STUDY OF SEISMIC DEMANDS OF SYMMETRICAL AND ASYMMETRICAL RCC BUILDINGS USING RUBBER BASE ISOLATOR

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ABSTRACT

One of nature's most devastating forces, earthquakes have historically been responsible for widespread human casualties and extensive material destruction, particularly to man-made buildings. However, earthquakes provide architects and engineers with a variety of crucial design requirements that are not often considered throughout the design process. Earthquake isolation, based on tried and tested methods vetted by several academics, may be utilized to solve a variety of issues in seismic design. Since the beginning of the twenty first century, the use of base isolation techniques to safeguard buildings against seismic threats has been widely recognized as one of the most successful methods available. This is due to the fact that earthquake attacks can be mitigated by isolating the building's base, and that a flexible base can effectively decouple the building from the ground motion, with the result that the accelerations caused by the building's response are typically smaller than those caused by the earthquake itself. The purpose of this paper is to show how effective base isolation approaches, such as the use of a lead rubber base isolator, are for asymmetric buildings of varying heights. In this part, we look at structures with 5, 10, 15, and 20 stories. Space frames made of reinforced concrete that can withstand a moment load due to gravity or seismic activity. A nonlinear analysis engine in ETABS version 20 software (CSI Ltd) is used to assess the building's compliance with seismic code IS-1893:2016.

Keywords: Rubber bearing Base isolation, High rise building, nonlinear time history, dissipation of energy.

1.General

A natural earthquake occurs when the earth's crust trembles or moves abruptly. A natural shock wave excludes shock waves caused by nuclear tests, man-made explosions, etc. We live on a planet made up of plates. A fault is a junction between two plates. According to the Indian context, this fault extends from Himachal Pradesh through Uttaranchal, Bihar, Assam, and Burma. In Indonesia, that plate descends through the Andaman-Nicobar Islands and the Bay of Bengal. Earthquakes occur when the rocks are subjected to stress due to the movement of the plate.

People don't die in earthquakes, but buildings do. In designing a safe structure, it is up to a structural engineer to determine the parameters based on past experiences and to plan for potential hazards in the future. Engineers have developed methods through finite element computer technology/software to improve the performance of structures subjected to earthquakes by modeling, analyzing, and meticulously displaying the results. One would never have imagined that Civil Engineering research had reached such far-reaching horizons. Computer science and technology developed in the last few decades have saved a lot of human effort and time for structural engineers.

1.1 Objectives of the Study

The present work aims to:

- Using the non-linear time history analysis, we studied the seismic demands of different regular and irregular R.C. buildings.
- To show how base isolators affect low-rise to high-rise symmetric and asymmetric buildings.
- To conduct time history analysis for the evaluation of dynamic structural response under loading which may vary according to a specified time function.

2. Literature Review

S.M. Wilkinson and R.A. Hailey Non-linear time history analysis was conducted on a plane frame model that may be used to examine tall structures experiencing earthquake effects. In a normal plane frame, the model has plastic hinges with optimal plastic qualities. Lumped mass formulation is characterized by the displacements being defined by dynamic degrees of freedom, which are effectively the translation & moment of inertia of diaphragm around the vertical axis. The Runga-Kutta approach was chosen as the dynamic integration algorithm. This was followed by a comparison to the static approach. The authors conclude that a simple approach for the efficient study of tall structures has been offered. The model reliably foretells higher vibrational modes, allowing us to take their impact on building collapse into account..

Fabio Mazza and Mirko Mazza This study is an attempt to quantify the primary impacts of tensile axial stresses in the elastomeric bearings of base-isolation system upon that nonlinear seismic response of r.c. framed structures exposed to vertical and horizontal components of near-fault earthquakes. To address this shortcoming, three base-isolated r.c. office buildings of three, seven, and ten stories are designed in accordance with the Italian technical code NTC18, taking into account 3 parameters of the nominal stiffness ratio & assuming each of the buildings are situated in a high-risk seismic zone. Each building undergoes an incremental dynamic study of three distinct near-fault EQs: one with the dominant horizontal component, another with the dominant vertical component, and a third with similar vertical and lateral components.

