# Comparative Performance Evaluation of Modern Retrofittng Solutions for Soft Storey High Rise Buildings

Dr. Vijay Kumar Halakatti[1], Monisha [2]

[1] *Associate Professor, Department of Civil Engineering, Global institute of Engineering and Technology*

[2] *M. T Student, Department of Civil Engineering, Global institute of Engineering and Technology*

***Abstract*—Soft story buildings are often found in areas with high seismic activity and can be particularly vulnerable to earthquakes. Adding structural components like walls, columns, or braces to weak stories is typically necessary for retrofitting soft story buildings. In order to prevent soft story, this study assesses the effectiveness of seismic retrofitting, a contemporary structural solution that can be applied to buildings, for soft story mitigation techniques like flag shear walls and diagonal, horizontal, and vertical stiffeners. This system offers both financial advantages and enhanced performance in high-rise buildings when compared to earlier approaches.**

## I.INTRODUCTION

The goal of the study, "Seismic assessment and strengthening techniques of soft-story steel buildings," is to investigate the use of flag shear walls and shear wall panels as a seismic-resistant solution in RCC constructions. This method provides significant lateral stiffness, strength, and energy dissipation potential, which are essential characteristics for withstanding seismic forces and preventing building collapse in earthquake scenarios.

The purpose of this study is to provide a thorough overview of various strengthening techniques for soft-story buildings, their effectiveness, and their limitations. The goal of these techniques is to improve the structure's lateral rigidity and strength, thereby reducing the risk of structural collapse during an earthquake. The use of stiffeners in shear wall panels is to enhance their performance by increasing their resistance to buckling and reducing their weight, respectively. The stiffeners can prevent buckling under compressive loads. The purpose of this study is to provide a thorough overview of various strengthening techniques for soft-story buildings, their effectiveness, and their limitations. The goal of these techniques is to improve the structure's lateral rigidity and strength, thereby reducing the risk of structural collapse during an earthquake. The use of stiffeners in shear wall panels is to enhance their performance by increasing their resistance to buckling and reducing their weight, respectively. The stiffeners can prevent buckling under compressive loads.

## II.LITERATURE REVIEW

M. S. Ujwal, G. Shiva Kumar (2024): According to M. S. Ujwal and G. Shiva Kumar (2024), a soft story is defined as a level in a building that is either less than 80% stiffer than the average of the three stories above it or less than 70% stiffer than the one directly above it. A soft story layout in construction usually happens when one story of a building is less rigid or more flexible than the other floors. Because of their decreased stiffness, these stories are more susceptible to lateral forces during earthquakes and must rely on columns for support. Weak columns have the potential to cause serious damage or perhaps the structure's complete collapse. The behavior of high-rise structures with soft stories at different locations is examined in this study, along with the effects of bracings and shear walls at soft story levels.

Teba Salim Ibrahim and Halla Jasem Mohamad (2024): According to Teba Salim Ibrahim and Halla Jasem Mohamad (2024), a soft story is necessary to give the building a useful space like open meeting rooms or car garages. Since it is very challenging to undertake experimental study to solve this issue, more analytical examination was required to understand the impact of these flexible floors on the building's behavior during earthquakes. The study examined how soft story placement affected the nonlinear time history response in two different building types: one with equal spans and the other with asymmetrical spans

Selemon Matiyas [a], Nathnael Workeluel (2023): soft-story structures' weak lower levels make them susceptible to seismic forces, which can cause serious damage or even collapse during earthquakes. To reduce this danger, a number of analysis and strengthening strategies have been devised, each with pros and cons. The goal of this study is to give a thorough analysis of the many soft-story building strengthening methods, their efficacy, and their drawbacks. Additionally, it covers a variety of strengthening measures, including local strengthening techniques (such as beam jacketing, column jacketing, beam-column junction jacketing, and strengthening of individual footings) and global strengthening techniques (such as adding shear walls, infill walls, steel bracing, wall thickening techniques, wing walls/buttresses, mass reduction, and base isolation).
Niloufar Mashhadiali, Ali Kheyroddin (2018 Published by Elsevier Ltd): The goal of this work is to enhance the seismic response of conventional steel-braced frames by putting forth a novel braced frame known as the hexa-braced frame (Niloufar Mashhadiali, Ali Kheyroddin, 2018; Elsevier Ltd.). By joining the V and inverted-V bracings over three levels with vertical structural components, the proposed system creates the two-story hexagonal bracing configuration. The objective is to reduce the possibility of the soft-story mechanism, a problem with conventional steel-braced frames, by distributing the deformation needs along the height of the frame

