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# SEISMIC ANALYSIS WITH OPTIMUM POSITIONING OF SHEAR WALLS IN MULTISTOREY BUILDING

**Asha Bhayal** PG Student, Department of Civil Engineering, Prashanti Institute of Technologies and Sciences Ujjain, India :: ashabhayal02@gmail.com
**Prof. Rahul Sharma** Professor, Department of Civil Engineering, Prashanti Institute of Technologies and Sciences Ujjain, India

## ABSTRACT
Shear wall systems are among the most widely used and useful lateral load-resisting technology found in high-rise buildings. Their excellent plane rigidity and strength allow them to withstand both huge horizontal loads and gravity loads simultaneously. Shear walls are becoming more and more necessary for multi-story buildings in order to withstand lateral forces such as wind and seismic loads. Determining the ideal location for shear walls is vital. Shear barriers need to be placed exactly since any deviation will ruin your design. When the hardness center and mass center coincide, the shear wall's shear contribution is likewise significantly dependent on its distance from the mass center. The aim of this research is to determine the optimal structural plan for a multistory building G+10 with a significant restructuring of the shear wall placements. Four different shear wall placement scenarios for a multistory building that preserve zero eccentricity between the mass center and hardness center were evaluated, and then a computer application software was utilized to create a frame system. Testing is done on the framed structure for both gravity and lateral loads in accordance with IS requirements. The test results are analyzed to establish the optimal location for the shear wall.

**Keywords**: Concrete structures, shear wall, optimization, shear force, Equivalent static method, Base shear, Storey drift, Nodal displacements.

## 1.0 INTRODUCTION
An earthquake is a moving phenomenon that is brought on by vibrations in the ground; more precisely, it is the outcome of waves causing surface disturbances deep beneath the earth. Buildings that were not designed to withstand earthquakes are vulnerable. Even though a lot of Indian structures are made to resist continuous and static pressures, earthquakes seldom ever do. Currently, around 60% of India is regarded as earthquake-prone. As such, seismic stresses while planning structures. Following an earthquake, the superstructure and foundations sustain damage. Substructures are a building's base or lowest part. It is essential to comprehend how seismic stresses impact superstructures like beams, columns, slabs, and beam-column junctions, as well as substructures such the interaction between the ground and the foundation.

These days, because of the limited quantity of accessible land, high cost, scarcity, and fast rising metropolitan population, higher constructions are preferred. The importance of lateral load grows with a structure's height. The two structural solutions that are now most often employed for resisting lateral loads are shear walls and diagrids. Particularly useful in many structural engineering applications. Both gravitational loads and large horizontal loads may be supported by them at the same time. Tall structures employ the diagrid structural system because of its structural economy and adaptability to changing architectural styles. Diagrid: Because of its distinctive geometric structure, which offers both structural efficiency and aesthetic potential, diagonal grid structural systems are frequently employed for tall constructions. Tall building architects and structural designers are now again interested in the diagrid because to its structural efficacy and beauty.
Walls are robust vertical diaphragms that load in a plane parallel to the outside. They work in the

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construction industry. Shear walls endure brought on by wind and seismic activity, preventing buildings from collapsing, while load-bearing walls and columns sustain the building's compression load all the way. Owing to their exceptional strength and plane stiffness, which may be utilized to maintain gravity loads and endure large horizontal loads concurrently, they are highly valuable in many structural engineering applications. Large, towering buildings require shear walls significantly more, especially if they are situated in areas that are vulnerable.

**1.1 SHEAR WALL**

These walls are made to resist horizontal stresses such as seismic forces and airstreams. They are a component that can withstand earthquakes. These forces work in a manner akin to that of the wall's plane. Shear walls are a common feature in buildings that are tall. It will be shown from the bottom of the structure to its highest point. Shear walls, which can range in thickness from 150 to 400 mm, lessen the lateral sway of a structure. A stiff vertical diaphragm is used to transmit the loads into the Foundations. In the opposite frame must be erected to withstand the effects of a major earthquake. The type of material used, as well as the wall's length, thickness, and internal positioning inside the building, all affect how shear walls behave.


Figure 1: Shear wall

**1.2 ADVANTAGES OF SHEAR WALLS**

Shear walls have a number of benefits. Shear walls' primary job is to keep the structure stable when lateral forces are applied. They provide the structure a great deal of strength and rigidity. By withstanding lessen the building's lateral wobble. Shear walls are very simple to make and install, but depending on the building plan and design, they must be positioned carefully and in various cross-sectional forms, such as channel, L, T, box, and barbell shapes. Shear wall construction is a cost-effective and effective way to lessen earthquake damage.

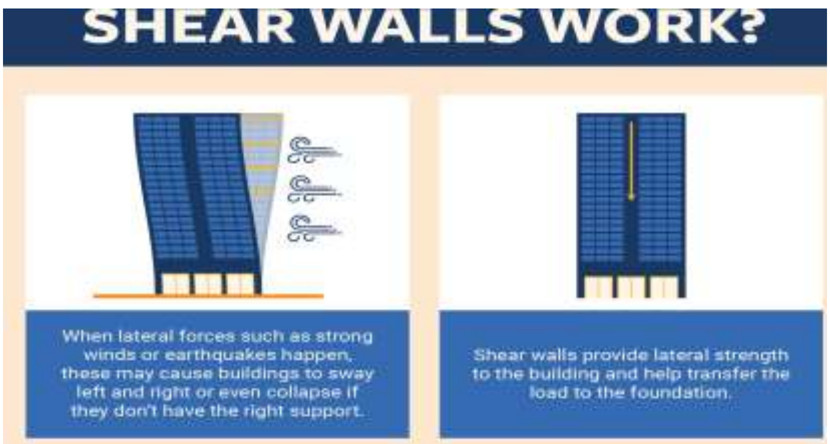


Figure 2: Working of Shear wall

## 2.0 LITERATURE REVIEW

Shear wall structures are a common seismic force-resistance method used for both reinforced concrete (RC) and reinforced masonry (RM) buildings, according to **Hossam El-Sokkary** and Khaled Galal (2020). The purpose of this article is to estimate the construction material amounts needed for RM shear walls in relation to RC walls. Three multistory RM shear wall structures situated in three distinct Canadian cities at varying heights were chosen. When RC material was employed in each example, the analysis and design events occurred often. For both the RM and RC scenarios, the amount of structural materials utilized for each building's shear walls was assessed and compared. Additionally, estimates and comparisons were made about the personnel and temporary work costs for RM and RC shear walls.

