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ANALYSIS OF FRAGILITY CURVES OF RC FLAT SLAB BUILDINGS WITH AND WITHOUT INFILL EFFECT USING PUSHOVER METHOD IN SAP

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Abstract- Limited in conventional buildings to overcome limited in conventional structures include the ease of construction and greater space need of buildings. Recently, flat slab buildings have evolved and been used in several cities to get around limitations. The use of flat slab structures for multistory commercial buildings is growing, however they are more susceptible to bigger displacements due to lateral load effects from earthquakes. Fragility analysis is used to evaluate the likelihood of structural damage from earthquakes as a function of ground motion indices and is useful for assessing the susceptibility of buildings. In order to create fragility curves for medium and high rise flat slab buildings with masonry infill walls, the knowledge from the current study will be useful. This work's main goal is to create fragility curves for the chance of structural damage for bare frame buildings will be calculated using fragility curves, and different seismic zones in India will be taken into account. In this assumption, the seismic zone PGA values represent the expected intensity ground motion. This model displays the lowest possible likelihood of damage outcomes for specified SAP intensities, both with and without infill.

Key words: Buildings with flat slabs, capacity curves, comparable diagonal struts, fragility curves, PGA, and pushover analyses all refer to bare frames.

1. INTRODUCTION

An unsupported reinforced concrete slab that is directly supported by concrete columns is referred to as a flat slab. The phrase "flat slab" describes a square slab known as "drop panels" that has a one- or two-sided support system, with the shear power of the slab being concentrated on the supporting columns. Drop panels are essential in this case since they boost the flooring system's general strength and capacity beneath the vertical loads while also enhancing the construction's financial viability. The height of drop panels is typically twice that of the slab. Flat slabs are considered to be appropriate for the majority of construction projects as well as asymmetrical column layouts like curved or ramped floors. Utilizing flat slabs has many advantages, such as depth solutions, Although installing flat slabs can be costly, they give architects and engineers a lot of creative latitude. The benefits of using flat slabs are numerous, not only in terms of their effectiveness for future design and layout but also in terms of how effectively they contribute to the total construction process, particularly in terms of minimizing installation stages and accelerating construction. If at all feasible, try to reduce the use of drop panels and increase the thickness of flat slabs. To preserve the benefits of level soffits for the floor surface, make sure drop panels are cast as a component of the column.

Flat slab

Infill wall

The infill wall of a construction with a three-dimensional framework structure is a supported wall that is frequently made of steel or reinforced concrete. The structural frame assures the bearing function since the infill wall fills the outer frames' boxes and aids in separating the interior from the exterior area. The infill wall stands out due to its unique static capacity to support its own weight. The infill wall is a sort of closure that is external, vertical, and opaque. In contrast to other types of walls, the infill wall is distinct from both the load-bearing and non-load-bearing partition that seperates two internal spaces. In terms of hydrothermal and acoustic performance, the latter accomplishes the same goals as the infill wall.

Masonry infill walls and, to a lesser extent, veneer walls are extensively utilized in many countries, particularly in reinforced concrete frame projects. In actuality, employing brick infill walls offers a durable and economical choice. They offer good cost-performance ratios, are aesthetically beautiful, and are easy to build.

Pre-cast concrete infill panels

This study's main objective is to use response spectrum analysis to calculate the lateral forces for normal and flat slabs and to compare the results with those for general slabs. to analyze the results using various parameters, such as drift, shear, bending torsion, etc. for flat slab and conventional slab construction. The effects of low, intermediate, and high frequency ground vibrations on buildings will be studied using pushover analysis, and the results will be compared. to use the Pushover method to analyze different curves.

SAP 2000

SAP2000, a multipurpose civil engineering program, is a great tool for designing and analyzing structural systems. To model, analyze, design, and optimize basic and advanced systems, spanning from 2D to 3D, of simple geometry to complex, one can use an efficient and user-friendly object-based modeling environment that streamlines and simplifies the engineering process. The SAPFire Analysis Engine, a part of SAP2000, is what powers the intricate process of finite-element analysis. Users get access to an additional range of advanced analytic possibilities while practicing cutting-edge nonlinear and dynamic consideration. Any user with any level of technical expertise can create any structural system using SAP2000. For efficient engineering, engineers created it.

2. LITERATURE REVIEW

Saksheshwari, Guruprasad T.N., and Raghu K.S. Additionally, it is noteworthy that flat slab buildings exhibit considerably greater storey drift compared to traditional beam and slab structures, particularly when situated in areas with soft soil conditions. These results underscore the utmost importance of meticulous structural design and meticulous seismic assessments, particularly in the context of flat slab systems, during the planning and construction phases.

Manu Naveen Kumar B M, Priyanka S (2015) In this study, we conduct a comparative analysis between flat slabs and traditional reinforced concrete (RC) slabs within high seismic zones. The research focuses on understanding the behavior of multi-story buildings, specifically those equipped with conventional RC frame structures and flat slabs. Our primary objective is to investigate how building height influences the performance of these structures when subjected to seismic forces. The study provides valuable insights into key parameters such as storey drift, lateral displacement, natural period of vibration, and seismic base shear.

Ms. Navyashree K and Sahana In this research, we investigate the application of flat slabs in multi-storey commercial buildings situated in high seismic zones. Our study encompasses six building models, including conventional RC frame structures and flat slab designs, with heights ranging from G+3 to G+12 stories. We assess the performance and vulnerability of both frame and flat slab models under various load conditions, focusing on seismic zone IV. The analysis is carried out utilizing the ETABS software. The primary objective of this study is to compare the behavior of multi-storey commercial buildings featuring flat slabs against those employing conventional RC frames with two-way slabs and beams. We aim to understand how building height influences the response of these structures to seismic forces. This research provides valuable insights into parameters such as lateral displacement, storey drift, storey shear, column moments, axial forces, and time period.

3. EARTHQUAKE LOADING

The internal forces of a building's bulk that are caused by an earthquake's shaking of its base are known as earthquake loading. Design for earthquake resistance focuses mostly on translational inertial forces. A structure is more affected by these translational inertial pressures than by vertical or rotational shaking elements. There are other potent earthquake forces as well, including ground slip, subsidence, and local subgrade liquefaction brought on by vibration, among others. The magnitude of an earthquake has an inverse relationship with its frequency. Even though a structure might be built to survive the strongest earthquakes without suffering significant damage, the need for such strength over the course of the project's lifespan would not be worth the significant additional cost.

To evaluate seismic loading, there are two primary methods. These techniques consider the properties of the structure as well as the prior seismic activity in the area. The first way is the similar lateral force process. The projected maximum ground acceleration, the fundamental period of the structure, and other relevant characteristics are used to determine the maximum base shear.

The second method uses a modal analysis to calculate the maximum modal response by examining the structure's modal frequencies and combining them with earthquake design spectra.

