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Study of Seismic Demands of Symmetrical and Asymmetrical RCC Buildings using Rubber Base Isolator

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ABSTRACT

Earthquakes are one of nature's biggest perils; throughout historic time they have caused major loss of life and serious damage to property, 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. Seismic isolation may be utilized to effectively solve a variety of seismic design challenges, based on well-established methodologies examined by various academics. In the past two decades, the use of base isolation strategies to safeguard buildings from earthquake threats has risen in popularity as experts recognize its efficacy. The earthquake's impacts are mitigated by the flexible base, which isolates the structure from the ground motion, and the accelerations caused by the structure's reaction are often less than those caused by the earthquake itself. The purpose of this paper is to show how different types of asymmetrical buildings, both low and high rise, benefit from base isolation methods such the usage of a lead rubber base isolator. 5–, 10–, 15–, and 20–story structures are the focus of this analysis. Space frames made of reinforced concrete that can withstand a moment of force due to both gravity and seismic activity. Using the ETABS version 20 nonlinear version software (CSI Ltd) analytical engine, we do a seismic evaluation of the building in compliance with code IS-1893:2016.

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

1.0 General

When the crust of the Earth shakes or shifts suddenly, it is called an earthquake. Shock waves from nuclear testing, explosions, etc., do not count as natural shock waves. Our world is a sphere constructed of plates. Where two plates meet is called a fault. Indian geographers have determined that this fault runs from Himachal Pradesh, over Uttaranchal, Bihar, Assam, and into Burma. That plate plunges into Indonesia through the Andaman and Nicobar Islands and the Bay of Bengal. When the rocks experience strain because of the plate's motion, an earthquake occurs.

Earthquakes are destructive to structures but not to humans. A structural engineer's job is to design a building that can withstand natural disasters and other threats by anticipating such dangers and setting realistic parameters based on historical data. Using finite element computer technology/software, engineers have devised techniques to enhance the resilience of buildings during earthquakes. Never before has Civil Engineering research expanded to such far-reaching areas. The advancements in computer science and technology over the last several decades have helped structural engineers save a lot of time and money. The seismic hazard determines the minimum amount of ground acceleration that a building must be able to sustain before failing. Structures often have some yielding as a consequence of the strong forces applied to them during an earthquake. The purpose of earthquake engineering is to minimize the number of lives lost when buildings collapse. Attempts in the past to design buildings to resist the stresses generated by earthquakes led to fragile constructions with many heavy structural components and expensive building costs. The concept of a limit state represents a major step forward in the design of methods. The development of performance-based designs was facilitated by limit state techniques, which in turn allowed for the use of thinner members and simplified building processes, resulting in cheaper costs and shorter build times. The ductility of the buildings allowed for careful monitoring and evaluation of their performance before, during, and after the earthquakes. The structure's response to loads may be better understood with the use of a mathematical model. This may be done using any commercially-available structural modeling, analysis, or design program. It is crucial for structural engineers to be able to predict how a structure will behave under a certain set of loads and assurance level.

Designing for earthquakes requires two distinct phases. It is crucial to design a reliable structural system that ensures not only the safety of people within but also their continued use and operation in the event of a seismic catastrophe. It is the engineer's art to come up with a system that not only meets seismic performance objectives but also accounts for constraints imposed by owner, the architect, as well as other professionals involved in the design as well as construction of a building, and this is why earthquake engineering is not a science. The method of making these maps is not based on precise mathematical calculations, but rather on expert opinion, experience, and knowledge of how earthquakes behave. An efficient structural system may be configured and roughly sized with the help of basic understanding of ground motion and elastic and inelastic dynamic response characteristics. Non-Linear Time History analysis is the most precise method for analyzing structures and assessing their performance under specified loads. For buildings that are not as crucial or as vulnerable to earthquakes, other traditional approaches, such as Non-Linear Static Methods (NSPs) and Linear Dynamic Methods, have been developed (LDMs). Results from these methods are not guaranteed to be reliable.

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.

2.1 Literature Review

S.M. Wilkinson and R.A. Hailey using a plane frame model that can account for seismic forces, non-linear time history analysis was undertaken. In a normal plane frame, the model has plastic hinges with optimal plastic qualities. The hallmark of Lumped mass formulation is that the translation & moment of inertia of diaphragm around the vertical axis explain the displacements. A Runga-Kutta approach was used for the dynamic integration. After then, it was compared to the static approach. This paper concludes that a simpler model for the efficient study of high-rise structures has been offered. The model reliably foretells the higher modes of vibration, allowing us to take into account their impact on structure collapse.

Fabio Mazza and Mirko Mazza The purpose of this research is to assess the primary influences of tensile axial stresses upon that nonlinear seismic response of r.c. framed structures exposed to vertical and horizontal components of near-fault earthquakes. In order 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 values of the nominal stiffness ratio & assuming that all 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 horizontal and vertical components.

Heng Wang a , Wenai Shen a,b,* , Yamin Li a , Hongping Zhu a,b ,Songye Zhu c The dynamic behavior, optimum parameters, and seismic performance of a BIS system using a new inerter-based damper dubbed EIMD were presented and studied theoretically and numerically. Closed-form solutions for 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 a thorough parametric research to determine the varying law of aforementioned parameters as a function of the inertance-to-mass ratio and the supplementary damping ratio of the EIMD. Extra period elongation is possible with the EIMD because of inertance, which is a notable aspect of the EIMD since it does not reduce the static lateral stiffness of the base isolation system. To accommodate additional lateral stresses operating on the structure, such wind loads, the high-performance EIMD permits a BIS with reasonably high lateral stiffness. Increasing the EIMD's inertance-to-mass ratio and supplementary damping ratio, on the other hand, is always useful for regulating the base floor response.

Mohit Kumar Prajapati1 , Sagar Jamle2. Ongoing research into the topic of seismic influence has uncovered a wealth of data highlighting the need of doing more research. The wealth of data gathered from earlier studies has been invaluable for elaborating this analysis. Understanding the many sorts of analytic techniques and how they might be used to these studies has been facilitated by this research. The impact of pressures on a building's performance may now be studied with considerably less effort thanks to this software's streamlined analysis tools. The ultimate conclusion is as follows: 1) Because of the increased potential for uneven distribution of weight, it is important to minimize the presence of these abnormalities whenever feasible. It messes up the geometry of the building. Floating columns investigate where has to be used, but better approaches to eliminate the undistributed loads and the requirement for their usage should be used cautiously. 2), members of floating columns need more ductile detailing. 3), there is more lateral and vertical movement of the stories as a result of the uneven floors. 4) Determine the S.F. and B.M. 5) In addition to lowering lateral stresses, isolating the base may also lessen shear at the foundation. 6) seismic forces produce kinetic energy in a structure, and dampers assist disperse that energy. Include a conclusion that discusses the paper's strengths, weaknesses, and potential uses. Don't repeat the abstract in the conclusion, but do summarize the paper's key arguments and findings. The significance of work or potential future applications and expansions might be discussed in more depth in the last section.

S. Gyawali1*, D. Thapa2, T. R. Bhattarai Seismic parameters were derived from SAP's analytical program output. We studied, evaluated, and compared the outcomes. The accuracy of the SAP analysis was checked by comparing it to the output of the ETABS program. The following are the results of the study.

- When comparing the LRB building to the fixed base building, the base shear value is lowered by 45-50%..
- The LRB has raised the building's top-story displacement by between 81% and 99%.
- The LRB has reduced the top-story drift of the structure by as much as 61%.
- LRB has raised the first three modes of the building's basic time period by as much as 126–147 percent.
- In terms of seismic performance, plan and vertical irregular base-isolated structures performed better than regular base-isolated buildings.

• When comparing the strength and seismic performance of plan irregular and vertical irregular base-isolated structures, the latter were determined to be superior.

• It was also discovered that base-isolated structures with irregular vertical shapes were safer against torsional forces than other types of base-isolated buildings.

In conclusion, this study found that, when comparing seismic performance between LRB irregular and LRB regular structures, the latter fared better in terms of reaction spectrum analysis.

Dario De Domenico*, Giuseppe Ricciardi This article presents a case study of an earthquake-resistant design for a structure with a reinforced concrete frame. In order to enhance the building's seismic performance, a novel method is investigated: using the base isolation in combination with a tuned mass damper (TMD) installed in the basement, below the isolation level. Below the first floor, low-damping rubber isolators are strategically positioned throughout the building's perimeter to provide seismic base isolation. A big-mass TMD, often made up of a box filled with large aggregate concrete, is installed at the building's core. The TMD consists of a box in the basement and a series of lead-core rubber isolators that link the box to the base isolation system and act as dampers and springs. Sliding mechanisms with reduced friction separate the TMD box from the ground. Minimizing an objective function derived from a stochastic dynamic analysis of a simplified three-degree-of-freedom system consisting of the main struc[1]ture, the base isolation, and the TMD allows for the detection of the optimal design parameters of the auxiliary TMD isolators. The primary structure displacement relative to the ground, the inter-story displacements, the overall acceleration, and an energy[1] based indication are the four goal functions explored. Nonlinear time-history studies showing that generated accelerograms agree with the response spectrum of the installation site prove the efficacy of this design philosophy and the accompanying optimization technique, applied for the first time to a real instance. The seismic performance of the building is summarized by several response indicators, such as the deformation of the isolators, the displacement demand of the structure, the base shear, the inter-story drifts, and the shear forces and bending moments on the beam-column members, all of which show that this structural system is superior to both the fixed-base building and the conventional application of the base isolation.

3. Methodology

3.1 General

The NLTHA uses dynamic inelastic analysis to predict how well a structure will perform under a variety of conditions, including during an earthquake, and then compares that prediction to the performance of similar structures that have been retrofitted with base isolators and tuned mass dampers to measure the resulting reduction in response. It relies on the evaluation of many performance characteristics, such as global drift, inter-story drift, elastic element deformations (absolute or normalized against a yield value), deformations between elements, and element and connection forces. Seismic forces and deformation demand may be estimated by analysis of the inelastic deformation time history. This will allow us to take into consideration the reorganization of internal forces that happens when the structure is exposed to inertia forces beyond its elastic range. The NLTHA is predicted to offer information on various response properties, in contrast to the still-debatable accuracy of linear elastic analysis and linear dynamic analysis. To ensure the load route is complete and adequate, we must examine the whole structural system, its connections, the stiff nonstructural materials of substantial strength, and the foundation system.