The work Seismic Analysis of Multi-Storey Irregular Building with Different Structural Systems, **Vishal N., Ramesh Kannan M., Keerthika L. (2020).** The response spectrum method was used to model and analyze the structural behavior of a 20-story building with vertical setback irregularity, both with and without Construction Sequence Analysis (CSA). Different structural systems were used in CSI ETABS V16 in accordance with BIS 1893:2016 (Part 1).All that is required for the analysis to be both cost-effective and safe for the structure is the sequential application of loads in each story. Ultimately, for every structural system, results like axial force, shear force, bending moment, and reaction like storey displacement, storey shear, and storey drift are displayed and compared.

This article presents a reliability analysis of a multi-story building with floating columns using Staad.pro-V8i, written by **Maneesh Ahirwar and Er. Rahul Satbhaiya (2020).** In order to lessen the irregularity caused by the building's floating columns, this research contracts with the rigidity stability of every floor. Using the commercial FEM program StaadPro v8i.0, comprehensive analysis was used to do modeling.

**Mohammed Imranuddin, Abdul Kareem, and Kha Yasir (2019)** used computer-aided program Etabs to analyze a 16-story high-rise structure with and without a shear wall. Axial, lateral, and wind loads are all examined in the model. Analysis of response spectra is also performed. The two models with distinct load scenarios are seen to have different displacements. He came to the conclusion that adding shear walls at the corner where lateral pressures are the lowest reduces lateral loads. He also noted that high-rise structures need more than static analysis. The provision of dynamic analysis is essential. When compared to other models, the response spectrum analysis shows that the model with the shear wall in the corners and core has the least displacement values in both the x and y directions.

**According to Venkatesh K. et al. (2018),** In ETABS (2016), a commercial building's analysis and design were completed. It is a G+4 construction with a frame made of reinforced concrete. Additionally, we provide ground floor parking for cars and two-wheelers. Since IS 456:2000 is the fundamental code for concrete structure building, all structural members are designed utilizing the limit state approach in compliance with design aids and the IS 456:2000 code. Any building in India must follow the National Building Code (NBC) for its planning to be recognized, hence the structure is designed in compliance with this code. The business building is well ventilated, has many exits, and is equipped with electricity and water supply. According to the Building Code, assembly buildings have a ceiling height of one meter (NBC).

**In 2017, Rinkesh R. Bhandarkar, Utsav M. Ratanpara, and Mohammed Qureshi** designed and analyzed a 22-meter-tall multistory structure with and without a shear wall. Analyzing story drift, displacement, shear, story stiffness model period, and frequency on various floors was his primary goal. Making the structure earthquake-resistant against seismic effects was another goal. The following findings were noted: 1) Shear wall structures have less displacement and story drift than framed structures. 2) Shear walls have higher story stiffness than framed structures do. 3) In a framed construction, the modal period and frequency are lower. 4) Shear wall structures perform better than framed structures. 5) Building a frame building is less expensive. 6) Shear wall structures are more appropriate in areas that are prone to earthquakes because of their high rigidity.

**Chodhary N. et al.** carried out a pushover study in 2014 on two shear-walled R.C. framed structures. The initial building was symmetrical and had two bays that were five meters in the x and four meters in the y directions. The second construction had an L-shaped, asymmetrical plan. The lateral forces that the shear wall was resisting were examined using this tool. The primary focus of this study is the impact of shear walls built along the longer and shorter sides of R.C. frame constructions. The foundation of the structure will experience less shear and movement. Base shear, narrative drift, spectral acceleration, spectral displacement, and story displacement have all been compared. It is discovered that the addition of a shear wall significantly reduces base shear and roof displacement in both symmetrical and asymmetrical designs. Shear walls must be erected on the smaller side of the asymmetrical building.

**Montuori G. et al. (2014)** investigated the geometrical patterns of diagrids in great detail and methodically. Other geometric arrangements are compared with regularly patterned diagrid structures. It was accomplished by changing the variable-angle (VA) and variable-density (VD) of the diagonals along the structure's height. Eight unique diagrid patterns are designed and planned for a ninety-story model building: two variable density patterns, three regular patterns with angles of sixty, seventy, and eightty degrees, and three models for regular patterns. The diagrid structures that emerge are analyzed for wind and gravity loads, and an evaluation of many performance indicators is conducted.

**Sepideh Korsavi1 et al. (2014)** looked at case studies to see how the diagrid framework changed over time to become concepts related to architecture, structure, and sustainability. It has been determined that these constructions, despite being new, have significantly improved in terms of height, angle, modules, shapes, and materials based on their shared characteristics. These developments are primarily related to structural concepts (resistance against seismic or wind forces), architectural concepts (aesthetics, flexibility, daylight penetration, creation of free, twisted, and complex forms), and sustainability concepts (lightness, economic considerations), as per the justifications and analyses provided in each section. These constructions' diamond-shaped modules are all the same, but how they were used in various projects varied depending on structural, architectural, and sustainability considerations.

**Kumar et al. (2014)** studied the research has been to examine the behavior and resistance of different types of shear walls under cycles loads. The analytical result shows the relative appropriateness of inner and exterior shear walls.

**Sengupta S. 2014** analyzes how various shear wall thicknesses affect multistory structures in all of India's seismic zones and how much reinforcing is necessary in relation to those thicknesses. ETABS software is used in the development of building models that have shear walls. Comparative research is done for various shear wall thicknesses at various building heights (5, 10, and 15 storeys), with the shear walls remaining in their original locations. The necessary percentages of reinforcement are found for each scenario. It has been demonstrated that when seismicity and story count rise, the proportion of reinforcement rises for a given shear wall thickness. Additionally, it is noted that the percentage of reinforcement rises for every zone falling inside a particular range of shear wall thickness before falling outside of that range. The findings demonstrate that thickening shear walls is not necessarily the best technique to create an earthquake-resistant construction.

**Harshalata R. et al. (2014)** created and evaluated G+6 story steel building frames with and without steel plate shear walls in order to investigate the impact of these walls on the behavior of buildings. In zone III, a similar static analysis is performed for a steel moment-resisting building frame with six stories (G+6). STAAD.Pro is used to analyze the steel plate shear wall and the structure. Axial force, deflection, shear force, and bending moment are among the factors taken into account while

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evaluating a building's seismic performance. The results show that the use of steel plate shear walls reduces the amount of steel used in a building and the value of various metrics when compared to constructions without such walls. Shear walls made of steel are more cost-effective than steel buildings without shear walls made of steel plates.

