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COMPARITIVE STUDY ON DIFFERENT TYPES OF RETROFITTING TECHNIQUES USING ETABS

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Abstract - *Earthquakes are a critical problem worldwide because it ends in disastrous damages including failure and collapse of buildings, losing human lives and losing of homes. In addition, earthquakes cause a large financial loss and built structures and recovery costs of damaged buildings and infrastructure. This paper aims at analysing multi-storey building against seismic loads and suggesting retrofitting techniques to decrease the total displacement of the building and increase the frequency of seismic vibrations, using the structural engineering software ETABS version 16. Procedure for application of a seismic retrofitting methodology has been experienced. However, the goal is to achieve a sustainable and efficient structure with permitted functionality and increased ductility*

Key Words: **seismic load, retrofitting techniques, seismic vibrations, etabs 16**

1.INTRODUCTION

In this study, a half-scale two-storey masonry building was designed to study the dynamic response and seismic behaviour of buildings before and after retrofitting with bracings and column jacketing, testing were performed on the models with and without retrofitting until it reached a near-local-collapse state. The present paper aims to provide knowledge based on seismic retrofitting on buildings considering IS1893-2016. Particularly old buildings have not been designed considering IS1893 -2016. Hence, it is a profitable way of learning on how these specific buildings can be modified in case of an earthquake rather than demolish them. In more detail, the particular method that is used for this project is to analyse the building globally and check the entire behaviour of the structure; focusing mainly on reducing the displacements of the structure after using the methodology seismic retrofitting, which is introduced the code. It is important to mention that for the seismic retrofitting which is basically a modification technique concerning the structure's capacity and strength; there are many ways to perform it.

1.1 Seismic retrofitting techniques

Strengthening of buildings that do not fulfil the requirements for seismic resistance can be made by retrofit techniques, through experimental and analytical studies. There are different seismic retrofitting techniques available, depending on the characteristics and condition of the building.

a) Steel bracing: Steel bracing may be a retrofitting technique in structural level. The steel bracing is considered as one of the most effective methods to enhance the stiffness, decrease the lateral displacements and improve the global strengthening of existing structures with unstable performance during earthquakes.

b) Shear walls: One of the most common structural levels retrofitting technique is including shear walls. It is an effective method that controls the overall global lateral drifts of existing structures. The method involves infilling additional shear wall members in bays that have to be strengthened; the infilling walls can be of shotcrete, steel and precast panels.

c) Masonry infill walls: Another retrofitting method is masonry infill walls. It is an effective method for reparation of unsteady structures by adding brick masonry walls between solid frames. The main feature of this method is that the capacity of the structure can be evaluated to check its effectiveness regarding strength and ductility. The advantage of this method is that it provides stiffness and resistance to the structure; analytical studies show an increment of 15 to 40 times in stiffness and 2.75 to 9 times in strength compared to bare steel frames due to changes in the lateral load transfer mechanism.

d) Column jacketing: Column jacketing is a member level retrofitting method which improves the strength and ductility of insufficient structure elements of beams and columns. During earthquakes, it is very important to not have weak column components in the structure, since they can result in failure mechanisms. The columns are controlled by axial load and shear and flexural strength, therefore column jacketing is considered to be a proper local strengthening, Column jacketing is used around existing columns by adding concrete, longitudinal reinforcement and transverse reinforcement. Jacketing can be added to one, two, three or four sides of the member according to the available space conditions around the columns.

1.2 Selected seismic retrofitting method and design seismic load

In this paper for the seismic retrofitting, it has been decided a combination of two different methods. The first method is the shear wall (prefabricated reinforced concrete walls/panels) and the second method is the steel diagonal bracing with a hollow section. The main purpose of choosing two different methods and combine them it is to stabilise properly the building under seismic vibrations. A crucial point of using these two types of seismic retrofitting methods it is also to increase the frequency of the building under the seismic vibrations. Increasing the frequency it is possible to decrease the displacements of the building in every floor level; thus, less displacements can lead to less damages, avoiding also any possible failures. The final results of this method are going to be presented and discussed further on in the next Chapters, where we are able to check if this theory is true or not.