NLTHA may be the only earthquake simulation approach capable of faithfully reproducing how buildings react to actual earthquake forces. Gaining these advantages, however, requires a great deal of extra analysis work in the forms of include all important parts, modeling their inelastic load-deformation characteristics, and carrying out incremental inelastic assessments, ideally using three-dimensional analytical models. Unfortunately, effective analytical tools that are both user-friendly and comprehensive are still in short supply. Unlike linear seismic static analysis, linear seismic dynamic analysis, or non-linear static analysis, all of which have codes, NLTHA is controlled by special documents around the globe in the form of ATC-40, FEMA 273 and FEMA-356 [2000] papers. To prove that the response is estimated at each stage of earthquake loading, the NLTHA shows that the structure deforms inelastically as the earthquake loads proceed.

Designing for earthquake resistance in the past led to fragile, heavy parts, and a high total cost of construction because of the need to support the weight of the structure. In the process of creating design methods, the idea of limit states was crucial. Performance-based engineering approaches were established thanks to limit-state procedures, which allowed for the creation of structures with fewer but thinner components, as well as decreases in both building costs and build times. Ductility allowed designers the leeway to evaluate and track the performance of the structures while they were being built in order to ensure that they could withstand the seismic energy emitted by earthquakes without causing damage. Mathematical modeling of the structure with its performance under loads allows for predictions to be made during the design process. Almost any piece of commercially-available structural modeling, analysis, or design software will do the job. The capacity of a structural engineer to foresee how a building will respond to loads applied in a certain configuration and at a given degree of security is crucial. Non-linear time history analysis is the most precise method for analyzing the structures and assessing their performance under the specified stress. For less crucial or seismically risky buildings, non-linear static approaches (NSPs) have been developed.

3.2 Non-Linear Time History Analysis (Nltha)

Time-history analysis is an iterative process in which the loading and response history are assessed throughout a range of t=sequences of times. When assessing the reaction at each stage, we take into account both the loading history across the interval and the starting circumstances (displacements and velocities) at the start of the stage. By gradually changing one or more of the structure's attributes (such stiffness, k), non-linear behavior may be taken into account with ease. Accordingly, this strategy is the most efficient way for resolving non-linear issues.

It is possible to use inelastic dynamic time history analysis as a tool for forecasting seismic force and deformation requirements. When inertia forces are applied to the structural system beyond the structural elastic range of motion, this method approximates the resulting redistribution of internal forces. NLTHA is looked upon as a way to acquire insight into various response properties that are otherwise inaccessible through linear elastic and linear dynamic analysis. In addition, verifying a full and sufficient load route remains an open question that might affect the reliability of this computation. All structural parts, all joints, all stiff non-structural parts, and the underpinnings are included. If you want to know how a building would react to an actual earthquake, NLTHA is your best bet. While these advantages are undeniable, it is also clear that more analysis work will be required to fully realize them, as all elements will need to be accounted for, their inelastic load-deformation characteristics modeled, and incremental inelastic analyses performed, preferably with the aid of a three-dimensional analytical model. Except in a few rare cases, sufficient analytical tools are not yet available for this purpose.

3.3 Analysis Procedures

It is always necessary to use elaborate and time-consuming methods in order to determine the vulnerability of buildings based on the assignment of scores. Methods involving more detailed analysis and more refined models take even longer and are therefore only used after assessing potentially hazardous buildings in multiple phases. For earthquake scenario projects involving the assessment of a large number of buildings, it is not suitable. It is necessary to outline briefly the major analytical procedures in order to develop effective simple methods based on these concepts. Analyses can be classified as linear (linear static and linear) or nonlinear (non-linear static and non-linear).

4. 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 Techniques Results for Symmetric and Asymmetric Five-Story Buildings are outlined first, followed by the results for symmetric and asymmetric Twenty-Story Buildings. Thereafter, the results of the base isolation analyses are discussed, including the storey drifts, the base shear, the torsion, etc., for both symmetric and asymmetric buildings, as well as the storey effect of symmetric and asymmetric buildings, as measured by comparing the structural responses of five- and twenty-story buildings.

4.1 ***Base Isolation Of Twenty-Storey Symmetric Building***

Table 1 Story displacement of G+20 normal building

Story displacement				
	without base isolation		with base isolation	
Story	**X-Dir**	**Y-Dir**	**X-Dir**	**Y-Dir**
Story	mm	mm	mm	mm
Base	0	0	58.40946	58.40945
Story1	6.0723	6.0723	80.54078	80.54077
Story5	19.96	19.96	101.6727	101.6726
Story4	37.4824	37.4824	120.2634	120.2634
Story6	55.9613	55.9613	136.6163	136.6163
Story2	73.6401	73.6401	151.0332	151.0332
Story3	89.7312	89.7312	163.8472	163.8472
Story7	104.0701	104.0701	175.4266	175.4266
Story8	117.2589	117.2589	186.0591	186.0591
Story9	130.6826	130.6826	196.0228	196.0228
Story10	145.9166	145.9166	205.53	205.53
Story11	163.0597	163.0597	214.7224	214.7225
Story12	180.4602	180.4602	223.9511	223.9511
Story13	194.8369	194.8369	232.4945	232.4945
Story14	205.6421	205.6421	240.2421	240.2421
Story15	212.838	212.838	246.8491	246.8491

Story16	215.5299	215.5299	252.2423	252.2423
Story17	216.5007	216.5007	256.267	256.267
Story18	216.8507	216.8507	259.0387	259.0387
Story19	217.4215	217.4215	260.7965	260.7965
Story20	218.1258	218.1258	261.776	261.7761
Story21	219.5304	219.5304	262.386	262.386
Story22	222.2452	222.2452	262.8268	262.8268

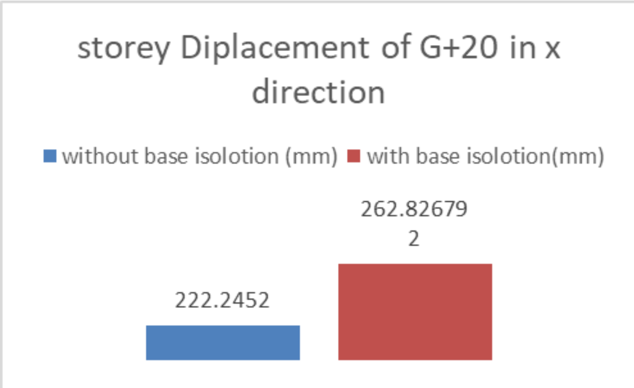


Fig 1: Story displacement of 20 stories in the x-direction

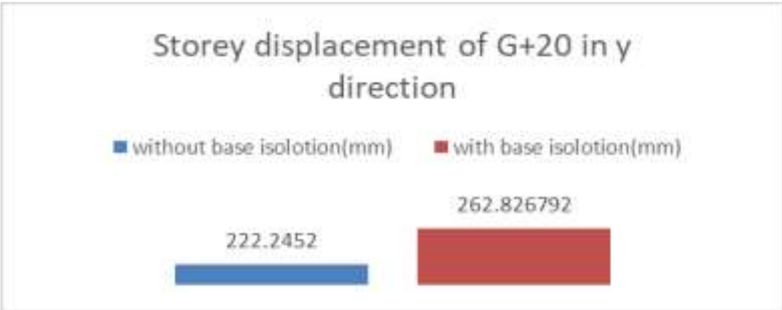


Fig 2: Story displacement of 20 stories in the y-direction

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 likely due to the increase in its lateral stiffness. The higher its lateral stiffness, the less damage it will sustain from lateral loads. The displacement in the present considered model should not exceed 264 mm.

Table 2 Story drifts of G+20 normal building

Story drifts				
	without base isolation		with base isolation	
Story	**X-Dir**	**Y-Dir**	**X-Dir**	**Y-Dir**
	mm	mm	mm	mm
Base	0	0		
Story1	0.0020241	0.002024	0.007377	0.007377
Story2	0.00462923	0.004629	0.007044	0.007044
Story3	0.0058408	0.005841	0.006197	0.006197
Story4	0.00615963	0.00616	0.005451	0.005451
Story5	0.00589293	0.005893	0.004806	0.004806
Story6	0.0053637	0.005364	0.004271	0.004271
Story7	0.00477963	0.00478	0.00386	0.00386
Story8	0.00439627	0.004396	0.003544	0.003544
Story9	0.00447457	0.004475	0.003321	0.003321
Story10	0.005078	0.005078	0.003169	0.003169
Story11	0.00571437	0.005714	0.003064	0.003064
Story12	0.00580017	0.0058	0.003076	0.003076
Story13	0.00479223	0.004792	0.002848	0.002848

Story14	0.00360173	0.003602	0.002583	0.002583
Story15	0.00239863	0.002399	0.002202	0.002202
Story16	0.0008973	0.000897	0.001798	0.001798
Story17	0.0003236	0.000324	0.001342	0.001342
Story18	0.00011667	0.000117	0.000924	0.000924
Story19	0.00019027	0.00019	0.000586	0.000586
Story20	0.00023477	0.000235	0.000327	0.000327
Story21	0.0004682	0.000468	0.000203	0.000203
Story22	0.00090493	0.000905	0.000147	0.000147

It is the relative displacement between the floor and roof in the building considered. As per IS1893:2016, the Storey drift should not exceed 0.004 times the Storey height. Higher the lateral stiffness, the less likely the damage will be. The Storey drift should be checked in accordance with clause 7.11.1 by the serviceability combination of loading, i.e., the load should be multiplied by 1.0. For the dynamic analysis, the estimated shell should not be less than the design base shear. It can be observed from the results shown below that the limit for Storey drift is 0.004x3000mm, which equals 12mm. Furthermore, all of the structures are within the permitted limits

