A Comparative Analysis of the Seismic Performance of Periphery and Corner RC shear walls on medium soil across varying Seismic Zones using CYPE Software

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Abstract : The increasing place of urbanization has led to a greater demand for high-rise reinforced cement concrete (RCC) buildings, where lateral stability under seismic forces is a major design consideration. Among various lateral load–resisting systems, shear walls are mainly for their high in-plane stiffness and strength, enabling them to counter significant horizontal loads while simultaneously carrying gravity loads. Their use has become one of the most efficient methods for improving the seismic performance of multi-storey structures. this study includes the, G+9 RCC building modeling and analyses using the CYPECAD to investigate and influence of shear wall on structural behavior, and the building is considered to be located in seismic zone-II representing moderate seismic and earthquake forces are considered as per is 1893-Part-1-2016 Using the equivalent static and design spectrum methods.

Introduction

In ancient methods of constructions in modern era that is from 17th century above in ancient structures such as Egyptian pyramids Greek temples, However until the early 20th century that shear walls became a widely deployed RCC framed element which are used in structural buildings to prevent seismic loads During the 1960's seismic observations a movement began in countries with frequent seismic activity such as Japan, America, New zeland, to change the building method codes as per the observations of major earthquake showed that the building with reinforced shear wall structure performed significantly better then convention framed structures. In 1970's formal research of earthquake observation made the potential of shear wall structure became major focus of research During the 1960's seismic observations a movement began in countries with frequent seismic activity such as Japan, America, New zeland, to change the building method codes as per the observations of major earthquake showed that the building with reinforced shear wall structure performed significantly better then convention framed structures. In 1970's formal research of earthquake observation made the potential of shear wall structure became major focus of research. The primary role of any structural system is to resist gravity-induced loads, as dead load, live load, and in some regions, snow load. The structure is subjected to Horizontal actions such as wind and seismic forces these loads causes stress, tilting or repeated motion if not restrained, a well good design structure should not only consider vertical loads but also ensures the required structural stability strength against the Horizontal forces. For maximum structural efficiency, shear walls should be arranged symmetrically in plan, as this reduces tensional effects. Depending on architectural constraints, they may be placed along one or both principal axes. In case of high-rise buildings, incorporating shear walls or alternative lateral load resisting systems is crucial to controlling inter-storey drift

NEED OF THE STUDY

The main motive of the study is to analyze RC structure of shear wall at corner of the Structure and Periphery of structure at medium soil conditions. By using cypecad software to analyze response spectrum of the structure and wind load at medium soil condition.By considering parameter such as time period center of stiffness, center of mass base shear made shapes drifts are calculated and have been compared in medium soil condition. The model analysis is calculated to know the response of the structure with shear wall.

1.1 There are several shear walls types

- **RC Shear wall**:- Reinforced concrete shear wall is a vertical element made of RC that resist lateral forces like earthquake, wind pressure,& blast loads. In buildings it acts like a vertical beam fixed at the foundation extending up to building height, purpose of the shear walls for the structure to increase lateral stiffness, Controls deflection & sway, resist horizontal forces and also prevent collapse or damage during earthquake. It mainly uses at the high rise structure like apartments commercial towers, hospital, educational buildings where safety is crucial and industrial structures.
- **Plywood Shear wall**:- Plywood shear wall is traditional material used in construction as a shear walls the creation a Prefabricated shear panels have enabled the introduction of robust shear components into narrow wall sections adjacent to openings within shear walls. Moreover, substituting traditional structural plywood with materials like sheet steel or steel-

backed shear panels, such as sure boards, in shear wall constructions has demonstrated significantly greater strength and improved seismic resistance

- **Midply:-** A midply shear wall is a specialized wood shear wall system in which the sheathing panel is installed at the center of the wall, positioned between two stud assemblies that are rotated 90 degrees. This configuration creates double-shear nail connections, in contrast to the single-shear connections found in conventional plywood shear walls. The result is a wall with markedly higher shear resistance and load capacity, delivering improved seismic behavior and overall structural stability. It works in
- **RC Hallow Concrete Block Masonry walls**:- Reinforced Concrete (RC) Hollow Block Masonry is a construction method that utilizes hollow concrete blocks with internal cavities. These gaps are later closed with steel reinforcement and concrete, producing a robust and durable wall system. Compared to ordinary hollow block masonry, this approach offers greater load-bearing strength, enhanced seismic performance, and improved thermal and acoustic insulation. The construction sequence involves laying the blocks with mortar, placing reinforcing bars inside the hollow cores, and subsequently filling them with poured concrete to create a continuous, reinforced structural unit.
- **Steel plate shear wall**:- Steel plate shear wall systems generally consist of a steel plate, vertical boundary columns, and horizontal floor beams. Together, the boundary columns and steel plate act like a vertical plate girder, where the columns function as the flanges and the steel plate serves as the web. The horizontal floor beams mainly serve as transverse stiffeners for this girder-like assembly. In recent years, these steel plate shear walls have been extensively used in regions prone to strong seismic activity due to their high effectiveness in resisting lateral forces.

1.2 OBJECTIVES OF THE STUDY:

The main objectives of the study is to observe reaction of RC shear wall in different soil condition

1. **Evaluate the effect of soil-structure interaction**:- The dynamic behavior of shear walls can be evaluated by contrasting a traditional fixed base model, where the foundation is assumed rigid, with a model that incorporates flexible soil conditions.When soil flexibility is considered, the structural response changes due to soil-structure interaction effects. The influence of soil type—ranging from hard to medium to soft soils significantly affects seismic performance. Softer soils generally magnify the interaction, causing rise in building's fundamental period and modifications to its effective damping characteristics.
2. **Compare the seismic response of different shear wall locations**:- The effect of shear wall placement can be studied by comparing configurations where walls are located along the periphery (exterior) of the structure versus at the corners. Each arrangement impacts critical seismic parameters differently, including base shear, story drift, and overall lateral displacement, particularly when evaluated under varying soil conditions. The positioning of shear walls also plays a major role in determining the building's global stiffness and its efficiency in resisting lateral loads, thereby affecting overall seismic performance.
3. **Analyze specific seismic performance parameters**:-
   a) **Base Shear**:- Evaluate the base shear for shear walls placed at the periphery versus the corners under different soil conditions. Research indicates that soil-structure interaction (SSI) can cause a notable reduction in base shear compared with fixed-base models, and extent of this reduction depends on thesoil's flexibility.
   b) **Lateral Displacement Story drift**:- Examine how both lateral deformation and inter-story drift vary with soil conditions and the location of the shear walls. Softer soils typically lead to greater displacements and drifts, emphasizing the need to account for SSI in seismic design.
   c) **Natural period**:- Assess changes in the building's fundamental natural period when soil flexibility is included. As soil stiffness decreases, the natural period tends to increase, which modifies the building's dynamic behavior under seismic loading.
4. **Determine the optimal configuration for different soil conditions**:-Determine which shear wall configuration—peripheral or corner—is most effective in reducing seismic forces and damage, considering the type of soil. Research suggests that core (central) shear walls tend to be more efficient on soft soil conditions, while corner-located shear walls generally perform better on firmer soils. Based on these findings, recommendations can be made for the ideal placement of shear walls, tailored to the soil conditions and the specific structural features of the building to optimize seismic resilience.
5. **Validate and model the structural behaviour**:- Apply analytical and numerical approach including finite element analysis (FEA) tools such as CYPE CAD, to model and simulate the interactions between shear walls and the soil-structure system