**Hiremath G. et al. (2014)** examined the impacts of relocating shear walls with varying and uniform thickness in high-rise buildings. Using ETABS v 9.7.1 software, they built six models of a 25-story structure and used displacements and storey drift to perform pushover analysis. An exploratory research in seismic zone IV is focused on a 25-story skyscraper with reinforced concrete shear walls in an attempt to mitigate the effects of an earthquake. The study concludes that erecting shear barriers in the right places significantly lessens earthquake-related displacements.

## 3.0 OBJECTIVES

Researches on the study are:

1. Design of high-rise structures is the project's primary objective.
2. To understand the design concepts for safe high-rise structures with and without shear walls.
3. To examine tall buildings with seismic effects.
4. Examine high-rise structure seismic analyses with and without shear walls with different positioning using staad.pro software.

## 4.0 METHODOLOGY OF PROPOSED WORK

1. Create the standard RC frame building with and without floating column using software Staad Pro.
2. Analyze the structure for vertical (DL, LL) and Lateral load SPEC as primary load cases. Load combination as mentioned in IS codes are considered for designs.
3. Analysis includes response spectrum analysis.
4. Analysis of produced models and study with comparison of the result obtained from analysis.

Compare the analysis results of structure obtained from Staad Pro with and without shear wall with different positioning of shear walls.

## 5.0 SOFTWARE ANALYSIS

### Case 1: Conventional Frame

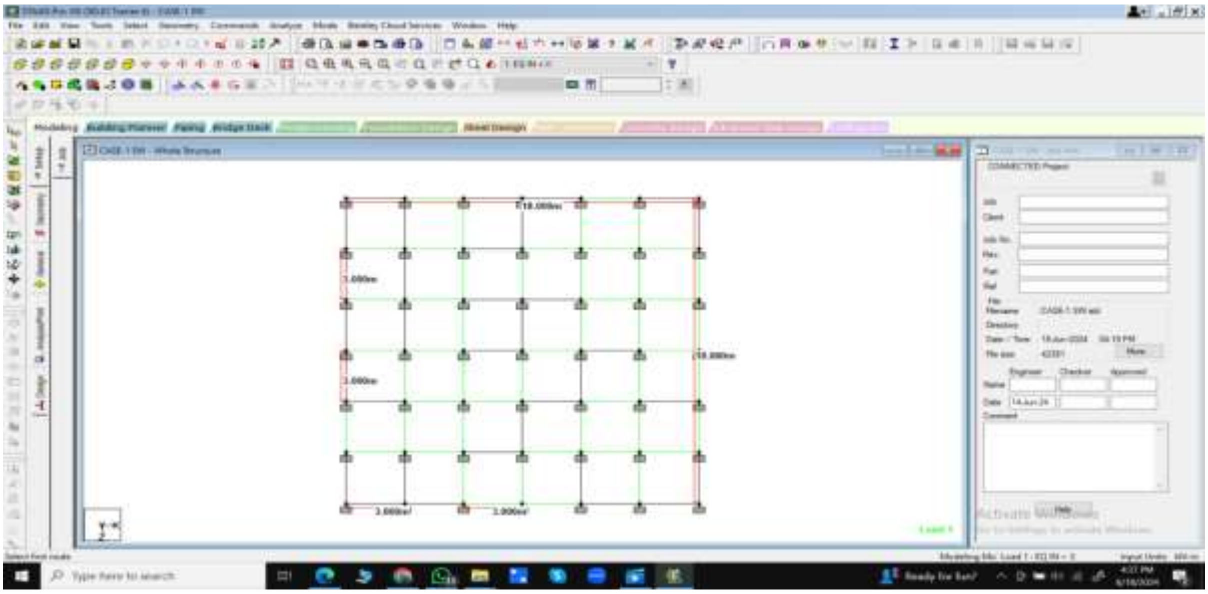

Figure 3: Plan

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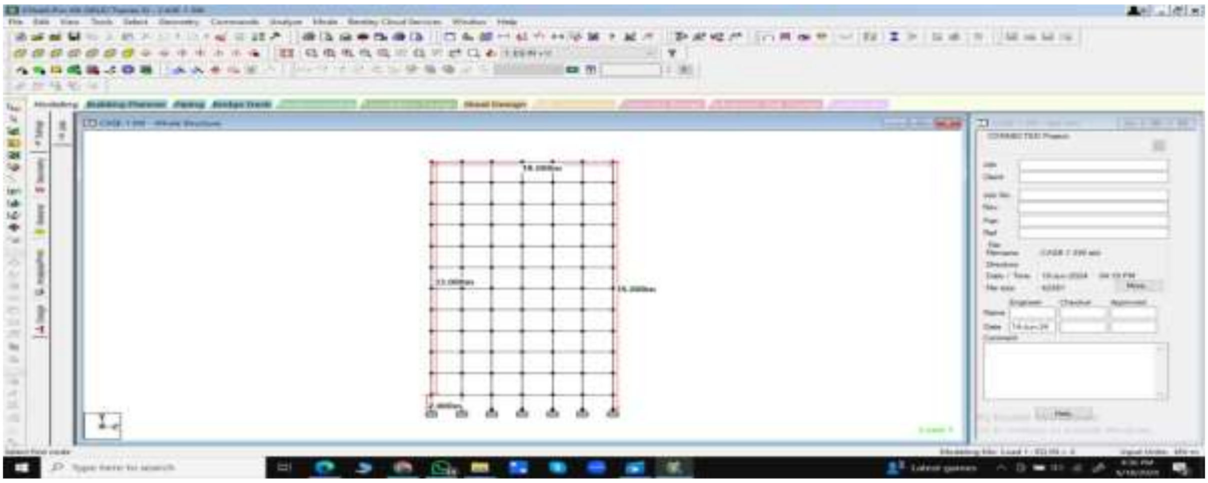

