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

Krishan Avatar Parashar[1], Mahendra Saini[2]
M. Tech Scholar[1], Assistant Professor[2], Regional Engineering College, Jaipur (Rajasthan)
Rajasthan Technical University (Kota)

ABSTRACT: - 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. Five- storey, ten- storey, fifteen storey, and twenty-storey structures are analysed here. In this study I have taken two models of normal shape (symmetric) and L-shape (asymmetric) with and without base isolators in 5 storey, 10 storey, 15 storey and 20 storey. I have analysed the comparison of base isolater with displacement of different storey. Space frames made of reinforced concrete that can withstand a tremor or earthquake thanks to a non-linear analysis of past events. Using the ETABS version 20 nonlinear version software (CSI Ltd) analytical engine, the building is assessed in compliance with seismic code IS-1893:2016.

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

1. INTRODUCTION

All natural disasters are unpredictable and devastating, but earthquakes are the hardest to prevent. Because of this, we need to create new analytic methods for determining how well buildings can withstand earthquakes. In the event of a moderate tremor, precautions are taken to make buildings safe in the event of a big quake. Attempt to save as much life as you can. Multiple international frameworks exist, each of which is regularly revised to reflect new developments in the field. According to the importance and cost of the structure, there are a lot of linear and nonlinear analysis methods. Building behavior is influenced by a variety of factors, like lateral strength, ductility, and regular configurations. Structures having standard geometry & equally distributed mass & rigidity are significantly simpler to repair than those with more complicated shapes. As the population grows, architects and engineers are forced to plan irregular configurations based on the needs of the latest generation. As a result, earthquake engineering has become a big deal.

1.1 IMPORTANCE OF SEISMIC ANALYSIS

It is essential to predict how a structure will respond to a specific load when designing a structure. Based on the codes and previous experiences, we have an in-depth understanding of the various load types & their intensities, as well as how they interact with various building types and site circumstances. Engineers choose study method based on the accuracy of the work required.

1.2 SEISMIC CONTROL

There are a number of simple techniques that may be utilized to lessen the effects of earthquakes and wind loads on buildings. Changes in rigidity, mass, damping, or form, in addition to the application of active or passive counterforces, all fall under this category of ideas. As of yet, a number of different techniques for controlling the structure have been implemented effectively. There are a number of suggested approaches that have the potential to increase productivity and the usefulness of existing apps.

2. LITERATURE REVIEW

Mohd Imran et. al. (2019) In this paper, a parametric study is performed on multi-storeyed building with and without outrigger systems, located in seismic zone IV. It is intended to describe the performance characteristics such as lateral displacement, time period, base shear etc. The study is carried out on a building with the help of different mathematical models considering shear walls and braces as outrigger systems at different locations for improving the seismic performance of the building without any outrigger system. Analytical models represent all existing components that influence the mass, strength, stiffness and deformability of structure. In this research, the response spectrum analysis is carried out on all the mathematical 3D model using the software ETABS 2015 and the comparisons of these models are presented. Finally, the optimum location of outrigger system is suggested.

Shahid ul Islam, Rajesh goal, Pooja Sharma (2018) In this research they studied combined performance of shear wall and RC-bracing system and also the effects of their relative position in high rise building (G+10). The aim of this study is comparison of performance of shear wall & Bracing system in high rise building under the lateral loading. Seismic parameters are taken in to consideration base shear and storey displacement.

Manjeet Dua (2018) Performed an analyse on a (G+15) storey building frame in Seismic zone-II using ETABS and compared the displacements observed in model once with shear wall and again without shear wall at different locations. It was observed that the best location of shear wall in multi storey building is near the core of the building. By providing shear wall, the structural seismic behaviour will be affected to a great extent and hence the strength and stiffness of building will be increased.

A. Ravi Kumar et. al. (2017) Conducted a thorough study for determining the solution for shear wall location in multi storey building based on its elastic and elasto- plastic behaviours. They analysed a 10 storey building, 40m in height for earthquake load using ETABS software. He decided that shear walls are one of the most successful building elements in resisting lateral forces during earthquake and for a developing nation like India. Shear wall construction is considered to be a foundation for construction industry.

Fasil Mohi Ud din (2017) In this paper the response structural analysis is carried out on G+10 high steel building with X bracing system. In this paper analyse using Etabs Natural frequency, fundamental time period, mode shape, and peak storey are calculated. This Paper is also discussed about efficiency and effectiveness with use bracing and with different steel profiles for bracing member for multi-storey steel frames.

3. METHODOLOGY

3.1 GENERAL

The NLTHA uses dynamic inelastic analysis to predict how well a structure will hold up under a variety of earthquake scenarios by assessing its deformation and strength needs for design earthquakes and then comparing those numbers to those of similar structures that have already been retrofitted with base isolators & tuned mass dampers.

3.2 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 thorough analysis & refined models take longer & are therefore only used after assessing potentially hazardous buildings in multiple phases.

3.3 LINEAR STATIC ANALYSIS

In linear static analysis technique, the building is treated as a single-degree-of-freedom (SDOF) system with linear elastic rigidity & viscous damping equivalent. To generate the same stresses, the seismic effect is based on a viscosities as Earthquake it depicts. By estimating the building's first fundamental frequency utilizing empirical relations or Rayleigh technique, we can calculate the spectral acceleration, which when multiplied by body's mass, gives us an estimate of the corresponding laterally strong strength.

3.3 NON-LINEAR STATIC ANALYSIS

Because of inelastic material response in a non-linear static analysis method, the construction model directly incorporates non-linear force deformation characteristics for each component and element. Several methods are available (such as ATC 40 and FEMA 273).

3.4 NON-LINEAR DYNAMIC ANALYSIS

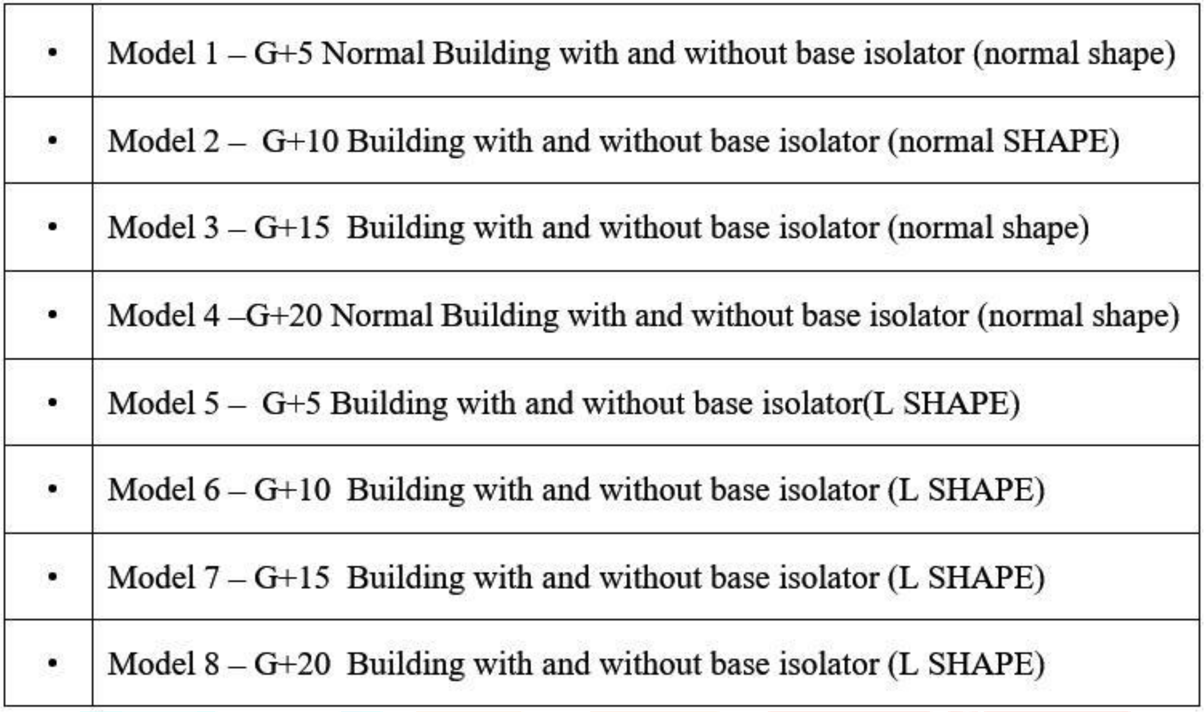
It is important to take into consideration the inelastic material reactions in both the non-linear static analysis and the non-linear dynamic analysis, therefore the building model utilized in both analyses is quite similar. When simulating seismic input, however, a time-history analysis is used to assess the structure's reaction in incremental increments.