II.METHODOLOGY

1. **Model Definition:-**
   a) Create the model of the G+9 building in CYPECAD, including all structural element beams, columns, slabs, foundations, and shear walls.

b) Define soil conditions by inputting properties corresponding to medium soil type. Incorporate soil-structure interaction effects by defining foundation stiffness.

2. **Shear Wall Input and Placement:-**

a) Define shear walls as vertical reinforced concrete elements in CYPECAD. Assign shear walls to different positions.

- Corner shear walls-Walls positioned at building corners.
- Peripheral Shear walls:- Walls places on exterior faces along the building perimeter.

a) Specify shear wall geometric properties such as thickness, height (from ground to 9th floor), and cross-sectional layout on each floor.

3. **Load Definition:-**

a) Assign dead loads, live loads, and earthquake loads according to relevant building codes-IS-1983-2016,IS-875 part-2-1987.

b) Define earthquake loads by generating a response spectrum or time-history analysis input per seismic zoning and soil characteristics.

4. **Analysis Settings:-**

a) Activate 3D spatial analysis including rigid diaphragm assumptions for floors for realistic force distribution.

b) Model lateral load effects and for combined effects.

c) Implement soil flexibility by adjusting foundation movement or adding flexible supports to simulate soil-structure interaction effects medium soils.

5. Structural Analysis:-

a) Run finite element analysis to determine

- Base shear for corner & peripheral shear wall
- Story drifts for corner & peripheral shear wall
- Displacements for corner & peripheral shear wall

6. **Comparative Assessment:-**

a) Compare dynamic response parameters such as

- Story drifts of corner & peripheral shear wall on medium soil at different seismic zones.
- Displacement of Corner & peripheral Shear wall on medium soil at different seismic zones.
- Base shear of Corner & peripheral Shear wall configurations on medium soils.

7. Detailing and Documentation:-

a) Generate detailed reinforcement drawings and quantities directly from CYPECAD for implemented shear walls.

b) Prepare comprehensive reports summarizing the influence of soil type, load combinations, and shear wall placement on seismic and wind behavior and structural safety.

c) This approach ensures accurate modeling of soil-structure interaction and seismic , providing insight into optimal shear wall placement for G+9 buildings on medium soil profiles using CYPECAD tools.

III.MODELING AND ANALYSIS

Modeling a G+9 building with a RC shear wall in CYPE software enquires the use of advanced tools and a structured approach, particularly due to the Rc walls configuration of the floors and foundation. CYPECAD offers robust capabilities for analyzing and designing multi-level buildings that feature unique geometries, making it an ideal choice for handling complex, rectangular layouts in both reinforced concrete and steel structures.

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3.1 Project Setup

A new project was created in CYPE by selecting the appropriate design standards, materials, and storey height parameters. The orientation of the site and building was defined to accurately seismic impacts on the structure, taking into the shear wall at corner of the Structure and Periphery of structure at medium soil condition.

