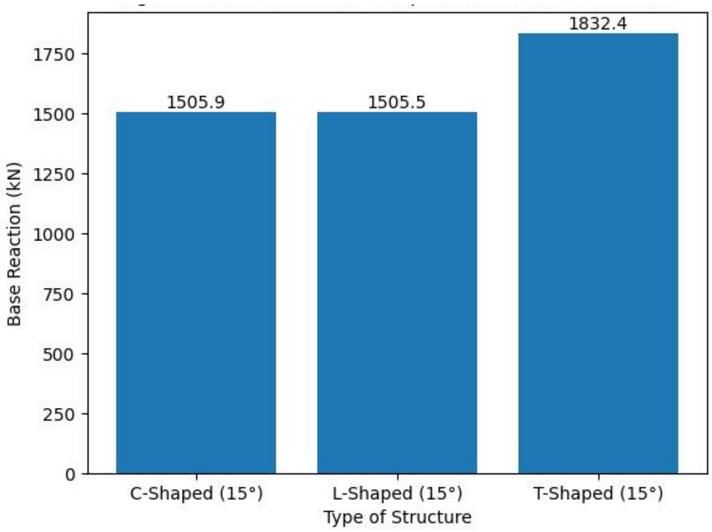
III. RESULTS AND DISCUSSION

3.1 Base Reaction

Base reaction is one of the most important parameters in structural analysis, as it represents the total force transferred from the structure to the foundation. It includes the combined effect of all loads acting on the structure, such as dead load, live load, and seismic load. In seismic analysis, base reaction (or base shear) indicates how the structure responds to earthquake forces and how much load is resisted at the foundation level. Therefore, it is an essential parameter for evaluating the stability and safety of the structure. In the present study, the base reaction values are obtained from STAAD Pro analysis for different shear wall configurations constructed on sloping ground. The comparison is made among three different models, namely C-shaped shear wall, L-shaped shear wall, and T-shaped shear wall, all considered for a 15° slope condition. The results are presented in tabular form for clarity and are further explained using graphical representation.

Table 3.1: Base Reaction (kN) for RCC Structure in STAAD Pro

Type of Structure	Base Reaction (kN)
15° Slope C-Shaped Shear Wall	1505.924
15° Slope L-Shaped Shear Wall	1505.501
15° Slope T-Shaped Shear Wall	1832.420



Graph 3.1: Base Reaction (kN) for RCC Structure in STAAD Pro

Observations:
From the above table and graphical comparison, the following observations are made:

1. The T-shaped shear wall model shows the maximum base reaction (1832.420 kN) among all configurations.
2. The C-shaped shear wall model shows a moderate base reaction value of 1505.924 kN.
3. The L-shaped shear wall model has the least base reaction (1505.501 kN) among the three models.
4. The difference between C-shaped and L-shaped models is very small, indicating similar stiffness characteristics.
5. The T-shaped model attracts significantly higher base reaction due to its geometry and increased stiffness in multiple directions.

3.2 Storey Displacement

Storey displacement is one of the most important parameters in structural analysis, as it indicates the lateral movement of each storey under seismic forces. It is a direct measure of the flexibility and stiffness of the structure. Excessive displacement can lead to structural damage, cracking, and serviceability issues. Therefore, it is essential to evaluate storey displacement for different structural configurations, especially for buildings constructed on sloping ground where irregularities are present.

In the present study, storey displacement values are obtained from STAAD Pro analysis for three different shear wall configurations, namely C-shaped, L-shaped, and T-shaped shear walls, all considered on a 15° sloping ground. The results are presented below in tabular form for comparison.