4. MODEL DESCRIPTION

4.1 MODEL DESCRIPTION

In this study, seismic response of a building is analysed under earthquake loading using ETABS 2020. The plan's asymmetrical arrangement in both the X and Y axes has bays that are each 4 meters in length. Both 30- and 50-story reinforced concrete ordinary moment-resisting frames with the same loads and characteristics, columns, and tube-in-tube at centre & peripheral locations of frame are under consideration.

Table 4.1 Modal discriptation



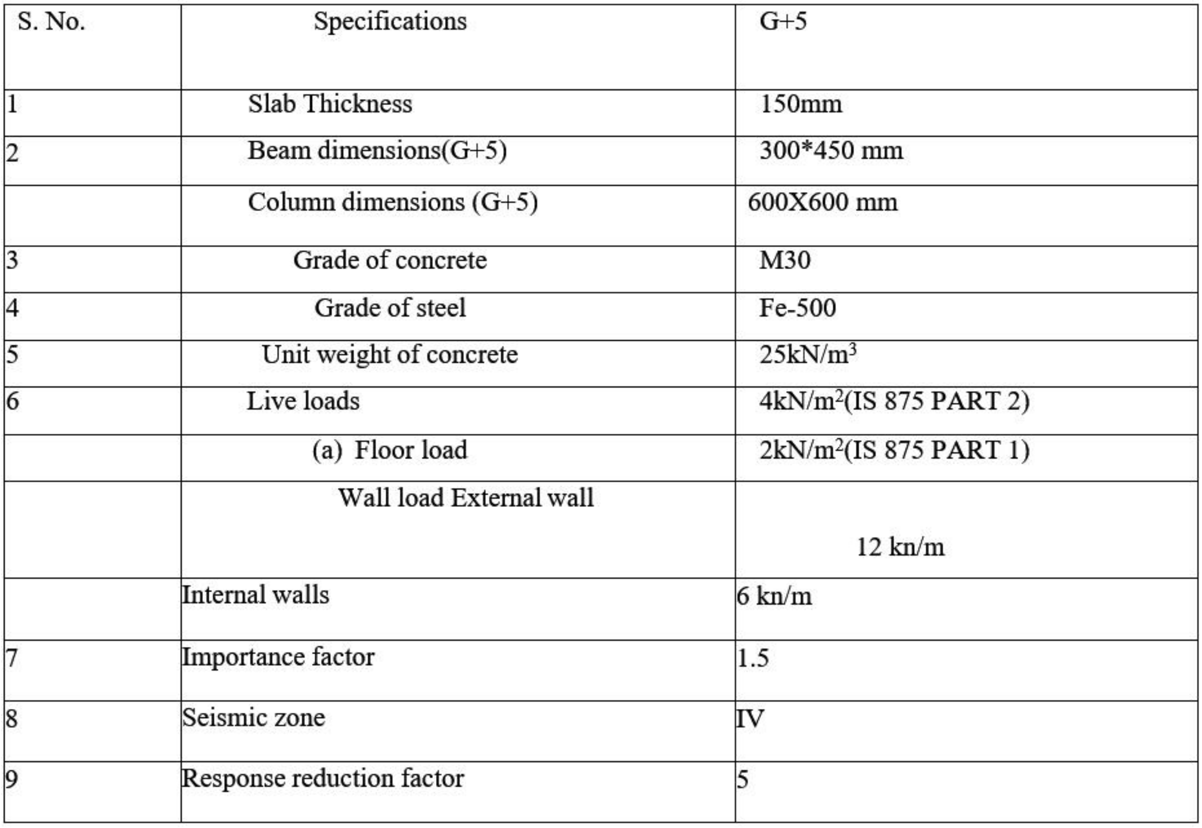
•	Model 1 – G+5 Normal Building with and without base isolator (normal shape)
•	Model 2 – G+10 Building with and without base isolator (normal SHAPE)
•	Model 3 – G+15 Building with and without base isolator (normal shape)
•	Model 4 –G+20 Normal Building with and without base isolator (normal shape)
•	Model 5 – G+5 Building with and without base isolator(L SHAPE)
•	Model 6 – G+10 Building with and without base isolator (L SHAPE)
•	Model 7 – G+15 Building with and without base isolator (L SHAPE)
•	Model 8 – G+20 Building with and without base isolator (L SHAPE)

Current building into study is a 5, 10, 15, and 20 –storey normal and L TYPE building in III seismic Zone. The building is designed for gravity loads and seismic loading. In x dir 11 bays at 6 m intervals and y –dir 11 bays at 6 m intervals.

4.2 Model 5 – G+5 Building with and without base isolation (L SHAPE)

Models: As it stands, the structure under investigation is an L-type five-storey building located in seismic zone IV. The structure can withstand earthquakes and other natural disasters because to its sturdy construction. In x- Dir 11 bays at 6 m intervals and y –Dir 11 bays at 6 m intervals.

Table 4.2 Preliminary data for G+5 L-Type Building

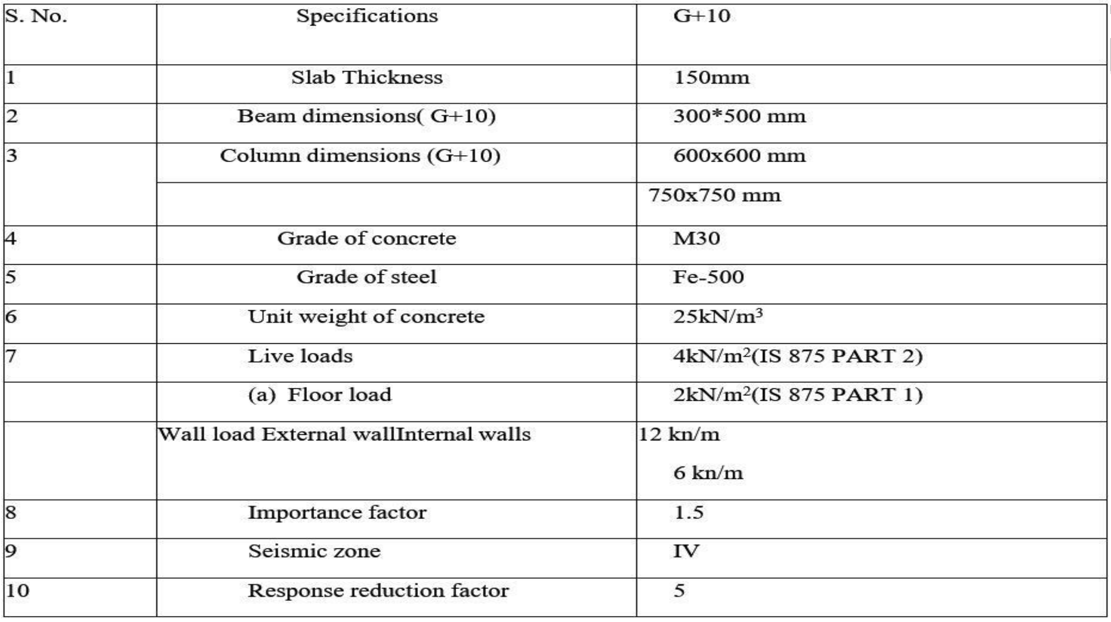


S. No.	Specifications	G+5
1	Slab Thickness	150mm
2	Beam dimensions(G+5)	300*450 mm
	Column dimensions (G+5)	600X600 mm
3	Grade of concrete	M30
4	Grade of steel	Fe-500
5	Unit weight of concrete	25kN/m^3
6	Live loads	4kN/m^2(IS 875 PART 2)
	(a) Floor load	2kN/m^2(IS 875 PART 1)
	Wall load External wall	12 kn/m
	Internal walls	6 kn/m
7	Importance factor	1.5
8	Seismic zone	IV
9	Response reduction factor	5