## III. MODEL INFORMATION

Model 1: First building is modelled with regular beams, Columns, Shear Core walls, and Slabs. The lateral load resisting structural system is adopted by studying IS 1893:2016 and labelled as regular model with Soft Story
Model 2: Second building is modelled with lateral load resisting structural system with Soft Story with Diagonal Stiffeners Shear Wall

- Soft Story with Diagonal Stiffeners Shear Wall at bottom level
- Soft Story with Diagonal Stiffeners Shear Wall at mid-level
- Soft Story with Diagonal Stiffeners Shear Wall at top level

Model 3: Third building is modelled with lateral load resisting structural system with Soft Story with Horizontal Stiffeners Shear Wall

- Soft Story with Horizontal Stiffeners Shear Wall at bottom level
- Soft Story with Horizontal Stiffeners Shear Wall at mid-level
- Soft Story with Horizontal Stiffeners Shear Wall at top level

Model 4: Fourth building is modelled with lateral load resisting structural system with Soft Story with Vertical Stiffeners Shear Wall

- Soft Story with Vertical Stiffeners Shear Wall at bottom level
- Soft Story with Vertical Stiffeners Shear Wall at mid-level
- Soft Story with Vertical Stiffeners Shear Wall at top level

Model 5: Fifth building is modelled with lateral load resisting structural system with Soft Story with Flag Shear wall

- Soft Story with Flag Shear wall at bottom level
- Soft Story with Flag Shear wall at mid-level
- Soft Story with Flag Shear wall at top level