Storey Displacement for C-Shaped Shear Wall:

Table 3.2: Storey Displacement for C-Shaped Shear Wall (mm)

Storey Level	Displacement (mm)
Terrace	34.339
Seventh	32.521
Sixth	29.072
Fifth	24.816

Fourth	20.319
Third	15.729
Second	11.131
First	6.572
Ground	2.675
Base	0

Storey Displacement for L-Shaped Shear Wall:

Table 3.3: Storey Displacement for L-Shaped Shear Wall (mm)

Storey Level	Displacement (mm)
Terrace	34.189
Seventh	31.865
Sixth	28.426
Fifth	24.238
Fourth	20.319
Third	20.130
Second	14.984
First	10.826
Ground	2.548
Base	0

Storey Displacement for T-Shaped Shear Wall:

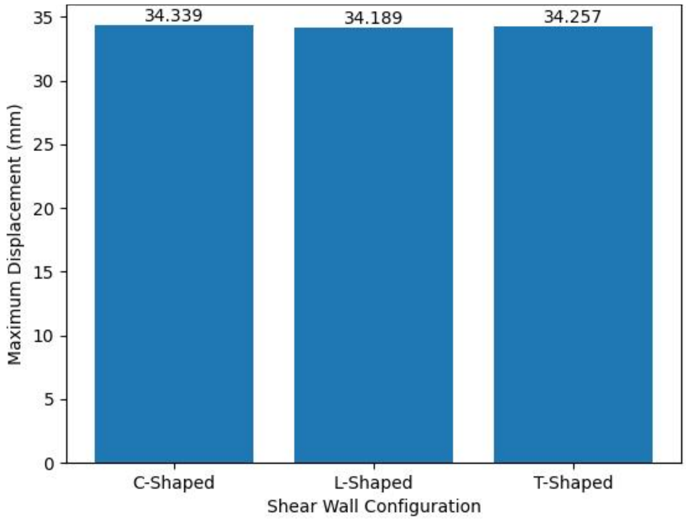
Table 3.4: Storey Displacement for T-Shaped Shear Wall (mm)

Storey Level	Displacement (mm)
Terrace	34.257
Seventh	31.929
Sixth	28.483
Fifth	24.286
Fourth	20.360
Third	20.170
Second	15.014
First	10.848
Ground	2.553
Base	0

Table 5.5: Comparison of Maximum Displacement (mm)

Model	Maximum Displacement (mm)

C-Shaped	34.339
L-Shaped	34.189
T-Shaped	34.257



Graph: 3.2 Comparison of Storey Displacement for C, L, and T Shear Walls)

Observations:
From the above tables and comparison, the following observations are made:

1. Maximum displacement occurs at the terrace level for all models.
2. Displacement gradually decreases from top to bottom in all cases.
3. The C-shaped model shows the highest displacement (34.339 mm).
4. The L-shaped model shows the lowest displacement (34.189 mm).
5. The T-shaped model shows intermediate displacement (34.257 mm).
6. All models show zero displacement at base level due to fixed support.
7. The variation pattern is smooth for all configurations.

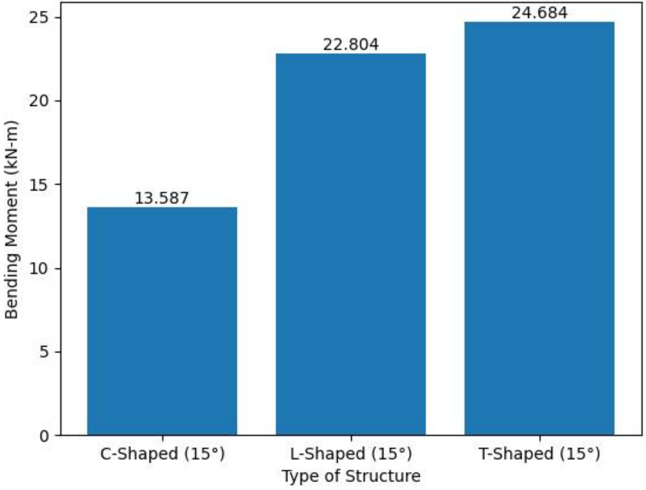
3.3 Bending Moment in Column

Bending moment is one of the most important internal force parameters in structural analysis, as it represents the rotational effect of loads acting on structural members such as columns and beams. In columns, bending moments are primarily generated due to lateral loads such as earthquake forces, wind loads, and also due to eccentric loading conditions. Evaluation of bending moment is essential for safe design, as excessive bending may lead to cracking, instability, and even structural failure. In the present study, the bending moment values in columns are obtained from STAAD Pro analysis for different shear wall configurations on a 15° sloping ground. The comparison is made among C-shaped, L-shaped, and T-shaped shear wall models to evaluate the effect of structural configuration on bending behavior.