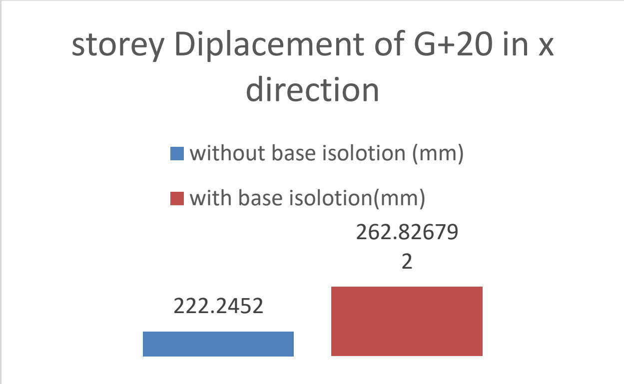
Heng Wang , Wenai Shen , Yamin Li , Hongping Zhu ,Songye Zhu They presented the results of a theoretical and numerical research of a BIS system equipped with a new inerter-based damper, EIMD, and analyzed its dynamic behavior, ideal parameters, and seismic performance. Closed-form solutions of the dynamic characteristic parameters, modal participation factors, and dynamic amplification factors are determined from a 2-DOF analytical model of the BIS with an EIMD. Using a standard 2-DOF BIS model, we conduct an extensive parametric investigation to determine the dependence of the aforementioned parameters on the inertance-to-mass ratio and the supplementary damping ratio of the EIMD. It is discovered that the EIMD may achieve extra period elongation because to inertance, which is a notable property of the EIMD since it does not reduce the static lateral stiffness of base isolation system. Since the high-performance EIMD allows for a BIS to have relatively high lateral stiffness, the structure can withstand additional lateral loads operating on it, such as wind loads. Increasing the EIMD's inertance-to-mass ratio and supplementary damping ratio, and, is always useful for regulating the base floor response..

Mohit Kumar Prajapati, Sagar Jamle. Ongoing research into the topic of seismic influence has uncovered a wealth of data highlighting the need of doing more research. Previous research's collected data were invaluable for this study's in-depth examination of the issue. The research has improved our understanding of the many analytical techniques that may be used to diverse building kinds. The impact of pressures on a building's performance may now be studied with considerably less effort thanks to this program's streamlined approach to force evaluation. This is the inescapable conclusion: These anomalies should be avoided as much as possible since they lead to uneven stress distribution. It messes up the geometry of the building. Floating columns research is required if necessary, but other approaches to prevent the undistributed loads should be utilized instead. Second, members of floating columns need more ductile detailing. Third, the aforementioned vertical irregularity causes for further drift and displacement of stories. Quantifying S.F. and B.M.

3. Results and Discussions

Different parameters, such as storey drifts, base shears, modal periods, torsion, etc., were used to achieve the results. Non-Linear Time History Analysis using Base Isolation approaches yielded the following findings for symmetric and asymmetric five-storey buildings first, followed by the corresponding results for symmetric and asymmetric twenty-storey buildings. Considering the Storey impact of both symmetric and asymmetric buildings and contrasting the Responses of the structure for five- and twenty-storey Buildings, the authors then discuss findings of Base isolation based on the storey drifts, Base shear, Torsion, etc.

3.1 Base Isolation Of Twenty-Storey Symmetric Building



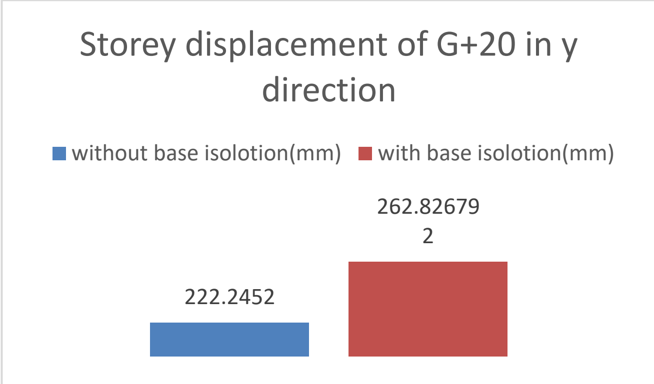
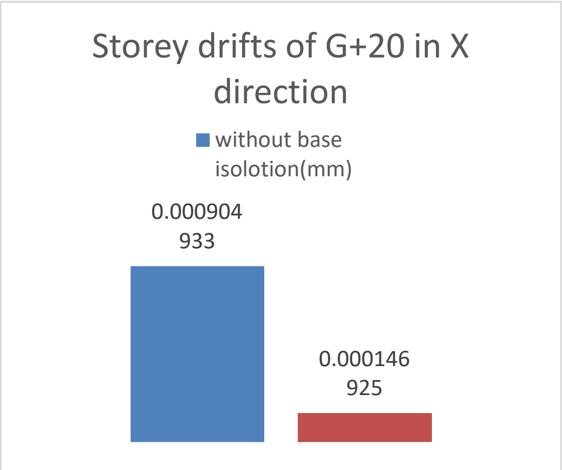


Fig 1: Storey displacement of 20 stories in the x-direction **Fig 2: Storey displacement of 20 stories in the y-direction**

According to IS 16700:2017 Cl 5.4.1, the displacement must not exceed the height of the building/250. This is the relative sway of the building from its original position. When a structure has a lesser displacement, it is most likelydue to the increase in its lateral stiffness. The higher its lateral stiffness, the less damage it will sustain from lateralloads. The displacement in the present considered model should not exceed 264 mm.