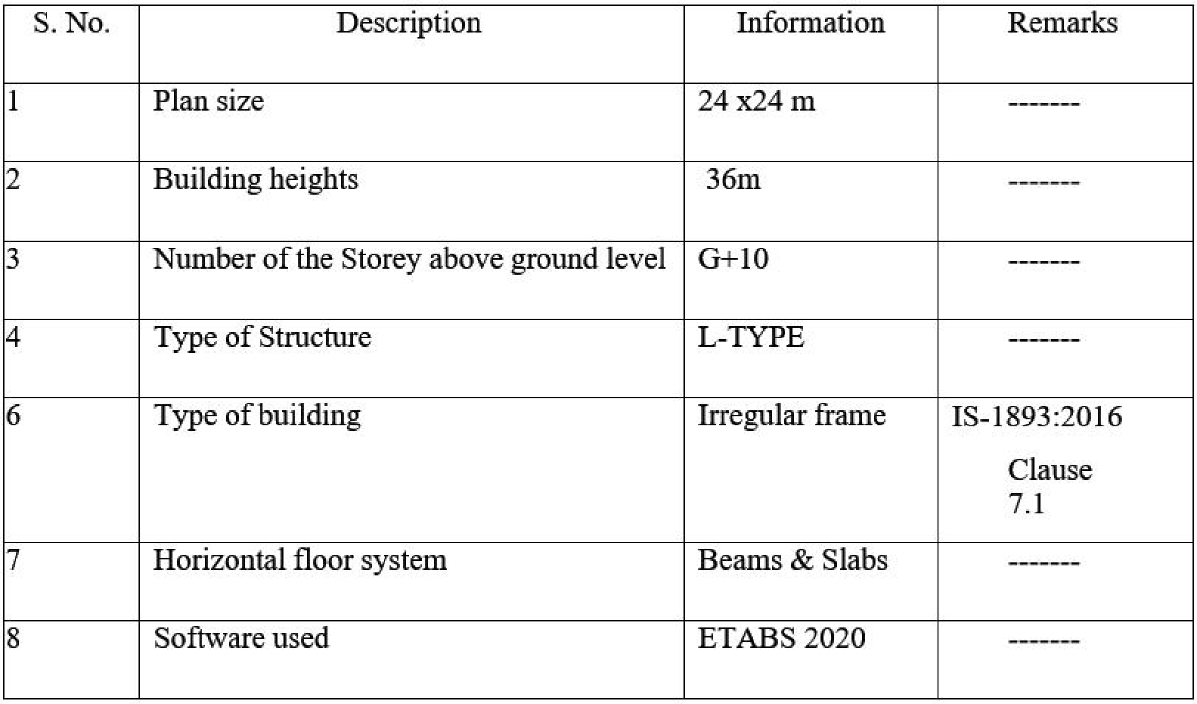
4.3 Model 6 – G+10 Building with and without base isolation (L SHAPE)

Models: The structure under investigation here is an L-type 10-storey building located in Seismic Zone IV. Both gravity and seismic loads have been accounted for in the structure's design. In x Dir 11 bays at 6 m intervals and y –Dir 11 bays at 6 m intervals.

Table 4.3 Preliminary data for G+10 L-Type Building



S. No.	Specifications	G+10
1	Slab Thickness	150mm
2	Beam dimensions(G+10)	300*500 mm
3	Column dimensions (G+10)	600x600 mm
		750x750 mm
4	Grade of concrete	M30
5	Grade of steel	Fe-500
6	Unit weight of concrete	25kN/m^3
7	Live loads	4kN/m^2(IS 875 PART 2)
	(a) Floor load	2kN/m^2(IS 875 PART 1)
	Wall load External wallInternal walls	12 kn/m 6 kn/m
8	Importance factor	1.5
9	Seismic zone	IV
10	Response reduction factor	5

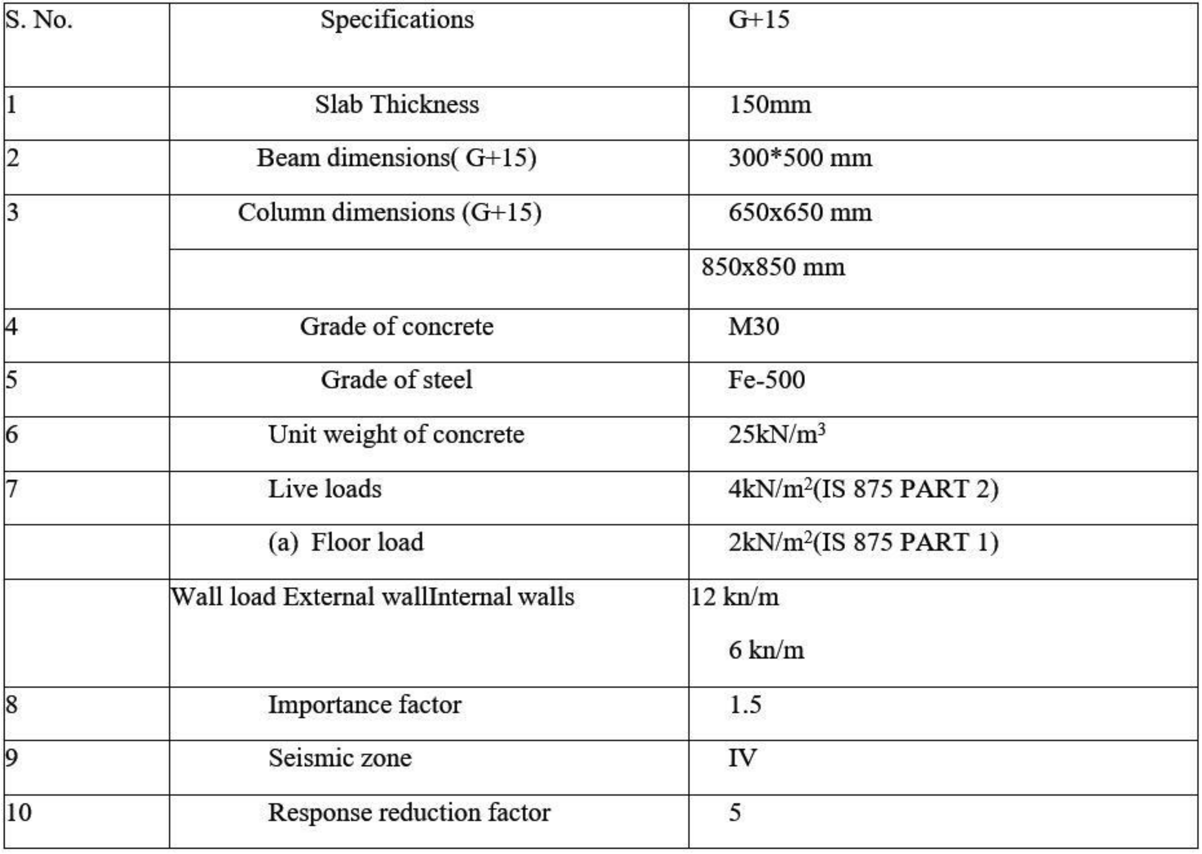


S. No.	Description	Information	Remarks
1	Plan size	24 x24 m	-------
2	Building heights	36m	-------
3	Number of the Storey above ground level	G+10	-------
4	Type of Structure	L-TYPE	-------
6	Type of building	Irregular frame	IS-1893:2016 Clause 7.1
7	Horizontal floor system	Beams & Slabs	-------
8	Software used	ETABS 2020	-------

4.4 Model 7 – G+15 Building with and without base isolator (L SHAPE)

Models: The structure under investigation here is an L-type 10-storey building located in Seismic Zone IV. Both gravity and seismic loads have been accounted for in the structure's design. In x Dir 11 bays at 6 m intervals and y –Dir 11 bays at 6 m intervals.