3.3.1 Bending Moment Results

Table 3.6: Bending Moment in Column (kN-m)

Type of Structure	**Bending Moment (kN-m)**
15° Slope C-Shaped Shear Wall	13.587
15° Slope L-Shaped Shear Wall	22.804
15° Slope T-Shaped Shear Wall	24.684



Graph 3.3: Comparison of Bending Moment in Column for C, L, and T Shear Walls)

Observations:

From the above table, the following observations are made:

1. The maximum bending moment is observed in T-shaped shear wall model (24.684 kN-m).
2. The L-shaped shear wall model shows moderate bending moment (22.804 kN-m).
3. The minimum bending moment is observed in C-shaped shear wall model (13.587 kN-m).
4. Bending moment increases with increase in structural stiffness.
5. The variation in bending moment is significant between C-shaped and T-shaped configurations.

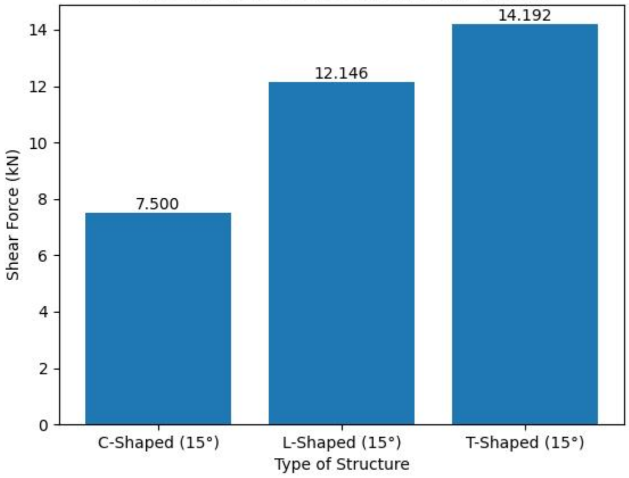
3.4 Shear Force in Column

Shear force is an important internal force developed in structural members due to applied loads, especially lateral loads such as earthquake forces. In columns, shear force plays a critical role in determining the safety and stability of the structure. Excessive shear force can lead to brittle failure, which is sudden and undesirable. Therefore, proper evaluation of shear force is essential for designing safe and earthquake-resistant structures. In the present study, shear force values in columns are obtained from STAAD Pro analysis for different shear wall configurations on a 15° sloping ground. The comparison is carried out among C-shaped, L-shaped, and T-shaped shear wall models to understand the influence of shear wall configuration on shear force distribution.

3.4.1 Shear Force Results

Table 3.7: Shear Force in Column (kN)

Type of Structure	Shear Force (kN)
15° Slope C-Shaped Shear Wall	7.500
15° Slope L-Shaped Shear Wall	12.146
15° Slope T-Shaped Shear Wall	14.192



Graph 3.4: Comparison of Shear Force in Column for C, L, and T Shear Walls)

Observations:

From the above table, the following observations are made:

1. The maximum shear force is observed in T-shaped shear wall model (14.192 kN).
2. The L-shaped shear wall model shows moderate shear force (12.146 kN).
3. The minimum shear force is observed in C-shaped shear wall model (7.500 kN).
4. Shear force increases with increase in structural stiffness.
5. The difference between models clearly indicates the influence of shear wall configuration.