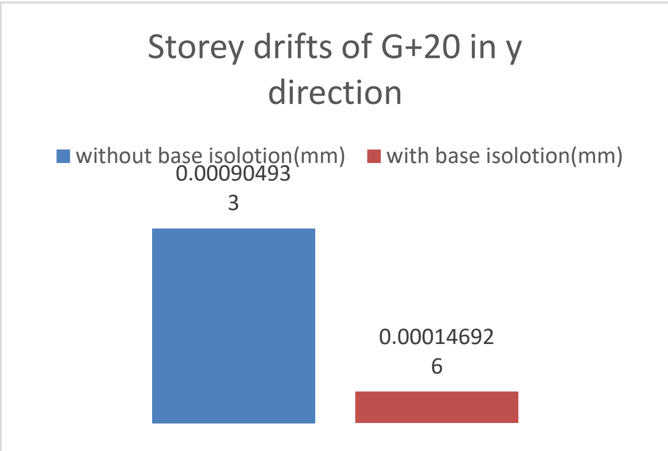
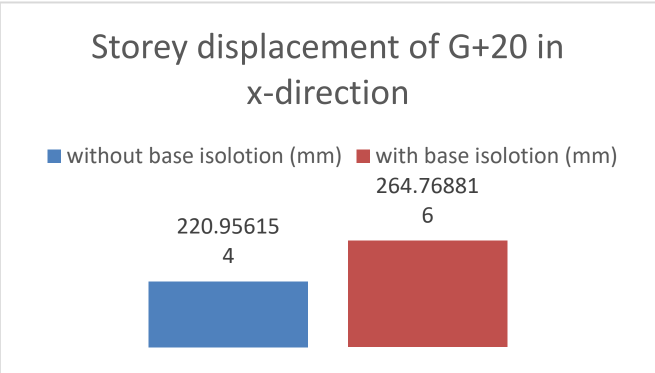


Fig 3: storey drifts of 20 stories in an x-direction **Fig 4: storey drifts of 20 stories in the y-direction**

3.2 Base Isolation Of Twenty-Storey Unsymmetric Building (L-Type)



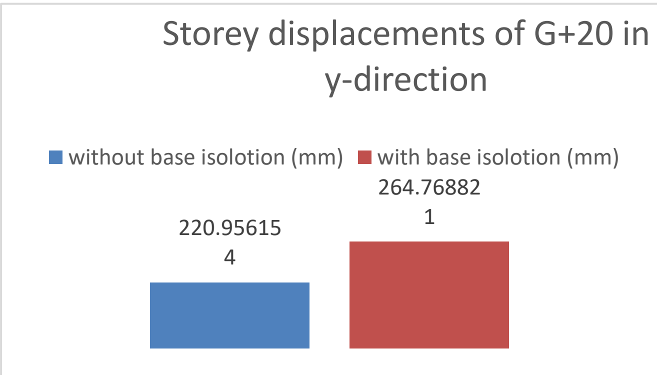


Fig 5: storey displacement of 20 stories in x-direction **Fig 6: storey displacements of 20 stories in y-direction**

As per the observation from the above Figures, it is found that the displacement of the Base isolation building increases. It is found that the normal building without base isolation has the least displacement compared to the base isolation model. The percentage of increases in the displacement of the base isolation structure is 16.6% and 16.66% compared to a normal structure.

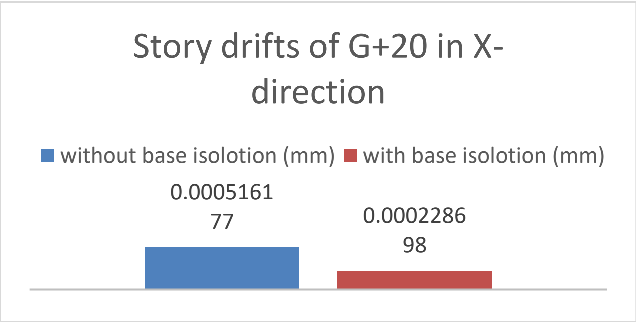


Fig 7: Storey drifts of 20 stories in an x-direction

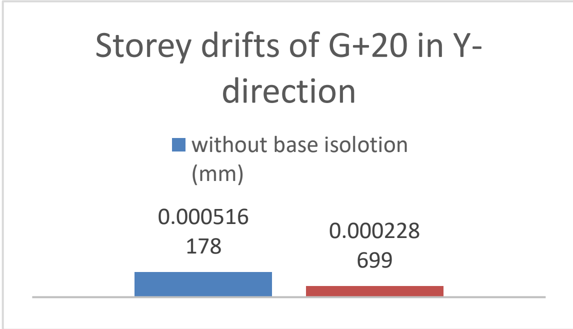


Fig 8: storey drifts of 20 stories in the y-direction

A normal model has had a Drift of 0.000516 mm and 0.000516 mm in both X & Y directions, with the use without base isolation structure. Drift values obtained with base isolation were 0.00022 mm and 0.00022 mm. Drift was reduced by 57.8 %. It is observed that the structure with base isolation has higher lateral stiffness which is significantly observed with the Drift parameter.