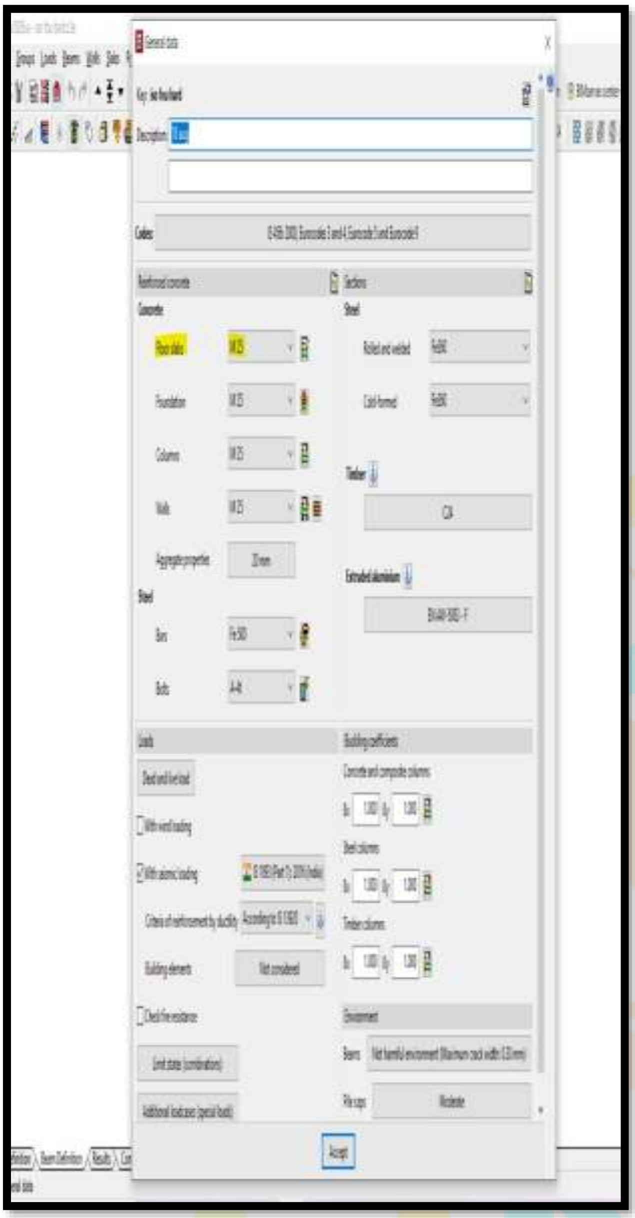

Fig 3.1:-Material property for Column

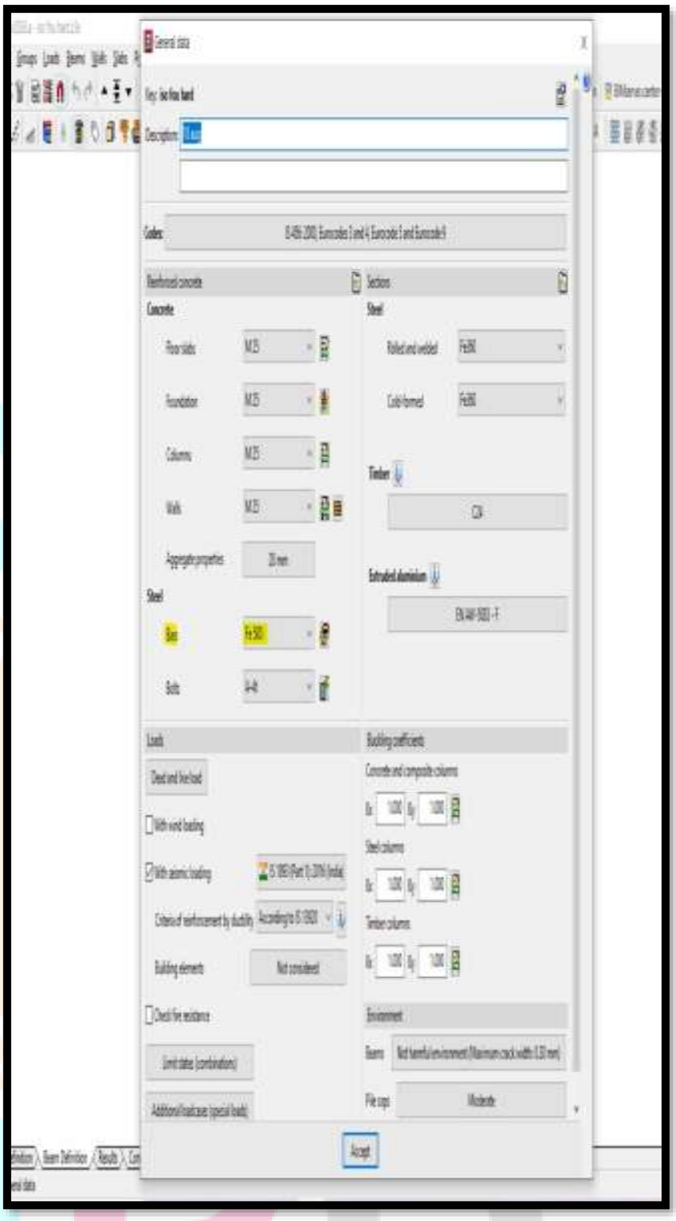

Fig 3.2:-Steel material property

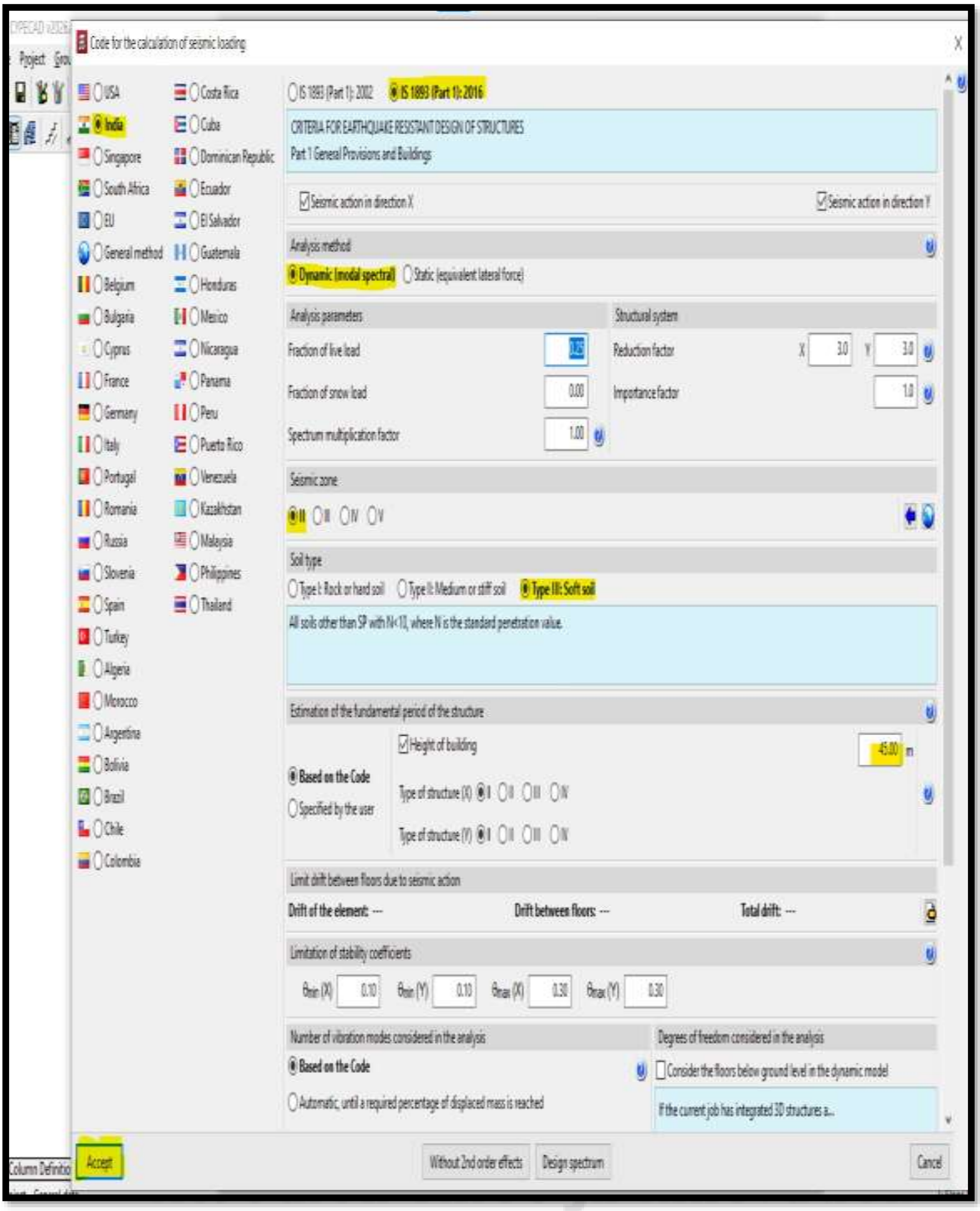

Fig 3.3:-Selecting type of soil strata and seismic zones

3.2 Modeling of Structural Elements

Columns and walls were positioned In alignment with architectural and structural requirements oo guarantee efficient load distribution throughout the irregular floors. Beams were created along the non-orthogonal edges inherent to the trapezoidal shape, using coordinate snapping and angular controls for accuracy. Floor slabs were defined as polygons and subdivided into finite elements to enable detailed structural analysis.