Table 4.4 Preliminary data for G+15 L-Type Building



S. No.	Specifications	G+15
1	Slab Thickness	150mm
2	Beam dimensions(G+15)	300*500 mm
3	Column dimensions (G+15)	650x650 mm
		850x850 mm
4	Grade of concrete	M30
5	Grade of steel	Fe-500
6	Unit weight of concrete	25kN/m^3
7	Live loads	4kN/m^2(IS 875 PART 2)
	(a) Floor load	2kN/m^2(IS 875 PART 1)
	Wall load External wallInternal walls	12 kn/m 6 kn/m
8	Importance factor	1.5
9	Seismic zone	IV
10	Response reduction factor	5

Table 4.5: General Data for G+15 L-Type Building

S. No.	Description	Information	Remarks
1	Plan size	24 x24 m	-------
2	Building heights	51m	-------
3	Number of the Storey above ground level	G+15	-------
4	Type of Structure	L-TYPE	-------
6	Type of building	Irregular frame	IS-1893:2016 Clause 7.1
7	Horizontal floor system	Beams & Slabs	-------
8	Software used	ETABS 2020	-------

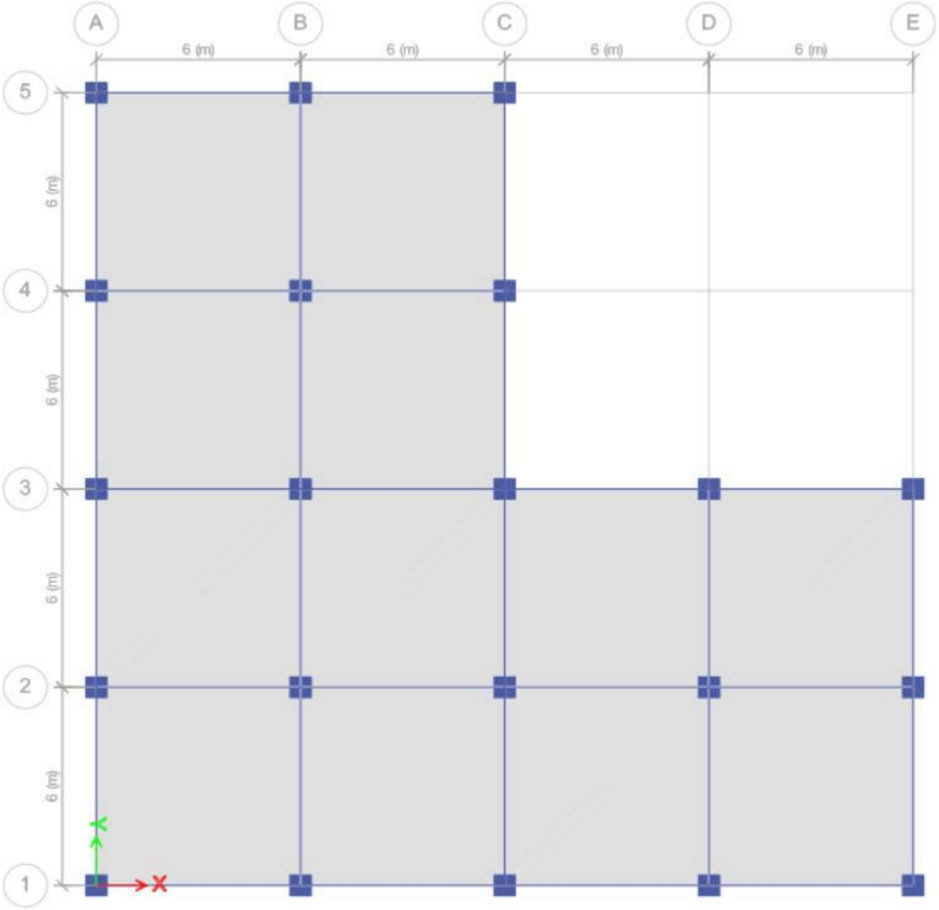


Figure 4.1: Plan view of 15 stories L –type building with and without base isolation

4.5 Model 8 – G+20 Building with and without base isolator (L SHAPE)

Models: Current into our analysis is 20–storey L-TYPE structure in IV seismic Zone. Structure is considered for gravity & seismic loading. In x- Dir 11 bays at 6 m intervals and y –Dir 11 bays at 6 m intervals.

Table 4.6 Preliminary data for G+20 L-Type Building

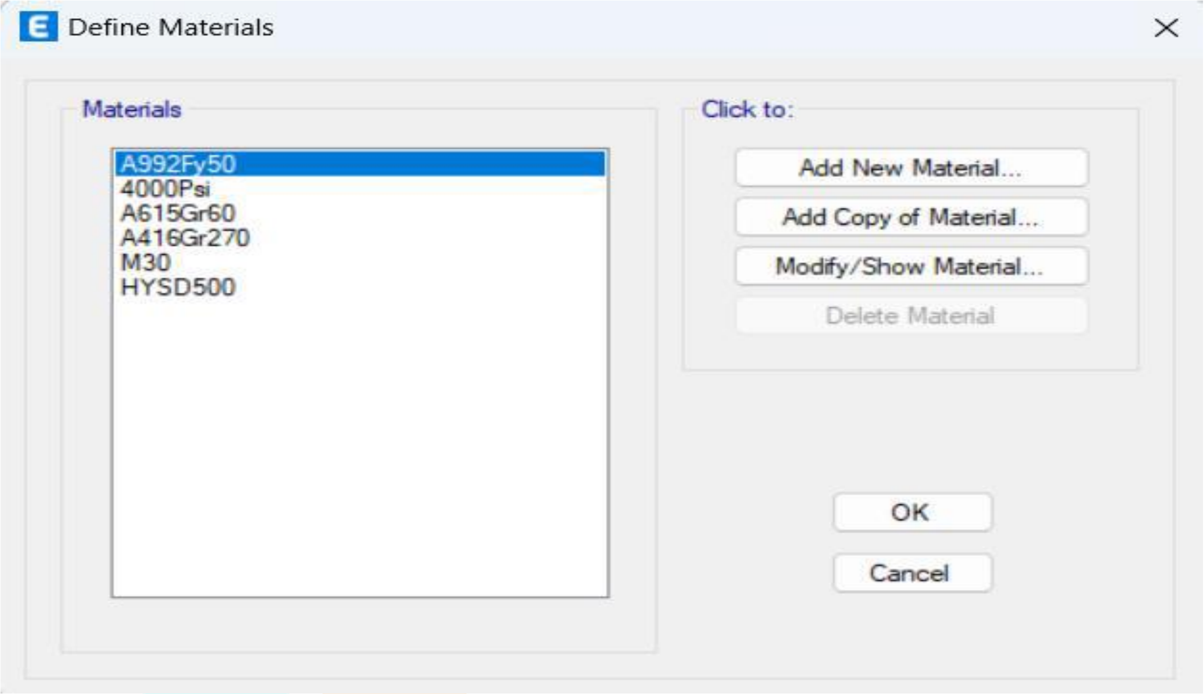
S. No.	Specifications	G+20
1	Slab Thickness	150mm
2	Beam dimensions(G+20)	300*500 mm
3	Column dimensions (G+20)	650x650 mm
		850x850 mm
4	Grade of concrete	M30
5	Grade of steel	Fe-500
6	Unit weight of concrete	25kN/m^3
7	Live loads	4kN/m^2(IS 875 PART 2)
	(a) Floor load	2kN/m^2(IS 875 PART 1)
	Wall load External wallInternal walls	12 kn/m 6 kn/m
8	Importance factor	1.5
9	Seismic zone	IV
10	Response reduction factor	5