3.3 Base Isolation Of Fifteen-Storey Symmetric Building

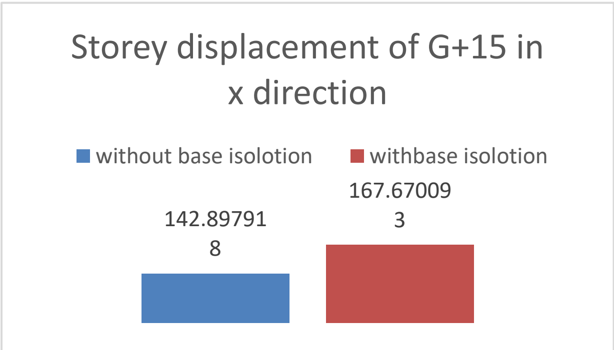


Fig 9: Storey displacements of 15 stories in x-direction

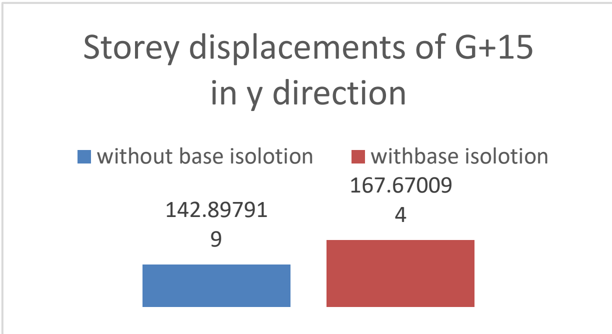


Fig 10: Storey displacement of 15 stories in y-direction

It is found that the displacement of the Base isolation building increases. It is found that the normal building without base isolation has the least displacement compared to the base isolation model. The percentage of increases in the displacement of the base isolation structure is 15.32% and 15.32% compared to the normal structure.

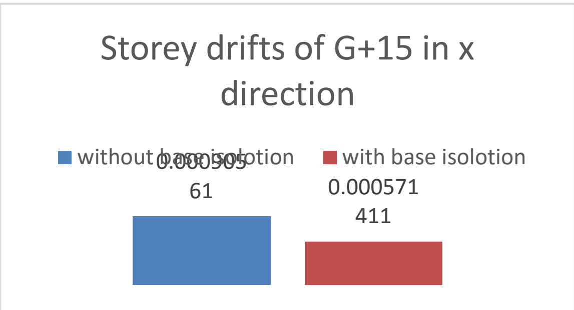


Fig 11: Storey drifts of 15 stories in x-direction

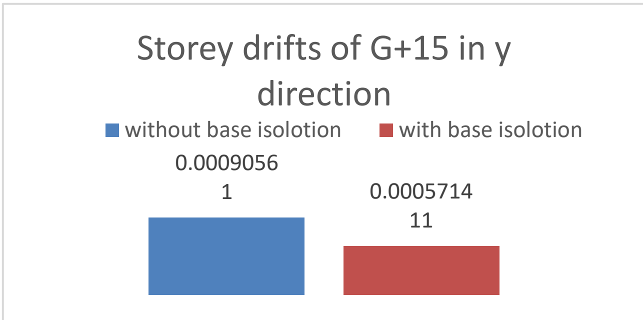


Fig 12: Storey drifts of 15 stories in y-direction

A normal model has had a Drift of 0.00090 mm and 0.00090 mm in both X & Y directions, with the use without base isolation structure. Drift values obtained with base isolation were 0.00057 mm and 0.00057 mm. Drift was reduced by 36.2 %. It is observed that the structure with base isolation has higher lateral stiffness which is significantly observed with the Drift parameter.