4. METHODOLOGY USED

Pushover analysis an overview

Pushover analysis, a type of nonlinear static analysis, has been used in practice since the 1970s, although its potential has only just come to light. This process is primarily used to calculate the seismic demand for an existing structure subjected to a chosen earthquake as well as the strength and drift capability of the structure. This process can also be used to evaluate the suitability of fresh structural designs. Pushover analysis has been included in numerous earthquake guidelines (ATC 40 and FEMA 356) and design codes (Euro code 8 and PCM 3274) in recent years due to its efficiency and computational ease. Pushover analysis is the process of subjecting a mathematical model that directly incorporates the nonlinear load-deformation characteristics of individual building components and elements to progressively higher lateral loads that represent earthquake inertia forces until a predetermined "target displacement" is exceeded. Under a chosen earthquake ground motion, the target displacement is the greatest displacement (elastic plus inelastic) of the building at the roof. A nonlinear static analysis algorithm is used in the structural Pushover analysis to estimate the force and deformation capacity as well as seismic demand. The storey drifts, global displacement (at the roof or any other reference point), storey forces, component deformation, and component forces make up the seismic demand parameters. The approach takes into account the redistribution of internal forces, geometrical nonlinearity, and material inelasticity.

Following is a summary of the response characteristics that can be learned from the pushover analysis:

1. Calculations of the structure's force and displacement capabilities. sequence of member yielding and development of the capacity curve as a whole.
2. Estimates of the deformation requirements for ductile elements and the force (axial, shear, and moment) requirements for potentially brittle elements.
3. Estimates of the expected damages to structural and non-structural elements under the ground motion of 20 earthquakes, together with related inter-storey drifts.
4. The order in which component failures occur and their impact on the overall structural stability.
5. Determining the important areas where high inelastic deformations are anticipated and spotting structural anomalies (in the building's design or elevation). For a small additional computing effort (modeling nonlinearity and change), pushover analysis provides all these advantages.

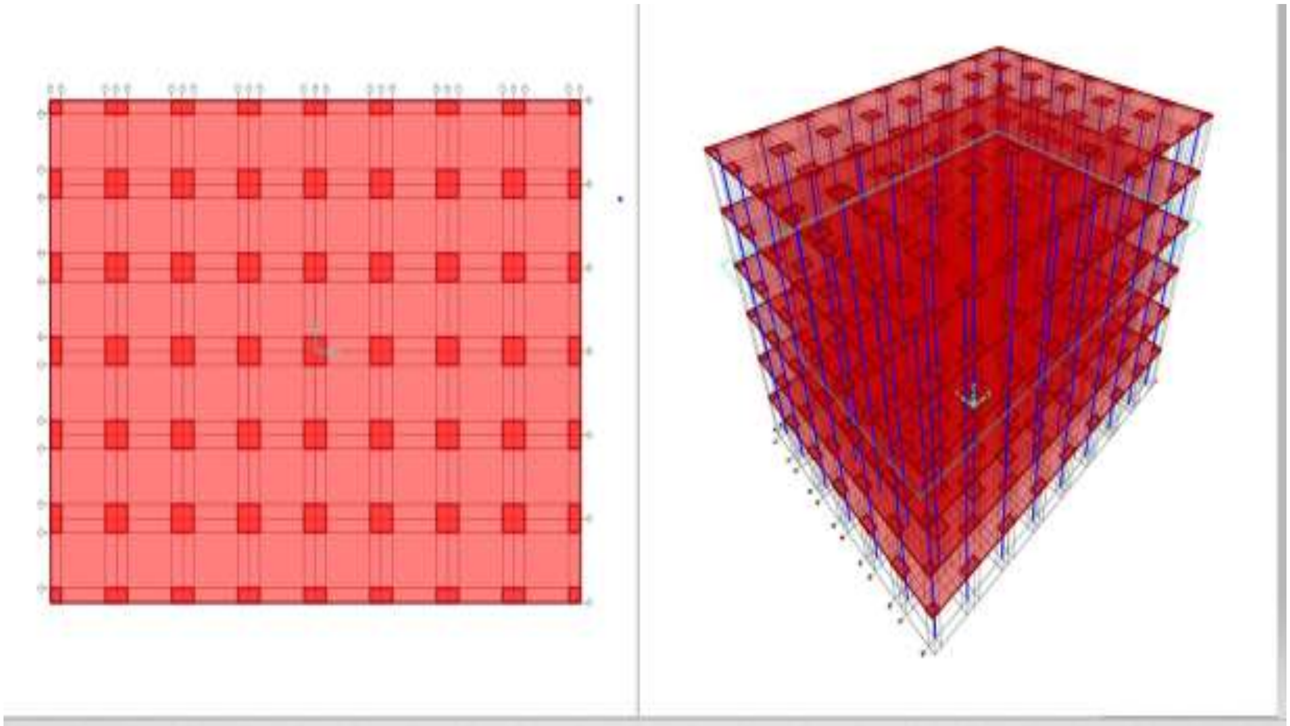
5. MODEL SPECIFICATIONS

The G+5 multi-story structure in India has been examined in the current study. Buildings in all seismic zones have been assumed for the sake of analysis. In SAP 2000 Software, a three-dimensional model of the building is created.

Basic parameters considered for the analysis are

1. Number of stories : G+5 (6 storied)
2. Number of bays along X axis :8no's
3. Number of bays along Y axis :6no's
4. Total Height of building : 15 m
5. Shape of building : Rectangular
6. Geometric details
    a) Ground floor height : 3 m
    b) Floor to floor height : 3 m
7. Material details
    a) Concrete Grade : M30 (COLUMNS AND BEAMS)
    b) Steel : HYSD reinforcement of Grade Fe500
    c) Bearing Capacity of Soil : 200 kN/m^2
8. Type Of Construction : Reinforced Cement Concrete FramedStructure
9. Column : 0.6 m × 0.6 m
10. Beams : 0.6 m × 0.46 m
11. Slab thickness : 0.150 m
12. Drop :0.2m
13. Grade of concrete : M30
14. Grade of Reinforcing steel : HYSD Fe500
15. Live load : 2.5 kN/m^2(IS: 875:1987)
16. Density of Reinforced concrete : 25 kN/m^3
17. Seismic Zones : Zone V
18. Site type : Medium (II) of IS Code 1893-2016
19. Importance factor : 1.0
20. Response reduction factor : 3
21. Damping Ratio : 5%
22. Structural class : C
23. Wind design code : IS 875: 1987 (Part 3)
24. RCC design code : IS 456:2000
25. Steel design code : IS 800: 2007
26. Earthquake design code : IS 1893 : 2016