Table 4.7: General Data for G+20 L-Type Building

S. No.	Description	Information	Remarks
1	Plan size	24 x24 m	-------
2	Building heights	66m	-------
3	Number of the Storey above ground level	G+20	-------
4	Type of Structure	L-TYPE	-------
6	Type of building	Irregular frame	IS-1893:2016 Clause 7.1
7	Horizontal floor system	Beams & Slabs	-------
8	Software used	ETABS 2020	-------

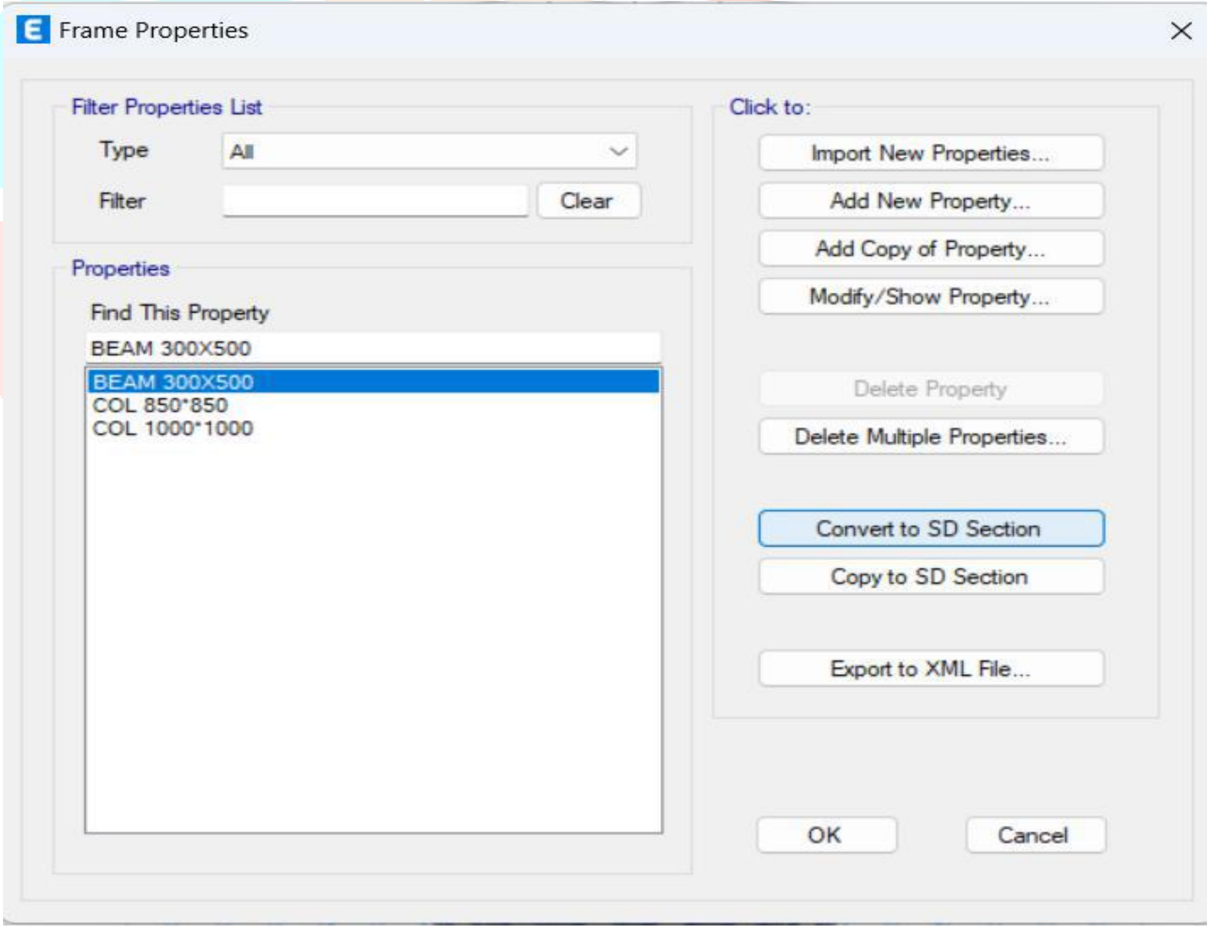
4.6 Pre-Process Steps into ETABS:

Step1: Materials Defining.



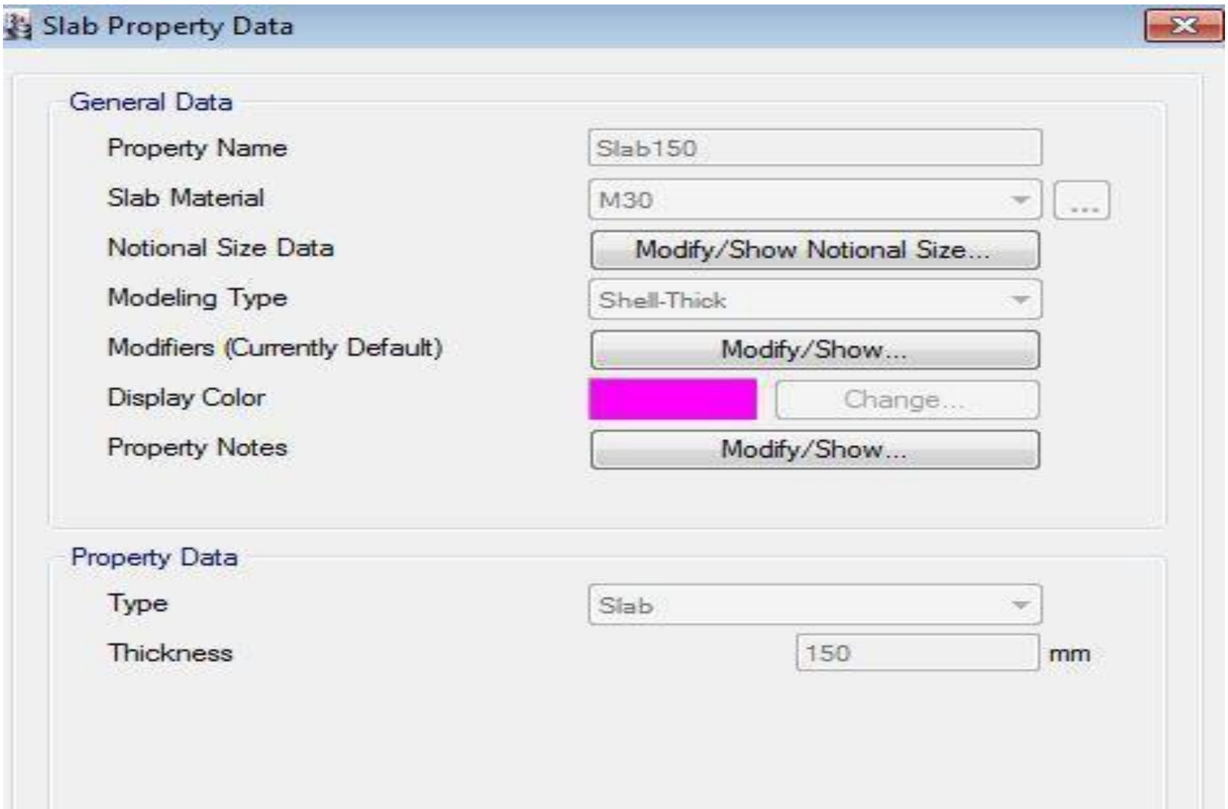
A992Fy50
4000Psi
A615Gr60
A416Gr270
M30
HYSD500