3.4 Base Isolation Of Fifteen-Storey Unsymmetric Building (L-Type)

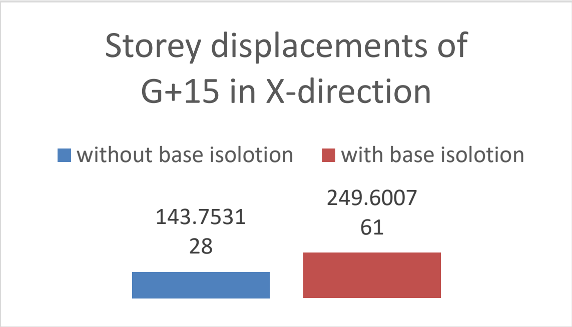


Fig 13: Storey displacements of 15 stores in x-direction

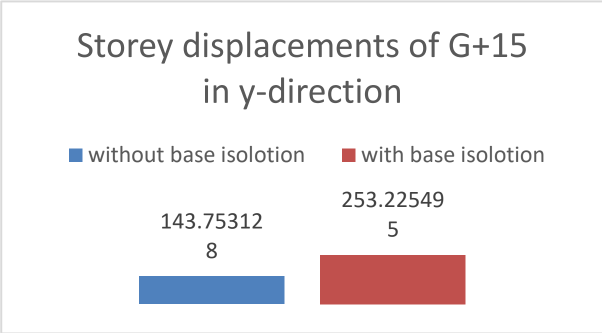


Fig 14: Storey displacements of 15 stores in the y-direction

As per the observation from the above Figures, it is found that the displacement of the Base isolation building increases. It is found that the normal building without base isolation has the least displacement compared to the base isolation model. The percentage of increases in the displacement of the base isolation structure is 43% and 43.2% compared to the normal structure.

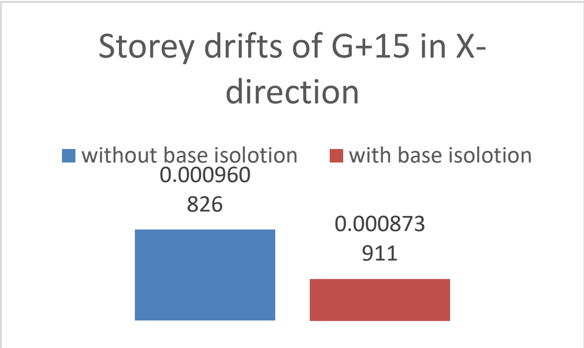


Fig 15: Storey drifts of 15 stores in x-direction

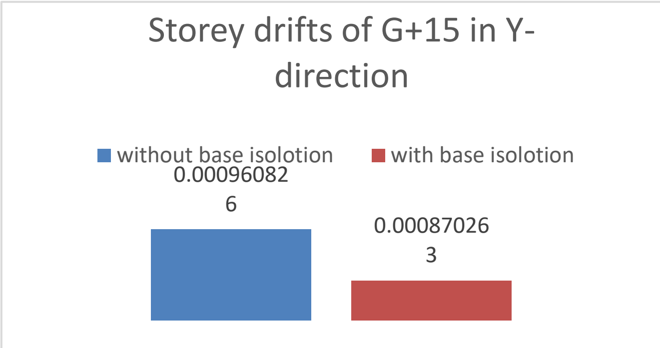


Fig 16: Storey drifts of 15 stores in y-direction

A normal model has had a Drift of 0.00096 mm and 0.00096 mm in both X & Y directions, with the use without base isolation structure. Drift values obtained with base isolation were 0.00087 mm and 0.00087 mm. Drift was reduced by 10.8 %. It is observed that the structure with base isolation has higher lateral stiffness which is significantly observed with the Drift parameter.

3.5 Base Isolation Of Ten-Storey Symmetric Building

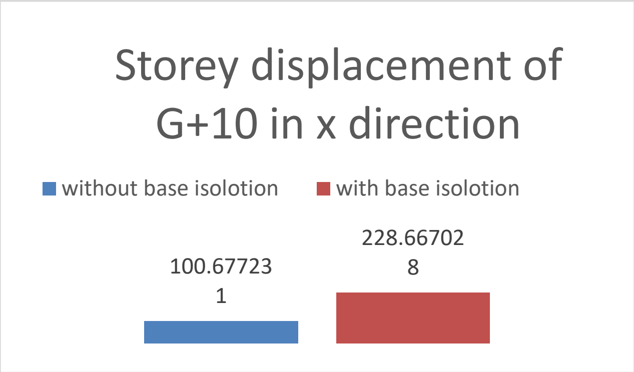


Fig 17: Storey displacements of 10 stores in x-direction

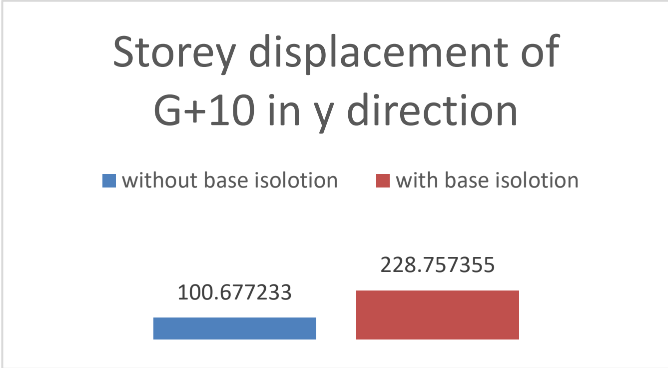


Fig 18: Storey displacements of 10 stores in y-direction

As per the observation from the above Figures, it is found that the displacement of the Base isolation building increases. It is found that the normal building without base isolation has the least displacement compared to the base isolation model. The percentage of increases in the displacement of the base isolation structure is 56.6% and 56.66% compared to the normal structure.