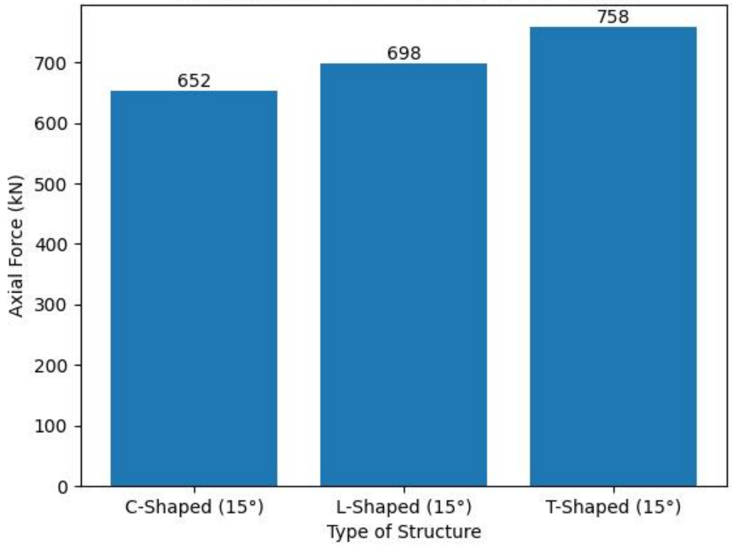
3.5 Axial Force in Column

Axial force is one of the primary forces acting on columns in a structural system, representing the vertical load carried by the column due to gravity loads and additional forces induced by lateral loads such as earthquakes. It is a crucial parameter in structural design, as it directly affects the load-carrying capacity and stability of columns. Excessive axial force may lead to compression failure, buckling, or instability of structural members. Therefore, proper evaluation of axial force is essential for ensuring safe and efficient design. In the present study, axial force values in columns are obtained from STAAD Pro analysis for different shear wall configurations on a 15° sloping ground. The comparison is made among C-shaped, L-shaped, and T-shaped shear wall models to understand the influence of structural configuration on axial load distribution.

3.5.1 Axial Force Results

Table 3.8: Axial Force in Column (kN)

Type of Structure	Axial Force (kN)
15° Slope C-Shaped Shear Wall	652
15° Slope L-Shaped Shear Wall	698
15° Slope T-Shaped Shear Wall	758



Graph 3.5: Comparison of Axial Force in Column for C, L, and T Shear Walls)

Observations:

From the above table, the following observations are made:

1. The maximum axial force is observed in T-shaped shear wall model (758 kN).
2. The L-shaped shear wall model shows moderate axial force (698 kN).
3. The minimum axial force is observed in C-shaped shear wall model (652 kN).
4. Axial force increases with increase in structural stiffness.
5. The variation indicates significant influence of shear wall configuration.

CONCLUSION

Based on the detailed structural analysis carried out for asymmetrical RCC buildings on sloping ground using different shear wall configurations, it is observed that the behavior of such buildings is highly influenced by geometric irregularity and variation in column heights. Structures constructed on sloping ground tend to exhibit non-uniform stiffness distribution, which results in significant torsional effects and uneven load transfer across the structure. The bare frame structure, without the provision of shear walls, shows maximum displacement and storey drift, indicating poor seismic performance and reduced structural safety. The inclusion of shear walls greatly enhances the overall structural behavior by increasing stiffness, reducing lateral displacement, controlling storey drift, and improving overall stability. It is also noted that for all structural models, storey displacement is maximum at the top and gradually decreases towards the base. Among the different configurations analyzed, the L-shaped shear wall model demonstrates the least displacement and drift, making it the most efficient configuration in terms of seismic performance. On the other hand, the T-shaped shear wall configuration exhibits maximum base reaction, bending moment, shear force, and axial force due to its higher stiffness and ability to resist loads in multiple directions. The C-shaped shear wall model shows comparatively lower internal forces but also provides less stiffness when compared to other configurations. It is evident that an increase in stiffness leads to higher base shear and internal forces, but also enhances the structure's resistance against lateral loads such as earthquakes. Furthermore, the positioning and configuration of shear walls play a critical role in minimizing torsional effects and improving seismic performance. The study clearly indicates that shear wall configuration significantly affects the structural response of buildings on sloping ground. Overall, the L-shaped shear wall configuration is found to be the most effective in improving the seismic performance among all the models considered in this study.

REFERENCES

1. Parbat, S. D., Badar, A. M., & Satone, S. R. (2021). Positioning of Shear Wall in L-Shaped Unsymmetrical Building on the Sloping Ground. IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 8, Issue 4, April 2021, ISSN 2348–7968.
2. Ghangare, N. C., Meshram, S. S., & Wasalwar, V. U. (2024). Optimal Placement of Shear Wall in Multistorey Buildings on Sloping Ground. IOP Conference Series: Earth and Environmental Science, Vol. 1409, ICACC-2024, Article No. 012035.