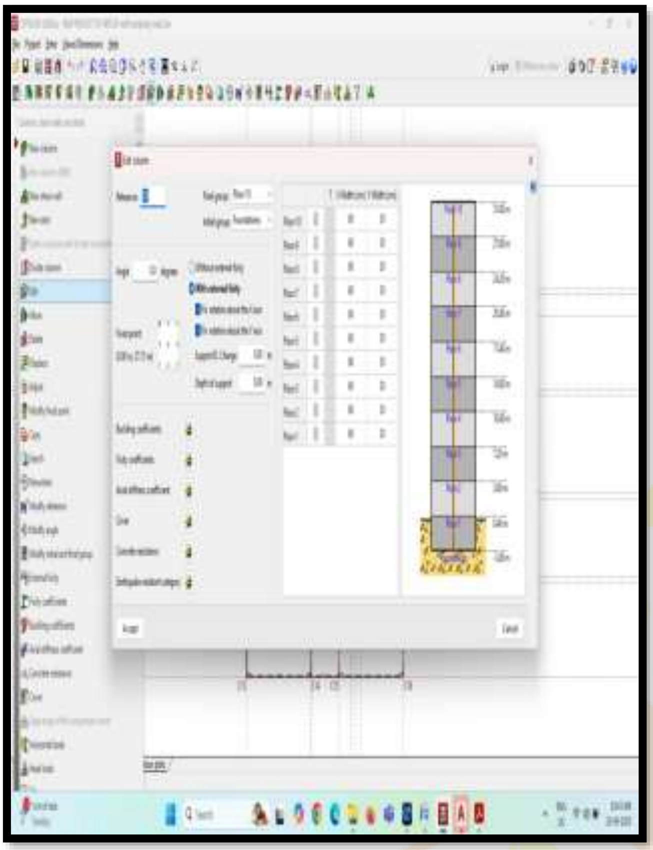

Fig 3.2.1:- Creating columns with dimensions

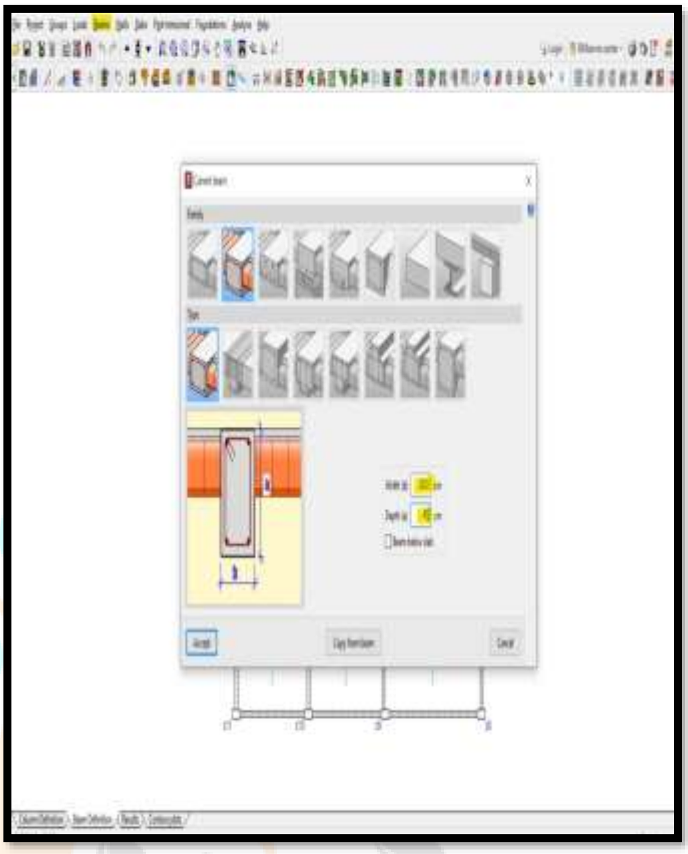

Fig 3.2.2:-Assigning beam details

Fig 3.2.3:-Assigning slab details

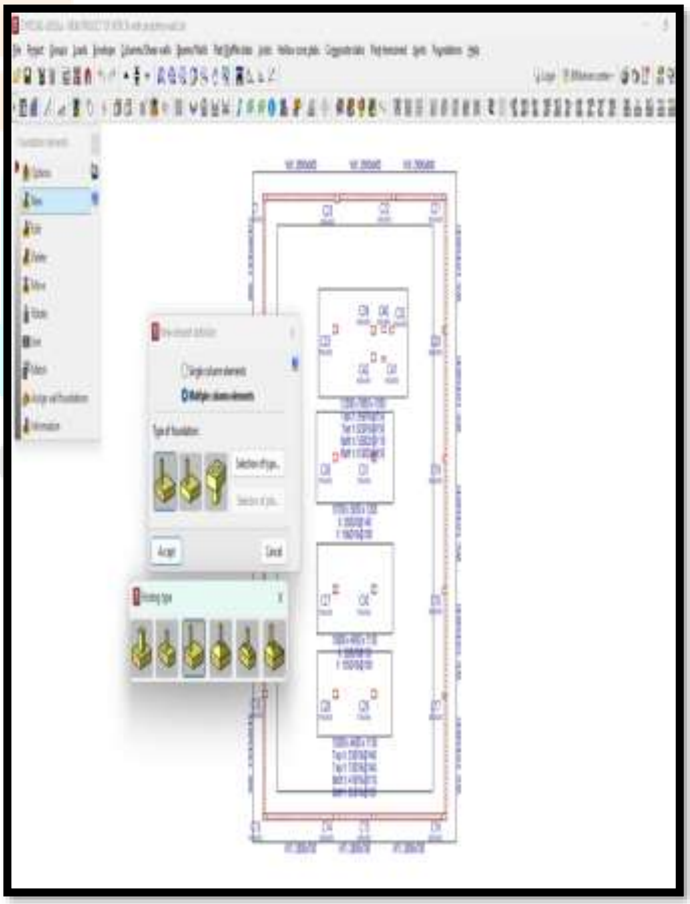

Fig 3.2.4:- Selecting the Type of Footings

IV. RESULTS AND DISCUSSION

4.1 Story Drift:- Story drift refers to the relative lateral displacement between two consecutive floors of a building when subjected to lateral forces. The use of shear walls helps minimize this movement. Shear walls placed at the building's corners are generally the most effective in limiting story drift because they add significant stiffness and resistance against sideways forces. While shear walls along the periphery also help reduce drift, their effectiveness is usually less compared to corner placements