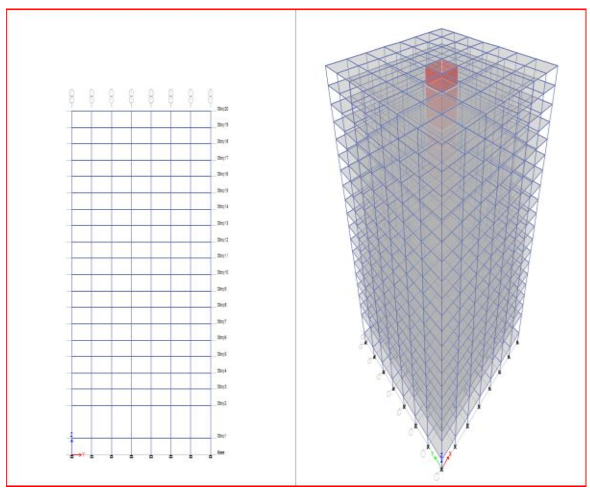


Figure 1: Elevation and 3-d view of normal model for G+20

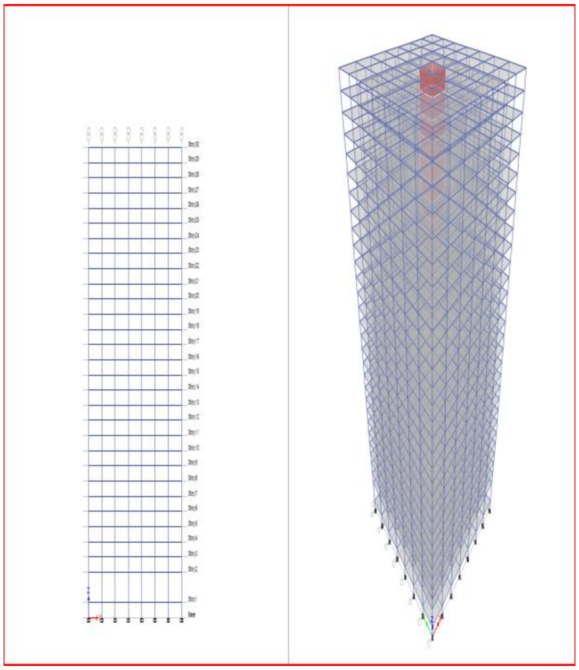


Figure 2: Elevation and 3-d view of normal model G+30

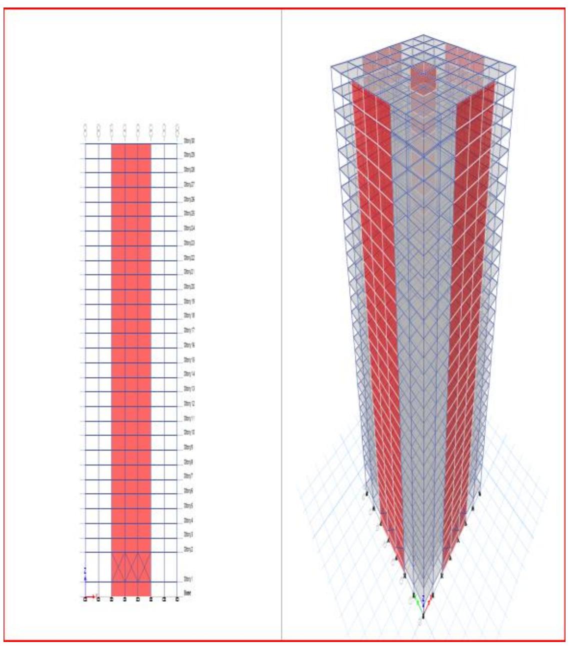


Figure 3 Elevation and 3-d view of Soft Story model with diagonal stiffeners

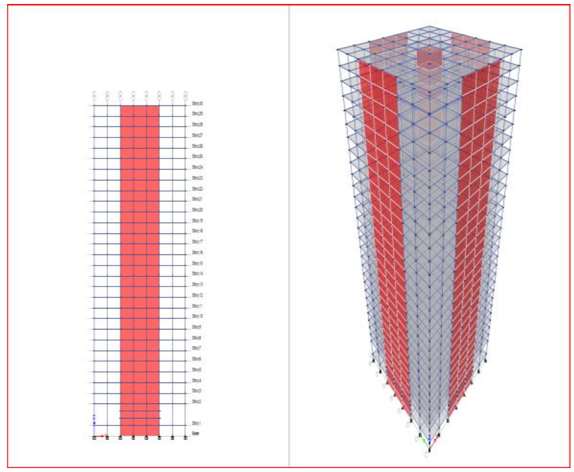


Figure 4 Elevation and 3-d view of Soft Story model with horizontal stiffeners