Model in SAP2000 Software

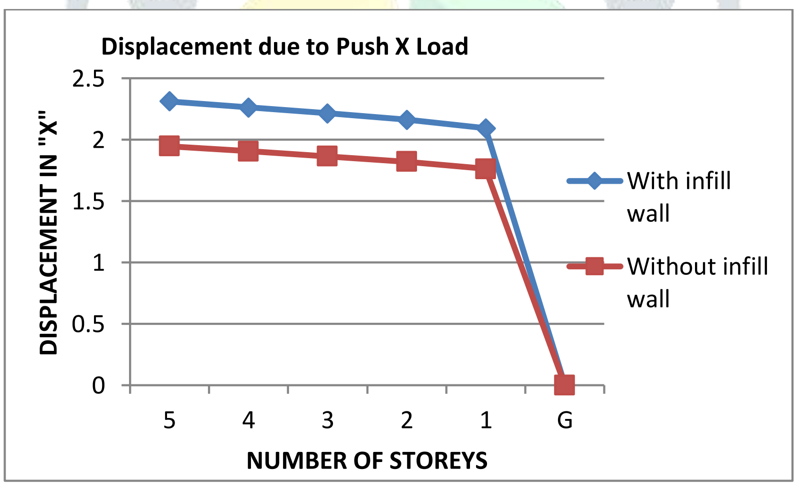


Skeletal structure of building in SAP2000

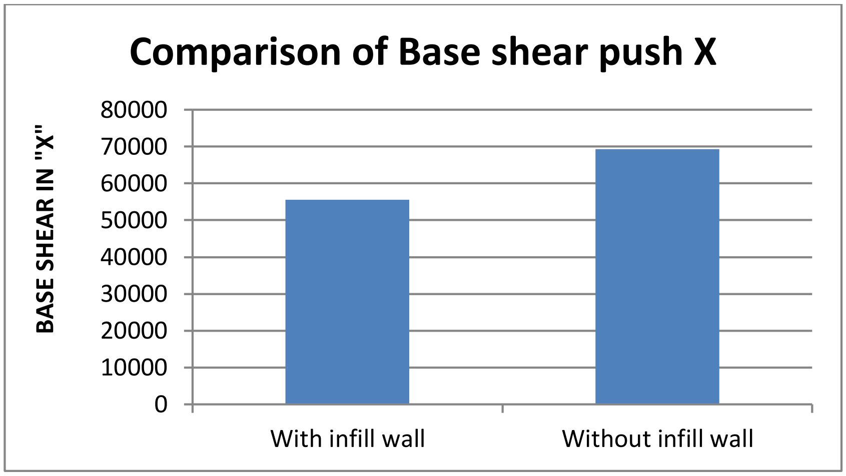
6. RESULTS AND ANALYSIS

Push X Results

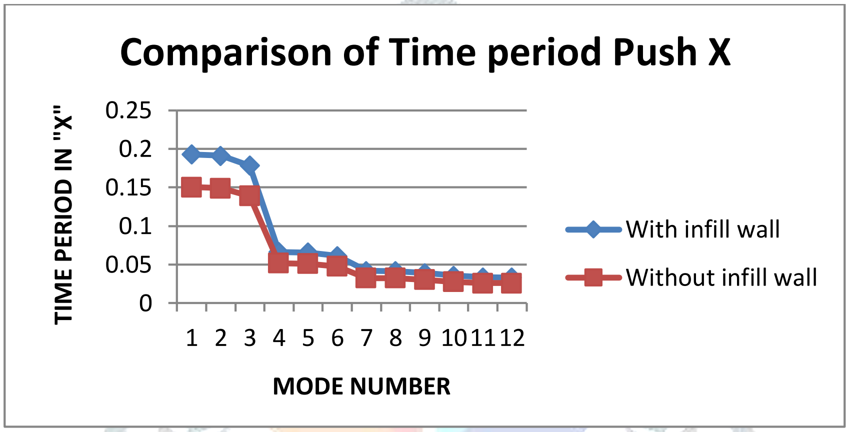
Displacement



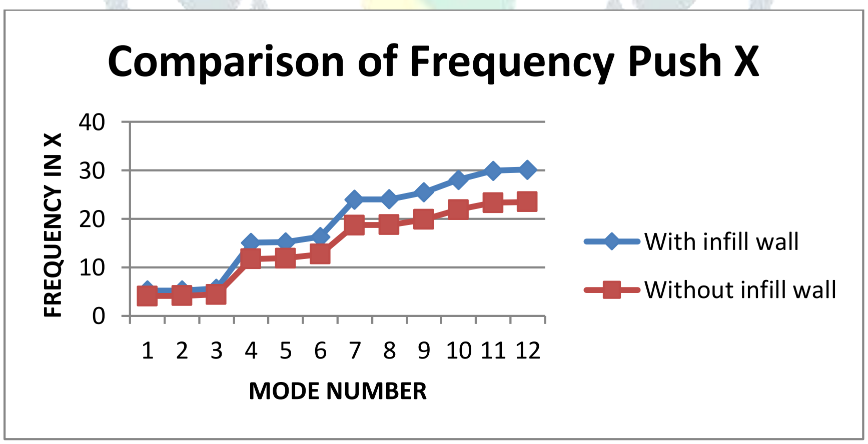
Base shear



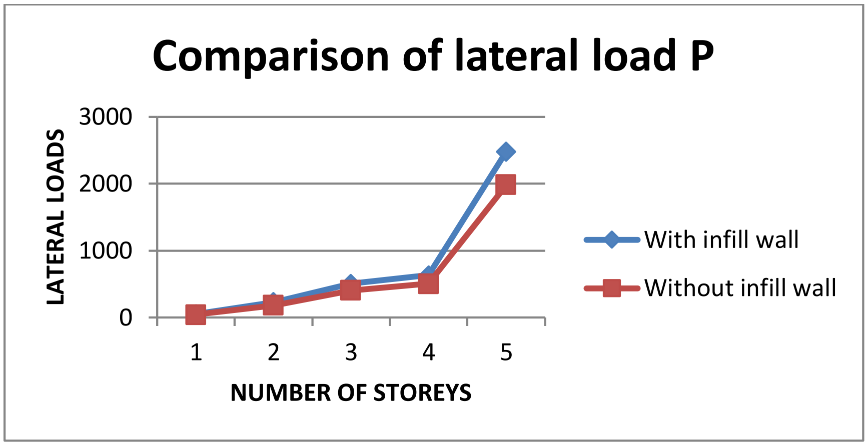
Time period



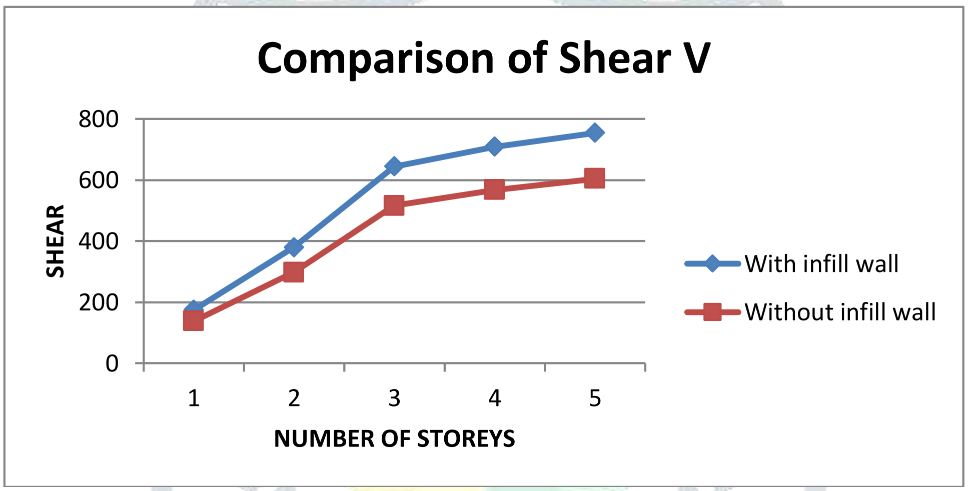
Frequency



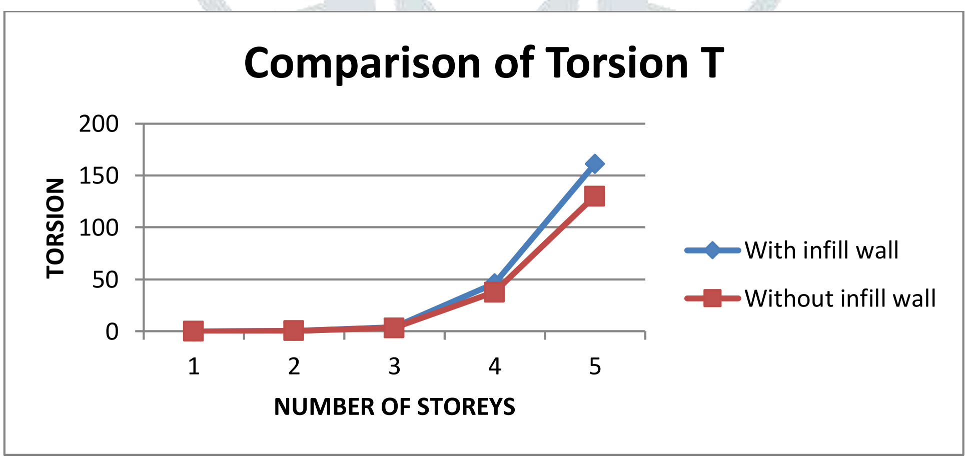
Lateral load P



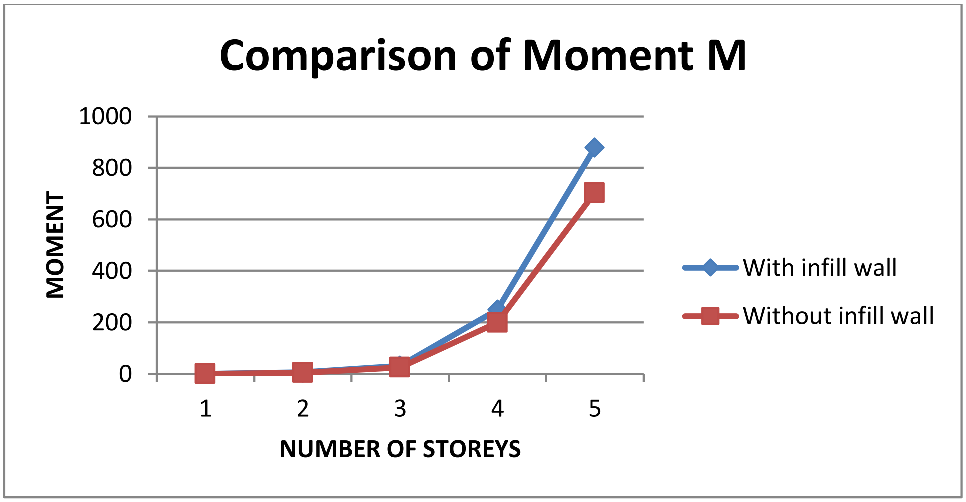
Shear V



Torsion T

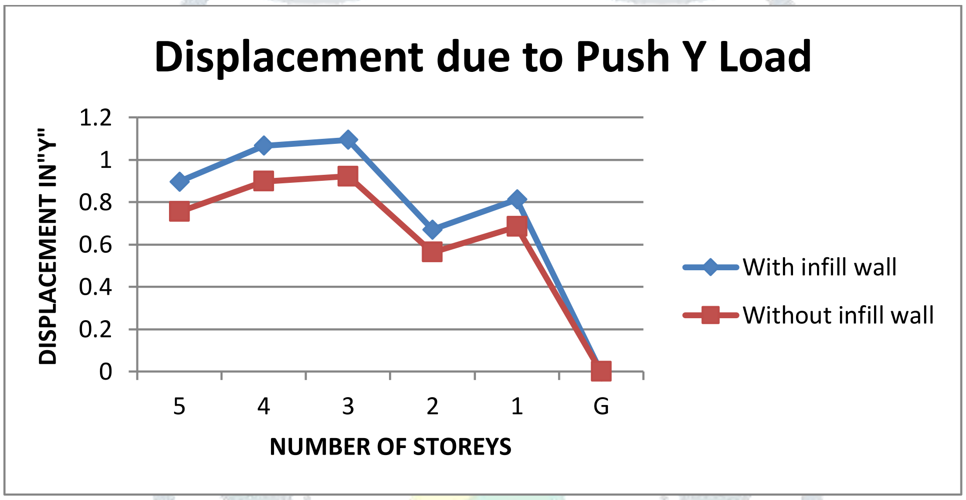


Bending M

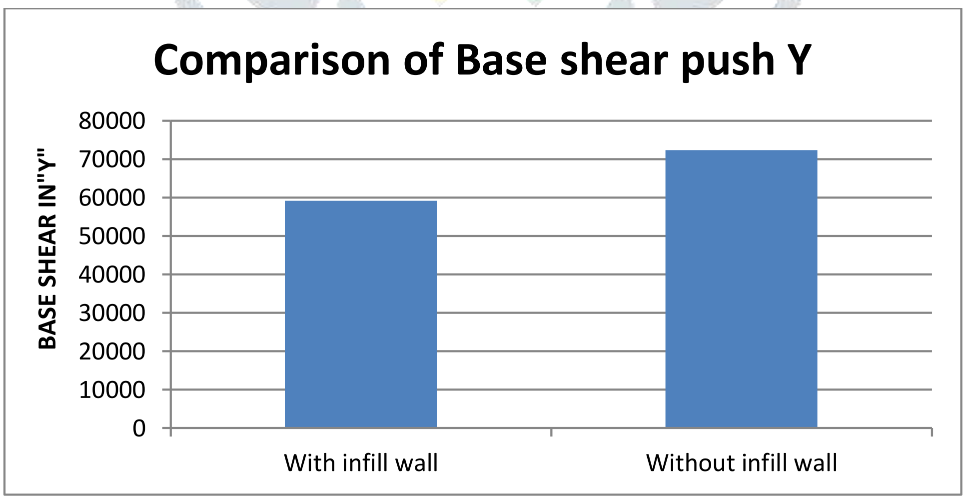


Push Y Results

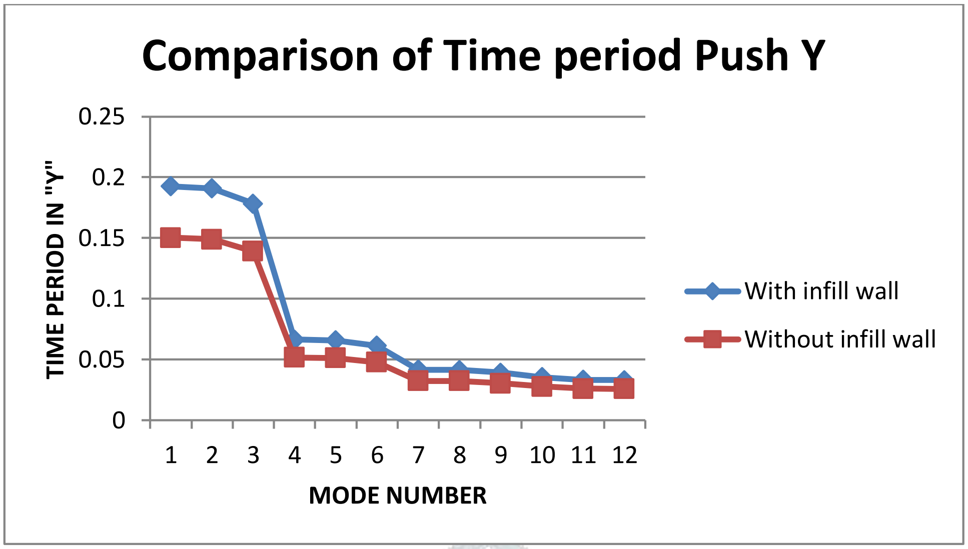