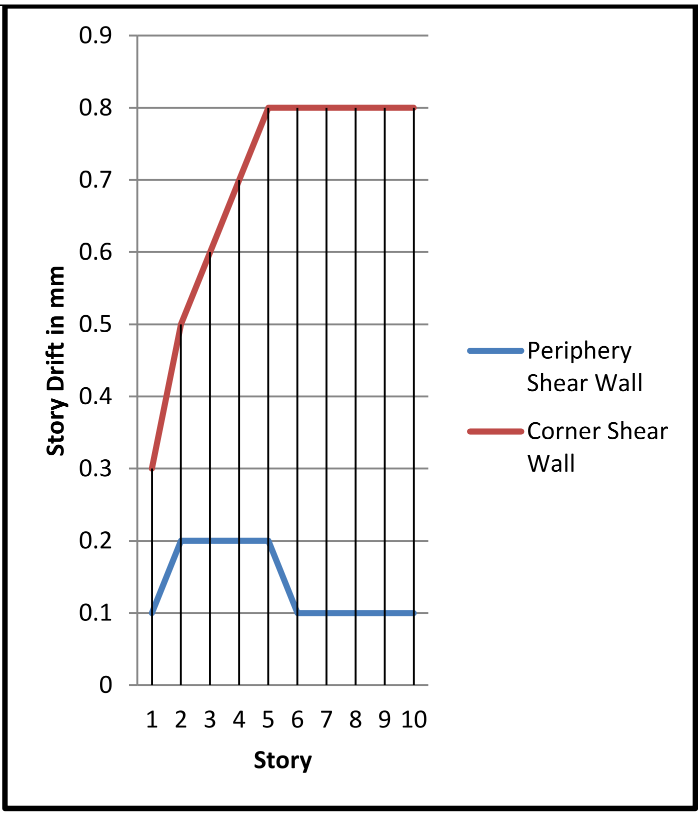

Fig 4.1.1: Comparing Graph of Story Drift for Periphery Shear Wall VS Corner Shear wall in Seismic Zone-II

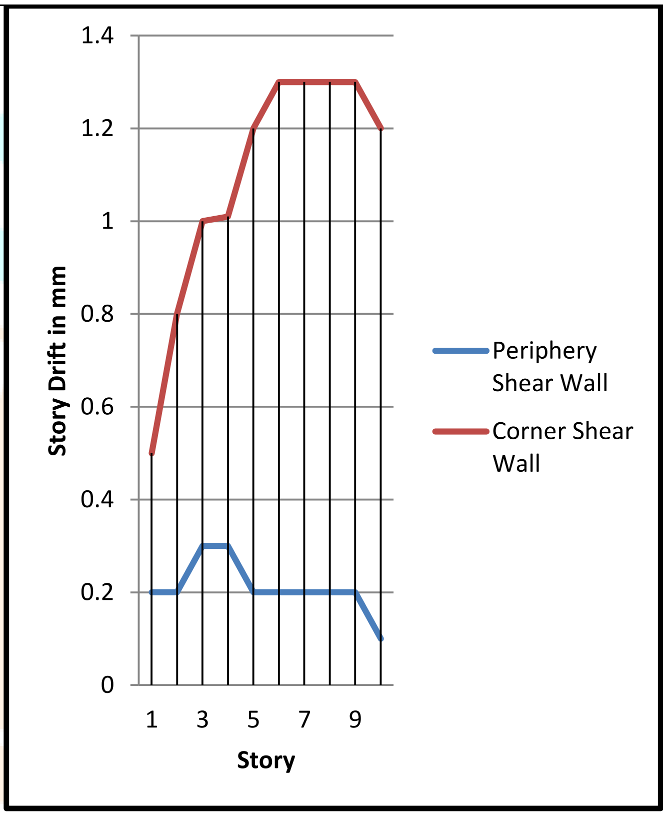

Fig 4.1.2: Comparing Graph of Story Drift for Periphery Shear Wall VS Corner Shear wall in Seismic Zone-III

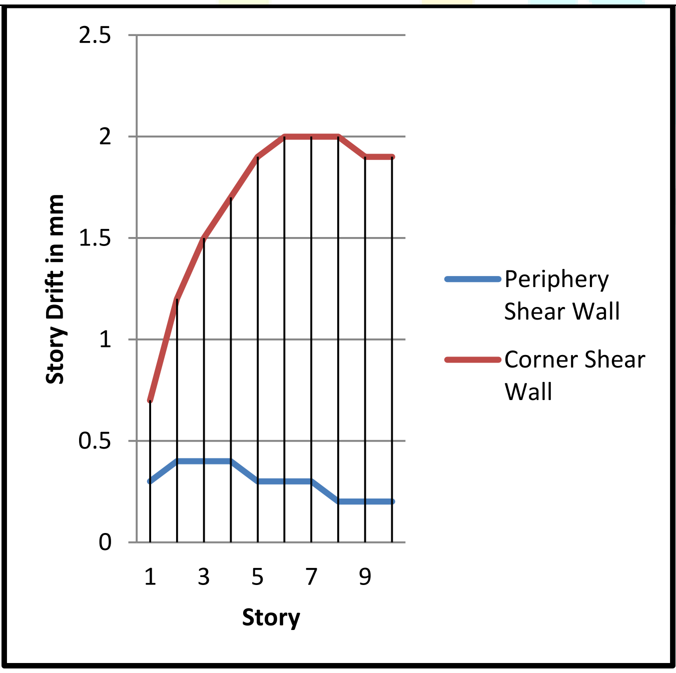

Fig 4.2.3: Comparing Graph of Story Drift for Periphery Shear Wall VS Corner Shear wall in Seismic Zone-IV

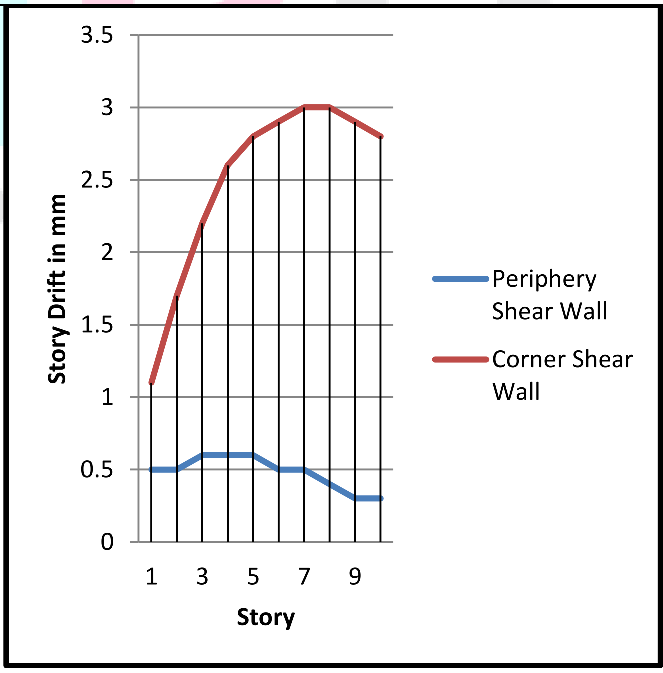

Fig 4.2.4: Comparing Graph of Story Drift for Periphery Shear Wall VS Corner Shear wall in Seismic Zone-V