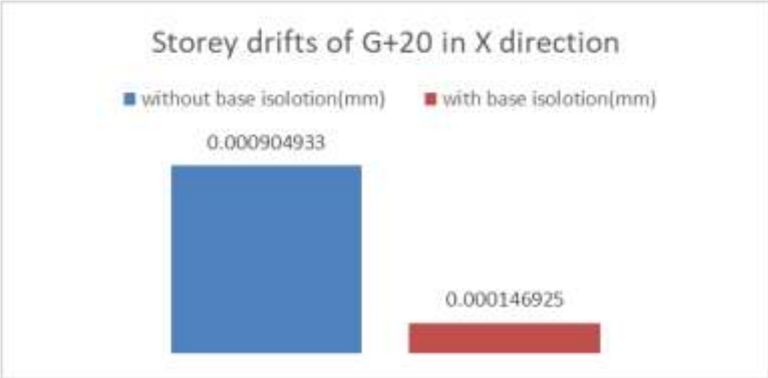


Fig 3: story drifts of 20 stories in an x-direction

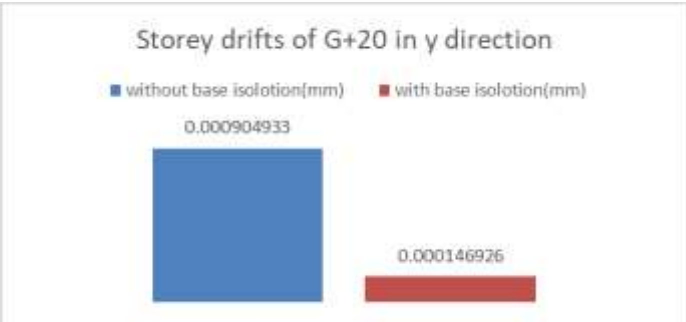


Fig 4: story drifts of 20 stories in the y-direction

Table 3: Time period of G+20(normal building)

Time period	
Without base isolation	With base isolation
3.18086	3.927614
3.18086	3.927614
2.800267	3.461947
1.049247	1.285363
1.049247	1.285363
0.948313	1.157791
0.584582	0.704828
0.584582	0.704828
0.53083	0.638036
0.389394	0.461996
0.389394	0.461996
0.355157	0.422037

Due to the movement of tectonic plates beneath the surface of the earth there are massive waves generated due to the sliding of plates which are known as seismic waves these seismic waves collaborate together and reach the surface of the earth and give a massive vibration in their duration of occurrence this makes the earth tremble, the foot of the structure vibrates with the earth and the structure oscillates back and forth, the time taken by the structure for each complete cycle of oscillation is the same, and it is called fundamental natural period T of the building. The lesser the time period, the more rigid will be the structure

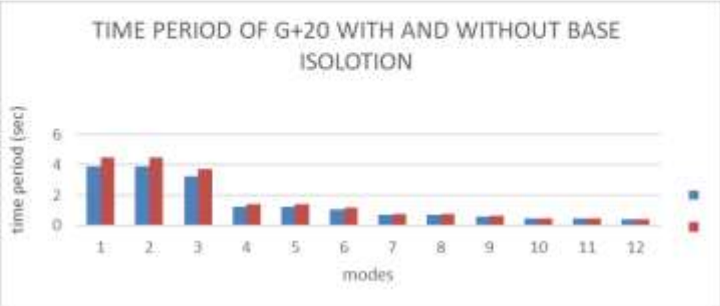


Fig 5: Time period of 20 stories

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

Table 4 Story displacement of G+20 (L-type building)

Story displacement				
without base isolation (mm)		with base isolation (mm)		
Story	**X-Dir**	**Y-Dir**	**X-Dir**	**Y-Dir**
	mm	mm	mm	mm
Base	0	0	53.39953	53.39953
Story1	5.836475	5.836475	76.24568	76.24568
Story2	19.26775	19.26775	97.17793	97.17793
Story3	36.27754	36.27754	115.7131	115.7131
Story4	54.24829	54.24829	132.1166	132.1166
Story5	71.51833	71.51833	146.7057	146.7057
Story6	87.25399	87.25399	159.7964	159.7964
Story7	101.3732	101.3732	171.6812	171.6812
Story8	114.6385	114.6385	182.6693	182.6693
Story9	128.59	128.59	193.0559	193.0559
Story10	144.8539	144.8539	202.9968	202.9968
Story11	163.0514	163.0514	212.6208	212.6208
Story12	181.3334	181.3334	222.2774	222.2774
Story13	196.3666	196.3666	231.2832	231.2832
Story14	207.5032	207.5032	239.4086	239.4086
Story15	214.734	214.734	246.5059	246.5059
Story16	216.2684	216.2684	252.3112	252.3112
Story17	216.9173	216.9173	256.7325	256.7325
Story18	218.094	218.094	259.9121	259.9121
Story19	218.4501	218.4501	261.9723	261.9723
Story20	218.4773	218.4773	263.2449	263.2449
Story21	219.4076	219.4076	264.0827	264.0827
Story22	220.9562	220.9562	264.7688	264.7688

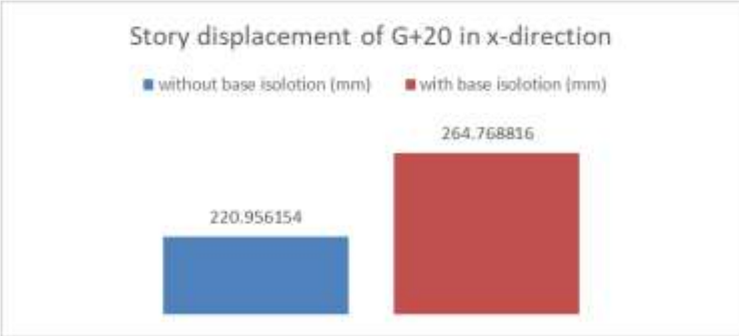


Fig 6: story displacements of 20 stories in the x-direction

Fig 7: story displacements of 20 stories in the y-direction

As per the observation from the above Figures 5.6 and 5.7, 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.

Table 5 Story drifts of G+20 (L-type building)

Story drifts				
	without base isolation (mm)		with base isolation (mm)	
Story	**X-Dir**	**Y-Dir**	**X-Dir**	**Y-Dir**
Base				
Story1	0.001945492	0.001945	0.007615382	0.007615384
Story2	0.004477091	0.004477	0.006977416	0.006977416
Story3	0.005669929	0.00567	0.006178399	0.006178399
Story4	0.00599025	0.00599	0.005467839	0.005467839
Story5	0.005756681	0.005757	0.004863025	0.004863025
Story6	0.005245219	0.005245	0.004363573	0.004363573
Story7	0.004706394	0.004706	0.003961584	0.003961584
Story8	0.004421761	0.004422	0.0036627	0.0036627
Story9	0.00465052	0.004651	0.003462196	0.003462196
Story10	0.005421309	0.005421	0.00331364	0.00331364
Story11	0.006065829	0.006066	0.003207995	0.003207996
Story12	0.006094007	0.006094	0.003218884	0.003218883
Story13	0.005011066	0.005011	0.003001932	0.003001932
Story14	0.003712176	0.003712	0.002708444	0.002708444
Story15	0.002410276	0.00241	0.002365766	0.002365766
Story16	0.000511484	0.000511	0.001935115	0.001935115
Story17	0.000216291	0.000216	0.001473752	0.001473753
Story18	0.000392236	0.000392	0.001059869	0.001059869
Story19	0.000118693	0.000119	0.000686752	0.000686752
Story20	9.05233E-06	9.05E-06	0.000424198	0.000424198
Story21	0.000310119	0.00031	0.000279268	0.000279268
Story22	0.000516177	0.000516	0.000228698	0.000228699

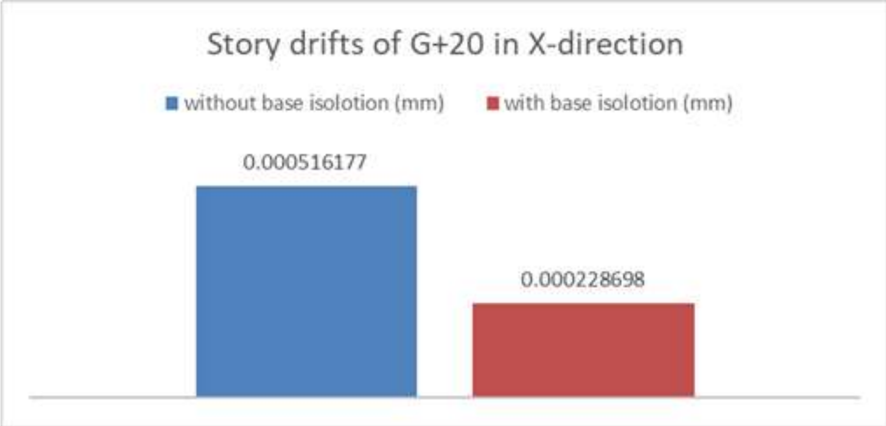


Fig 8: Story drifts of 20 stories in an x-direction

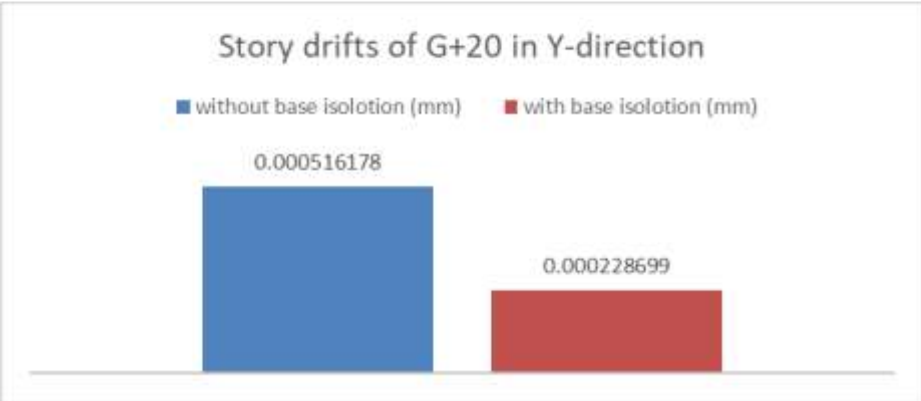


Fig 9: story drifts of 20 stories in the y-direction

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.