Displacement



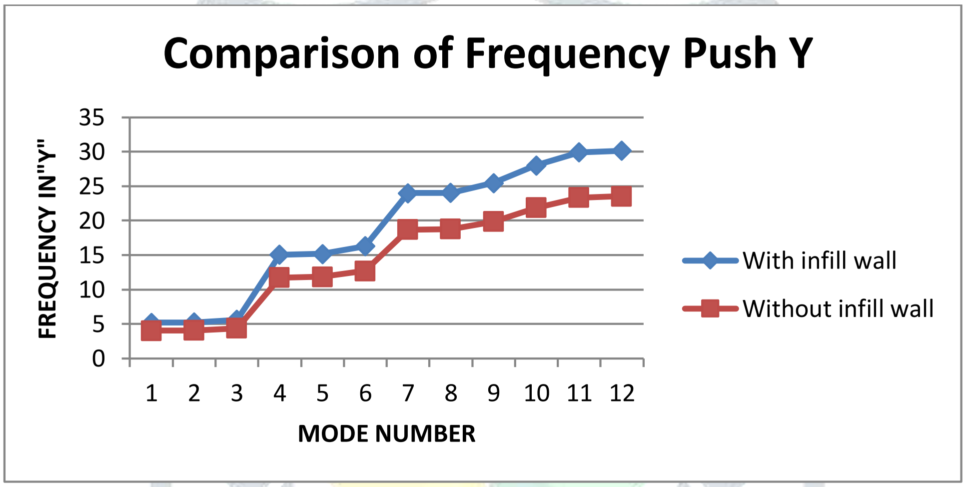
Base shear



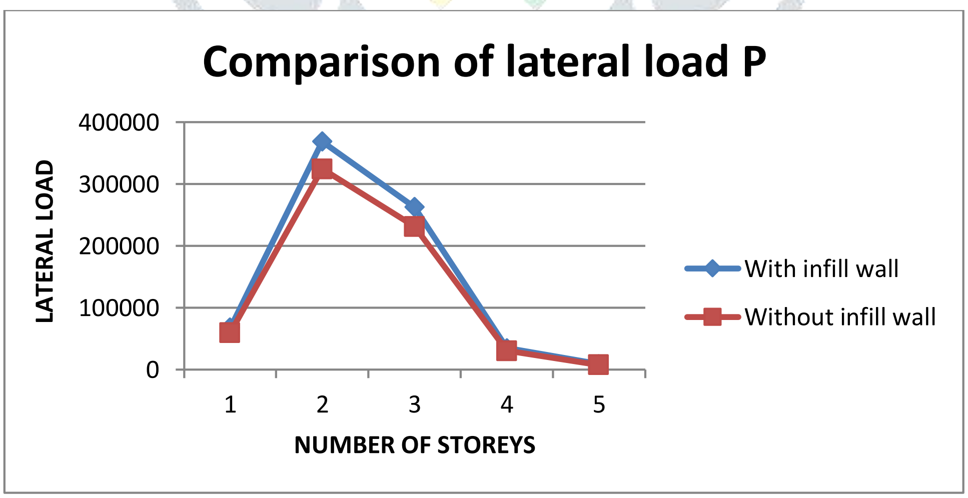
Time period



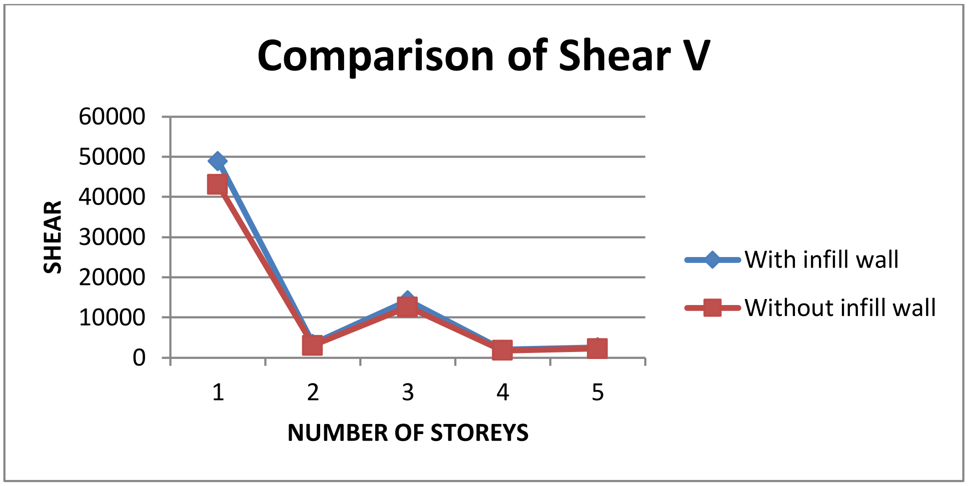
Frequency



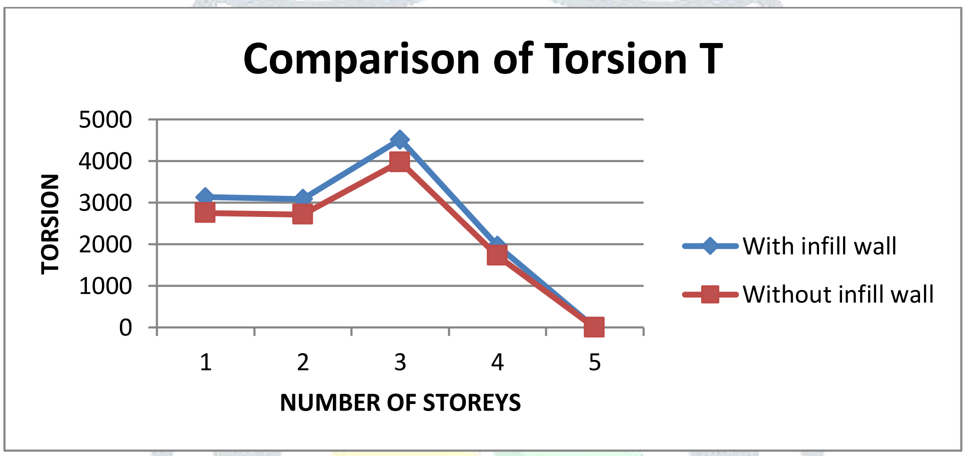
Lateral load P



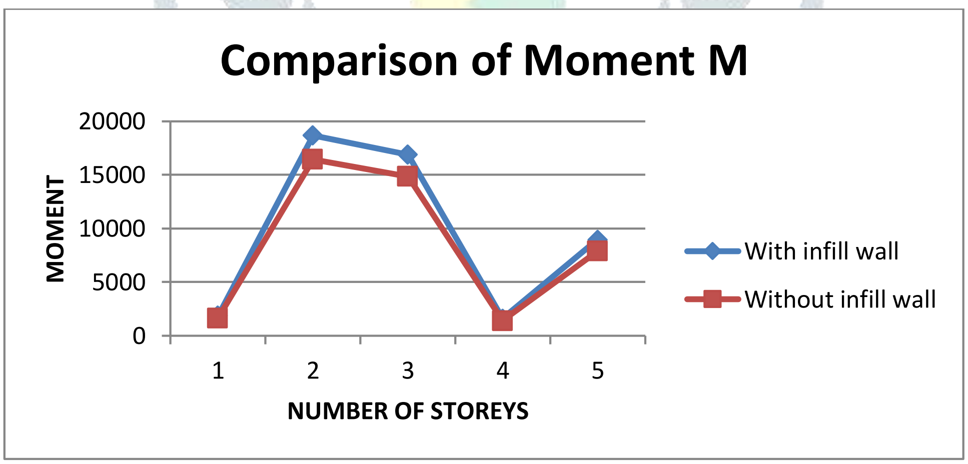
Shear V



Torsion T



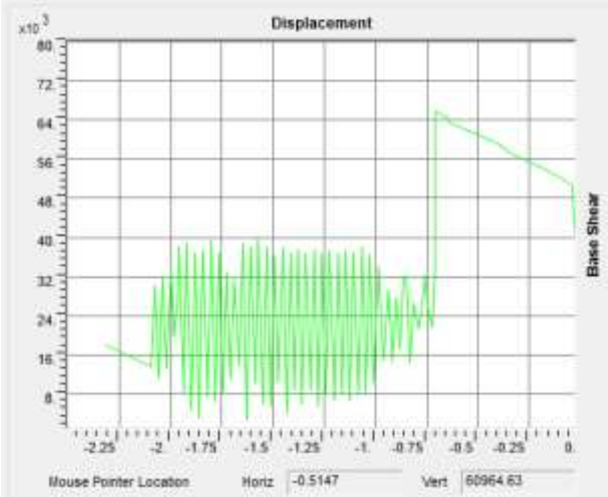
Bending M

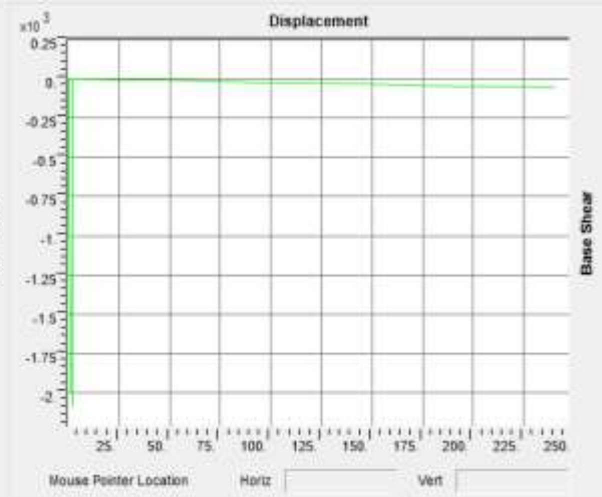


Curves

Push X

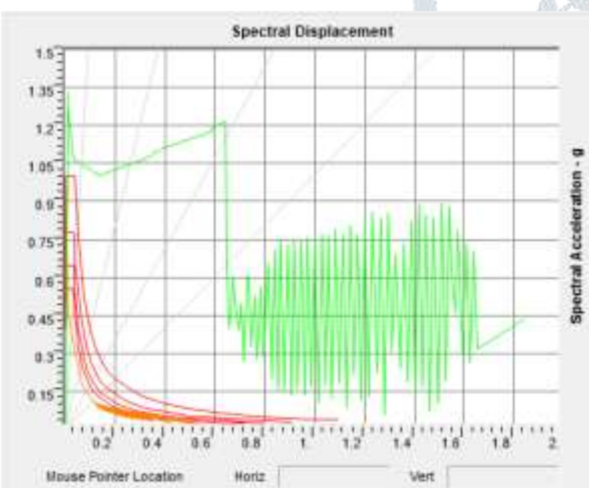
Base shear Vs Displacement

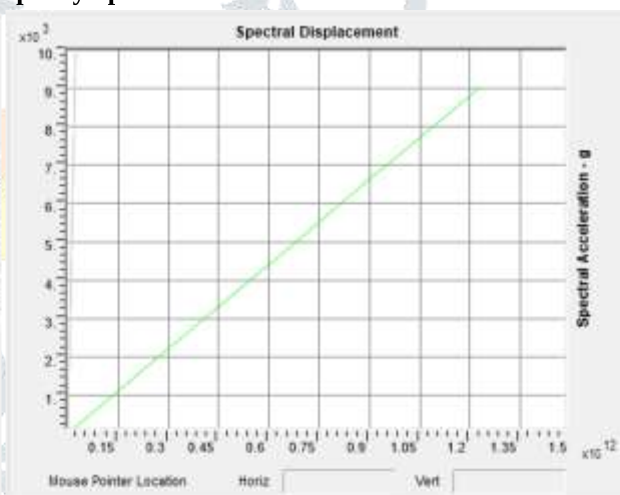




With infill walls without infill walls

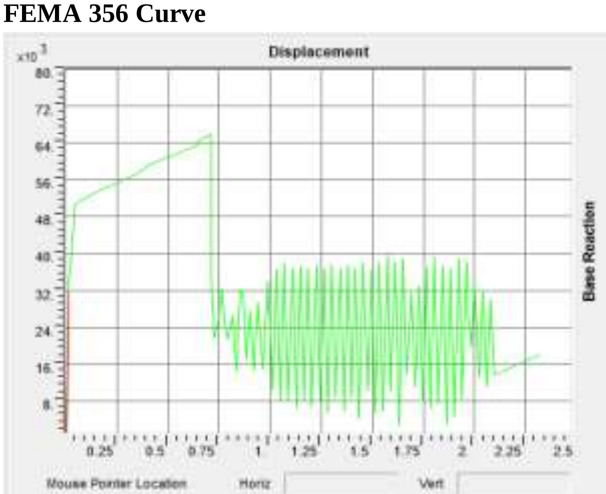
Capacity Spectrum Plot

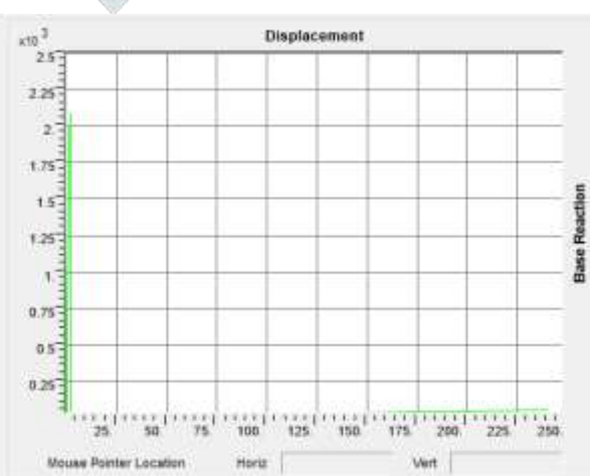