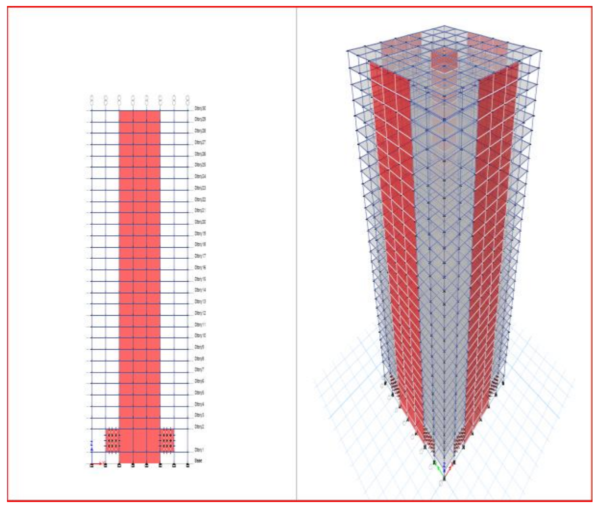


Figure 5: Elevation and 3-d view of Soft Story model with Flag shear wall

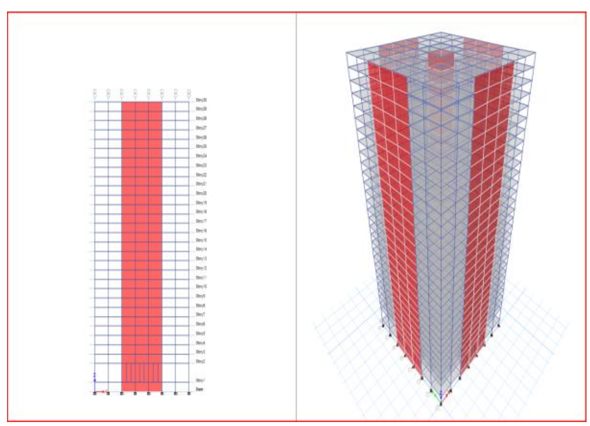
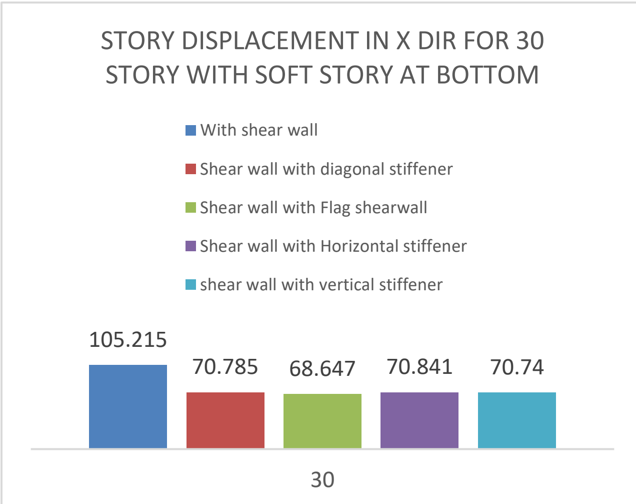
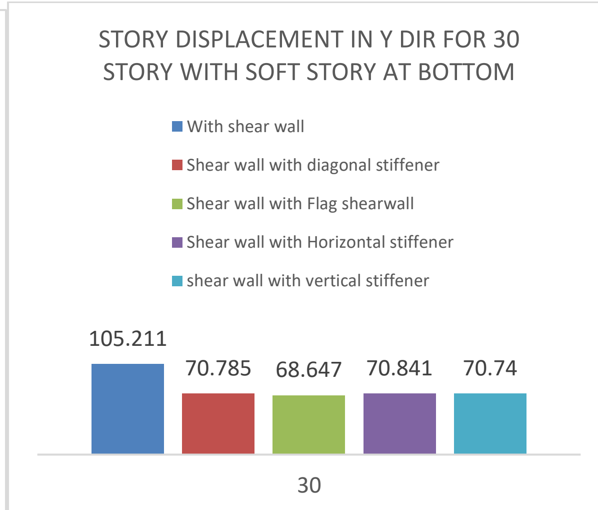


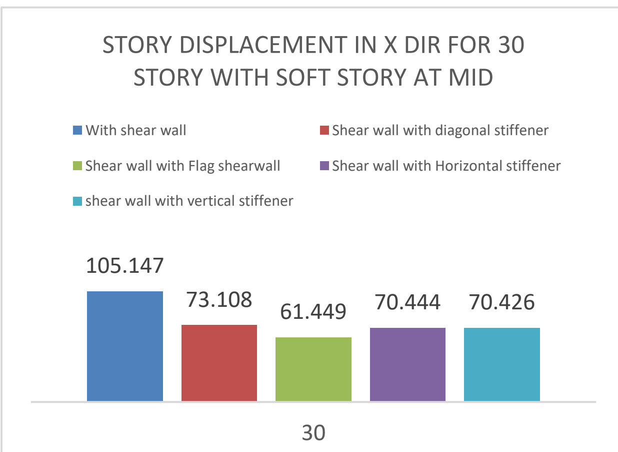
Figure 5: Elevation and 3-d view of Soft Story model with vertical wall

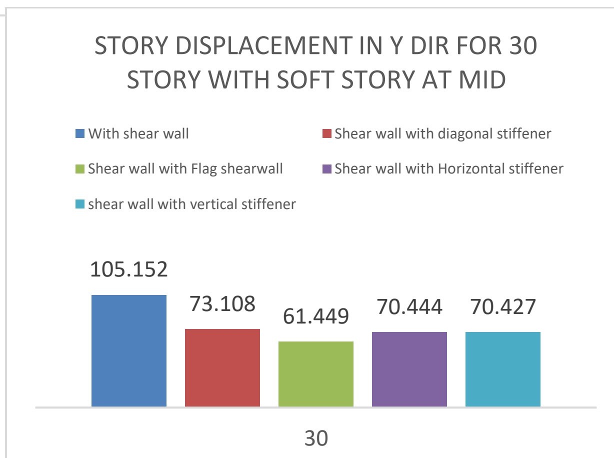
## IV. RESULTS FOR 30 STORY WITH SOFT STORY AT BOTTOM