The design seismic load and ground type have been selected according to IS1893-2016. Consequently, after applying this method of seismic retrofitting; the resulted frequencies are going to be evaluated with previous studies.

2. Methodology

The building model is a 3d Model of existing building, It was designed for gravity, using the Indian standards without specific provisions for earthquake resistance.

Four models are made to compare the results.

Model 1.
A 3d model of building is made to scale in etabs and it is subjected to gravity loads as per IS1893-2016 and the seismic response of the building is noted.

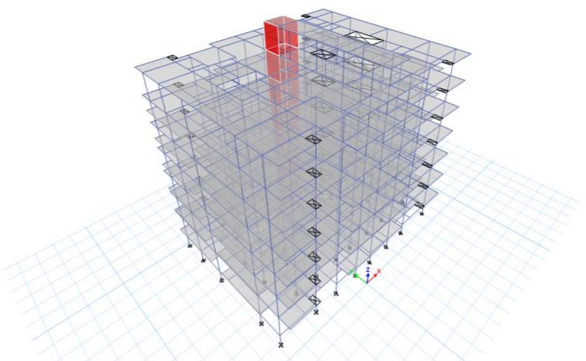

Fig1: 3D Model of MODEL 1

Model 2.
A 3d model of building is made to scale in etabs with steel bracings (ISMC300B/B)and it is subjected to seismic loads as per IS1893-2016 and the seismic response of the building is noted.

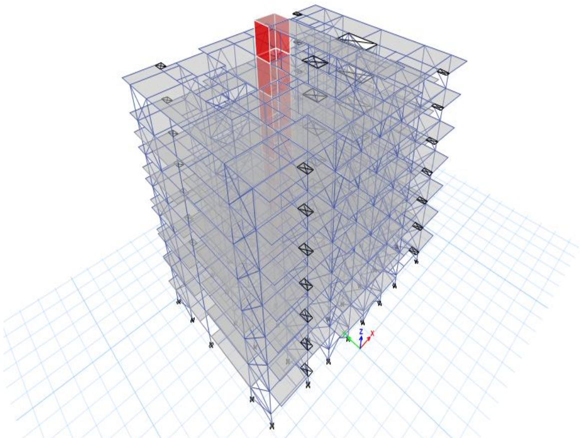

Fig 2: 3D Model of MODEL 2

Model 3.
A 3d model of building is made to scale in etabs with concrete shear walls and it is subjected to seismic loads as per IS1893-2016 and the seismic response of the building is noted.

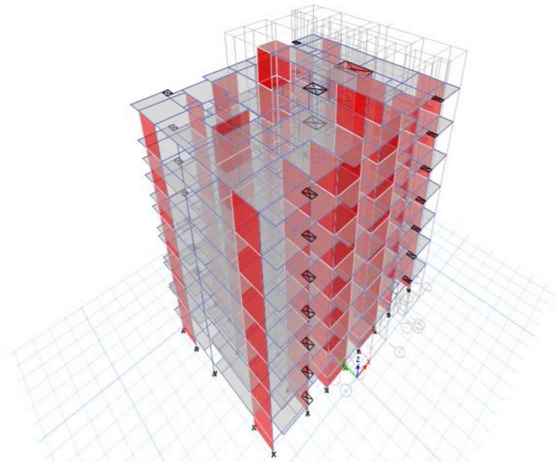

Figure 3: 3D Model of MODEL 3

Model 4
A 3d model of existing building is made to scale in etabs with concrete shear walls (150mm and 200mm)and it is subjected to seismic loads as per IS1893-2016 and the seismic response of the building is noted.

