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# **A Comparative Study on Seismic Behaviour of G+12 Multistory Building for Different Location of Shear Wall using ETABS**

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**ABSTRACT:** In recent decades, the use of shear walls and tube structures has significantly advanced the height capabilities of concrete buildings, leading to more complex structural behaviour in modern RC tall buildings. This paper examines the structural aspects of a 12-story RC building, situated in various seismic zones, where a shear wall system with irregular openings is employed to resist both lateral and gravity loads. These irregular openings, which are often introduced to meet functional needs such as doors and windows, can influence the behaviour of structural elements like shear walls and coupling beams.

Given that the size and location of these openings are often determined by architectural requirements without fully considering their impact on the building's structural behaviour, this study focuses on evaluating the effects of these variables. The analysis is conducted using ETABS through a Response Spectrum Analysis approach. The study investigates different configurations of shear walls—positioned at the corners, center, and alternative locations—and compares the results in terms of storey drift, shear, torsion, time period, frequency, and base shear against a model without shear walls.

**KEYWORDS:** structural forms, shear wall, drift, shear, moments, torsion, base shear.

## **I. INTRODUCTION**

In India, a lot of medium-rise apartment buildings are being built with shear walls to enhance earthquake resistance in reinforced concrete frames. These shear walls frequently feature openings for windows, doors, and ducts for practical purposes. The quantity, placement, and dimensions of these openings have a major impact on the wall's performance and how stress is distributed within it.

Framed structures with shear walls are commonly used in high-rise buildings, which also have numerous openings for elevator entrances, staircases, and other access points. Typically, plane stress elements and beam elements are used to model the shear walls and frames, respectively, in the analysis of such buildings. A plane stress element should have drilling degrees of freedom to accurately represent the connection between the shear wall core and frames; otherwise, the bending moment at the end of a beam cannot be transferred to the shear wall.

Large openings, such as those found in function halls, conference halls, and movie theaters, can significantly impact the structure's behaviour, affecting deflection and stress in the members. These openings can seriously affect the efficiency and accuracy of the analysis.

### **Shear wall**

Shear walls are vertical structural elements engineered to handle lateral forces caused by wind or seismic activity. Their design and placement play a crucial role in how they perform under such forces. Lateral loads are transferred across the structure, functioning like a horizontal diaphragm, to the shear walls that are aligned with the direction of these forces. Due to their significant rigidity, these shear walls resist horizontal forces, behaving like deep beams and

counteracting overturning through shear and flexural responses. A core that is eccentrically located relative to the building shape must handle tension, bending, and direct shear, while torsion may develop even in symmetrically arranged shear wall buildings when wind impacts the facades' surface textures or when it does not act through the building's center of mass (Schueller, 1977).

Stiffness of shear walls is much higher than the stiffness of horizontal rigid frames and therefore may be very economical up to 35 stories. Shear walls will take all lateral loading when coupled with frames in a low to mid volume construction and the frame can be designed for gravity loads only. The ultimate behaviour of a shear wall with respect to resistance, thickness and width is very different; the first two are linear but Width make more impact. A coupled shear wall system, one of the most common types of systems that consist to two or more walls in same plane or approximate with rigid beams and slab at floor levels. This results in a drastically higher horizontal stiffness than if the walls would have behaved individually as unconnected cantilevers.

#### **Shear wall components:**

Reinforced concrete and reinforced masonry shear walls are rarely simple structures. When walls contain doors, windows, or other openings, they must be considered as an assembly of various components: relatively flexible parts like column segments and wall piers, and relatively stiff parts like wall segments. Column segments are vertical members with a height greater than three times their thickness and a width less than two and one-half times their thickness. They primarily bear axial loads and may contribute minimally to the lateral force resistance of the shear wall, but their rigidity is significant. When integrated with a wall, the projecting part of a column from the wall's face is known as a pilaster, and these segments should be designed following ACI 318 standards for concrete. Wall piers are wall segments with a horizontal length between two and one-half to six times their thickness and a clear height of at least twice their horizontal length. Wall segments, which are longer than wall piers, are the main components providing resistance in the shear wall.