4.2 Column Displacement:- Column displacement in buildings can be minimized by strategically placing shear walls at corner and peripheral locations, as these walls provide additional stiffness and help counter lateral forces such as those generated during earthquakes. Corner shear walls are particularly effective in enhancing stability and improving torsional resistance, while shear walls positioned along the sides (peripheral walls) contribute to a more uniform distribution of forces and better control of story drift. The most suitable arrangement depends on the architectural design and loading conditions, though peripheral placement often results in greater overall reduction of displacement compared to relying solely on corner walls.

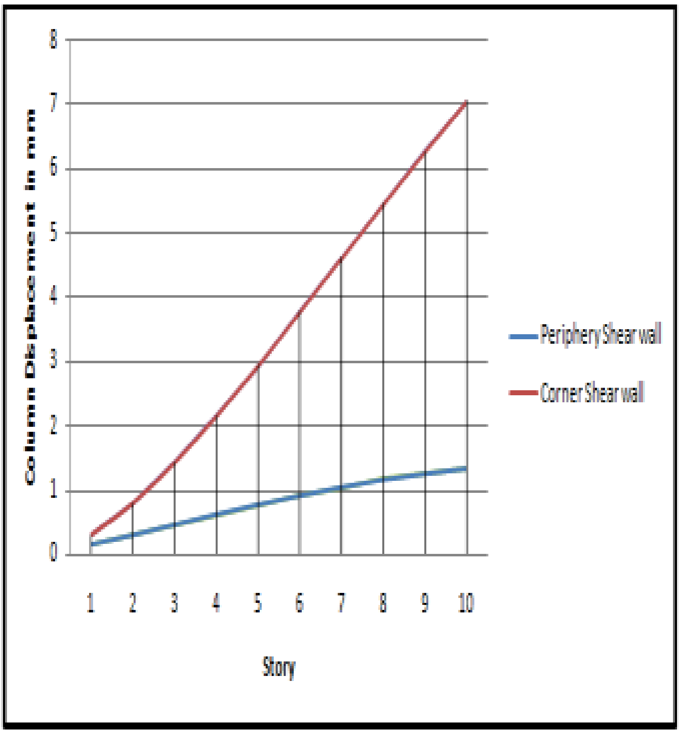

Fig 4.2.1: Comparing Graph of Column Displacement for Periphery Shear Wall VS Corner Shear wall in Seismic Zone-II

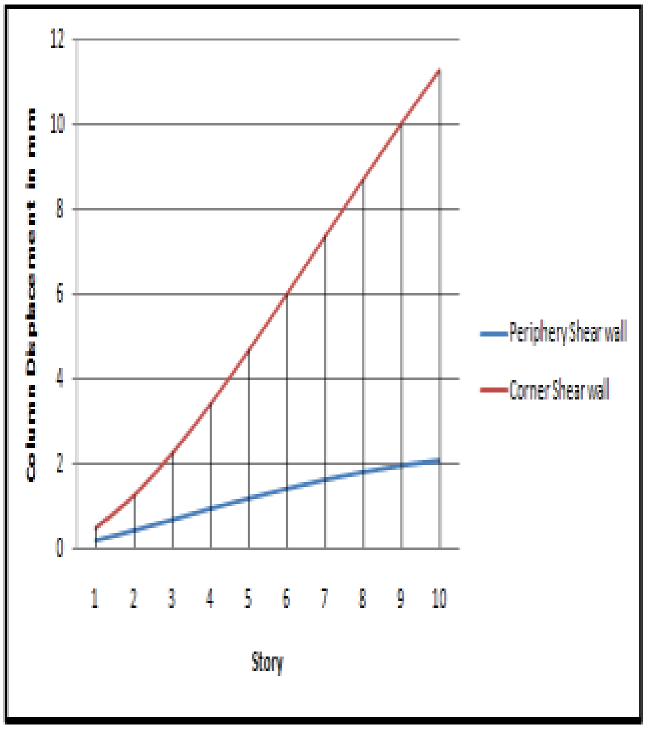

Fig 4.2.2: Comparing Graph of Column Displacement for Periphery Shear Wall VS Corner Shear wall in Seismic Zone-III

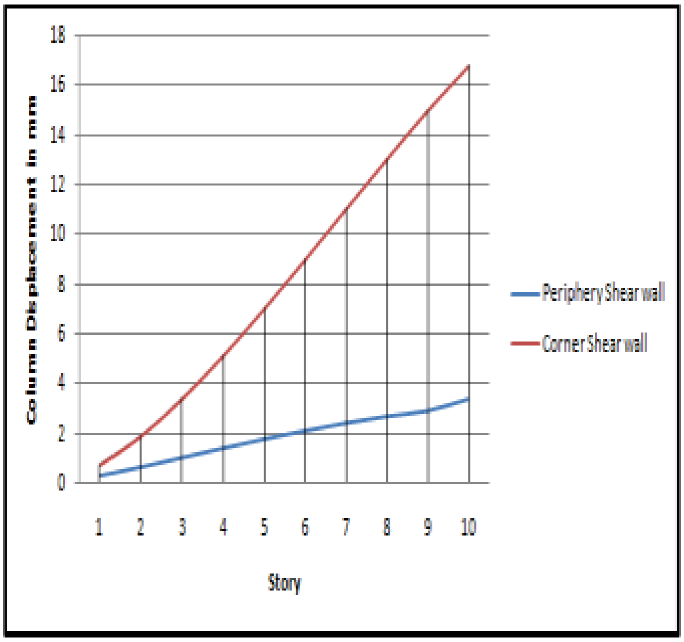

Fig 4.2.3: Comparing Graph of Column Displacement for Periphery Shear Wall VS Corner Shear wall in Seismic Zone-IV