Step-2: Section Defining (beam, column & slab)



Type: All
Filter:
Find This Property: BEAM 300X500

BEAM 300X500
COL 850*850
COL 1000*1000



Slab Property Data

General Data

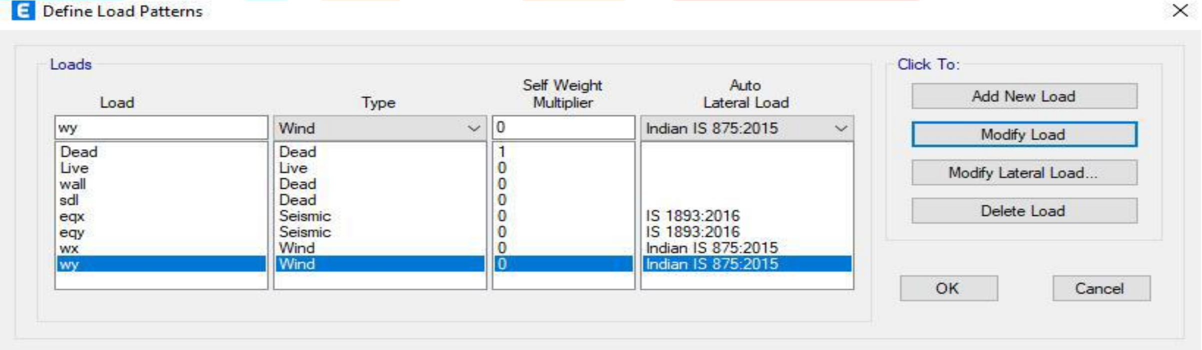
Property Name	Slab150
Slab Material	M30
Notional Size Data	Modify/Show Notional Size...
Modeling Type	Shell-Thick
Modifiers (Currently Default)	Modify/Show...
Display Color	Change...
Property Notes	Modify/Show...

Property Data

Type	Slab
Thickness	150 mm

Fig 4.2- Slab Section properties

Step 3: Defining loads



Define Load Patterns

Loads

Load	Type	Self Weight Multiplier	Auto Lateral Load
wy	Wind	0	Indian IS 875:2015
Dead	Dead	1	
Live	Live	0	
wall	Dead	0	
sdl	Dead	0	
eqx	Seismic	0	IS 1893:2016
eqy	Seismic	0	IS 1893:2016
wx	Wind	0	Indian IS 875:2015
wy	Wind	0	Indian IS 875:2015

Fig 4.3 Loads pattern definitions

Step 4: Assigning loads

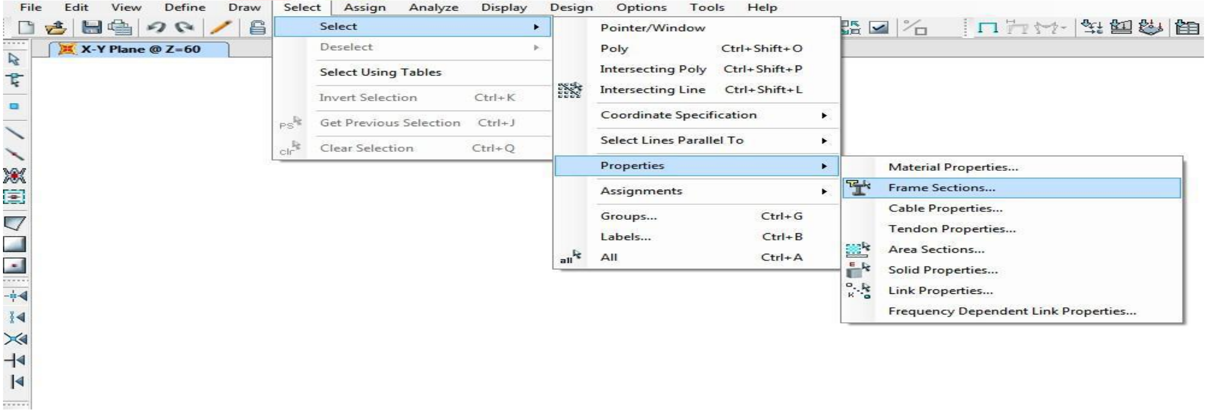


Fig 4.4- Assigning Loads

4.7 ANALYSIS METHODS

Linear static, linear dynamic, nonlinear static, & nonlinear dynamic analysis are the four main categories. Material nonlinearity & geometric nonlinearity may be integrated into the study to enhance the outcomes. Structures' strength, deformation, ductility, and distribution of demands can be assessed using these methods.

4.8 Equivalent Static Method

This is linear static method of analysis, in which the response of the building is assumed to be linearly elastic. Therefore, the equivalent static method of analysis follows a linear analysis procedure as well. In accordance with IS1893-2016, the analysis was carried out.

5. RESULTS AND DISCUSSIONS

Different parameters, like storey drifts, base shears, modal periods, torsion, etc., were used to achieve the results. Non-Linear Time History Analysis with Base Isolation Methods Outcomes for Symmetric and Asymmetric Five-Story Buildings are Presented First, Followed by Symmetric and Asymmetric Twenty-Story Buildings.