Table 6: Time period of G+20(L-type building)

TIME PERIOD	
without isolation	with isolation
3.183758	3.911327
3.178184	3.906339
2.817588	3.46181
1.046978	1.281574
1.046129	1.278769
0.954336	1.16406
0.579444	0.69853
0.57931	0.698411
0.53058	0.63737
0.384533	0.456468
0.384528	0.456396
0.353795	0.420696

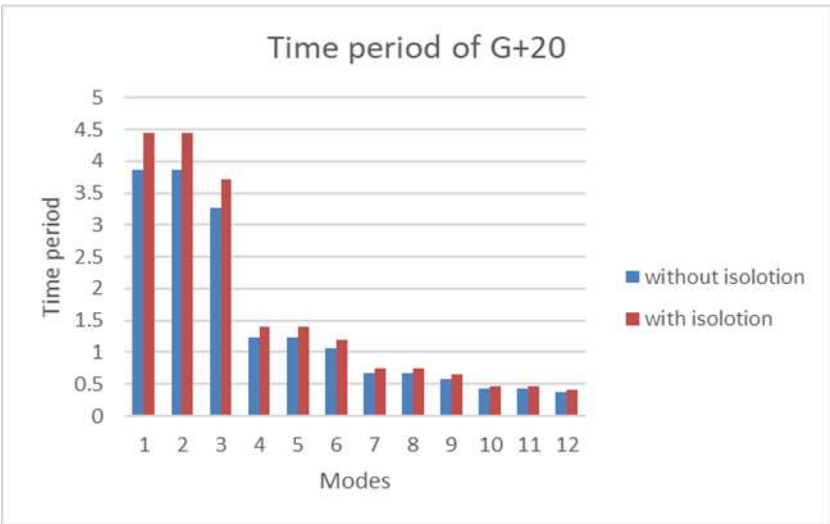


Fig 10: Time period of 20 stories (L-type building)

In Figure it can be observed that the structure without base isolation is having the least time period of 3.18 sec of all models while the base isolation model is having a time period of 3.9 sec which is the highest of all.

4.3 Base Isolation Of Fifteen-Storey Symmetric Building

Table 7 Story displacement of G+15 normal building

STORY DISPLACEMENT				
	without base isolation		with base isolation	
Story	**X-DIR**	**Y-DIR**	**X-DIR**	**X-DIR**
	mm	mm	mm	mm
Base	0	0	0.062626	0.062626
Story1	5.522972	5.522971	25.41924	25.41924
Story2	18.24677	18.24677	48.04177	48.04177
Story3	34.47441	34.47441	68.41054	68.41054
Story4	51.80244	51.80244	86.62678	86.62678
Story5	68.68916	68.68916	102.6119	102.6119
Story6	84.11948	84.11948	116.3703	116.3703
Story7	97.40833	97.40833	127.7795	127.7795
Story8	108.295	108.295	136.9321	136.9321
Story9	116.6546	116.6546	144.0433	144.0433
Story10	122.6573	122.6573	149.447	149.447
Story11	126.7811	126.7811	153.6717	153.6717
Story12	128.8901	128.8901	156.8992	156.8992
Story13	129.8772	129.8772	159.3115	159.3115
Story14	132.4404	132.4404	161.5545	161.5545
Story15	136.5043	136.5043	163.8375	163.8375
Story16	140.1811	140.1811	165.9559	165.9559
Story17	142.8979	142.8979	167.6701	167.6701

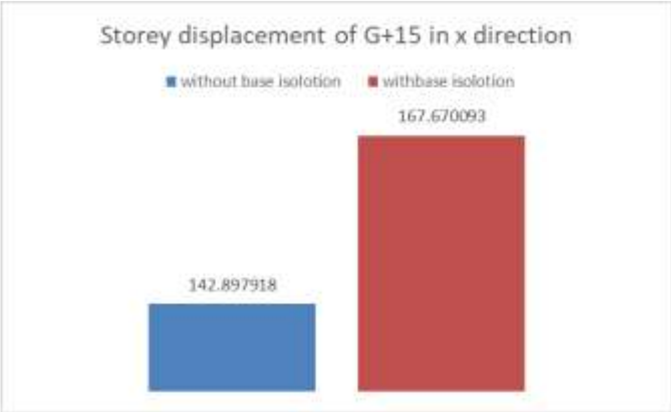


Fig 11: Story displacements of 15 stories in the x-direction

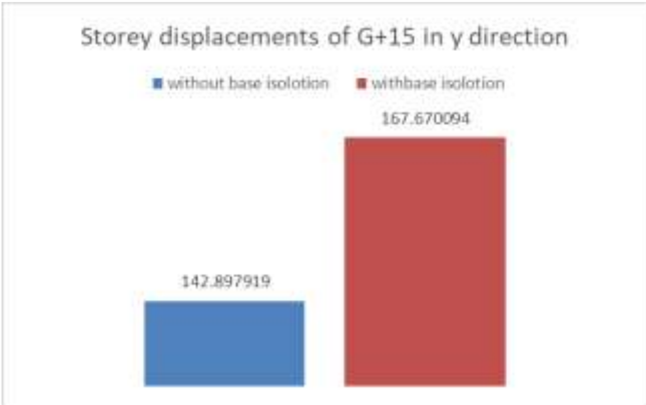


Fig 12: Story displacement of 15 stories in the y-direction

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.

Table 8 Story drifts of G+15 normal building

Story drifts				
	without base isolation		**with base isolation**	
Story	**X-Dir**	**Y-Dir**	**X-Dir**	**Y-Dir**
Base	0	0	0.05589003	0.05589
Story1	0.0476326	0.047633	0.0558714	0.055871
Story2	0.0476168	0.047617	0.05587141	0.055871
Story3	0.0476168	0.047617	0.05587141	0.055871
Story4	0.0476168	0.047617	0.05587141	0.055871
Story5	0.0476168	0.047617	0.05587141	0.055871
Story6	0.0476168	0.047617	0.05587141	0.055871
Story7	0.0476168	0.047617	0.05587141	0.055871
Story8	0.0476168	0.047617	0.05587141	0.055871
Story9	0.0476168	0.047617	0.05587141	0.055871
Story10	0.0476168	0.047617	0.05587141	0.055871
Story11	0.0476168	0.047617	0.05587141	0.055871
Story12	0.0476168	0.047617	0.05587141	0.055871
Story13	0.0476168	0.047617	0.05587141	0.055871
Story14	0.0476168	0.047617	0.05587141	0.055871
Story15	0.0476168	0.047617	0.05587141	0.055871

Story16	0.0476168	0.047617	0.05587141	0.055871
Story17	0.0476168	0.047617	0.05587141	0.055871

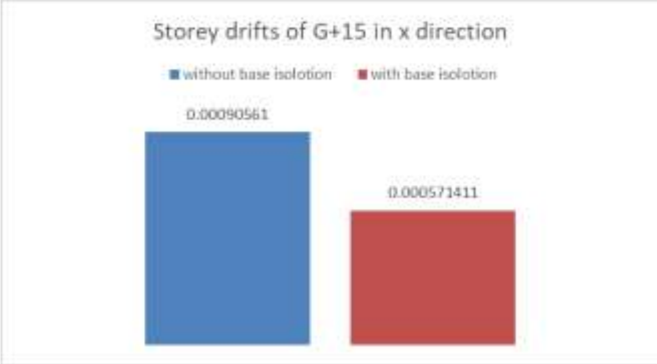


Fig 13: Story drifts of 15 stories in an x-direction

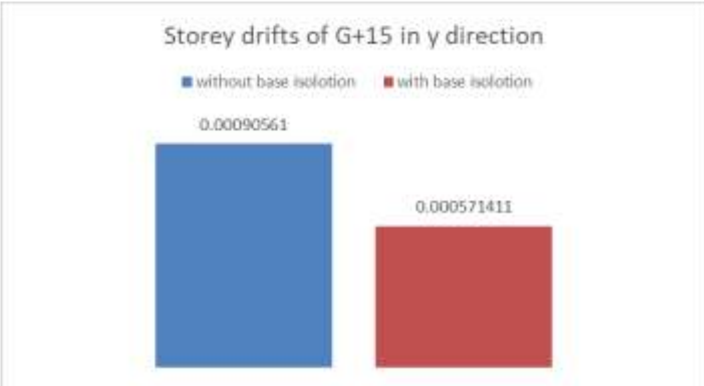


Fig 14: Story drifts of 15 stories in the y-direction

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.

Table 9: Time period of G+15 normal building

Time period	
Without base isolation	With base isolation
2.391483	2.767565
2.391483	2.767565
2.110158	2.418773
0.763385	0.869041
0.763385	0.869041
0.691914	0.779223
0.417391	0.464434
0.417391	0.464434
0.379352	0.420647
0.263791	0.290818
0.263791	0.290818
0.240775	0.264331

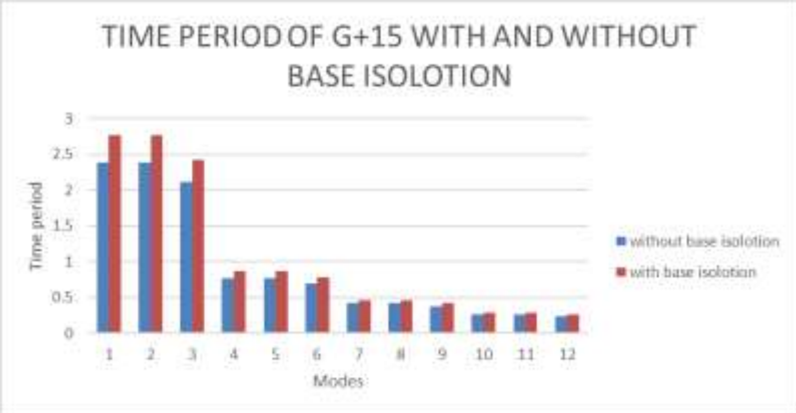


Fig 15: Time period of 15 stories

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

Table 10: Story displacements of G+15(L-type building)