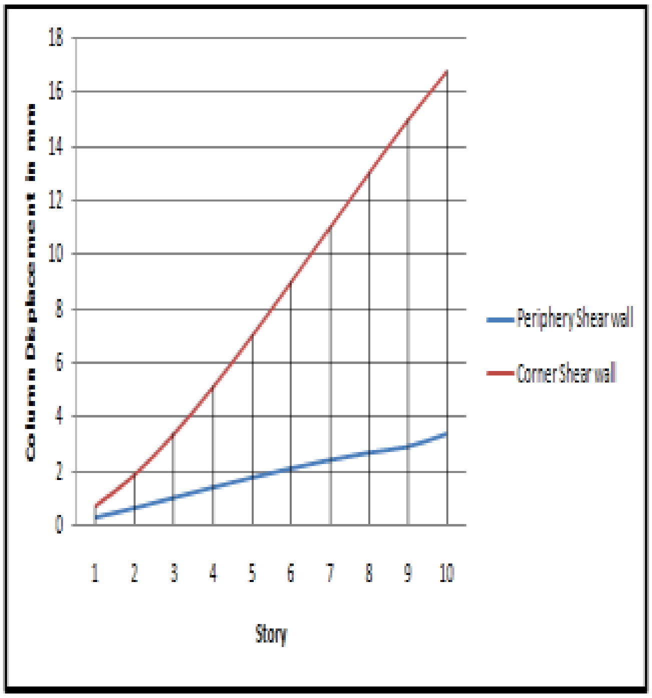

Fig 4.2.4: Comparing Graph of Column Displacement for Periphery Shear Wall VS Corner Shear wall in Seismic Zone-V

4.3 Base Shear:- Peripheral shear walls are generally positioned along the outer edges of a building, whereas corner shear walls are located at the building's corners. Both arrangements enhance stiffness and strength to resist lateral seismic forces, but their placement significantly affects overall structural behavior and base shear distribution. Corner shear walls usually provide greater stiffness but may attract higher base shear because of their influence on structural dynamics and torsional response. However, research indicates that placing shear walls at corners can also help in reducing story drift and improving seismic performance compared to alternative configurations

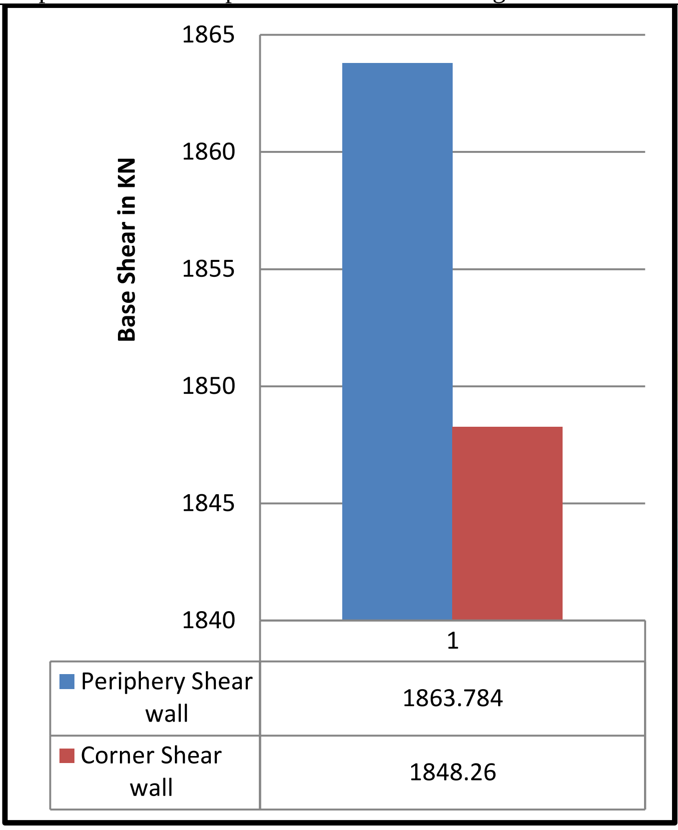

Fig 4.2.1: Comparing Graph of Base Shear for Periphery Shear Wall VS Corner Shear wall in Seismic Zone-II

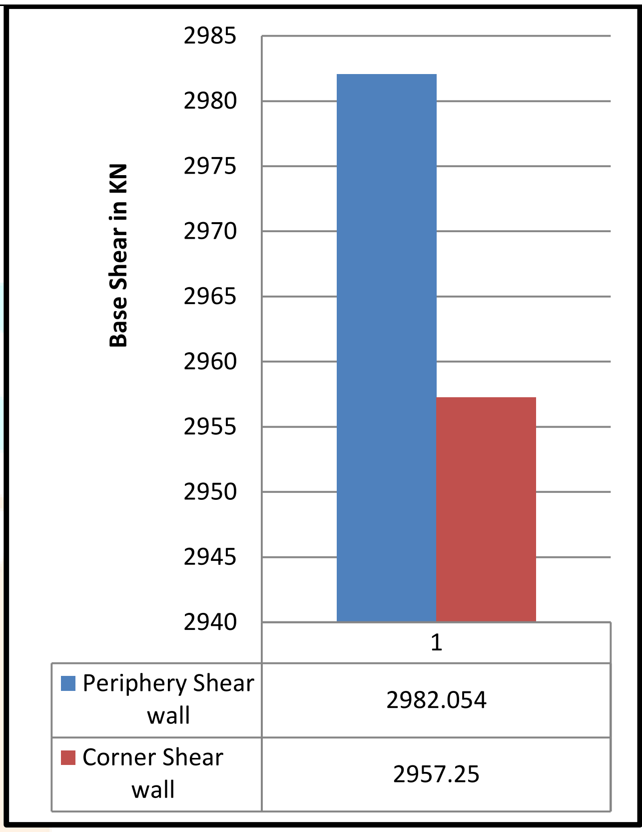

Fig 4.2.2: Comparing Graph of Base Shear for Periphery Shear Wall VS Corner Shear wall in Seismic Zone-III

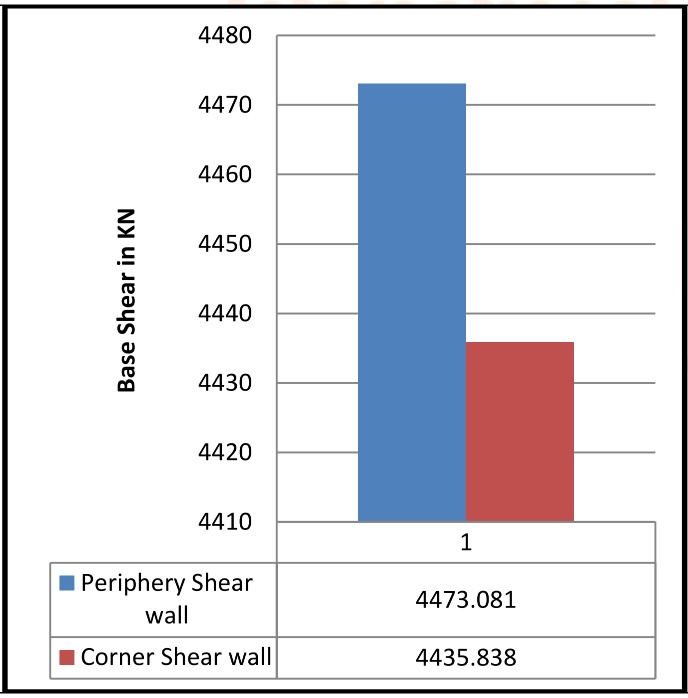

Fig 4.2.3: Comparing Graph of Base Shear for Periphery Shear Wall VS Corner Shear wall in Seismic Zone-IV