#### **NECESSITY, IMPORTANCE FEATURES IN PLANNING AND DESIGN OF SHEAR WALLS:**

In all high-rise buildings, ensuring sufficient stiffness and controlling excessive displacements are just as crucial as providing adequate strength. The shearwall system offers two key benefits compared to a frame system:

1. It delivers the necessary strength to withstand large lateral forces without significantly increasing costs.
2. It provides enough stiffness to limit lateral displacements within acceptable limits, thereby reducing the risk of non-structural damage.

Shear walls should be positioned strategically so that they also serve functional purposes without disrupting the building's architecture. Often, enclosures around the elevator shafts are used as shear cores. Additionally, shear walls should be placed along both axes to provide lateral stiffness in both directions, which is particularly important for square-shaped buildings. To prevent torsional effects, shear walls should be symmetrically placed around the axis. Lastly, shear walls should extend all the way down to the foundation level.

#### **DRIFT:**

The drift index, defined as the ratio of the maximum deflection at the top of a building to its total height, offers a simple estimation of a building's lateral stiffness. The inter-story drift, which corresponds to the deflection within a single storey, provides insight into potential localized excessive deformation. Controlling lateral deflection is crucial for modern buildings, which lack the traditional stiffness provided by heavy internal partitions and outer cladding. Establishing drift index limits is a significant design decision, yet there are no universally accepted values or firm guidance in many national codes. Designers must therefore approximate a value based on building usage, design criteria, construction type, materials, cladding, lateral loads, and past experiences with similar buildings. Design drift index limits typically range from 0.001 to 0.005, with lower coefficients recommended for taller buildings to maintain acceptable story deflections. According to IS: 1893-1984 (Clause 4.2.3), the maximum allowable inter-story drift due to earthquake forces is 0.004 or 0.4%. This study aims to investigate the qualitative and quantitative aspects of drift in a 15-story building with shear walls featuring openings at different levels, subjected to lateral earthquake loads.



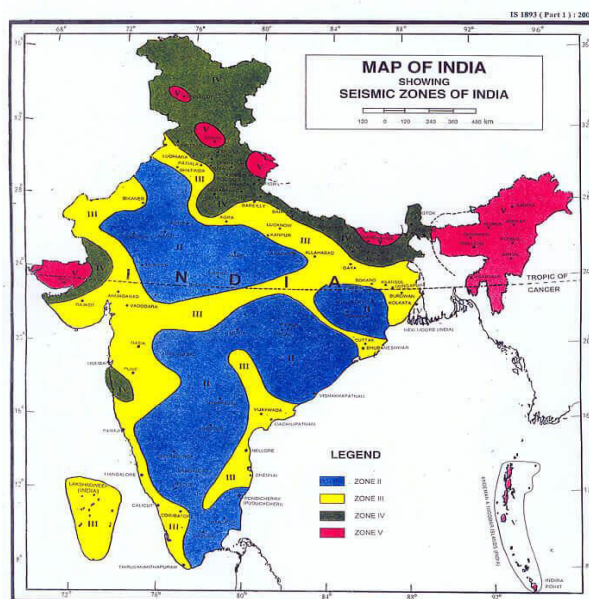
**OBJECTIVE OF THE STUDY**

Here are the revised project objectives:

1. To analyze the seismic response of multi-story buildings according to IS 1893:2002.
2. To compare multi-story buildings with shear walls located at corners, centers, and alternate positions across various seismic zones.
3. To evaluate and compare the story drift, shear force, bending moment, and torsional behaviour of buildings with different shear wall placements.
4. To study the buildings in response spectrum analysis.