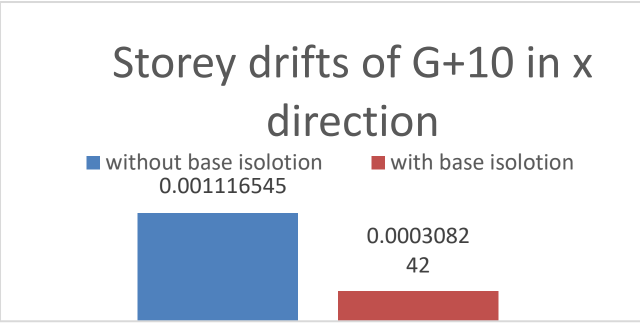


Fig 19: Storey drifts of 10 stores in the x-direction

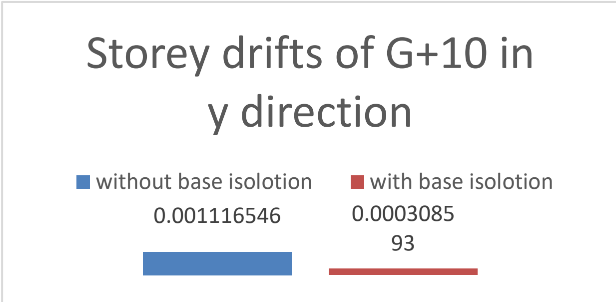


Fig 20: Storey drifts of 10 stores in the y-direction

A normal model has had a Drift of 0.00116 mm and 0.00116 mm in both X & Y directions, with the use without base isolation structure. Drift values obtained with base isolation were 0.0003 mm and 0.0003 mm. Drift was reduced by 72 %. It is observed that the structure with base isolation has higher lateral stiffness which is significantly observed with the Drift parameter.

3.6 Base Isolation Of Ten-Storey Unsymmetric Building (L-Type)

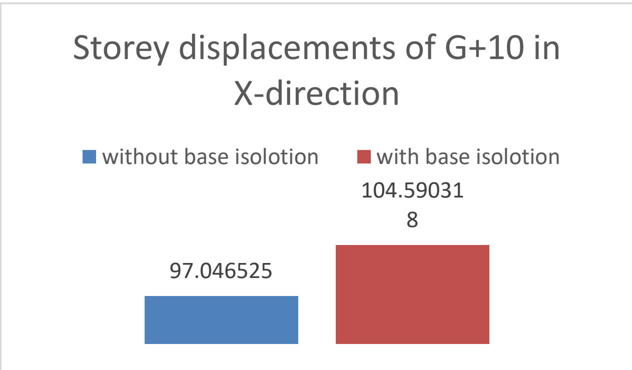


Fig 21: Storey displacements of 10 stores in x- direction

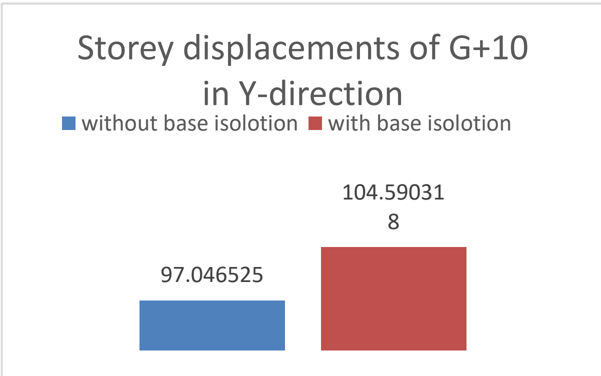


Fig 22: Storey displacements of 10 stores in y-direction

As per the observation from the above Figures, it is found that the displacement of the Base isolation building increases. It is found that the normal building without base isolation has the least displacement compared to the base isolation model. The percentage of increases in the displacement of the base isolation structure is 16.6% and 16.66% compared to the normal structure.