Figure 4: Elevation

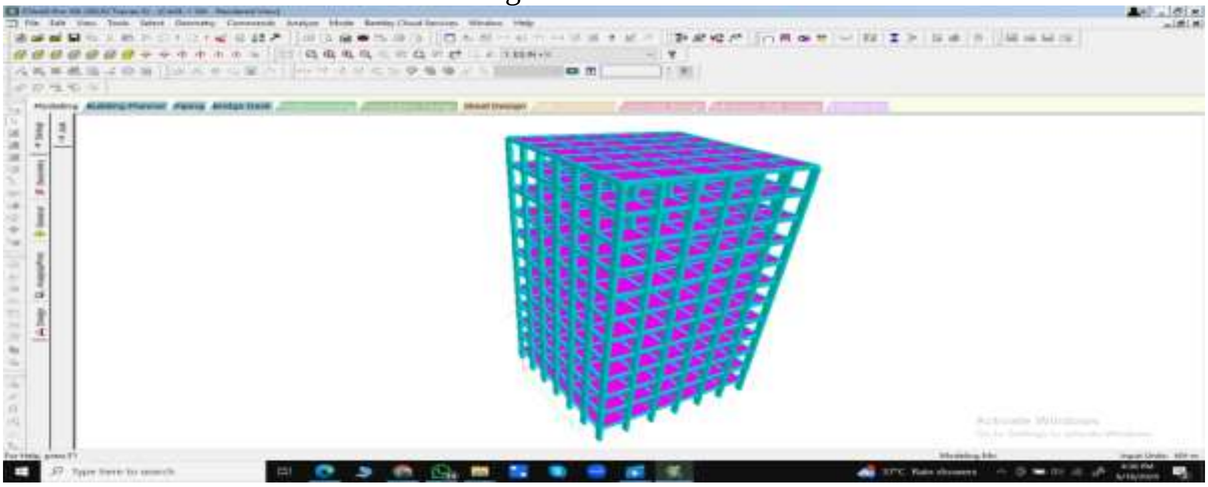

Figure 5: 3D elevation

**Case 2: Building with Shear Walls on Periphery at Corners**

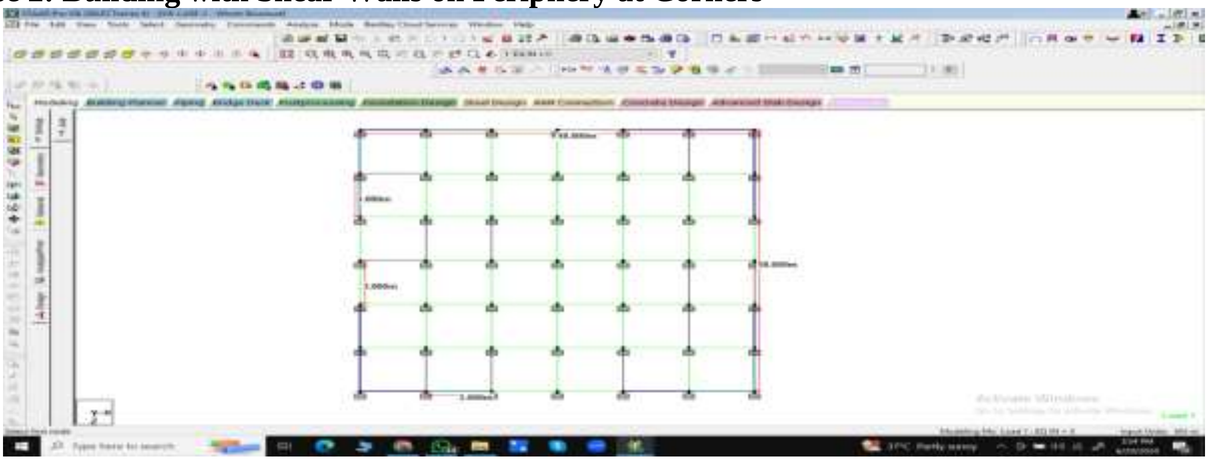

Figure 6: Plan

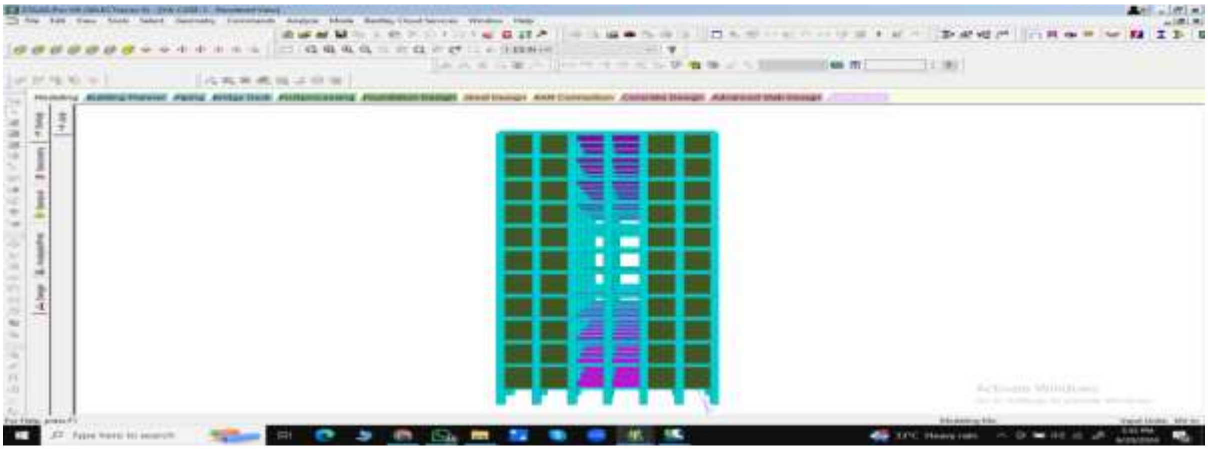

Figure 7: 3D elevation

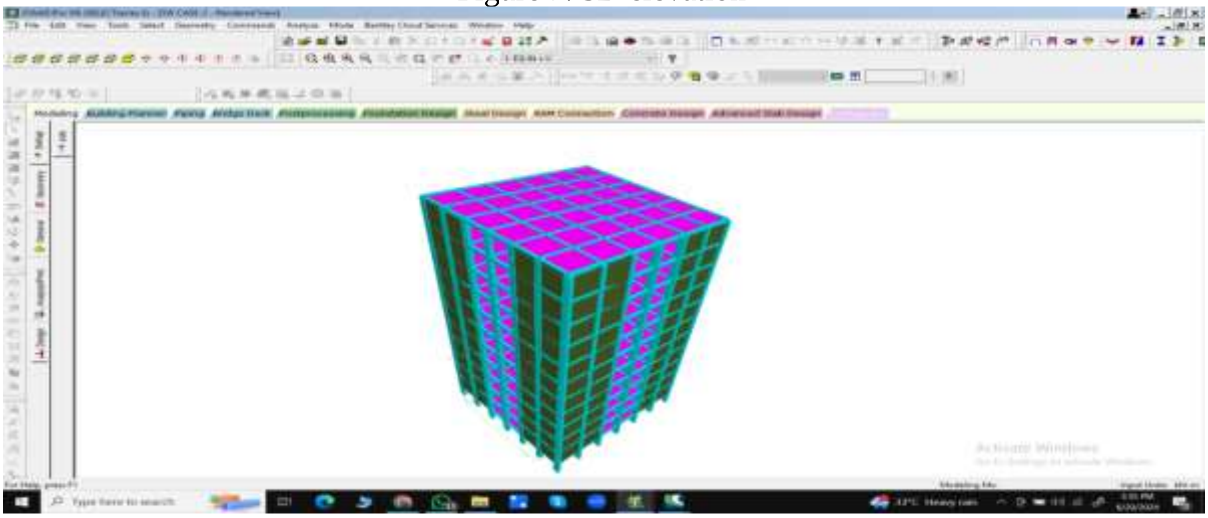

Figure 8: 3D elevation with shear wall

**Case 3: Building with Shear Walls on Periphery at Centers**

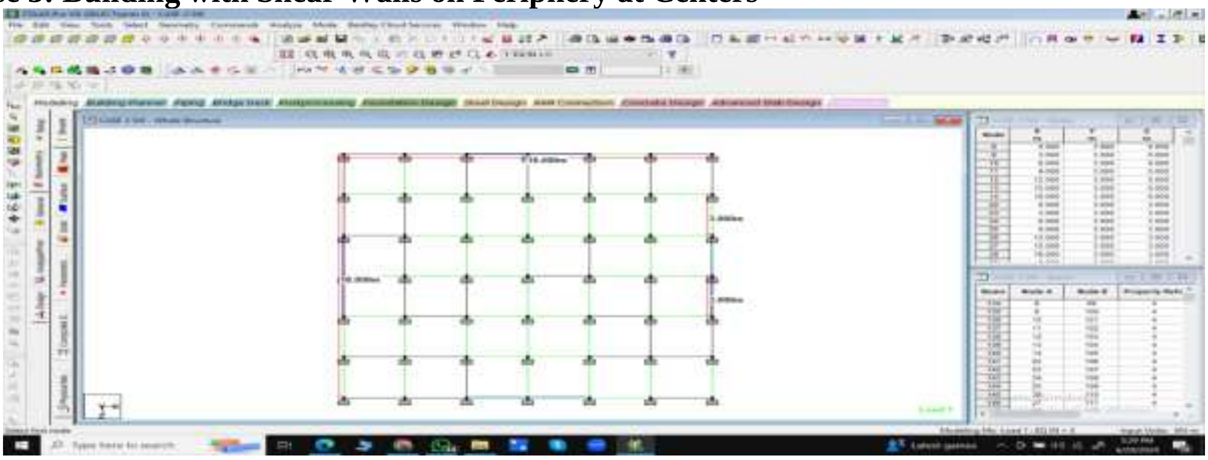

Figure 9: Plan