**II. SEISMIC ZONES OF INDIA**

Each country does planning of its domain dependent on all catastrophic events like earthquake, twister, flood and well of lava and so on.. This planning is done based on previous history and components liable for such catastrophe of present around there. This planning causes individuals to design their home and other infrastructure so they don't turn into the casualty of such calamity and can withstand catastrophes with as least as conceivable death toll and property. Code of training of all countries for design of structures and other structure suggested design rules dependent on such planning or zoning.



**Seismic zone have been categorized as follows:**

**1. ZONE V**

The regions within this zone face the highest risk from earthquake impacts. The earthquake intensity here is MSK-IX or above, with a zone factor of 0.36, reflecting a considerable level of seismic activity. This area, known as the Very High Damage Risk Zone, includes locations like the Rann of Kutch and certain eastern regions.

**Difference Between Earthquake Intensity and Magnitude:**

Intensity is expressed using Roman numerals and indicates the severity of an earthquake based on its effects on the earth's surface, people, and structures. A higher numeral denotes greater intensity and more significant damage. Magnitude, however, quantifies the energy released at the earthquake's epicenter. Intensity is gauged by the Modified Mercalli Scale (MMS), while magnitude is measured on the Richter scale.

## 2. Zone VI:

This zone has a lower risk of earthquake impact compared to Zone V. The earthquake intensity in this area ranges between MSK VIII and MSK-IX, and it is classified as a High Damage Risk Zone with a zone factor of 0.24. Regions such as the Northern areas, Northeastern regions, and Delhi fall within this zone.

## 3. Zone III:

This zone is known as the Moderate Damage Risk Zone, with a lower earthquake risk. The earthquake intensity here is rated as MSK VII, and the zone factor is 0.16. Regions that fall into this category include parts of Gujarat and Maharashtra, as well as the Andaman and Nicobar Islands.

## 4. Zone II:

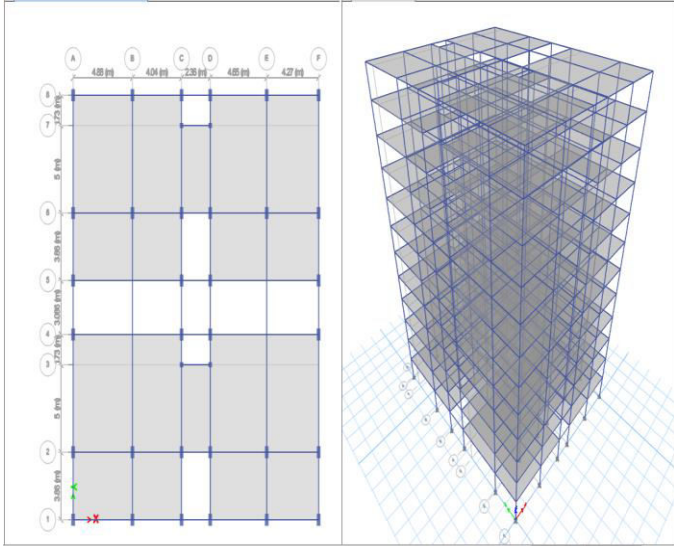
This zone, known as the Low Damage Risk Zone, has the least risk of an earthquake, with an intensity of MSK VI and a zone factor of 0.10. Most of India falls within this zone. In Zone II, the intensity is VI on the MSK scale, while in Zone V, it is IX or higher, indicating that the damage and impact would be more severe in Zone V.