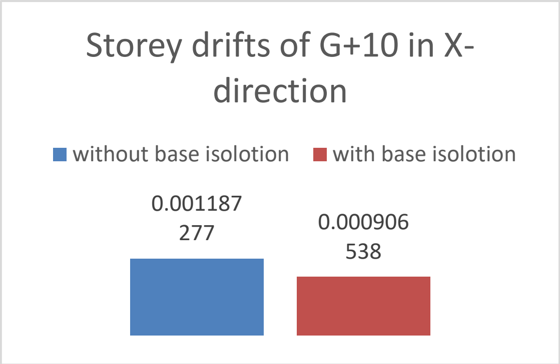


Fig 23: Storey drifts of 10 stores in the x-direction

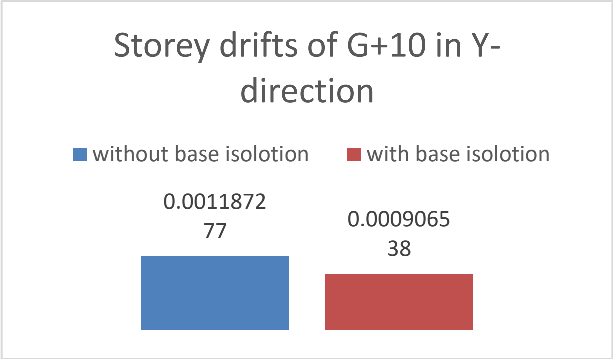


Figure 24: Storey drifts of 10 stores in the y-direction

A normal model has had a Drift of 0.00118 mm and 0.00118 mm in both X & Y directions, with the use without base isolation structure. Drift values obtained with base isolation were 0.00090 mm and 0.00090 mm. Drift was reduced by 23.72 %. It is observed that the structure with base isolation has higher lateral stiffness which is significantly observed with the Drift parameter.

3.7 Base Isolation Of Five Storey Symmetric Building

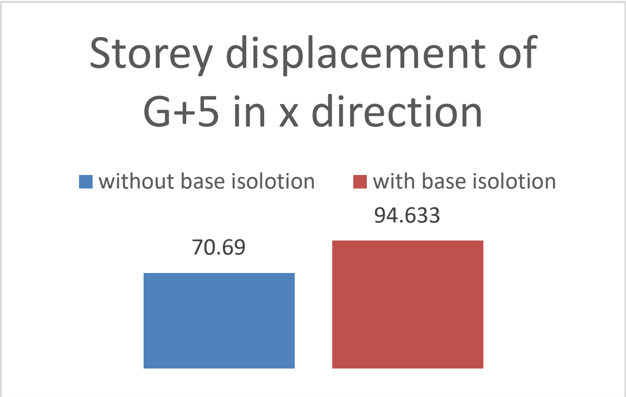


Fig 25: Storey displacements of 5 stores in x-direction

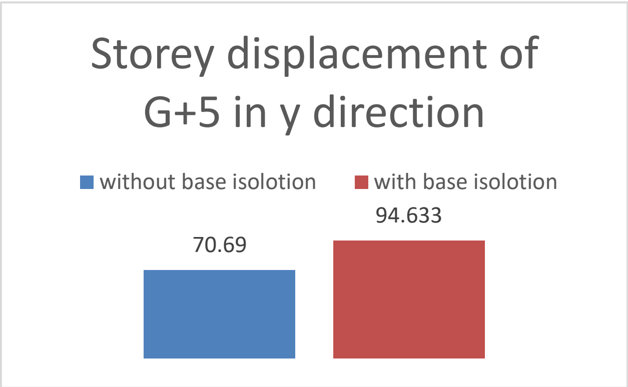


Fig 26: Storey displacements of 5 stores in y-direction

As per the observation from the above Figures, it is found that the displacement of the Base isolation building increases. It is found that the normal building without base isolation has the least displacement compared to the base isolation model. The percentage of increases in the displacement of the base isolation structure is 25.3.6% and 25.36% compared to the normal structure.

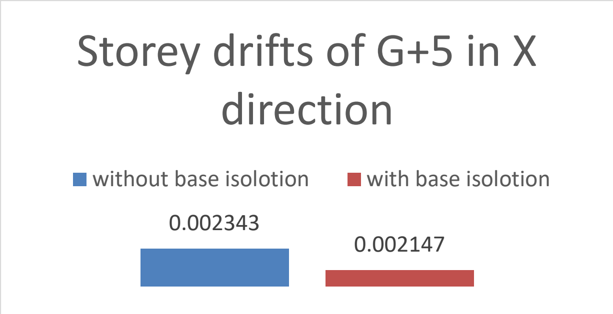


Fig 27: Storey drifts of 5 stores in the x-direction

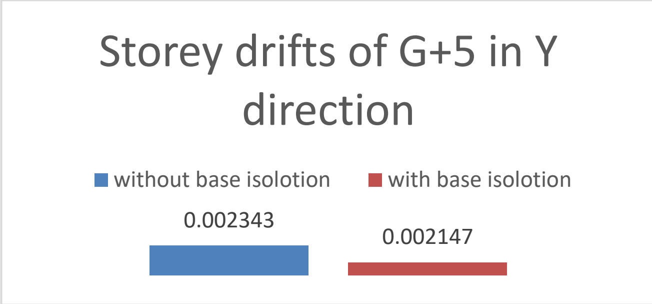


Fig 28: Storey drifts of 5 stores in the y-direction

A normal model has had a Drift of 0.00234 mm and 0.00234 mm in both X & Y directions, with the use without base isolation structure. Drift values obtained with base isolation were 0.0021 mm and 0.0021 mm. Drift was reduced by 10.56 %. It is observed that the structure with base isolation has higher lateral stiffness which is significantly observed with the Drift parameter.