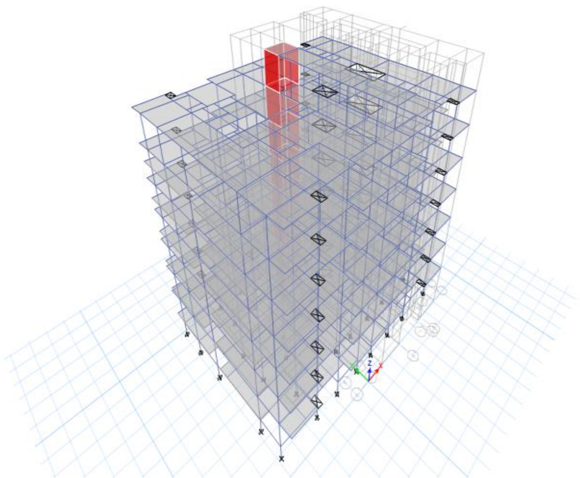

Figure 4:3D Model of MODEL 4

3. Results and Evaluations

All the outcomes have been obtained after successfully completing the seismic analysis of the model, once before applying the seismic retrofitting and another after applying the seismic retrofitting. The aim of the project, as mentioned before, is to analyse only the global behaviour without taking into consideration the local behaviour of the model. Therefore, there will not be any analysis regarding the connections between the structural elements, material properties and steel design of the elements. Therefore, evaluation of the forces and moments will not be considered since, it is not much relevant to study the structural members in the global behaviour.

3.1 Displacement

The maximum values of displacements are tabulated by comparing X and Y directions. The values of displacement of different models are obtained by subjecting the models to response spectrum analysis and time history analysis (linear) shows max displacement.

Table -1: Max Displacement values for (Response spectrum and time history in X direction)

SL NO	MODEL	MAX DISPLACEMENT (mm) SPECX	MAX DISPLACEMENT (mm) THX
1	MODEL 1	62.79	43.47
2	MODEL 2	23.09	24.69
3	MODEL 3	12.21	12.72
4	MODEL 4	31.37	26.815

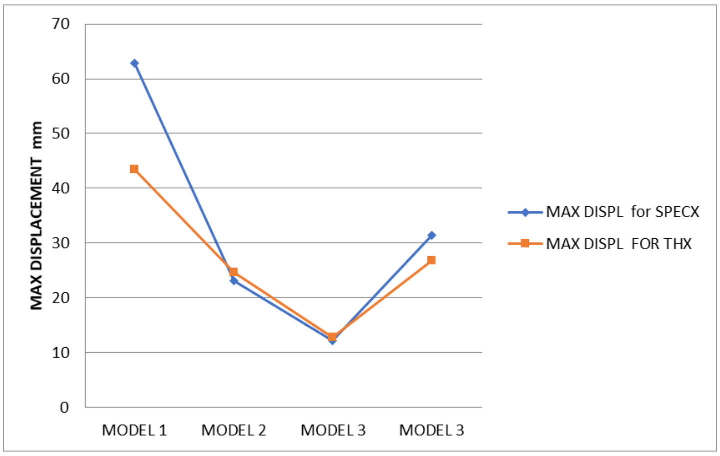

Fig 5: Graph of Maximum Displacement

Table -2: Max Displacement values for (Response spectrum and time history in y direction)

SL NO	MODEL	MAX DISPLACEMENT (mm) SPECY	MAX DISPLACEMENT (mm) THY
1	MODEL 1	21.44	26.01
2	MODEL 2	12.51	8.79
3	MODEL 3	12.36	13.57
4	MODEL 3	13.18	14.33

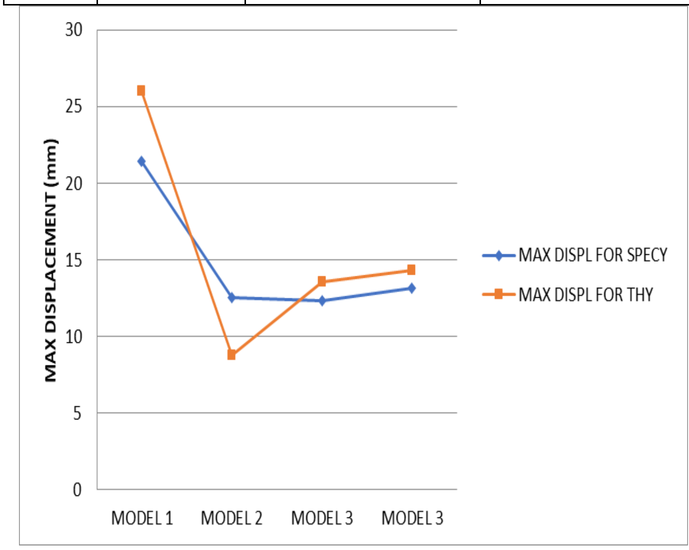

Fig.6: Graph of Maximum Displacement

Table 3: Max Displacement values for (Response spectrum X and Y direction)