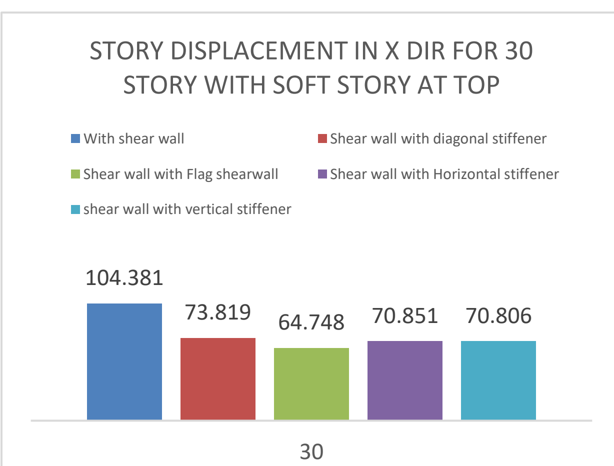



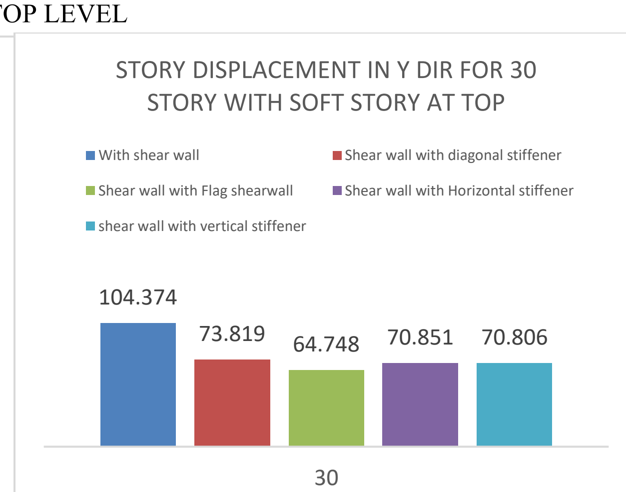

RESULTS FOR 30 STORY WITH SOFT STORY AT MIDDLE LEVEL



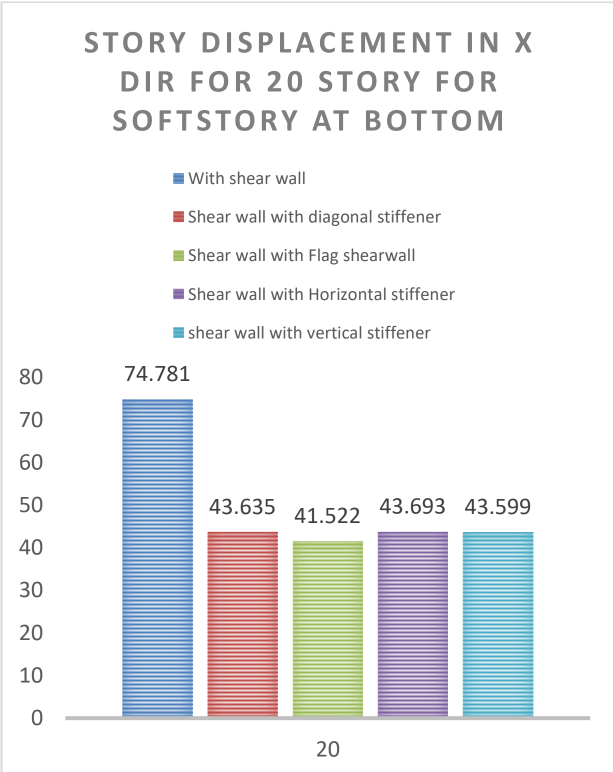



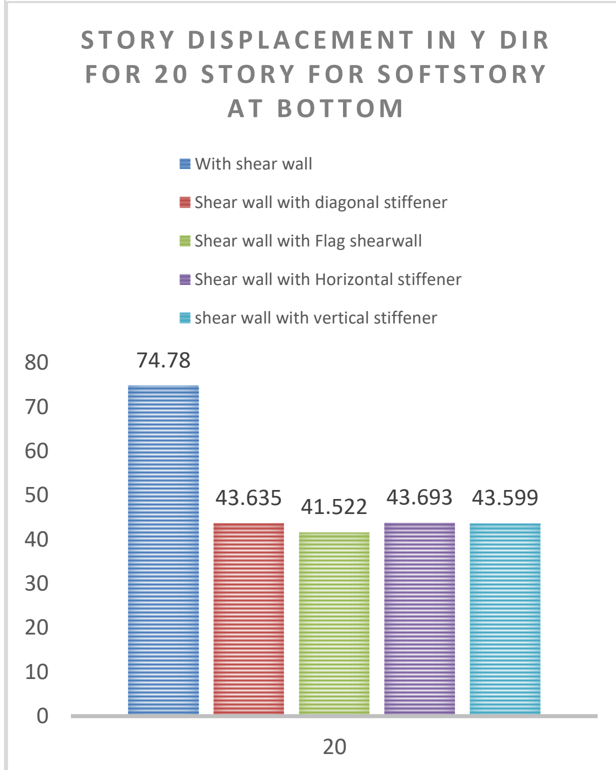