3.8 Base Isolation Of Five Storey Unsymmetric Building (L-Type)

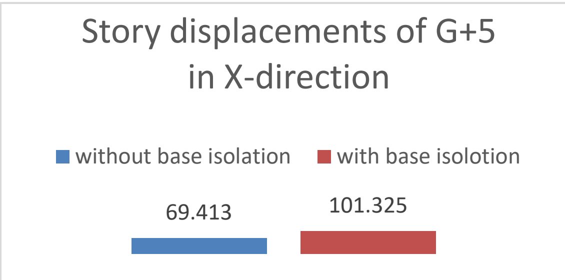


Fig 29: Storey displacements of 5 stores in x-direction

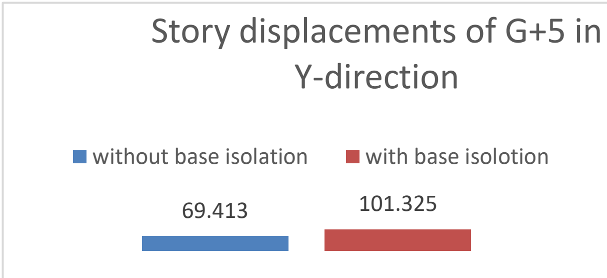


Fig 30: Storey displacements of 5 storey in y direction

As per the observation from the above Figures, it is found that the displacement of the Base isolation building increases. It is found that the normal building without base isolation has the least displacement compared to the base isolation model. The percentage of increases in the displacement of the base isolation structure is 25.3.6% and 25.36% compared to the normal structure.

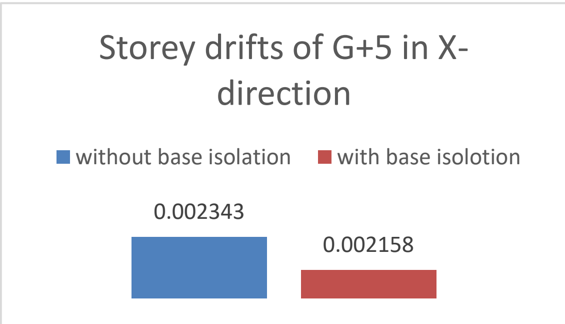


Fig 31: Storey drifts of 5 stores in the x-direction

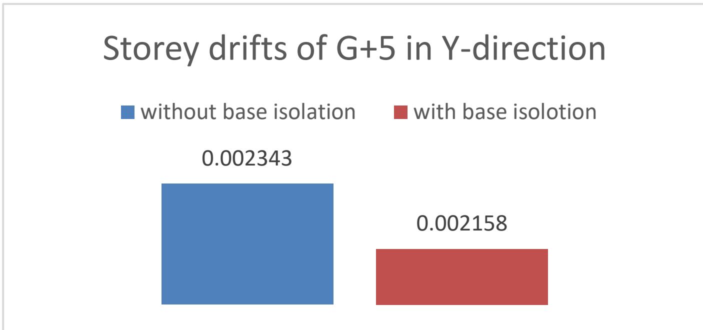


Fig 32: Storey drifts of 5 stores in the y-direction

A normal model has had a Drift of 0.00234 mm and 0.00234 mm in both X & Y directions, with the use without base isolation structure. Drift values obtained with base isolation were 0.0021 mm and 0.0021 mm. Drift was reduced by 10.56 %. It is observed that the structure with base isolation has higher lateral stiffness which is significantly observed with the Drift parameter.

4. Conclusions

1. For a symmetric five-storey structure, the storey drifts were reduced by 25%, while for an asymmetric five-storey building, they were reduced by 26.5%. Indicating that Low-Rise Buildings Can Benefit from Base Isolators . Twenty-storey structures benefitted from the isolation method, which reduced storey drifts by 16% for symmetric buildings and by 15.98% for asymmetric ones.

2. Based on the 75% reduction in Base shear for symmetric Buildings and the 75% reduction in Base shear and Base torsion moment respectively for asymmetric Buildings, Base Isolators were found to be excellent seismic control devices for five-storey buildings in controlling forced Responses like base shear.
3. Conclusions indicated that base isolators performed well as seismic control devices for low-rise to high-rise symmetric and asymmetric structures alone.
4. The practice of isolating the building's base from the ground has been proven effective in making structures resistant to earthquakes.
5. We may anticipate a similar uptake of base isolators in India in the near future, since they are widely utilized elsewhere in the globe in seismically active regions. As they are both technically sound and financially viable, base isolators should be actively promoted, at least in seismic zones 4 and 5. In the event of an earthquake, using foundation isolators may lessen the amount of damage done to the building's structure and the amount of drift that occurs between floors. After some cosmetic work, the building will be ready for occupancy.
6. Since the lateral displacement at the base never equals zero, base-isolated structures display less lateral deflection and fewer moment values than the fixed base structure.

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