SL NO	MODEL	MAX DISPLACEMENT (mm) SPECX	MAX DISPLACEMENT (mm) SPECY
1	MODEL 1	62.79	21.44
2	MODEL 2	23.09	12.51
3	MODEL 3	12.21	12.36
4	MODEL 4	31.37	13.18

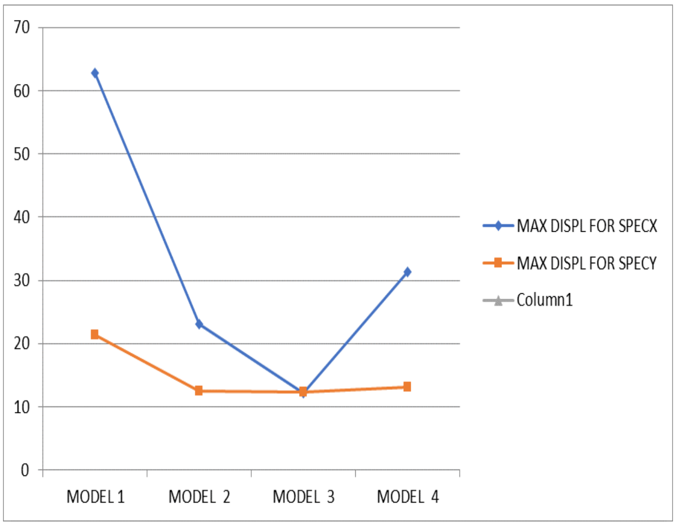

Fig.7: Graph of Maximum Displacement

Table 4: Max Displacement values for (time history in X and Y direction)

SL NO	MODEL	MAX DISPLACEMENT (mm) THX	MAX DISPLACEMENT (mm) THY
1	MODEL 1	43.47	26.01
2	MODEL 2	24.69	8.79
3	MODEL 3	12.72	13.57
4	MODEL 3	26.815	14.33

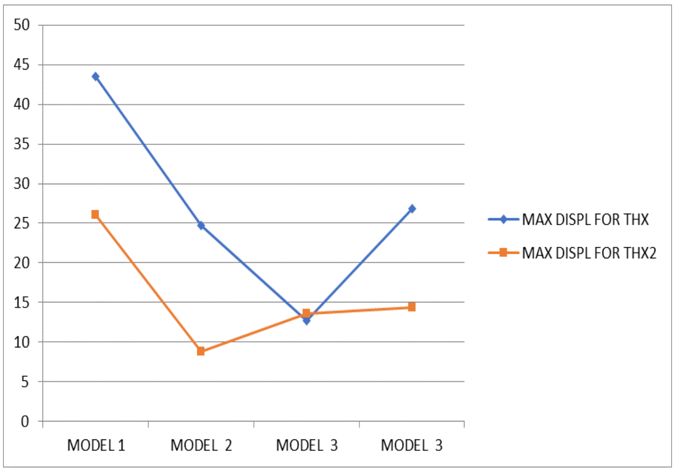

Fig.8: Graph of Maximum Displacement

3.2 Storey Drift Ratio

The maximum values of storey drift are tabulated by comparing X and Y directions. The values of displacement of different models are obtained by subjecting the models to response spectrum analysis and time history analysis (linear) shows max storey drift.

Table 5: Max Storey Drift values for (Response Spectrum and Time History in X Direction)

SL NO	MODEL	MAX STOREY DRIFT SPECX	MAX STOREY DRIFT THX
1	MODEL 1	0.01847	0.01104
2	MODEL 2	0.00674	0.007168
3	MODEL 3	0.000601	0.00626
4	MODEL 4	0.009419	0.00691