## III. PROBLEM STATEMENT

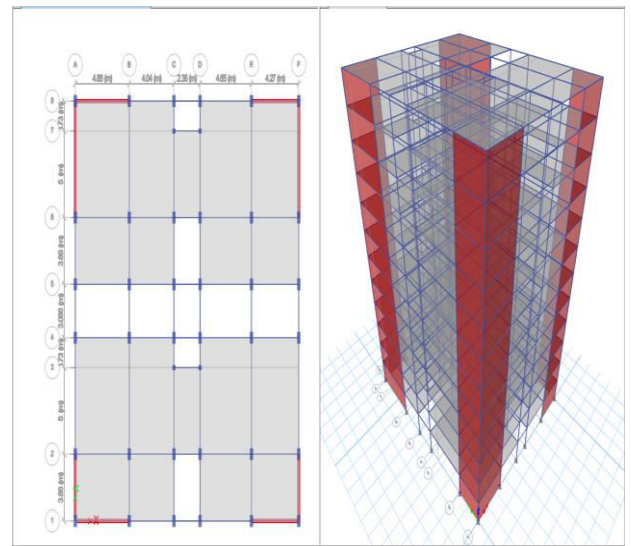
The following are the basic data considered for analysis

1. Height of typical Storey	=	3 m
2. Height of ground Storey	=	3 m
3. Length of the building	=	15 m
4. Width of the building	=	13 m
5. Height of the building	=	39 m
6. Number of stores	=	12 (P+G+10)
7. Wall thickness	=	230 mm
8. Slab Thickness	=	150 mm
9. Grade of concrete	=	M30
10. Grade of the steel	=	Fe500
11. Support	=	Fixed
12. Column size	=	460mmX690mm
13. Beam size	=	690mmX300mm
14. Location of Building	=	India
15. Live load	=	5 KN/m <sup>2</sup>
16. Dead load	=	3 KN/m <sup>2</sup>
17. Density of concrete	=	25 KN/m <sup>3</sup>
18. Seismic Zones	=	Zone 5, Zone 4, Zone 3, Zone 2
19. Site type	=	II
20. Importance factor	=	1.5
21. Response reduction factor	=	5
22. Damping Ratio	=	5%
23. Structure class	=	C
24. Basic wind speed	=	44m/s
25. Risk coefficient (K1)	=	1.08
26. Terrain size coefficient (K2)	=	1.14
27. Topography factor (K3)	=	1.36
28. Wind design code	=	IS 875: 2015 (Part 3)
29. RCC design code	=	IS 456:2000
30. Earth quake design code	=	IS 1893: 2016 (Part 1).