5.1 BASE ISOLATION OF TWENTY-STOREY SYMMETRIC BUILDING

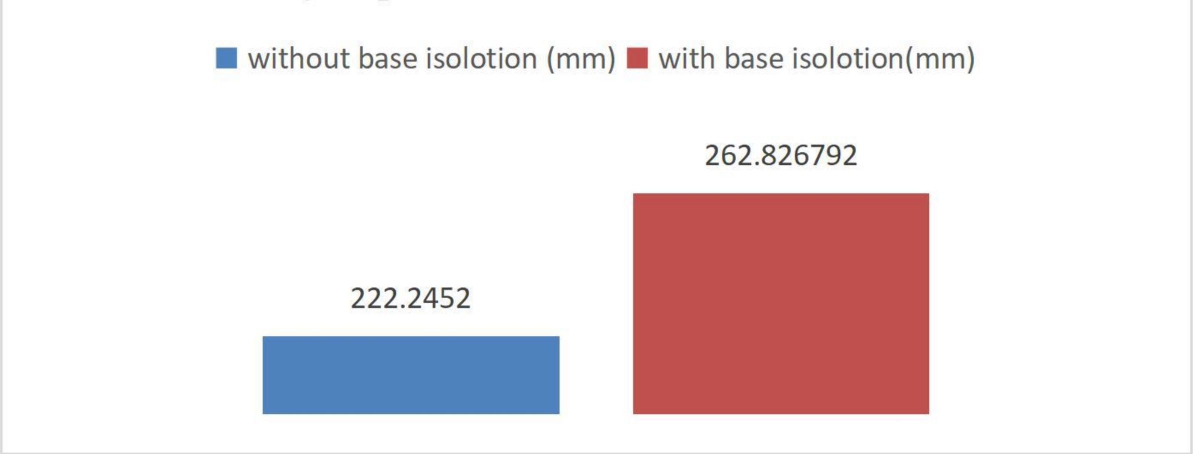


Figure 5.1: Story Displacement of 20 Stories into the X-Direction

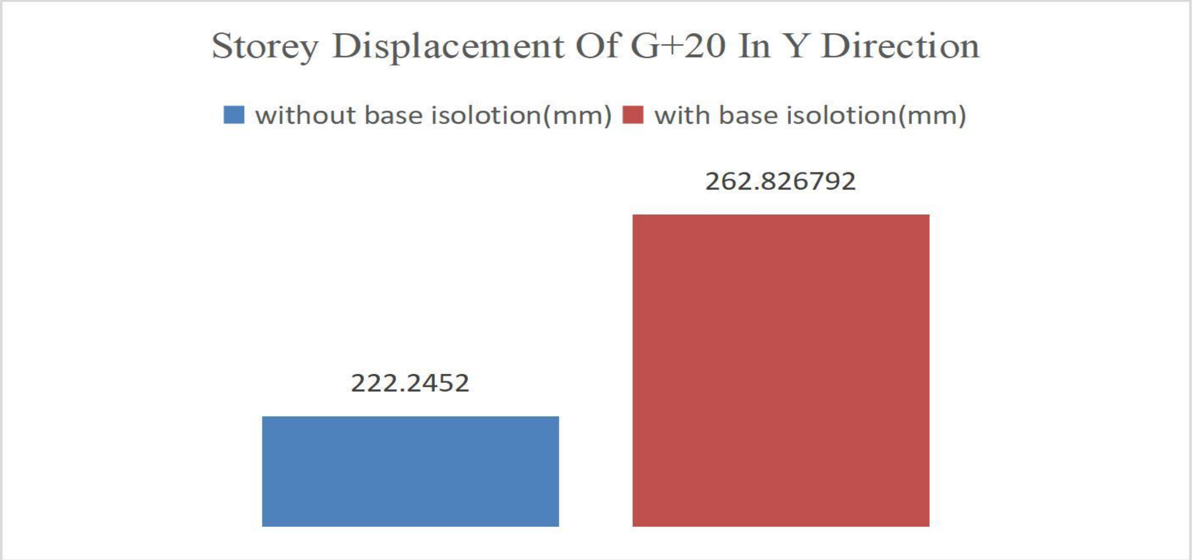


Figure 5.2: Story Displacement of 20 Stories In The Y-Direction

According to IS 16700:2017 Cl 5.4.1, the displacement must not exceed building height/250. This is relative sway of structure 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.

It is the relative displacement between the floor and roof in the building considered. As per IS1893:2016, Storey drifting must not surpass 0.004 times height of Storey. Higher 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

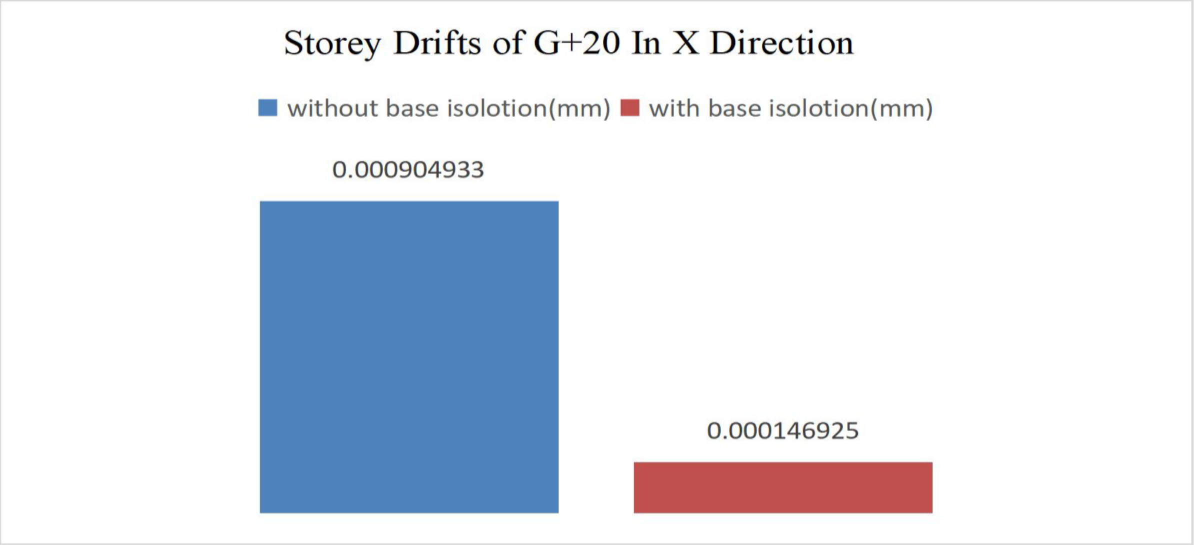


Figure 5.3: Story Drifts of 20 Stories In An X-Direction

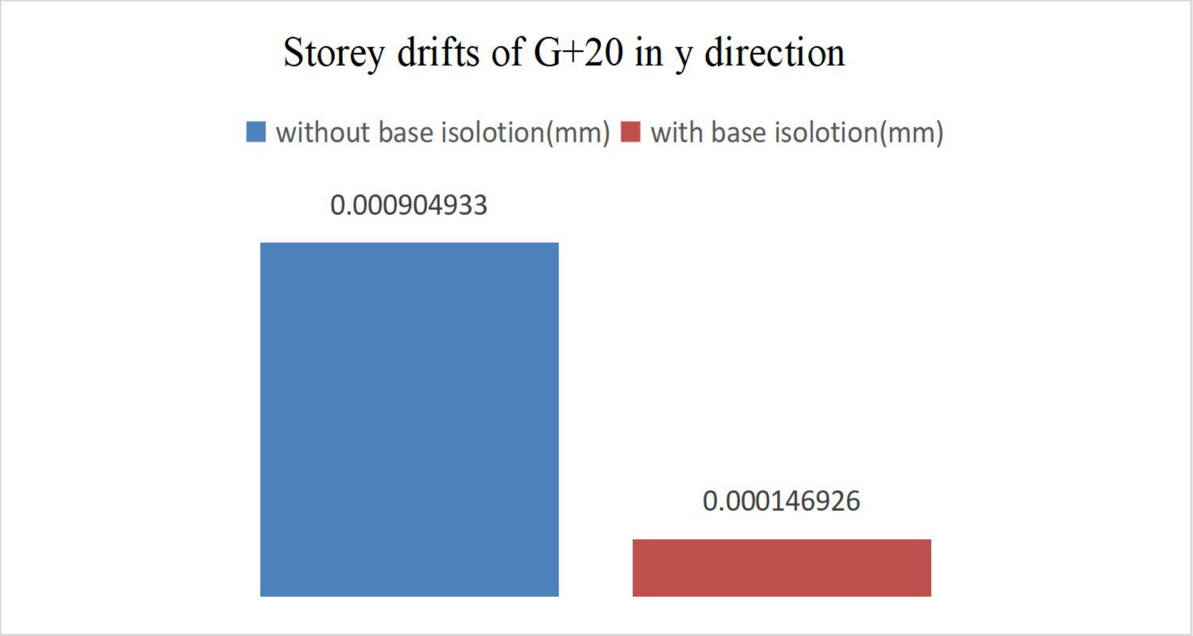


Figure 5.4: story drifts of 20 stories in the y-direction

Due to the movement of tectonic plates beneath earth surface there's 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, time taken by building for each oscillation cycle is the same, and it's termed fundamental natural period T of building. Lesser the time period, more rigid will be the structure.