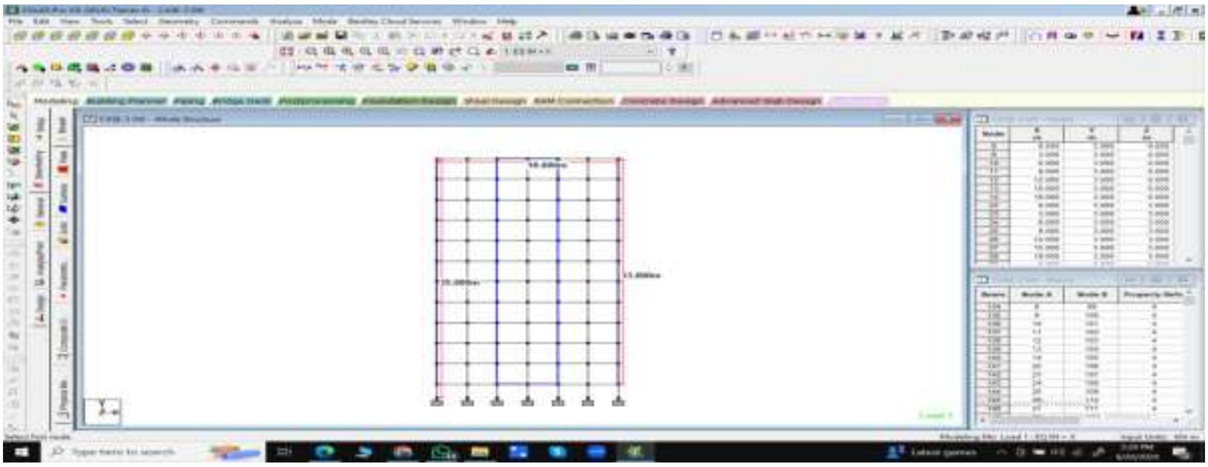

Figure 10: Elevation

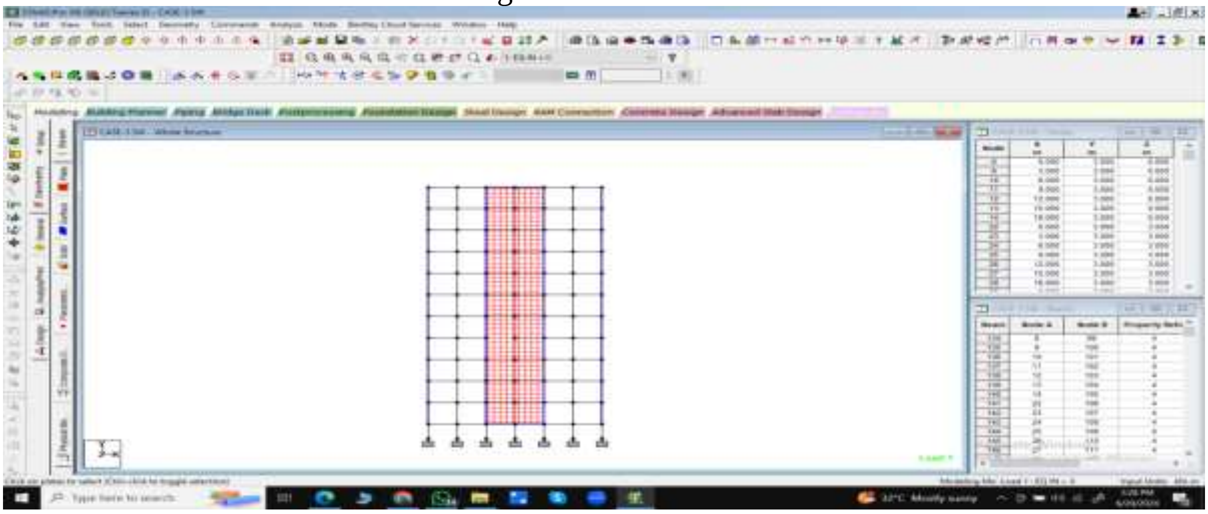

Figure 11: Elevation with shear wall

**Case 4: Building with Box-type Shear Wall at the center of the geometry**

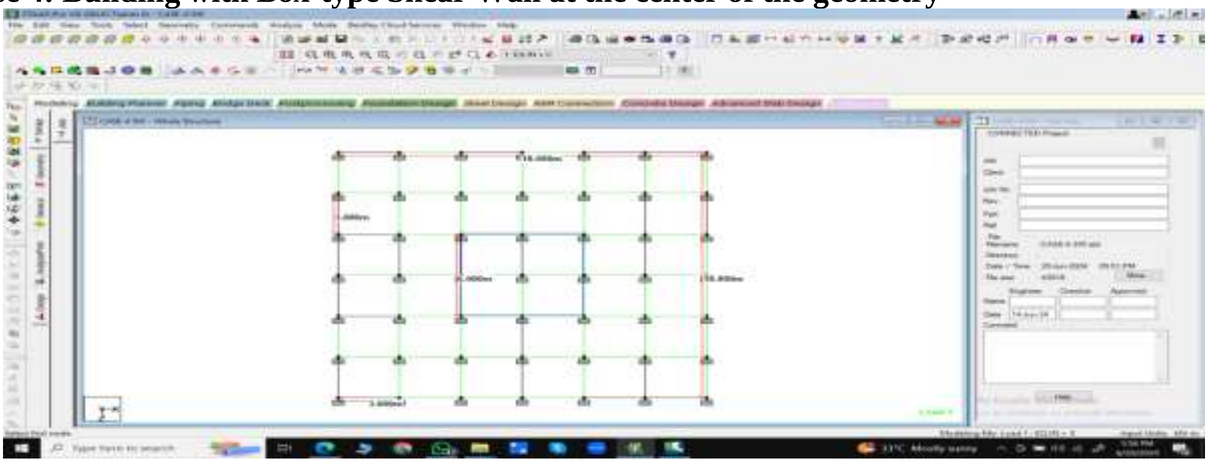

Figure 12: Plan

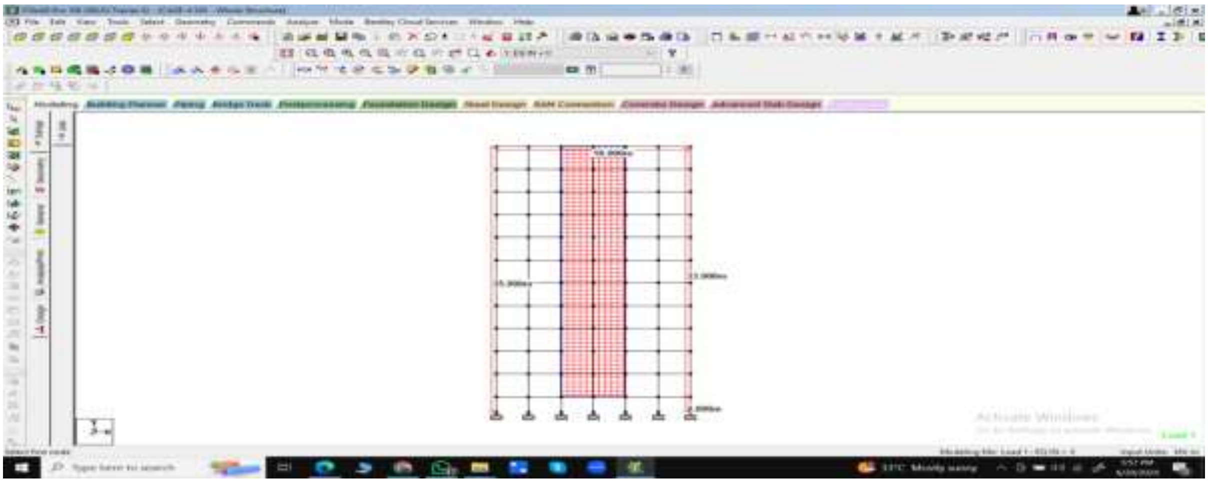

Figure 13: Elevation

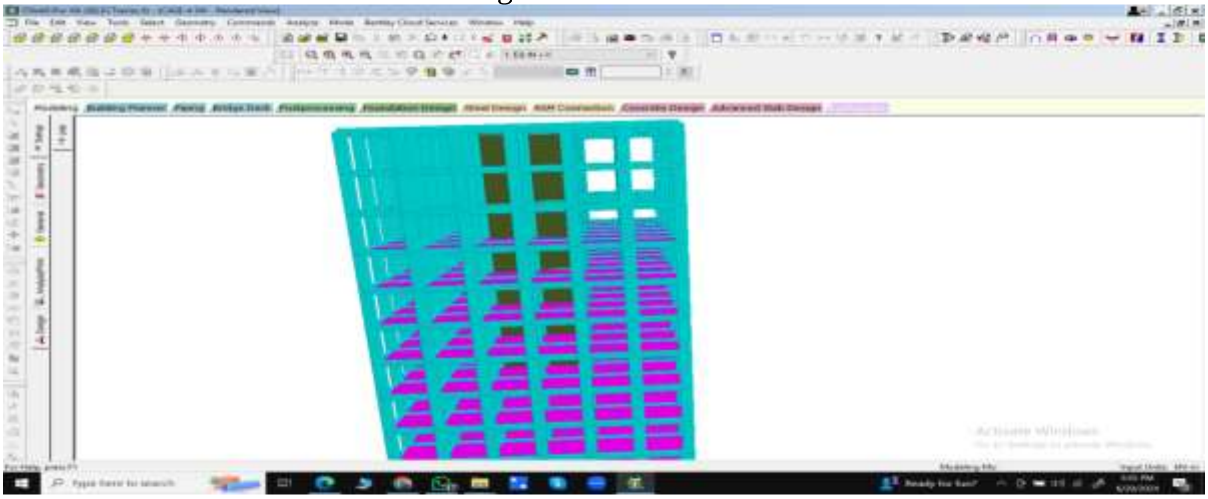

Figure 14: 3D Elevation

**6.0 RESULTS AND DISCUSSION**

| Variables (Beam End Force Summary) | Without shear wall | With shear wall | | |
|---|---|---|---|---|
| | Conventional Frame | Building with Shear Walls on Periphery at Corners | Building with Shear Walls on Periphery at Centers | Building with Box-type Shear Wall at the center of the geometry |
| Base reaction (KN) | 279.693 | 314.426 | 290.527 | 307.180 |
| Moment (KN-m) | 421.062 | 375.023 | 347.501 | 348.985 |
| Displacement (mm) | 32.35 | 8.734 | 8.270 | 8.394 |
| Storey Shear ( KN) | 280.168 | 314.426 | 290.527 | 307.180 |