RESULTS FOR 30 STORY WITH SOFT STORY AT TOP LEVEL



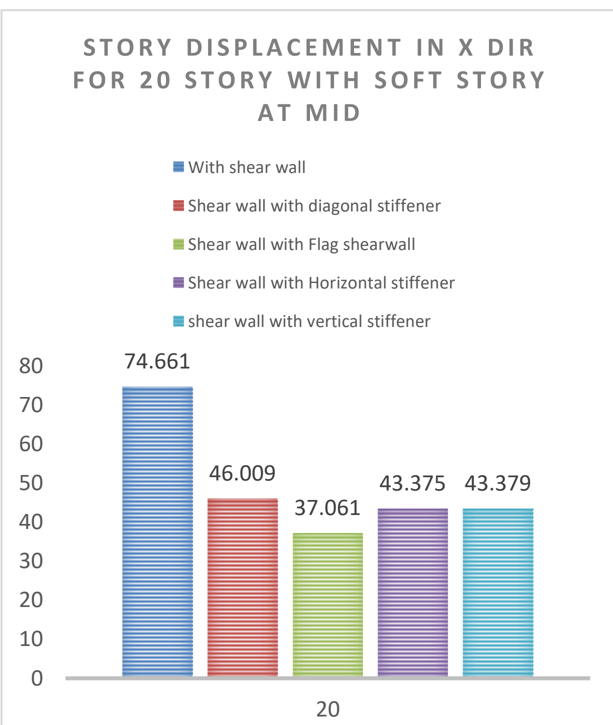



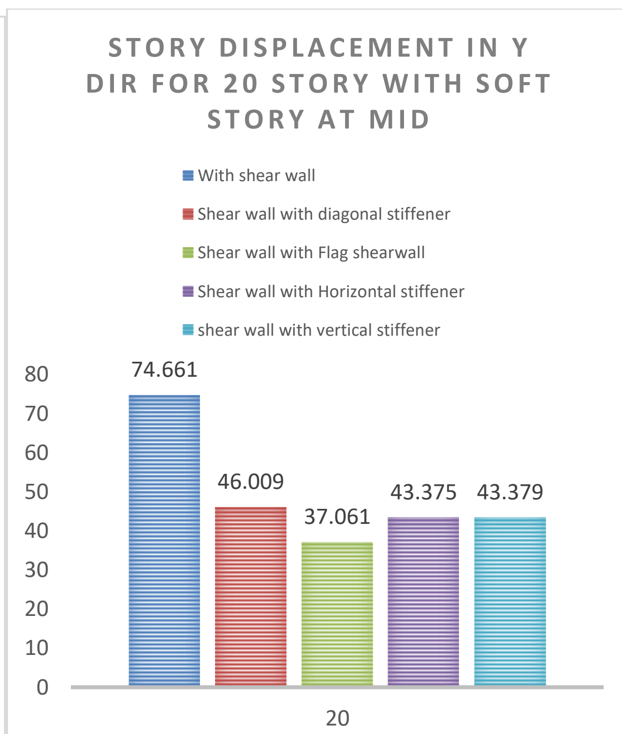
## V. RESULTS FOR 20 STORY WITH SOFT STORY AT BOTTOM