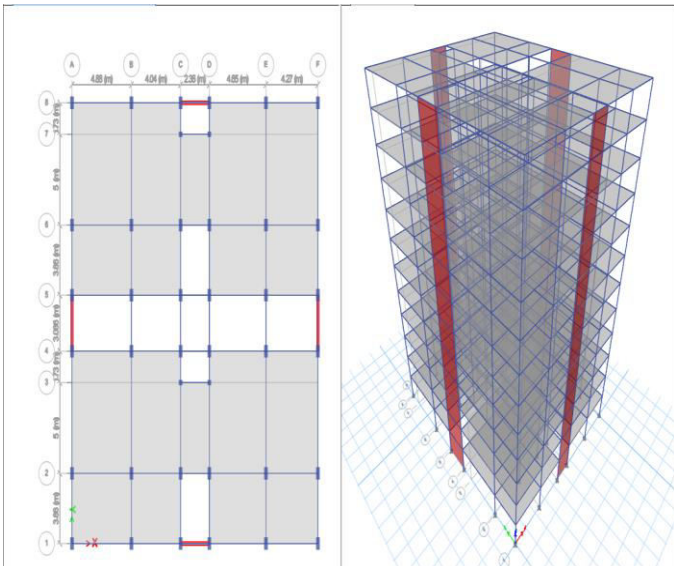
#### IV. MODELS IN ETABS SOFTWARE



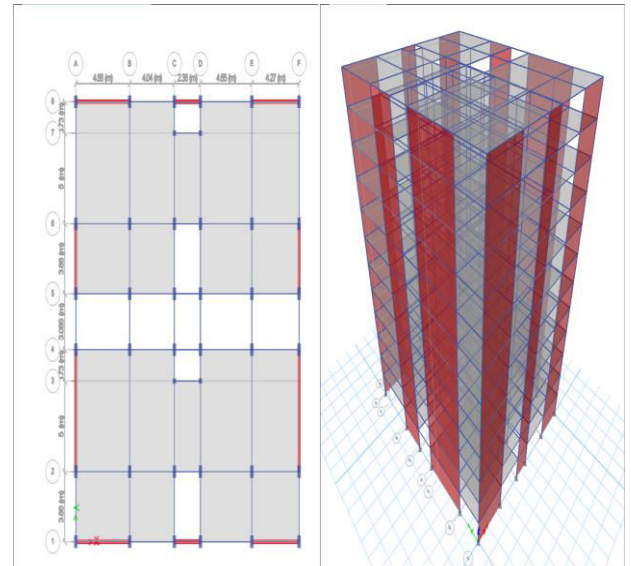
Without Shear wall



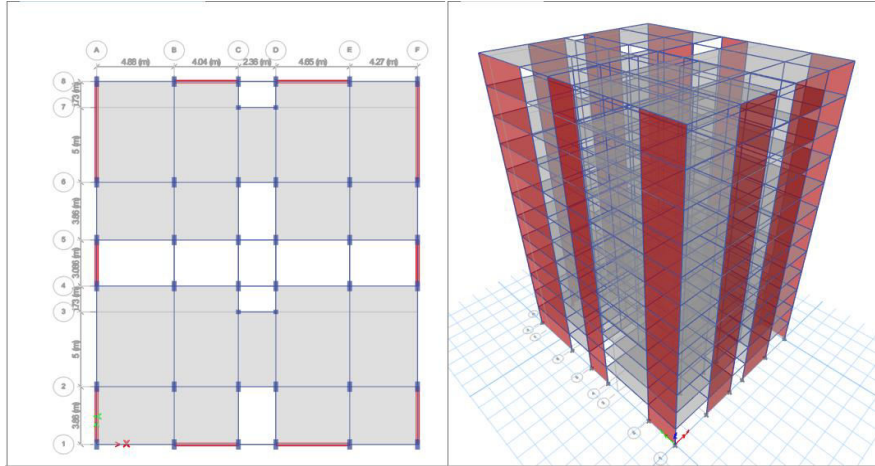
With corner shear wall



With center shear wall