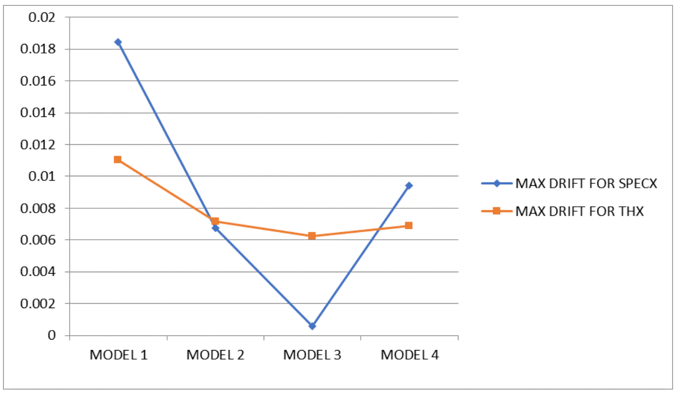

Fig.9: Graph of Maximum Storey Drift

Table 6: Max Storey Drift values for (Response Spectrum and Time History in y Direction)

SL NO	MODEL	MAX STOREY DRIFT SPECY	MAX STOREY DRIFT THY
1	MODEL 1	0.00686	0.006779
2	MODEL 2	0.003938	0.002656
3	MODEL 3	0.000654	0.000718
4	MODEL 4	0.004227	0.00421

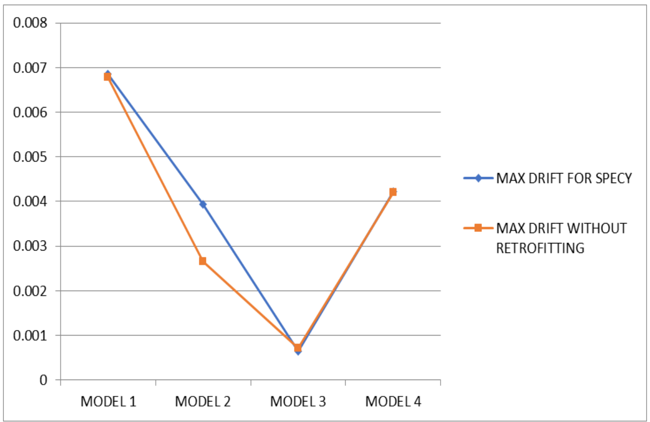

Fig.10: Graph of Maximum Storey Drift

Table 7: Max Storey Drift values for (Response Spectrum X and Y Direction)

SL NO	MODEL	MAX STOREY DRIFT SPECX	MAX STOREY DRIFT SPECY
1	MODEL 1	0.01847	0.00686
2	MODEL 2	0.00674	0.003938
3	MODEL 3	0.000601	0.000654
4	MODEL 4	0.009419	0.004227

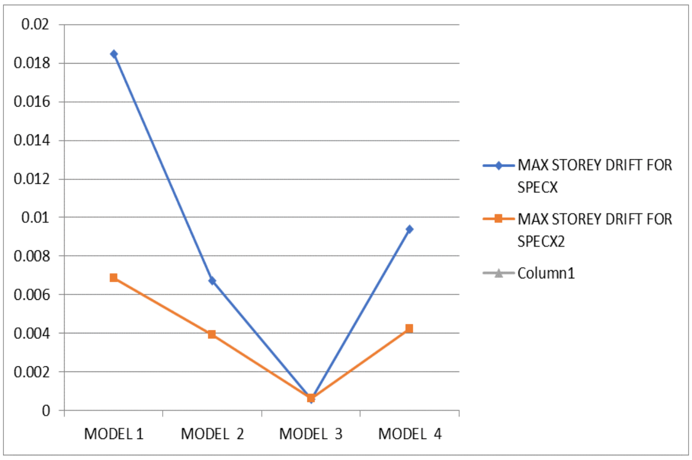

Fig.11: Graph of Maximum Storey Drift

Table 8: Max Storey Drift values for (Time history X and Y Direction)

SL NO	MODEL	MAX STOREY DRIFT THX	MAX STOREY DRIFT THY
1	MODEL 1	0.01104	0.006779
2	MODEL 2	0.007168	0.002656
3	MODEL 3	0.00626	0.000718
4	MODEL 4	0.00691	0.00421