Story displacement				
without base isolation		with base isolation		
Story	X-Dir	Y-Dir	X-Dir	Y-Dir
	mm	mm	mm	mm
Base	0	0	99.86347	106.3026
Story1	5.385763	5.385763	117.6011	123.7657
Story2	17.86672	17.86672	133.0725	138.9259
Story3	33.85386	33.85386	146.5765	152.101
Story4	50.97129	50.97129	158.5239	163.7002
Story5	67.63344	67.63344	169.4793	174.2786
Story6	82.86073	82.86073	179.9374	184.3144
Story7	95.94977	95.94977	190.0632	194.018
Story8	106.5858	106.5858	199.4836	203.1468
Story9	114.7614	114.7614	207.8552	211.3898
Story10	120.7233	120.7233	215.2607	218.7471
Story11	124.8858	124.8858	222.0215	225.5043
Story12	127.3113	127.3113	228.3782	231.8614
Story13	129.119	129.119	234.0406	237.5432
Story14	132.6393	132.6393	239.1544	242.6726
Story15	137.0602	137.0602	243.4999	247.0938
Story16	140.8707	140.8707	246.979	250.6147
Story17	143.7531	143.7531	249.6008	253.2255

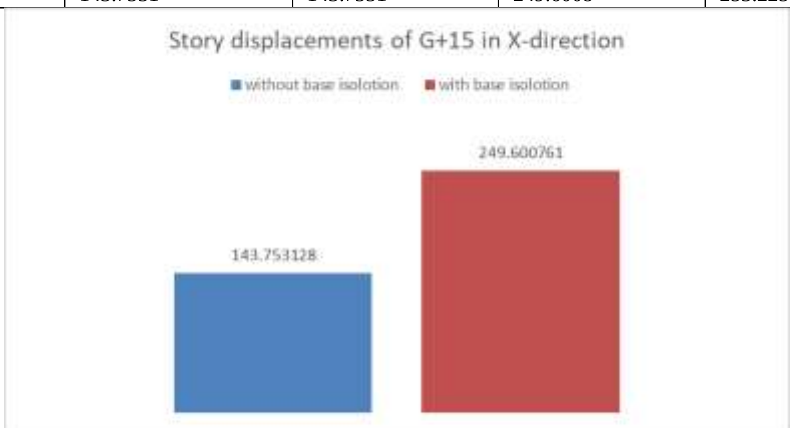
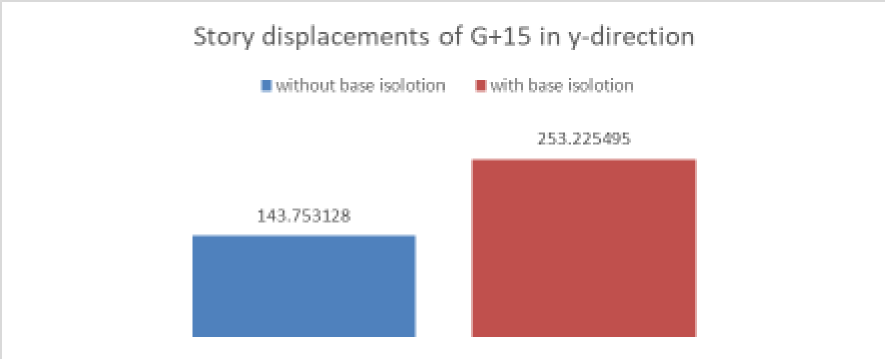


Fig 16: Story displacements of 15 stores in the x-direction



`Fig 17: Story 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.

Table 5.11 Story drifts of G+15 (L-type building)

Story drifts				
without base isolation		with base isolation		
Story	**X-Dir**	**Y-Dir**	**X-Dir**	**Y-Dir**
	mm	mm	mm	mm
Base	0	0	0.08320025	0.0832
Story1	0.04791771	0.047918	0.08317252	0.083173
Story2	0.04790174	0.047902	0.08317253	0.083173
Story3	0.04790174	0.047902	0.08317253	0.083173
Story4	0.04790174	0.047902	0.08317253	0.083173
Story5	0.04790174	0.047902	0.08317253	0.083173
Story6	0.04790174	0.047902	0.08317253	0.083173
Story7	0.04790174	0.047902	0.08317253	0.083173
Story8	0.04790174	0.047902	0.08317253	0.083173
Story9	0.04790174	0.047902	0.08317253	0.083173
Story10	0.04790174	0.047902	0.08317253	0.083173
Story11	0.04790174	0.047902	0.08317253	0.083173
Story12	0.04790174	0.047902	0.08317253	0.083173
Story13	0.04790174	0.047902	0.08317253	0.083173
Story14	0.04790174	0.047902	0.08317253	0.083173
Story15	0.04790174	0.047902	0.08317253	0.083173
Story16	0.04790174	0.047902	0.08317253	0.083173
Story17	0.04790174	0.047902	0.08317253	0.083173

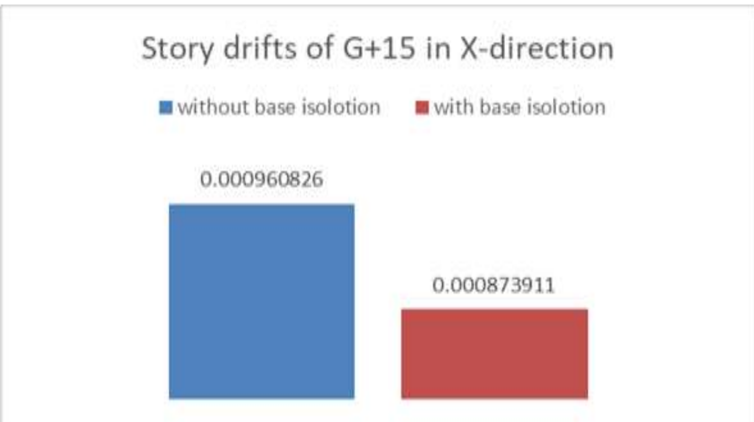


Fig 18: Story drifts of 15 stores in the x-direction

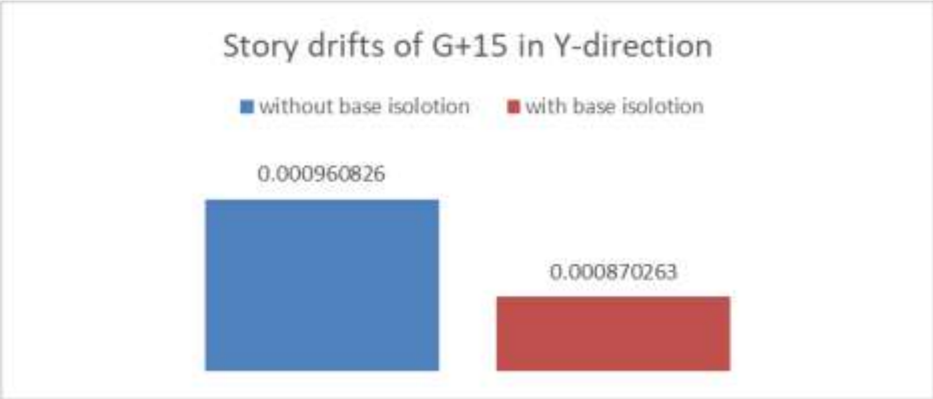


Fig 19: Story drifts of 15 stores in the y-direction

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.

Table 5.12: Time period of G+15(L-type building)

TIME PERIOD	
without base isolation	with base isolation
2.385608	3.543345
2.38437	3.533207
2.114613	3.13063
0.758076	1.063873
0.757926	1.060667
0.692858	0.956536
0.412348	0.551761
0.412268	0.551231
0.377676	0.504181
0.259212	0.345682
0.259146	0.345504
0.238477	0.315403

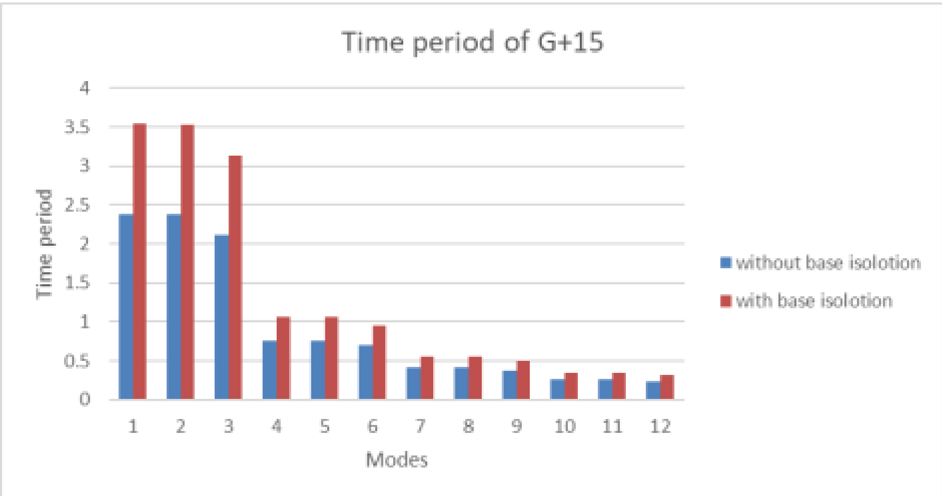


Fig 20: Time period of 15 stories

4.5 Base Isolation Of Ten-Storey Symmetric Building

Table 13 Story displacement of G+10 normal building

Story displacement				
	without base isolation		with base isolation	
Story	X-Dir	Y-Dir	X-Dir	Y-Dir
	mm	mm	mm	mm
Base	0	0	146.1468	146.1134
Story1	5.106221	5.106221	125.0761	125.0097
Story2	15.85074	15.85074	161.8308	161.8216
Story3	28.4538	28.4538	173.5882	173.5971
Story4	40.87367	40.87367	182.8047	182.8275
Story5	52.01887	52.01887	190.7085	190.738
Story6	61.27054	61.27054	198.1021	198.1419
Story7	68.21516	68.21516	206.8271	206.8833
Story8	71.9175	71.9175	214.854	214.924
Story9	83.09279	83.09279	221.2995	221.3797
Story10	91.54742	91.54742	225.545	225.6314
Story11	97.3276	97.32759	227.7423	227.8316
Story12	100.6772	100.6772	228.667	228.7574