With infill walls without infill walls

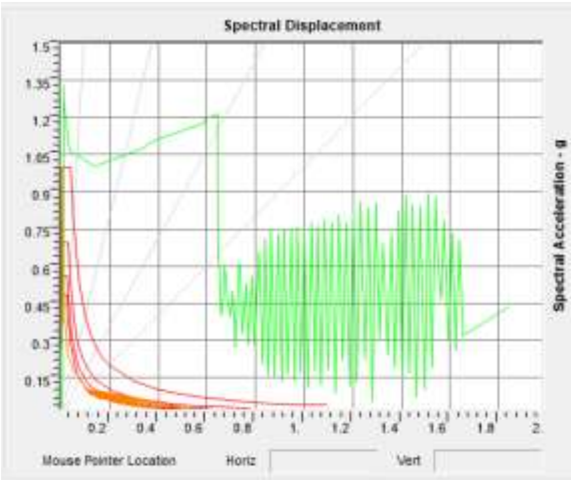
FEMA 356 Curve

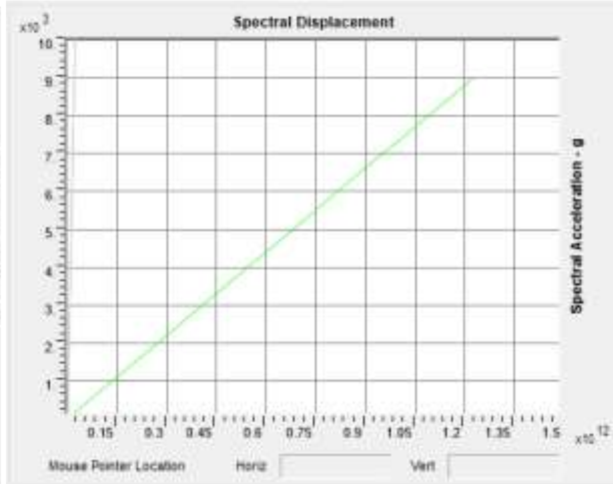




With infill walls without infill walls

FEMA 440 curve

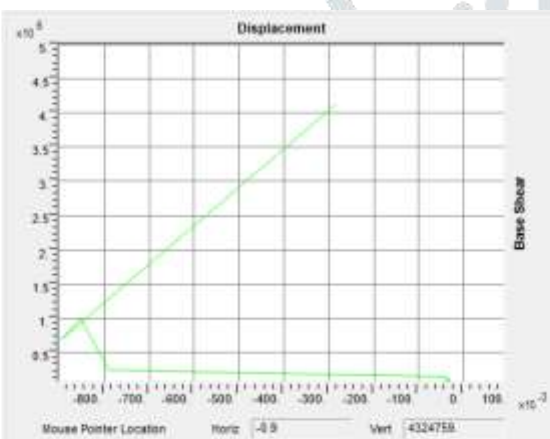


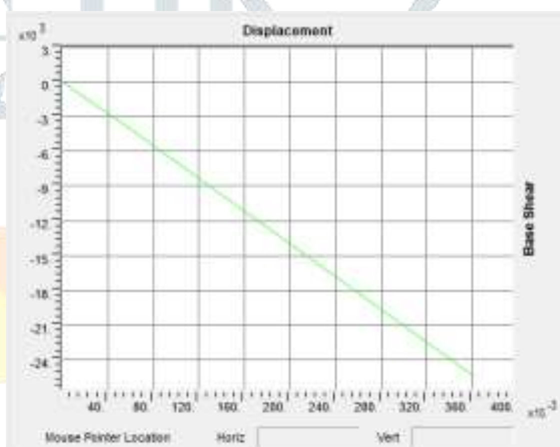


With infill walls without infill walls

Push Y

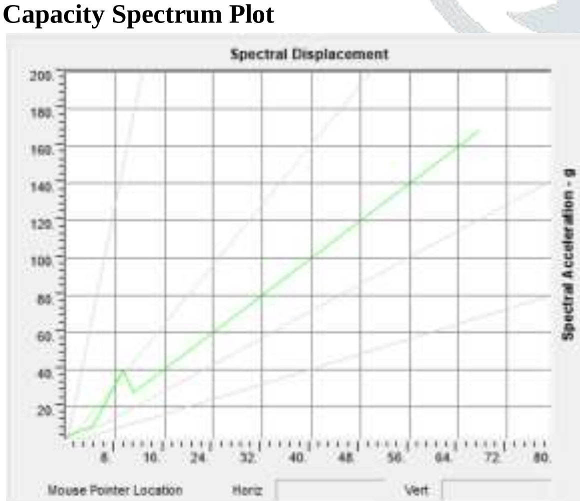
Base shear Vs Displacement

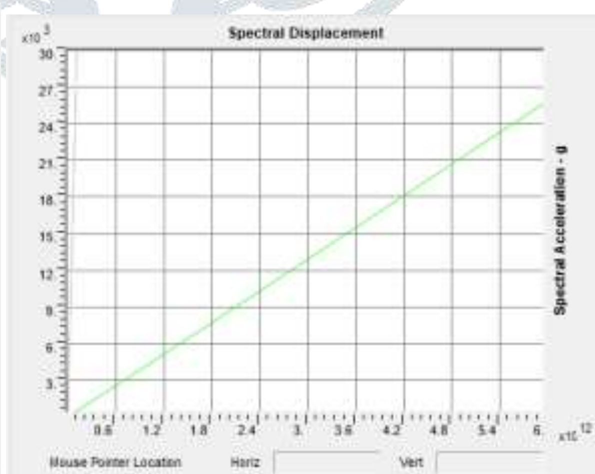




With infill walls without infill walls

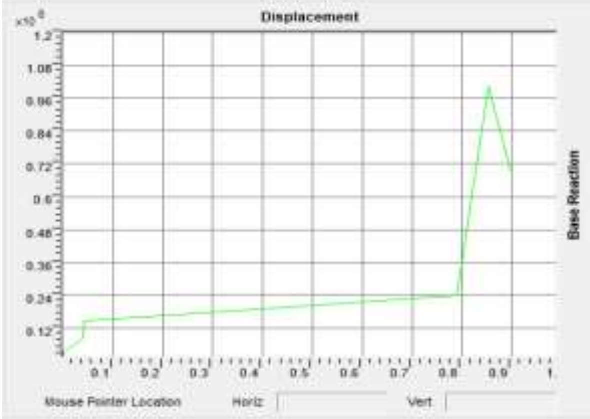
Capacity Spectrum Plot

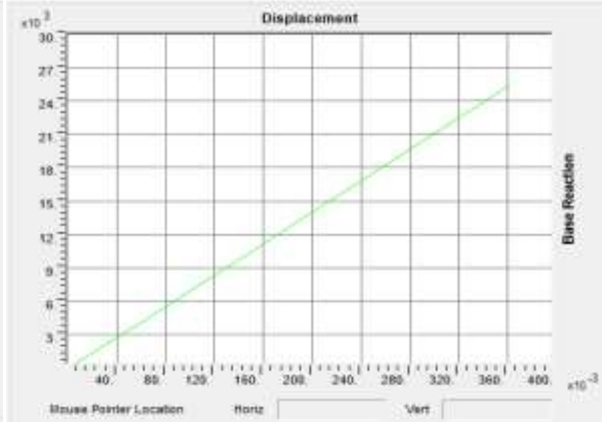




With infill walls without infill walls

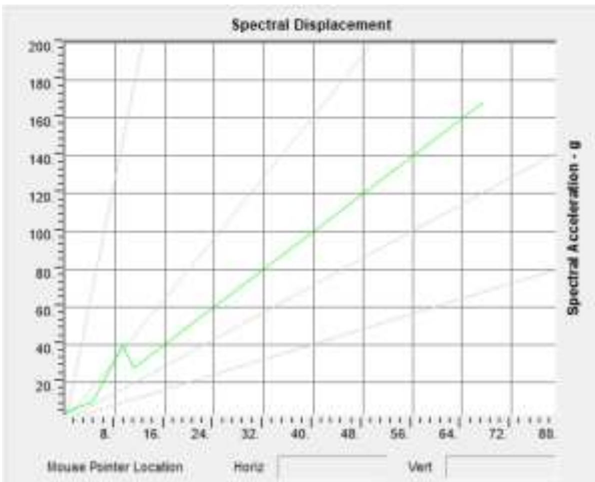
FEMA 356 curve