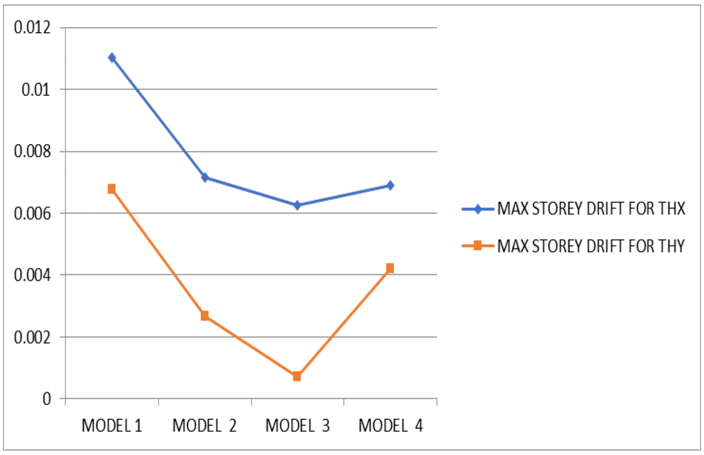

Fig.12: Graph of Maximum Storey Drift

3.3 Time period

Table 9: Time period values for different Models

SL NO	MODEL	MAX TIME PERIOD Seconds
1	MODEL 1	1.825
2	MODEL 2	1.025
3	MODEL 3	0.616
4	MODEL 4	1.236

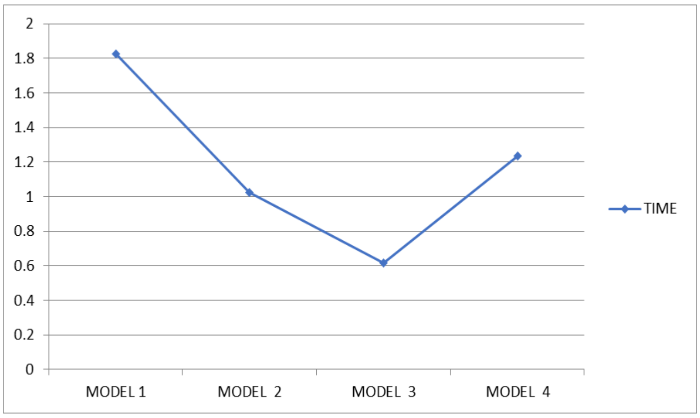

Figure 13: Graph of variation in time period.

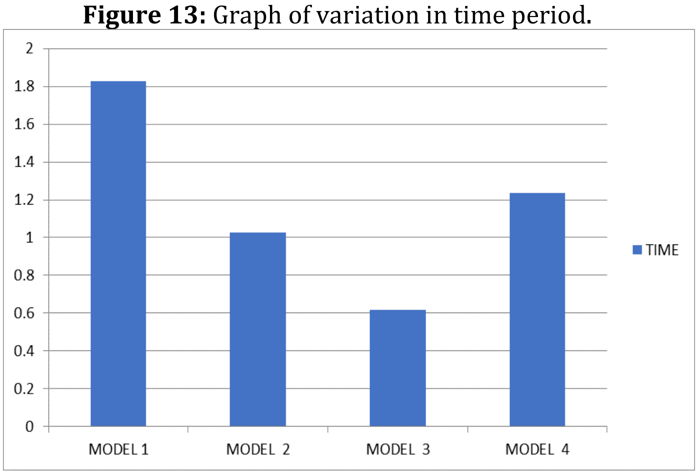

Figure 13.1: Bar Graph of variation in time period.

3.4 Base shear

Base shear is a measure of the maximum expected lateral force that will happen due to the seismic ground motion at the base of the structure. Since base shear value directly proportional to weight of the building, the regular model is having fewer loads compared to other models. Calculation of base shear rely on upon, soil conditions at the site, concurrence to potential sources of seismic activities.