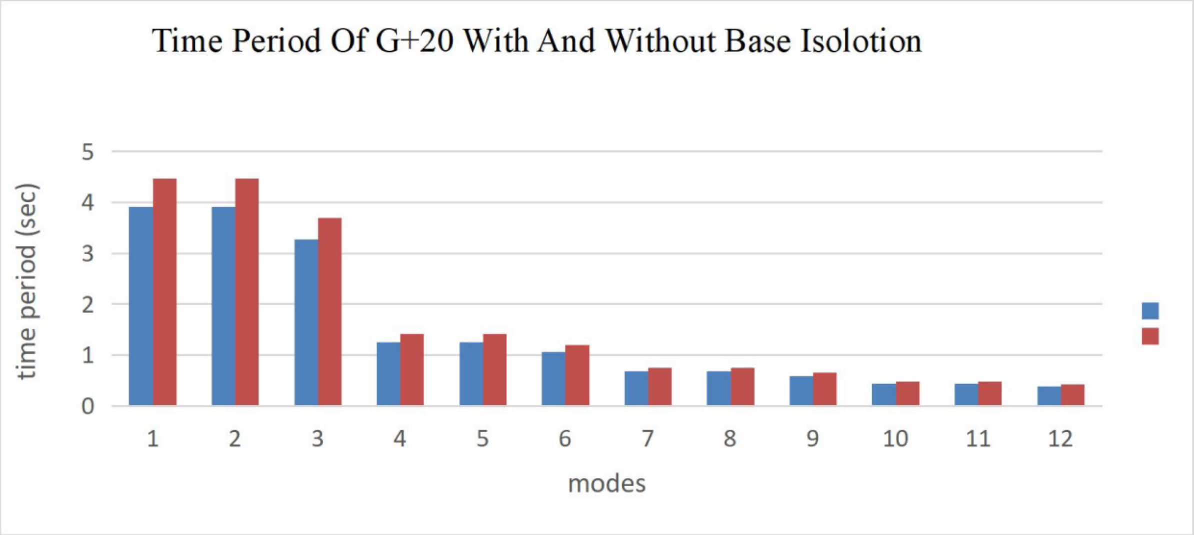


Figure 5.5: Time period of 20 stories

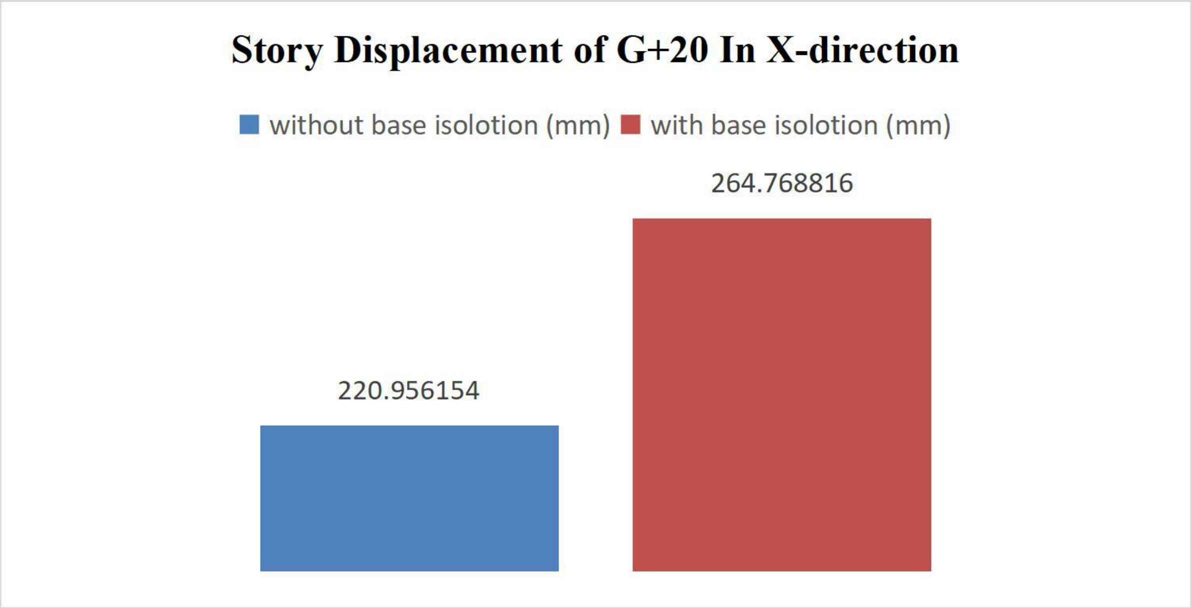


Figure 5.6: Story Displacements of 20 Stories In The X-Direction

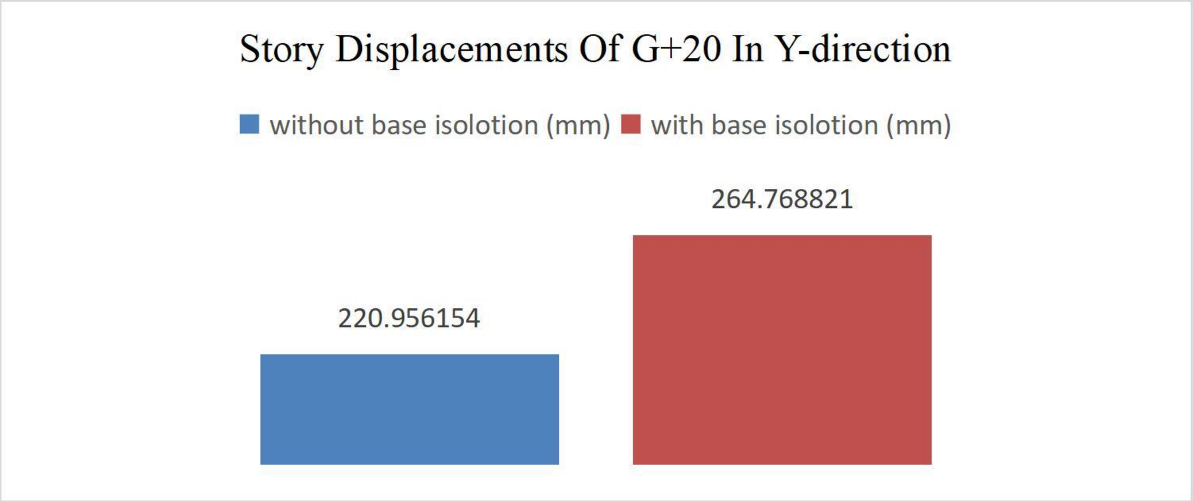


Figure 5.7: story displacements of 20 stories in the y-direction

As per the observation from the above Figures 5.6 and 5.7, it is found that the displacement of Base isolation building increases. It's found as normal building without base isolation has the least displacement comparing with base isolation model. Percentage of increases in displacement of the base isolation structure is 16.6% and 16.66% compared to a normal structure.

6. CONCLUSIONS

6.1 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.

6.2 CONCLUSIONS

1. In a symmetric five-story structure, the storey drifts were reduced by 25%, while in an asymmetric five-story building, they were reduced by 26.5%. Advocating the use of Base Isolators in Low-Rise Structures. The Storey Drifts for Twenty-storey Buildings were found to be reduced by 16% with symmetric buildings & with 15.98% for asymmetric buildings when the Isolation approach was used.
2. Base Isolators were found to be very effective seismic control devices for five-story buildings by reducing base shear by 75% for symmetric building structures then by lowering base shear & base torsion moment by 75% & 78% in both for asymmetric buildings.
3. Overall, the findings revealed that base isolators were very effective seismic control devices for only low-to high-rise symmetric and asymmetric structures.
4. The base isolation technique has been successfully used as an earthquake-resistant design strategy.
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 & 5, base isolators should be actively promoted due to their high technical effectiveness and low financial burden. Using foundation isolators lessens the amount of inter-story drift and therefore the amount of structural damage that occurs after an earthquake. Minor repairs are all that's needed to have the facility suitable for occupancy.
6. Since lateral displacement at base is not equal to 0, base-isolated structures display less lateral deflection & fewer moment values than fixed base structure.

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