3. Reddy, R. K. C., Ravella, D. P., Reddy, P. S., & Kumar, S. M. (2024). Study of Effective Location of Shear Wall in Multistoreyed Buildings for Optimum Seismic Response. ARPN Journal of Engineering and Applied Sciences, Vol. 19, No. 12, ISSN 1819-6608.
4. Pawar, S. P., Pise, C. P., Pawar, Y. P., Kadam, S. S., Mohite, D. D., Deshmukh, C. M., & Shelar, N. K. (2016). Effect of Positioning of RC Shear Walls of Different Shapes on Seismic Performance of Building Resting on Sloping Ground. International Journal of Civil Engineering and Technology, Vol. 7, Issue 3, pp. 373–384.
5. Dane, A., & Pendharkar, U. (2019). Effective Positioning of Shear Wall in G+5 Storey Building on Sloping Ground. International Journal of Engineering and Advanced Technology, Vol. 9, Issue 2, ISSN 2249-8958.
6. Lova Raju, K., & Balaji, K. V. G. D. (2015). Effective Location of Shear Wall on Performance of Building Frame Subjected to Earthquake Load. International Advanced Research Journal in Science, Engineering and Technology, Vol. 2, Issue 1.
7. Kamble, S. D., & Bhalchandra, S. A. (2016). Seismic Performance of the Building Resting on Sloping Ground with Shear Wall. International Journal of Engineering Research and Technology, IC-QUEST 2016, Vol. 4, Issue 30, ISSN 2278-0181.
8. Patil, K., & Shende, T. G. (2022). A Comparative Study of Different Shapes of Shear Wall in Asymmetrical Building on Different Sloping Ground. International Journal of Creative Research Thoughts, Vol. 10, Issue 6, ISSN 2320-2882.
9. Muhammed, K. A., & Varkey, D. (2022). Irregular Building over Sloped Ground Surface with Shear Walls or Bracings: A Review. International Journal for Research in Applied Science & Engineering Technology, Vol. 10, Issue VI, ISSN 2321-9653.
10. Gaikwad, U. V. (2017). Effect of Shear Wall on Seismic Behavior of Unsymmetrical Reinforced Concrete Structure. International Journal of Research and Scientific Innovation, Vol. IV, Issue X, ISSN 2321–2705.
11. Vaidya, P. R. (2014–2015). Seismic Analysis of Building with Shear Wall on Sloping Ground. International Journal of Civil and Structural Engineering Research, Vol. 2, Issue 2, pp. 53–60.
12. Tiwari, S., & Hararwala, H. (2025). Seismic Analysis of Irregular Building on Sloped Terrain with Varying Shear Wall Configuration. International Journal of Research Publication and Reviews, Vol. 6, Issue 7, pp. 2831–2847, ISSN 2582-7421.
13. Bush, R. C., Shirkol, A. I., Sruthi, J. S., & Kumar, A. (2022). Study of Seismic Analysis of Asymmetric Building with Different Shapes of Staggered Openings and Without Openings in Shear Wall. Materials Today: Proceedings, Vol. 64, Part 2, pp. 964–969.
14. Khandelwal, D. N., & Mhetre, M. S. (2017). A Review on Effective Location and Optimum Height of Shear Walls in High-Rise Buildings. IJSART - International Journal of Science and Research Technology, Vol. 3, Issue 9, ISSN 2395-1052.
15. Kumar, R., Faizy, I. A., & Khan, A. (2024). A Review Paper on Analysis of Sloping Ground Tall Building Using Different Shapes of Shear Wall. International Journal of Trend in Scientific Research and Development, Vol. 8, Issue 3, e-ISSN 2456–6470.
16. Anjali, B. U., & Gopisiddappa. (2017). Effect of Positioning and Configuration of Shear Walls on Seismic Performance of RC Building Resting on Hilly and Plain Terrain. International Research Journal of Engineering and Technology, Vol. 4, Issue 6, pp. 2501–2506.