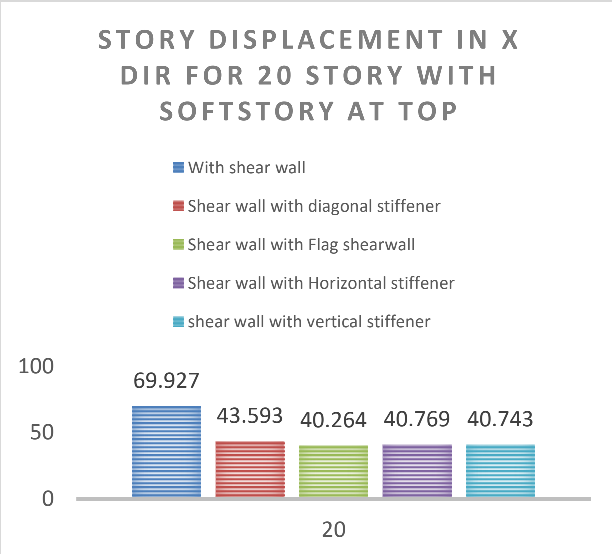



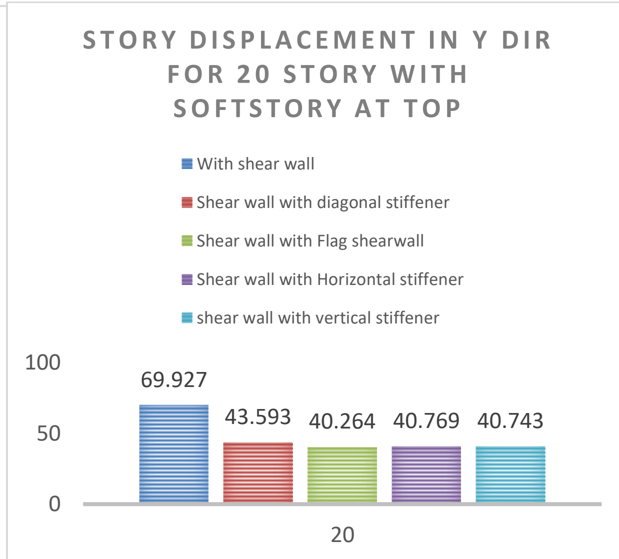

RESULTS FOR 20 STORY WITH SOFT STORY AT MIDDLE LEVEL



RESULTS FOR 20 STORY WITH SOFT STORY AT TOP LEVEL




## VI. CONCLUSION

1. The lateral displacement figures show that there should be less issues with the structure's lateral movement in the model with the FLAG shear wall. The top floor's maximum story displacement in a model with a flag shear wall is only roughly 35% of the displacement in a typical building. Keep in mind that all models' tale displacements fall within acceptable bounds.
2. The period of the first mode of vibration in a flag shear wall is roughly 50% shorter than the natural period in a typical building and roughly 10% shorter than the natural period in a model with diagonal, horizontal and vertical stiffeners, which is a significant difference. Natural period is directly related to the stiffness of the structure.
3. According to the stiffness data above, the flag shear wall tends to exhibit slightly greater stiffness values at all stories, but the diagonal, horizontal, and vertical stiffeners are moving extremely near to one another. In contrast to the other two models, the Flag shear wall exhibits far higher stiffness, and the stiffness line is positioned significantly above the other two. Observe that the stiffness of the other two models, as well as the diagonal, horizontal, and vertical stiffeners, is significantly stronger at lower levels but progressively decreases at upper floors. This is because height affects the rigidity and frames at various levels.
4. By effectively dispersing energy and managing interstory drift, the additional diagonal, horizontal, and vertical stiffeners enhance the original MRF's seismic performance.
5. By providing the MRF with initial stability and energy absorption, the additional diagonal, horizontal, and vertical stiffeners can lessen the structural displacement reaction during earthquakes. The frame's damage process is affected by the diagonal, horizontal, and vertical stiffeners' stiffness ratio between stories.
6. The total stiffness of a building's columns is its lateral strength; bracing is added at each level. Therefore, the failure is caused by poor strength on the lowest floor, particularly during an earthquake. A building's strength is deemed extremely weak and prone to failure during an earthquake if it lacks any lateral load resistance components, such as bracing.
7. The tale drift values fall within the allowed range of 1893, which is 0.004 times the story height.

## VII. FUTURE SCOPE

The analysis of a multi-story building under the influence of stiffness discontinuity in the current thesis takes into account various brace systems.

• The current work can be expanded to include a thorough analysis of different kinds of irregulars and a generalized conclusion for design or such irregular structures, which can aid in comprehending the behavior of such irregular buildings.

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