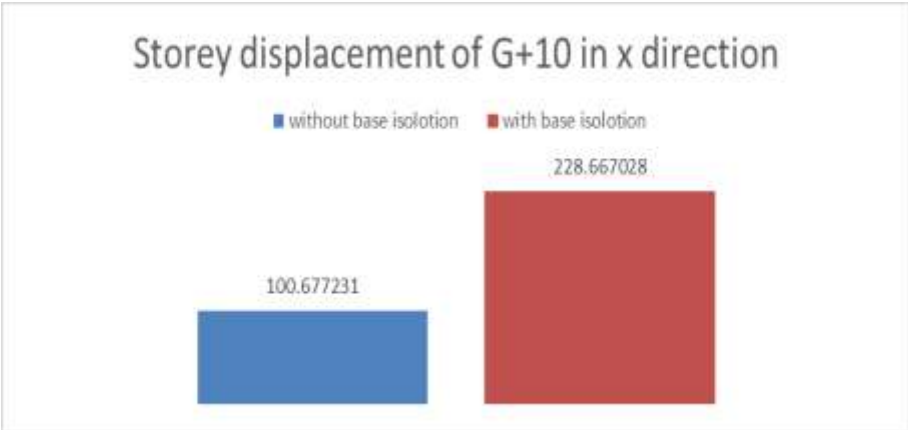


Fig 21: Story displacements of 10 stores in the x-direction

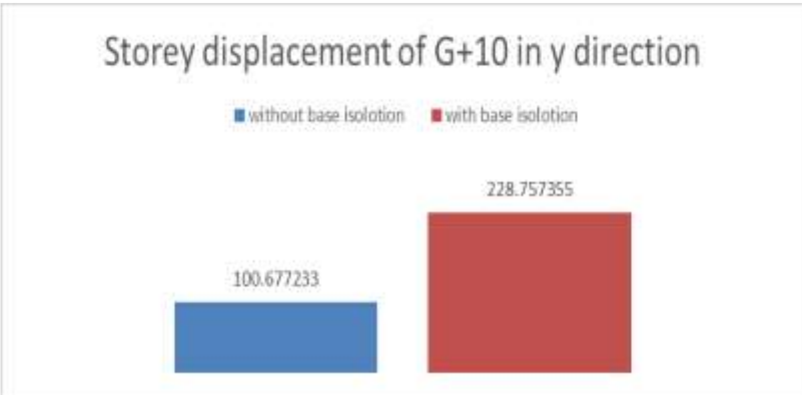


Fig 22: Story displacements of 10 stores in the y-direction

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 56.6% and 56.66% compared to the normal structure.

Table 14 Story drifts of G+10 normal building

Story drifts				
	without base isolation		**with base isolation**	
Story	**X-Dir**	**Y-Dir**	**X-Dir**	**Y-Dir**
	mm	mm	mm	mm
Base	0	0	0.07622234	0.076222
Story1	0.03355908	0.033559	0.07619694	0.076197
Story2	0.03354789	0.033548	0.07619694	0.076197
Story3	0.03354789	0.033548	0.07619694	0.076197
Story4	0.03354789	0.033548	0.07619694	0.076197
Story5	0.03354789	0.033548	0.07619694	0.076197
Story6	0.03354789	0.033548	0.07619694	0.076197
Story7	0.03354789	0.033548	0.07619694	0.076197
Story8	0.03354789	0.033548	0.07619694	0.076197
Story9	0.03354789	0.033548	0.07619694	0.076197
Story10	0.03354789	0.033548	0.07619694	0.076197
Story11	0.03354789	0.033548	0.07619694	0.076197
Story12	0.03354789	0.033548	0.07619694	0.076197

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

Fig 24: Story 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.

Table 15: Time period of G+10 normal building

Time period	
without base isolation	with base isolation
1.963603	3.160512
1.963603	3.140869
1.812294	2.829672
0.663834	0.937091
0.663834	0.935898
0.617396	0.863096
0.369318	0.481925
0.369318	0.481743
0.342976	0.446929
0.246453	0.309649
0.246453	0.30961
0.228246	0.287464

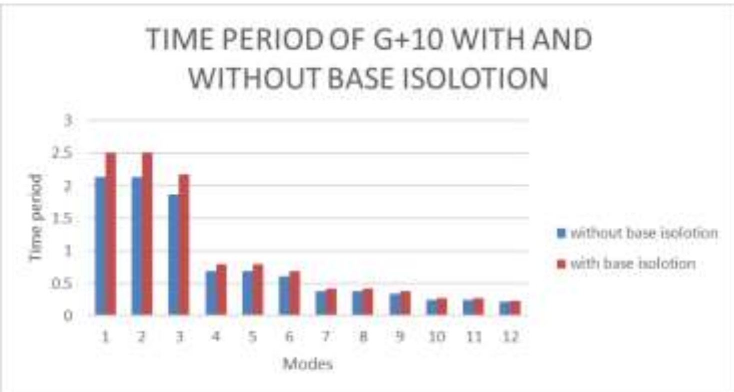


Fig 25: Time period of 10 stories

it can be observed that the structure without base isolation is having the least time period of 1.96 sec of all models while the base isolation model is having a time period of 3.16 sec which is the highest of all.

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

Table 16: Story displacement of G+10 (L-type building)

Story displacement				
	without base isolation		with base isolation	
Story	X-Dir	Y-Dir	X-Dir	Y-Dir
	mm	mm	mm	mm
Base	0	0	1116.207	6005.214
Story1	5.046147	5.046147	19.25285	19.25285
Story2	15.75398	15.75398	2225.913	12014.52
Story3	28.37467	28.37467	3335.387	18024.19
Story4	40.90615	40.90615	4444.615	24034.17
Story5	52.09563	52.09563	5553.489	30044.35
Story6	61.49455	61.49455	6661.926	36054.64
Story7	68.28719	68.28719	7769.61	42065
Story8	69.51222	69.51222	8876.01	48075.22
Story9	78.90578	78.90578	9981.45	54085.26
Story10	87.48729	87.48729	11086.42	60095.17
Story11	93.4847	93.4847	12191.53	66105.05
Story12	97.04653	97.04653	13297.29	72115

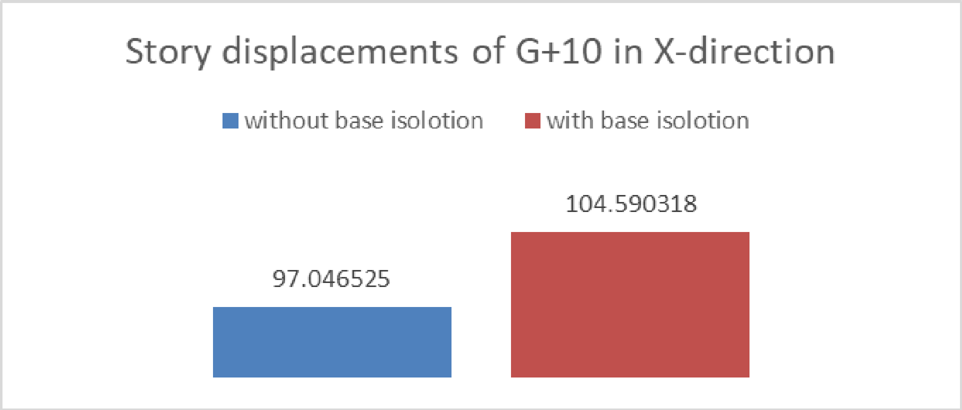


Fig 26: Story displacements of 10 stores in the x-direction

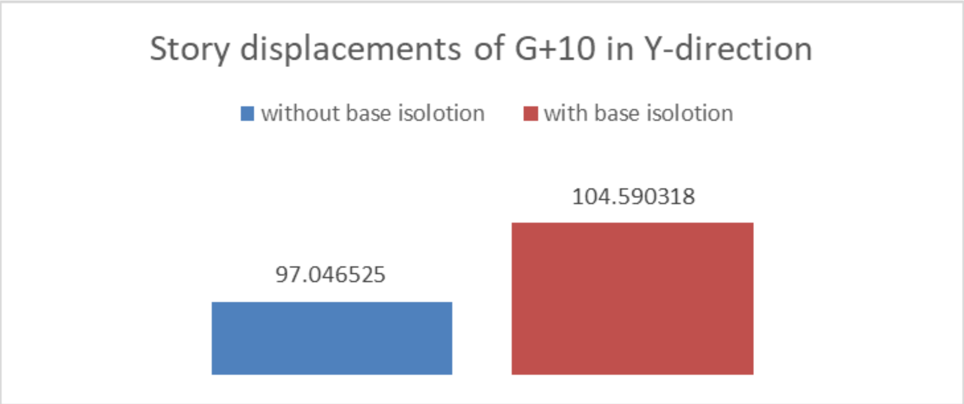


Fig 27: Story displacements of 10 stores in the y-direction

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 16.6% and 16.66% compared to the normal structure.

Table 17: Story drifts of G+10 L-type building

Story drifts				
	without base isolation		with base isolation	
Story	X-Dir	Y-Dir	X-Dir	Y-Dir
			mm	mm
Base	0	0	4.4324294	4.432429
Story1	0.03234884	0.032349	4.430952	4.430952
Story2	0.03233806	0.032338	4.4309525	4.430952
Story3	0.03233806	0.032338	4.4309525	4.430952
Story4	0.03233806	0.032338	4.4309525	4.430952
Story5	0.03233806	0.032338	4.4309525	4.430952
Story6	0.03233806	0.032338	4.4309525	4.430952
Story7	0.03233806	0.032338	4.4309525	4.430952
Story8	0.03233806	0.032338	4.4309525	4.430952
Story9	0.03233806	0.032338	4.4309525	4.430952
Story10	0.03233806	0.032338	4.4309525	4.430952
Story11	0.03233806	0.032338	4.4309525	4.430952
Story12	0.03233806	0.032338	4.4309525	4.430952

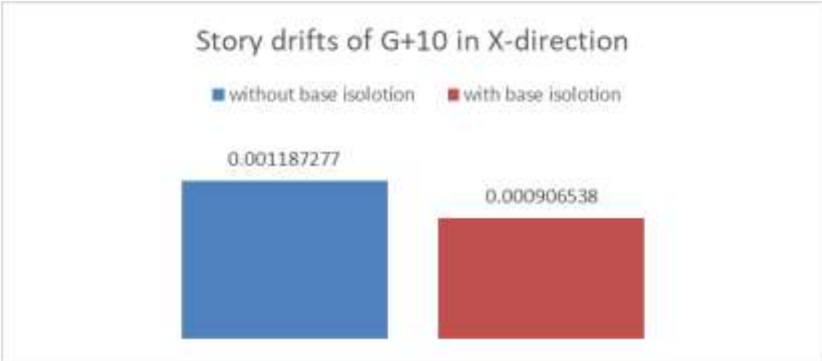


Fig 28: Story drifts of 10 stores in the x-direction

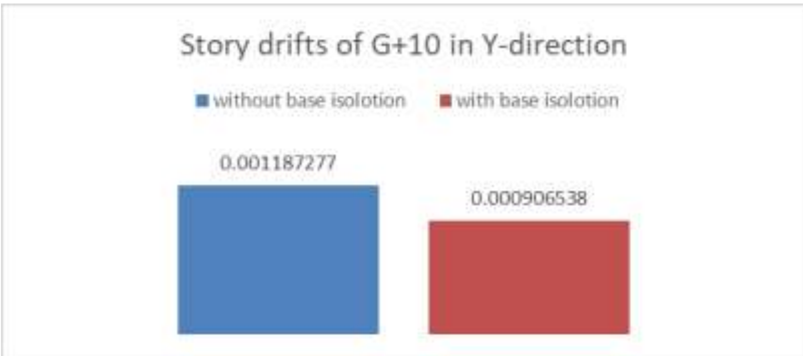


Figure 29: Story drifts of 10 stores in the y-direction

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.