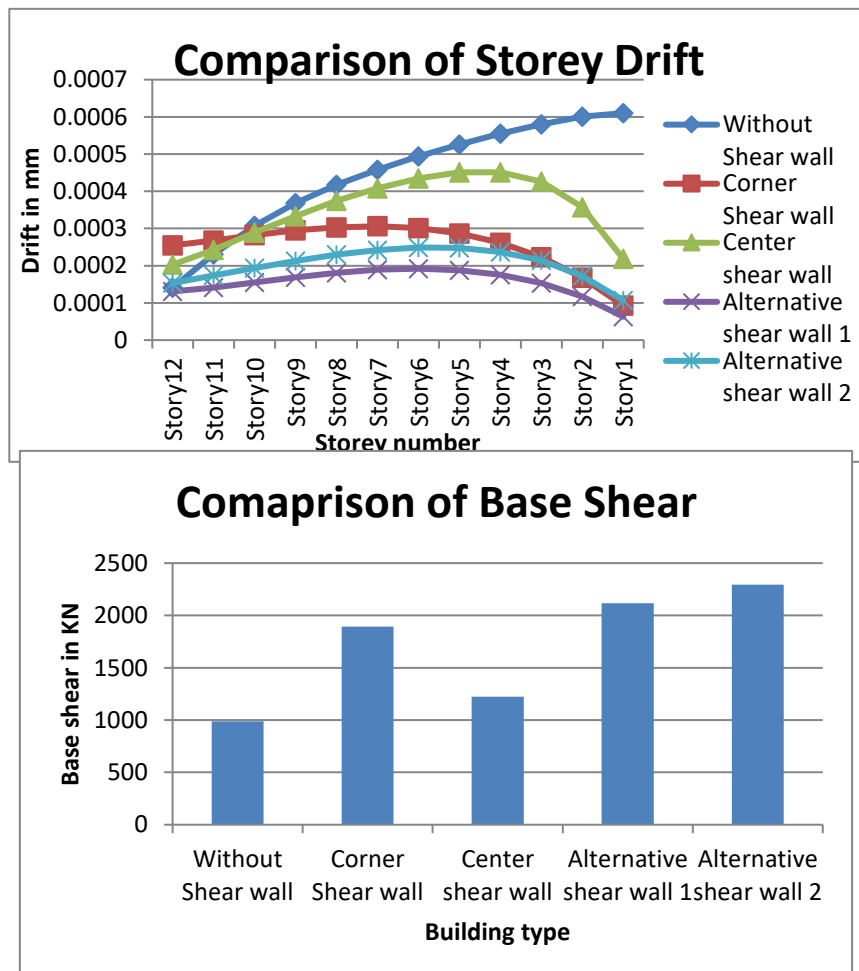
With alternative shear wall 1



With alternative shear wall 2

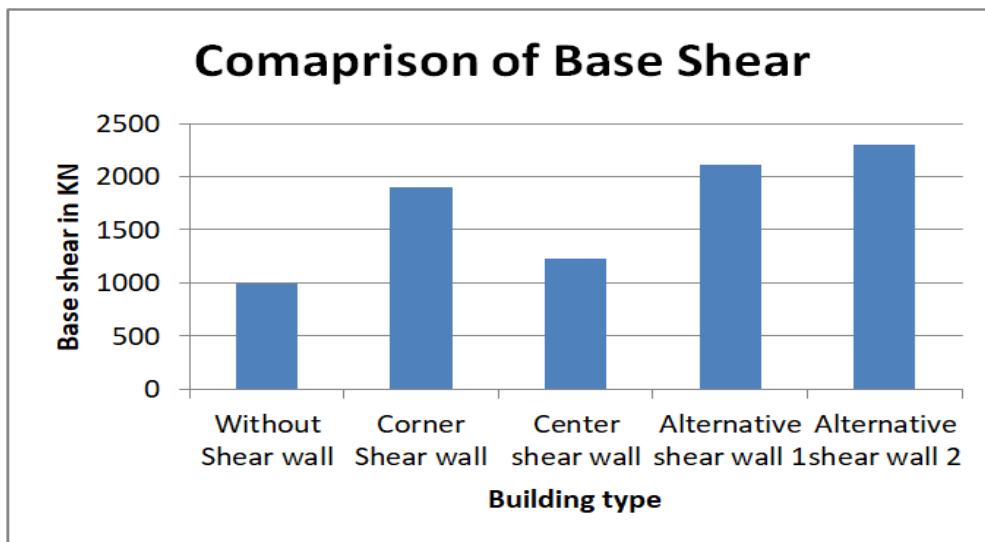
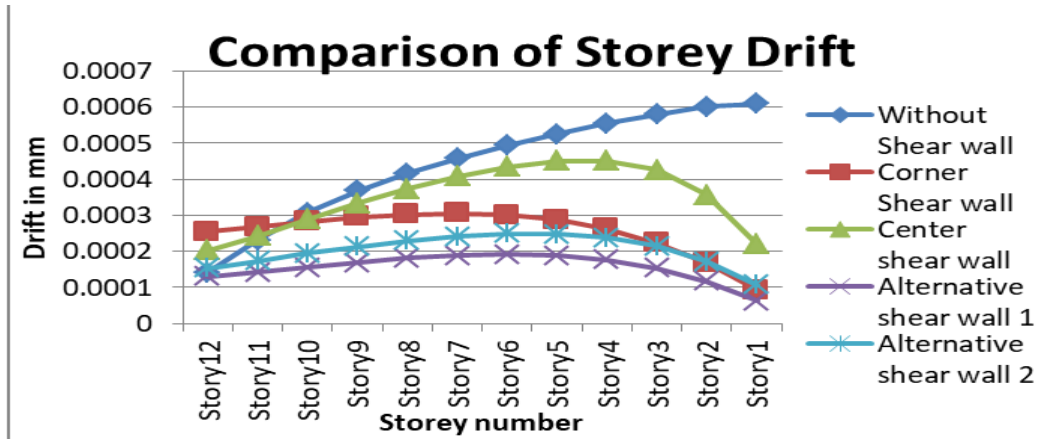
## V. RESULTS AND ANALYSIS