Table 10: Base shear values of analysis for optimal angle of diagrid

SL NO	MODEL	MAX BASE SHEAR kN
1	MODEL 1	1980.5145
2	MODEL 2	1995.9346
3	MODEL 3	2196.1025
4	MODEL 4	2076.4436

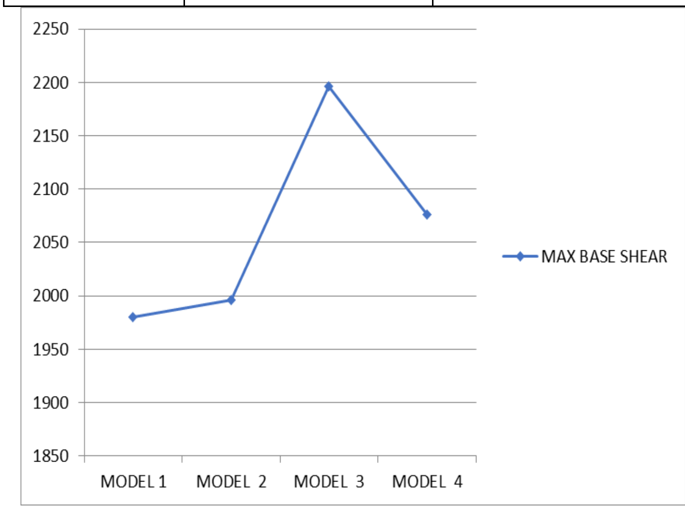

Figure 14: Graph of variation in base shear.

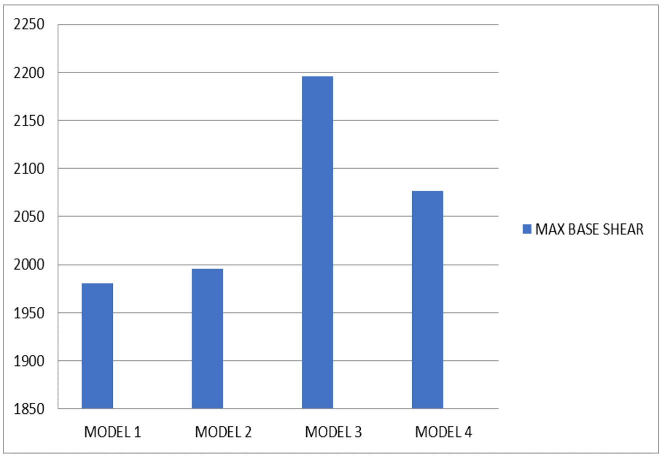

Figure 14.1: Graph of variation in base shear.

4. Discussion of result

In this study a G+8 structure was analysed in four models.

-Model 1 with dead load, live load and dynamic earthquake loading.

-Model 2 (With steel bracing) with dead load, live load and dynamic earthquake loading.

-Model 3 (With Shear walls) with dead load, live load and dynamic earthquake loading.

-Model 4 (With Steel jacketing of column) dead load, live load and dynamic earthquake loading.

All the above four models were checked for displacement, time period and base shear. The comparison between them was drawn and following results were obtained.

A. Displacement

From the results of displacement it is noted that the maximum reduction in lateral displacement for response spectrum is seen in Model 3 for 80.54% in X direction and 42.37 in Model3 for Y direction compared to normal Model1. For time history Model 3 (with Shear wall) shows a maximum lateral displacement reduction by about 70.72% in X direction and 66.21% in Y direction Model 2 (with steel bracing) show maximum reduction in displacement about 66.21%.

B. Time period

From the graphs and tables of time period in the results section it is clearly observed that the Model 3 (with shear wall) has reduced the maximum amount of time period. It is noted that in Model 3 the time period of the building was reduced by about 66.24% compared to Model 1. Whereas for the same case in Model 2, 3, 4 (with shear walls) the time period was reduced by only about 43.83%, 32.27%. Hence Model 3 is most effective in handling the lateral loads and reducing the time period of the building.

C. Base shear

From the graphs and tables of Base shear in the results section it is clearly observed that the Model 3 (with shear wall) has increased the maximum amount of base shear. It is noted that in Model 3 the base shear of the building was increased by about 10.88% compared to Model 1. Whereas for the same case in Model 2, 3, 4 (with shear walls) the base shear was increased by only about 0.778%, 4.8%. Hence Model 3 has maximum base shear compared to other models.

5. CONCLUSION

By considering all the four model and their behaviour in dynamic earthquake loading. It is concluded that Model 3 (with shear wall) gives the most suitable results. As it tends to reduce the time period of the building by 80.54% and reduce the lateral displacement in X and 42.37 in Y direction by a good margin.

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