Table 18: Time period of G+10 (L-type building)

IME PERIOD	
Without base isolation	With base isolation
1.950539	2.722551
1.949303	2.722245

1.816254	2.514371
0.656573	0.869471
0.656392	0.868801
0.617196	0.814216
0.363463	0.459059
0.363434	0.458946
0.341024	0.430588
0.241889	0.297867
0.241872	0.297862
0.226186	0.279501

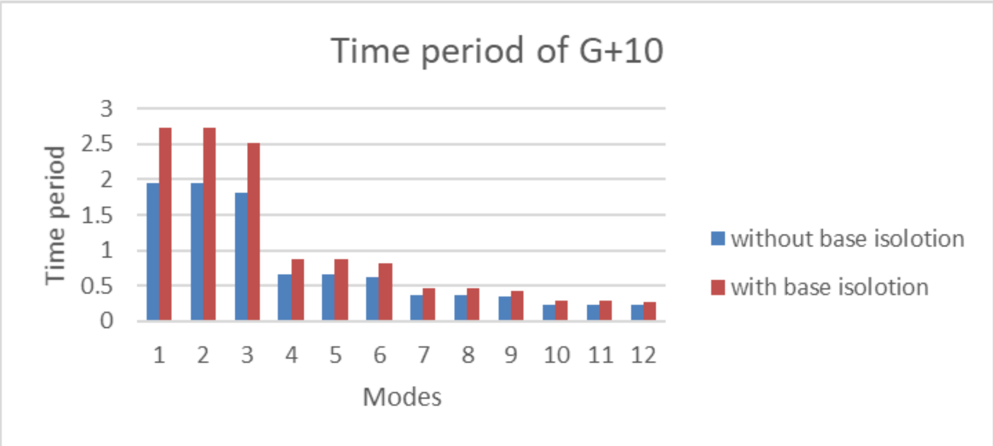


Fig 30: Time period of 10 stories

In Figure 5.30 .1 it can be observed that the structure without base isolation is having the least time period of 1.95 sec of all models while the base isolation model is having a time period of 2.72 sec which is the highest of all.

4.7 Base Isolation Of Five Storey Symmetric Building

Table 19: Story displacement of G+5 normal building

Story displacement of G+5 normal building				
	without base isolation		**with base isolation**	
Story	**X-Dir**	**Y-Dir**	**X-Dir**	**Y-Dir**
	mm	mm	mm	mm
Base	0	0	0.236	0.236
Story1	6.647	6.647	23.572	23.572
Story2	19.689	19.689	41.229	41.229
Story3	33.597	33.597	56.109	56.109
Story4	45.536	45.536	68.614	68.614
Story5	55.855	55.855	79.701	79.701
Story6	63.994	63.994	88.523	88.523
Story7	70.69	70.69	94.633	94.633

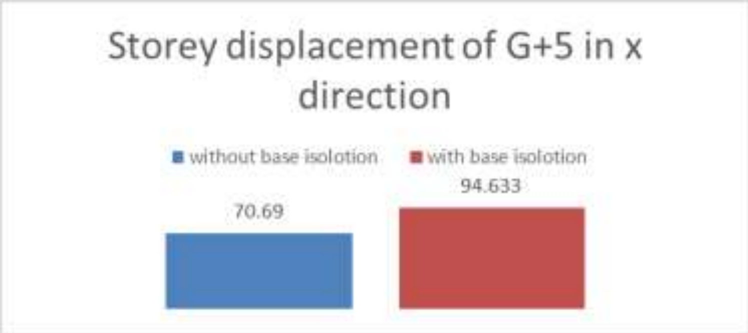


Fig 31: Story displacements of 5 stores in the x-direction

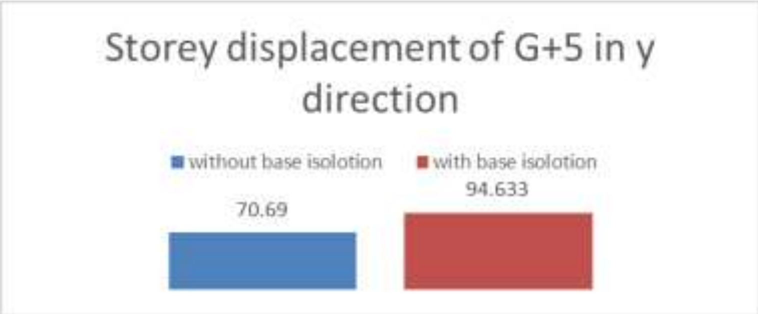


Fig 32: Story displacements of 5 stores in the y-direction

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 25.3.6% and 25.36% compared to the normal structure.

Table 20: Story drifts of G+5 normal building

Story drifts of G+5 (normal building)				
	without base isolation		with base isolation	
Story	X-Dir	Y-Dir	X-Dir	Y-Dir
Base	0	0	0	0
Story1	0.002216	0.002216	0.007779	0.007779
Story2	0.004347	0.004347	0.005942	0.005942
Story3	0.004636	0.004636	0.00501	0.00501
Story4	0.00428	0.00428	0.004469	0.004469
Story5	0.003891	0.003891	0.003896	0.003896
Story6	0.003232	0.003232	0.003074	0.003074
Story7	0.002343	0.002343	0.002147	0.002147

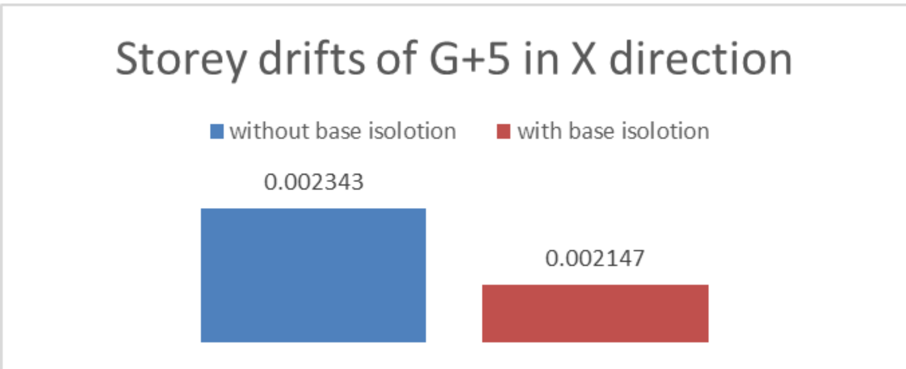


Fig 33: Story drifts of 5 stores in the x-direction

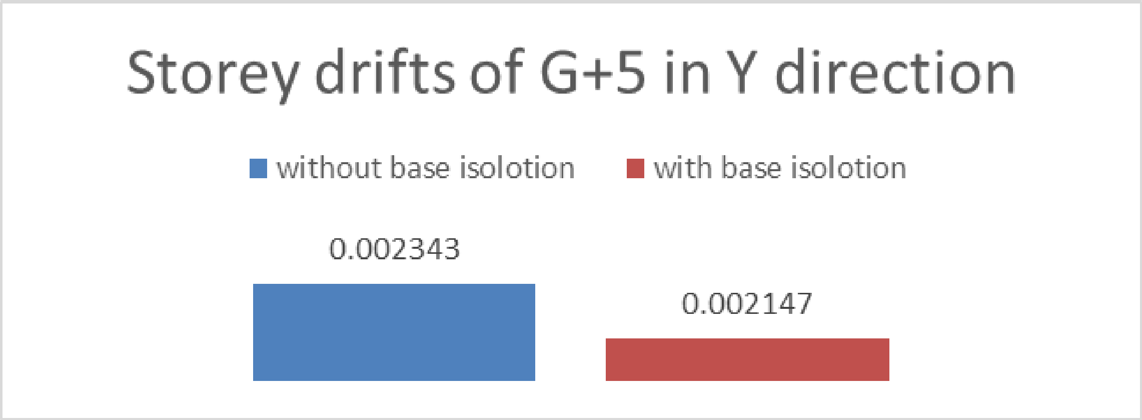


Fig 34: Story drifts of 5 stores in the x-direction

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.