**Base Reaction:** The reaction is carried out with & without shear wall

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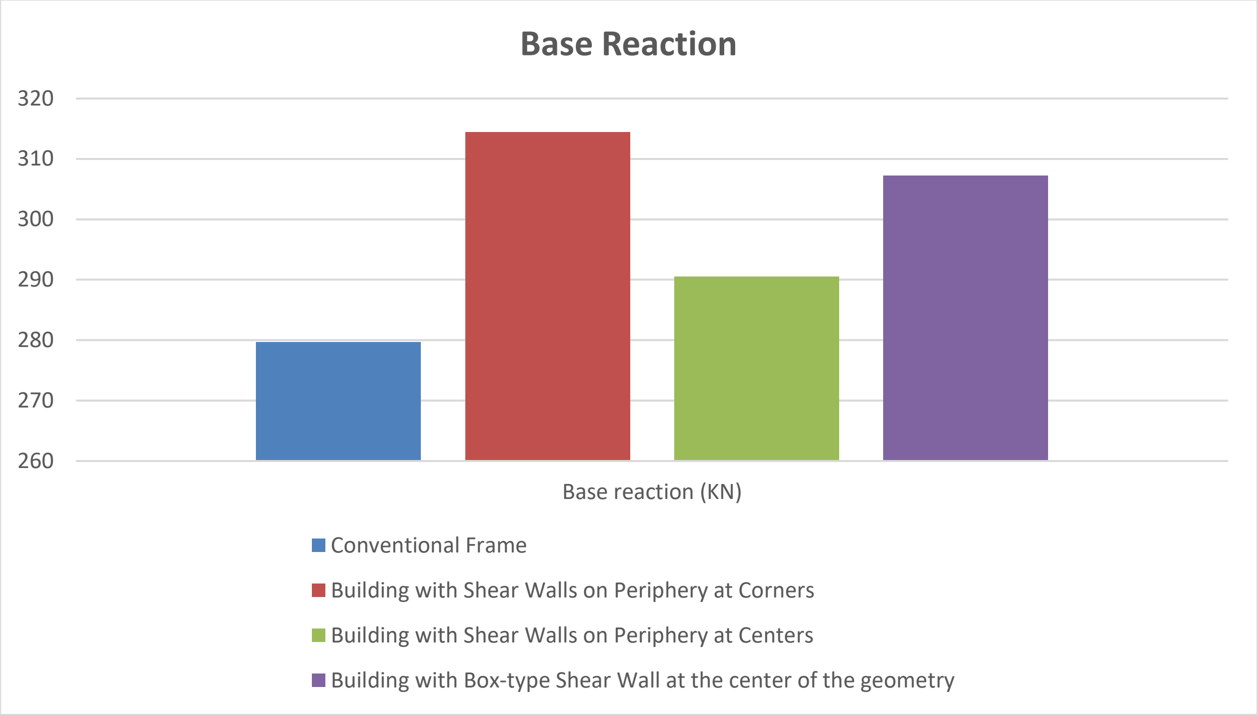