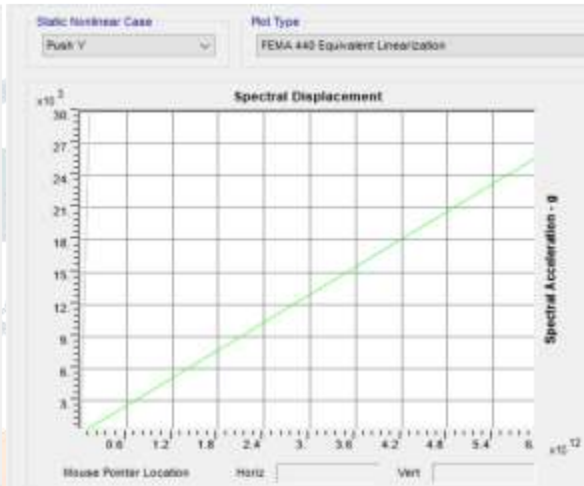




With infill walls without infill walls

FEMA 440 curve





With infill walls without infill walls

7. CONCLUSIONS

The following conclusions were drawn from this investigation.

1. For the same span/grid size, the greatest amount of concrete is needed for multi-story buildings with standard slabs, whereas the smallest amount is needed for multi-story buildings with flat slabs.
2. Compared to structures with infill wall slabs, flat slab buildings have lower values for displacements. The flat slab will have less displacement than typical slab systems from a displacement perspective.
3. Buildings with flat slab systems had higher shear force values in both the X and Y directions than did buildings with infill wall slabs. From top to bottom stories, shear force increases in value.
4. Buildings with flat slab systems have greater values for Building Torsion (T) than

5. The highest amount of concrete is used in flat slabs since they are thicker than grid slabs and include more steel than other combinations.
6. For all grid sizes and spans, flat slab multi-story buildings are determined to have the lowest construction costs. The cost per square meter for each slab method under consideration is found to vary depending on the span/grid size of the building. The flat slab approach is shown to have the lowest cost per square meter in this situation as well.

The analysis highlights the benefits of flat slab systems in multi-story buildings in its conclusion, especially in terms of material effectiveness and financial viability. They are an appealing alternative due to their overall cost efficiency despite increased shear forces and structural stresses. However, to achieve the best balance between structural stability, material utilization, and cost-effectiveness, the choice between flat slabs and infill wall slabs should be made in the context of the project, taking into account the individual project needs and the span/grid size.

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