Table 21: Time period of G+5 normal building

A time period of G+5 normal building	
Without base isolation	With base isolation
1.417	1.805
1.417	1.805
1.249	1.577
0.424	0.513
0.424	0.513
0.376	0.453
0.214	0.249
0.214	0.249
0.192	0.222
0.128	0.145
0.128	0.145
0.116	0.13

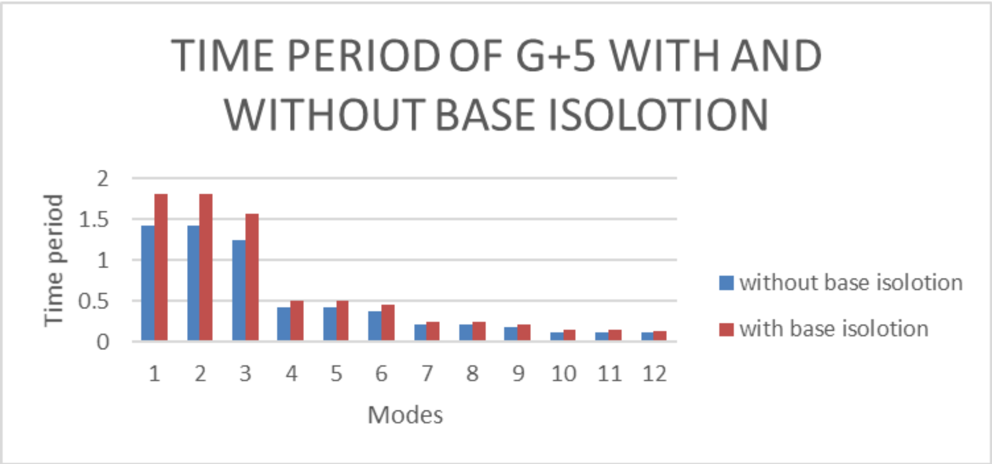


Fig 35: Time period of 5 stories

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

Table 5.22: Story displacement of G+5 L-type building

Story displacement of G+5 (L-type building)				
	without base isolation		with base isolation	
Location	X-Dir	Y-Dir	X-Dir	Y-Dir
	mm	mm	mm	mm
Top	0	0	0.027	0.027
Top	6.426	6.426	25.302	25.302
Top	18.964	18.964	44.572	44.572
Top	32.802	32.802	59.985	59.985
Top	45.199	45.199	73.442	73.442
Top	55.29	55.29	84.637	84.637
Top	63.684	63.684	94.399	94.399
Top	69.413	69.413	101.325	101.325

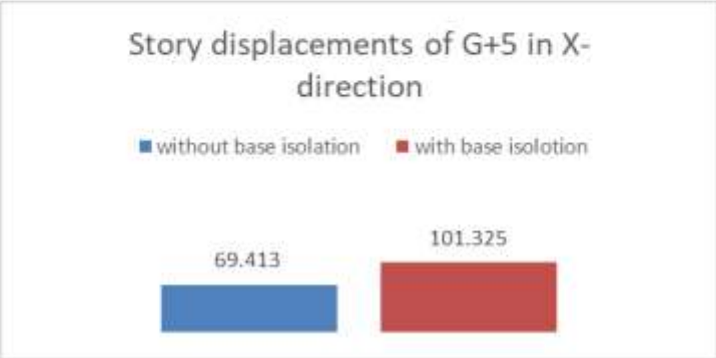


Fig 36: Story displacements of 5 stores in the x-direction

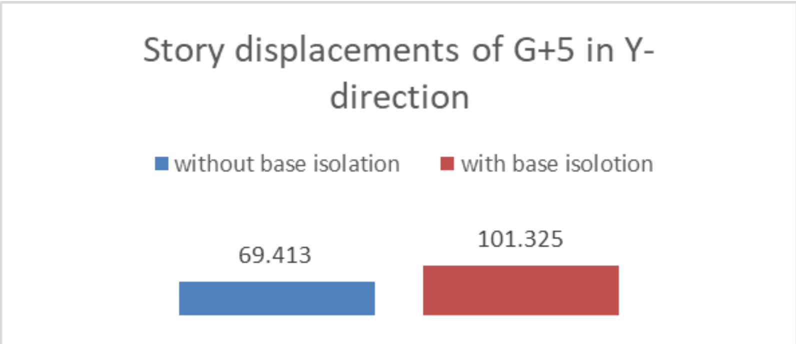


Fig 37: Story displacements of 5 stores in the y-direction

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 25.3.6% and 25.36% compared to the normal structure.

Table 23: Story displacement of G+5 L-type building

Story drifts of G+5 (L-type building)				
	without base isolation		with base isolation	
Story	X-Dir	Y-Dir	X-Dir	Y-Dir
Base	0	0	0	0
Story1	0.002216	0.002216	0.008425	0.008425
Story2	0.004347	0.004347	0.006423	0.006423
Story3	0.004636	0.004636	0.005407	0.005407
Story4	0.00428	0.00428	0.004823	0.004823

Story5	0.003891	0.003891	0.004163	0.004163
Story6	0.003232	0.003232	0.003307	0.003307
Story7	0.002343	0.002343	0.002358	0.002358

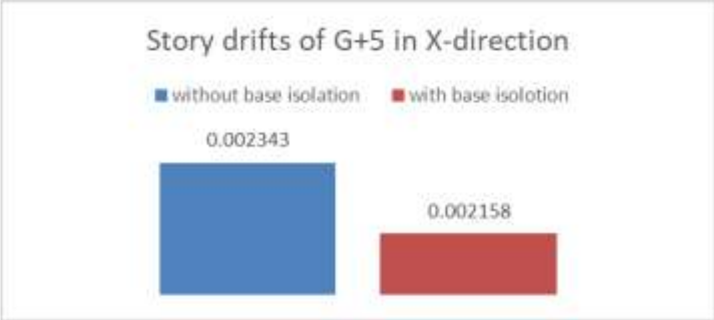


Fig 38: Story drifts of 5 stores in the x-direction

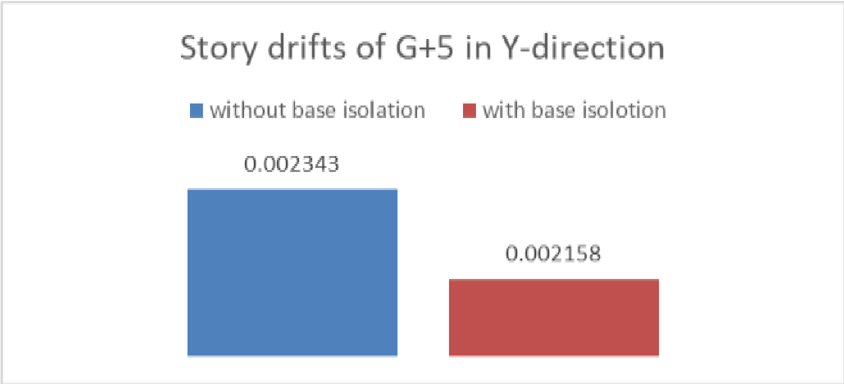


Fig 39: Story drifts of 5 stores in the y-direction

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.

Table 24: Time period of G+5 (L-type building)

A time period of G+5 (L-type building)	
Without base isolation	With base isolation
1.392	1.776
1.391	1.773
1.247	1.575
0.415	0.502
0.415	0.502
0.374	0.45
0.209	0.242
0.209	0.242
0.189	0.219
0.125	0.14
0.125	0.14
0.113	0.127

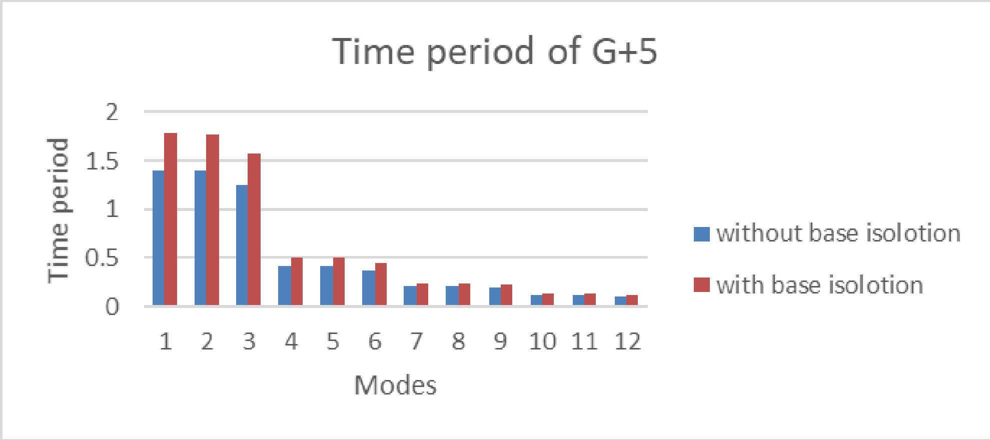


Fig 40: Time period of 5 stories

In Figure it can be observed that the structure without base isolation is having the least time period of 1.3 sec of all models while the base isolation model is having a time period of 1.7 sec which is the highest of all.

5. Conclusions

5.1 Summary

This dissertation investigates the comparison of low to high-rise buildings by considering 5, 10, 15 and 20 Storey buildings with and without base isolation for regular and irregular (L-Type) structures with a floor size of 24mX24m and typical Storey height of 3m, the first structural system i.e. L- Type RCC moment resisting frame. In the second structural system i.e. the normal system, Thus by investing response of the structure like Lateral displacement, Storey drift, and Time period. The seismic performance is studied using nonlinear dynamic analysis

It was found that comparing all the different structural systems, the base isolation system provides more effective than normal structure without base isolation, In terms of these parameters like lateral displacement, Storey drift, and time period.

5.2 Conclusions

1. Both the symmetric and asymmetric five-story structures had a reduction in their storey drifts of 25%, while the asymmetric buildings saw a reduction of 26.5%. Indicating that Low-Rise Buildings Can Benefit from Base Isolators (both symmetric as well as asymmetric). Twenty-story structures that used the isolation method saw a reduction in storey drifts of 16% for symmetric buildings and of 15%.98 for asymmetric buildings.

2. Based on the reduction in Base shear by 75% for symmetric Buildings and by 75% and 78% respectively in Base shear and Base torsion moment for asymmetric Buildings, it was determined that the Base Isolators are excellent seismic control devices for five-story buildings in controlling forced Responses such as base shear.

3. In general, the findings indicated that base isolators performed well as seismic control devices for low- to high-rise symmetric and asymmetric structures.

4. When designing against earthquakes, the base isolation technique has shown to be effective.

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. At the very least in seismic zones 4 and 5, base isolators should be actively promoted due to their high technical effectiveness and low financial burden. Base isolators mitigate earthquake-induced damage by stopping movement between floors. After some superficial maintenance, the building will be move-in ready.

6. There is less lateral deflection and fewer moment values in a base-isolated structure compared to a fixed base structure since the lateral displacement at the base is never zero.

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