### 1. Zone V Results

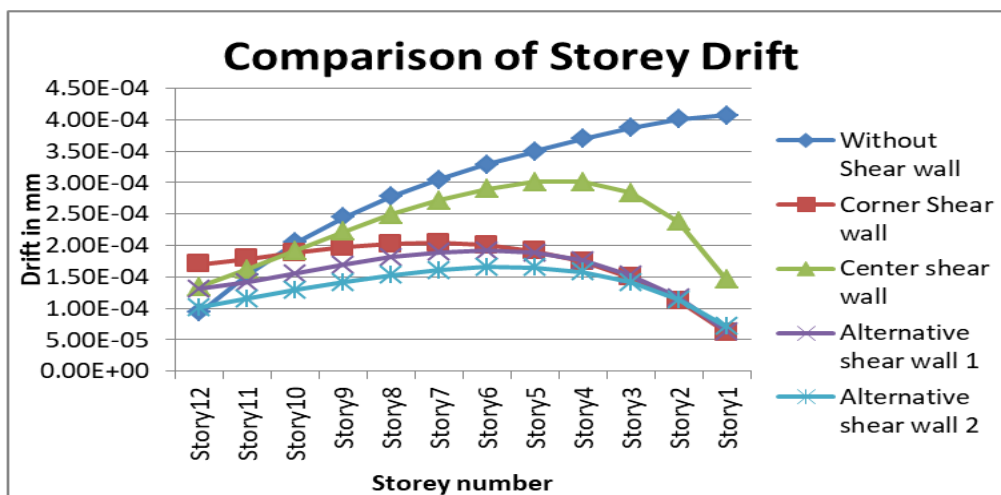




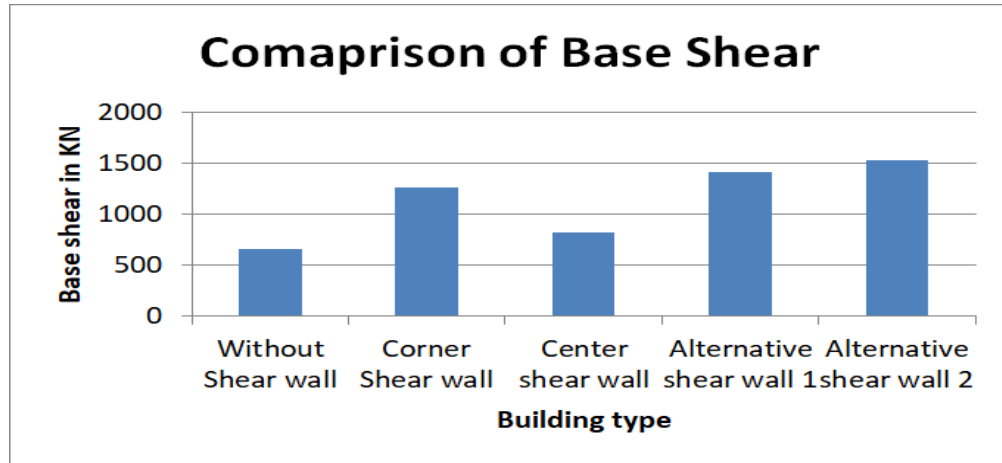
## 2. Zone IV Results



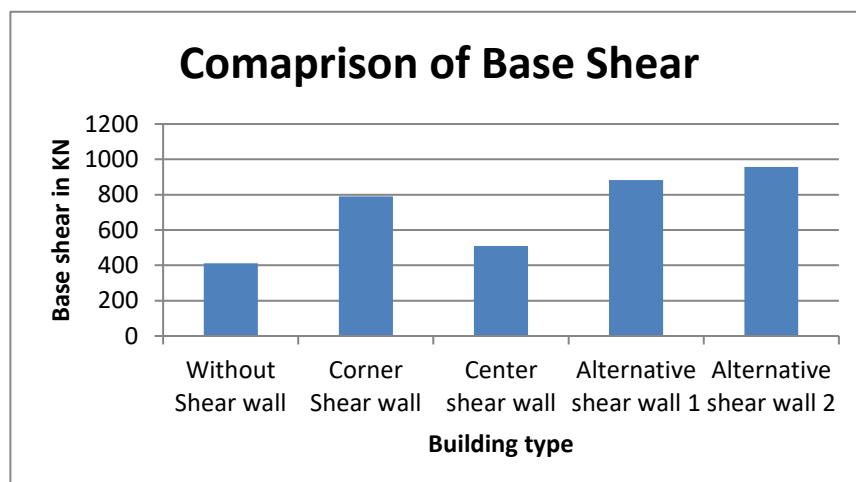
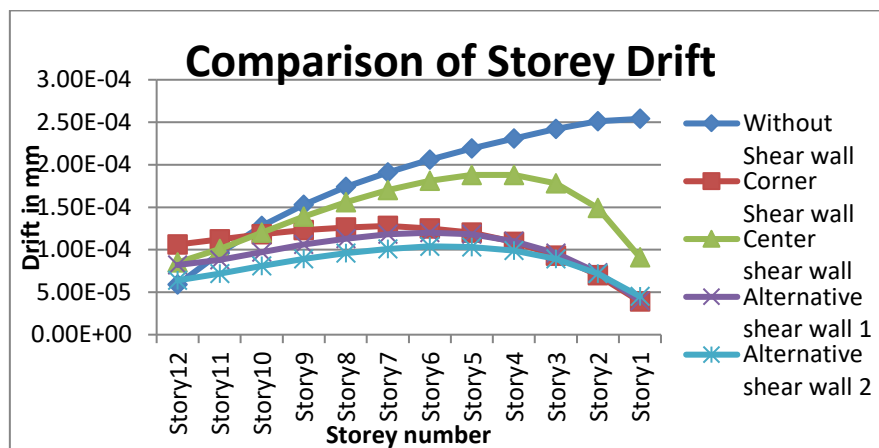
## 3. Zone III Results







#### 4. Zone II Results



## VI. CONCLUSIONS

From this study the following conclusions were made

1. The top deflection decreased and fell within the allowable limits after adding a shear wall in the shorter direction, with the alternative shear wall 2 case showing lower values compared to the other models.
2. The placement of the shear wall proved to be more effective near shorter columns than in other locations.
3. Placing shearwalls symmetrically in the outermost moment-resisting frames enhances the performance of a regularly shaped building.
4. The drift value is lower for the building with a shearwall in alternative 2 compared to the other cases.
5. The shear values in the X and Y directions were lower for the building with the shear wall positioned at alternative case 2 compared to the other buildings.
6. The bending values were lower for the building with a shearwall in alternative case 2 compared to the other buildings.
7. The deflection value for the building is lower in alternative case 2, where a shearwall is present, compared to the other cases.
8. It was observed for a particular opening in wall when the opening position is shifted from one position to other position.
9. From this study it was concluded that increase in the percentage of Shearwall results in decrease in the drift, deflection and increases the Shear force, bending moment.

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