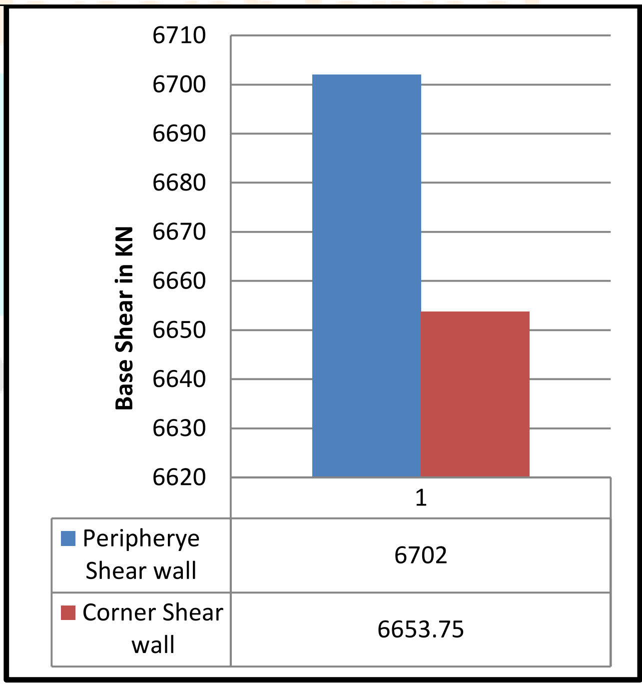

Fig 4.2.4: Comparing Graph of Base Shear for Periphery Shear Wall VS Corner Shear wall in Seismic Zone-V

4.4 DISCUSSION

4.4.1 Comparison of Column Displacement in Periphery and Corner Shear walls

1. **Peripheral shear walls Column Displacement** :-In the case of periphery shear walls, the data indicates very small displacement values across all seismic zones, even at the roof level. The maximum displacement in Zone V is only 4.71 mm, which is considerably lower than that of corner shear walls. This suggests that walls at the periphery better distribute lateral forces throughout the structural frame, thereby ensuring consistent stiffness and minimizing drift. Their position along the external boundary allows them to resist overturning and swaying more effectively, offering improved global stability.
2. **Corner shear walls, Column Displacement**:-on the other hand, display much higher displacement values, with the top storey in Zone V reaching 25.31mm, Although these walls do improve torsion l resistance and provide local stiffness at the building's edges, they attract higher shear forces due to their location. As a result, the displacement trend is significantly larger compared to periphery walls. This makes corner placement less efficient in controlling overall lateral deflections, particularly in higher seismic zones.

- Periphery walls ensure uniform force distribution, leading to minimal drift and deformation.
- Corner walls, while beneficial in resisting torsion, compromise drift control and generate larger deformations.
- As seismic intensity increases from Zone II to Zone V, the difference in displacement between periphery and corner shear wall systems becomes more pronounced, reinforcing the efficiency of peripheral placement.

4.4.2 Comparison of Story Drift in Periphery and Corner Shear wall

1. **Periphery shear walls** :-The drift values for periphery shear walls remain quite low across all seismic zones. In Zone II, the maximum story drift is only 0.2 mm at lower storeys, gradually rising with building height. Even under the most severe seismic condition (Zone V), the maximum drift is limited to about 0.6 mm. This trend highlights that periphery shear walls are very efficient in providing lateral stiffness and controlling drift, keeping the values well within permissible limits. The relatively uniform progression of drift along the height also contributes to an overall stable performance.
2. **Corner shear walls,**:- The drift values are substantially high compared to periphery walls. In Zone II, drift reaches 0.8 mm at upper storey s, while in Zone V it increases as high as 3.0 mm at the mid to top levels. Although these values help resist torsion l effects, they indicate that corner walls are less efficient at restricting lateral deformations. The rate of increase in drift with building height is also more pronounced than in the case of periphery walls.

4.4.3 Comparison of Base Shear in Periphery and Corner Shear wall

1. **Base Shear for Periphery Shear Walls**:-For the periphery shear wall configuration on medium soil, the base shear values increase steadily with seismic zone severity. Beginning with 1848.27 kN in Zone II, the values rise to 2982.23 kN in Zone III, 4473.08 kN in Zone IV, and reach a maximum of 6702.62 kN in Zone V. This progression reflects how structural demand escalates with higher seismic intensity, and periphery walls effectively transfer the increased seismic forces to the foundation.
2. **Base Shear for Corner Shear Walls**:-In the case of corner shear walls, a similar pattern is observed with values of 1848.27 kN in Zone II, 2957.23 kN in Zone III, 4435.84 kN in Zone IV, and 6653.75 kN in Zone V. Although these values are very close to those of periphery shear walls, they remain slightly lower at higher zones, suggesting minor differences in stiffness and force resistance characteristics.

4.5 CONCLUSION

1. **Column Displacement**: Buildings with periphery shear walls show significantly lower column displacement values across all seismic zones compared to corner shear walls. For example, the maximum displacement at the top storey in Zone V is 4.71 mm for periphery walls versus 25.31 mm for corner walls, indicating much better lateral stiffness and drift control in the periphery configuration.
2. **Story Drift**: Story drift values follow a similar pattern, with periphery shear walls exhibiting far smaller drift than corner walls. This demonstrates superior resistance to lateral sway and enhanced overall stability when shear walls are placed along the building's periphery.
3. **Base Shear**: Both periphery and corner shear wall configurations attract similar base shear values, with only a slight advantage (approximately 0.7% to 0.85% higher) for periphery walls in higher seismic zones. This reflects marginally greater stiffness and lateral load resistance capacity of periphery walls.
4. **Overall Performance**: The periphery placement of shear walls offers improved seismic performance by effectively controlling lateral displacements and story drifts while maintaining comparable force resistance. Although corner shear walls contribute to strength and torsional stability, their higher displacement and drift values suggest they are less effective in minimizing lateral deformation.
5. **Recommendation:** For buildings on medium soil in seismic regions, locating shear walls along the periphery is preferable for optimizing seismic resilience and reducing structural deformation under earthquake forces.

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