**Moment:** The moment is carried out with & without shear wall

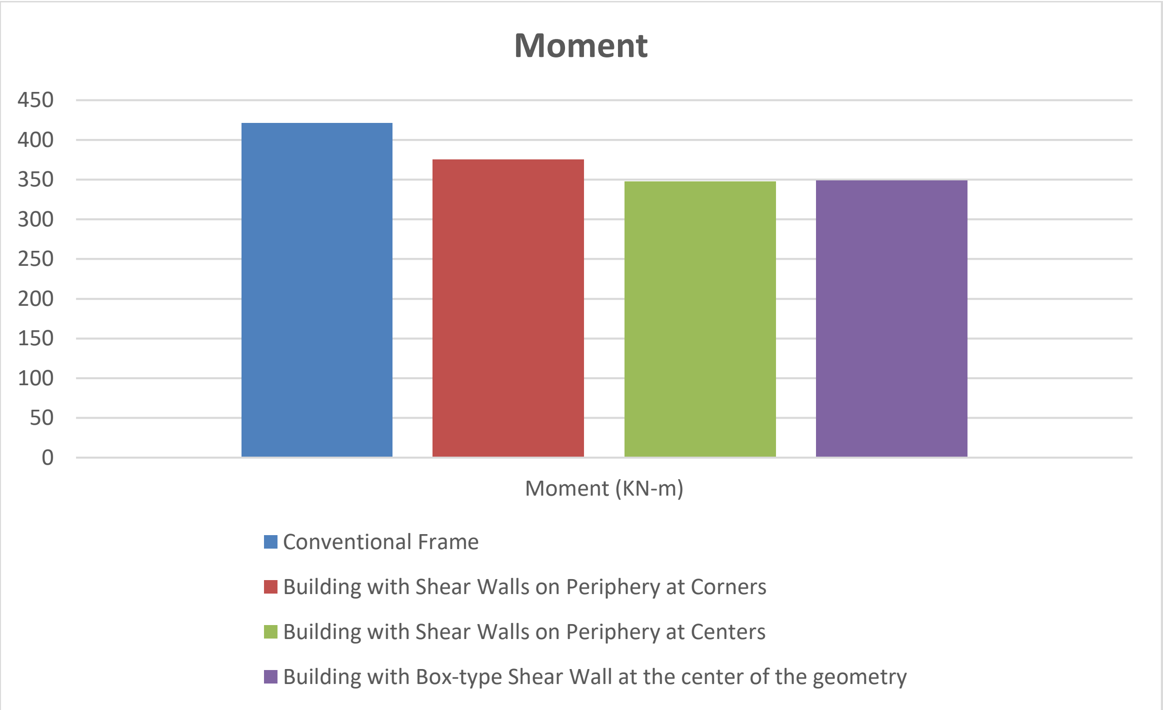


Figure 3 Variable of a Moment

**Displacement:** The displacement is carried out with & without shear wall

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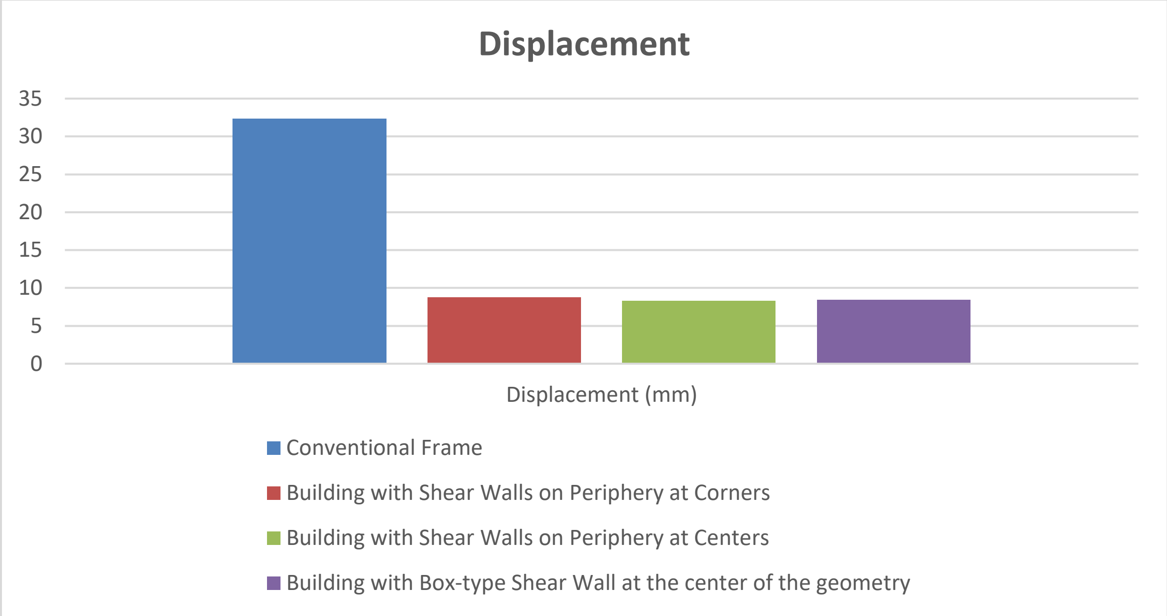


Figure 3 Variable of a Displacement

**Storey Shear:** The Storey Shear is carried out with & without shear wall

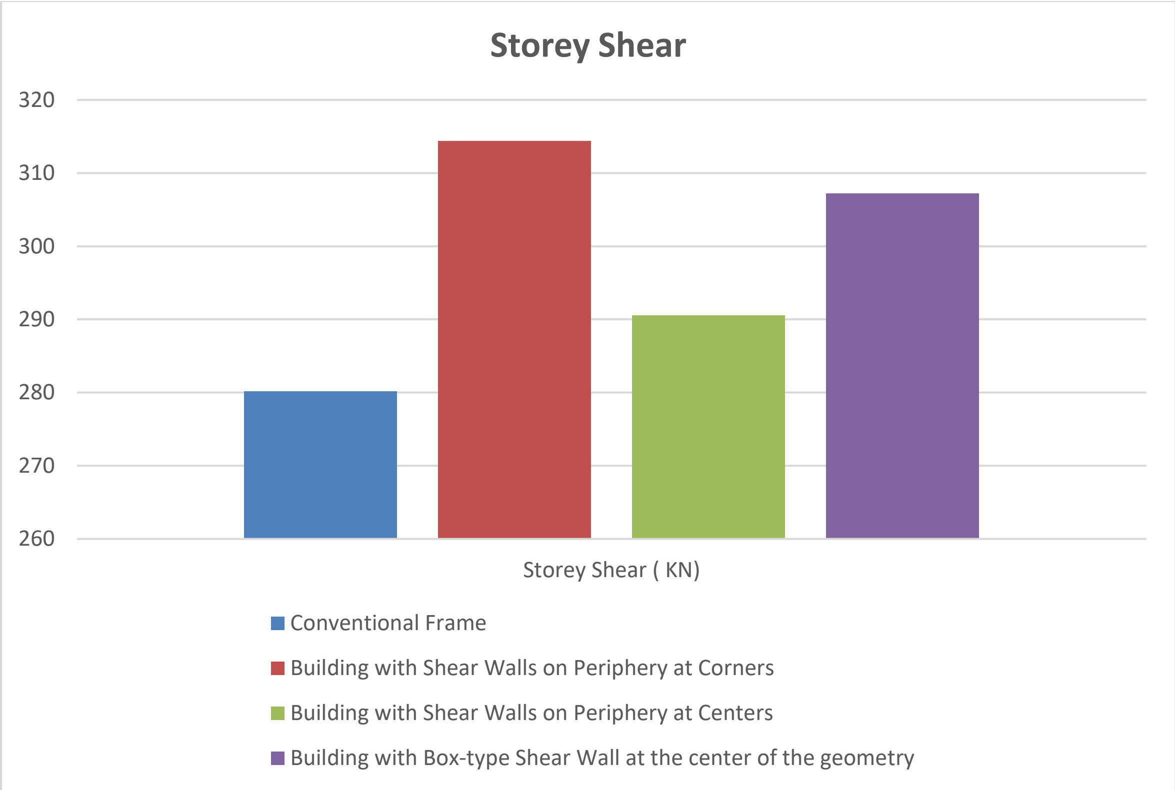


Figure 4 Variable of a Storey Shear

## 7.0 CONCLUSION

1. **Base Reaction (KN):**

- The base reaction is highest for the **Building with Shear Walls on Periphery at Corners** (314.426 KN) and lowest for the **Conventional Frame** (279.693 KN).
- Shear walls increase the base reaction due to their added stiffness and the ability to carry more vertical loads.

2. **Moment (KN-m):**
   - The **Conventional Frame** experiences the highest moment (421.062 KN-m), indicating it has the most significant bending forces without shear walls.
   - All shear wall configurations reduce the moment, with the **Building with Shear Walls on Periphery at Centers** showing the lowest moment (347.501 KN-m), demonstrating that shear walls help in distributing bending forces more effectively.
3. **Displacement (mm):**
   - The **Conventional Frame** shows the highest displacement (32.35 mm), indicating it is the most flexible and experiences the most lateral movement.
   - Shear walls drastically reduce displacement, with the **Building with Shear Walls on Periphery at Centers** having the least displacement (8.270 mm).
   - The **Box-type Shear Wall at the Center** also shows significant reduction in displacement (8.394 mm), indicating effective lateral stability.
4. **Storey Shear (KN):**
   - The storey shear values are consistent with the base reaction values, with the **Building with Shear Walls on Periphery at Corners** having the highest shear force (314.426 KN) and the **Conventional Frame** having the lowest (280.168 KN).
   - This consistency suggests that shear walls not only improve vertical load capacity but also enhance lateral force resistance.

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