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Dynamic Analysis of Steel Structure with Bracings and Dampers under Wind and Earthquake Loads

Pooja V[1], Dr. S Vijaya[2], Dr. B Shivakumaraswamy[3], Kavya H K[4]

[1]M Tech Student, [2]Head of the Department, [4]Assistant Professor,
[1, 2, 3, 4]Department of Civil Engineering, Dr. Ambedkar Institute of Technology, Bengaluru, Karnataka, India

ABSTRACT

In India residents are increasing gradually and the necessary land for living. It is a key requirement to survive anywhere. For that reason multi story building are best choice for construction in Metro cities where a smaller amount of property is presented. As designer knows multi story structure provides large floor area in small area and it is beneficial also. Hence, it is required to assemble high rise structure. If high rise structures are constructed than many structural troubles come to pass, such as lateral load effect, lateral displacement and stiffness etc. Normally for high rise structure wind and earth quake load effects are prevailing.

In the present study, a 15-storey building is considered. The structure is subjected to both wind and dynamic loadings. The Modelling and analysis are carried out using ETABS software. The structure is further stabilized by providing the Bracing system and Viscous Dampers. The performance of these structures is studied and compared using various parameters such as displacement, storey drift, base shear and time period. The results are extracted and conclusions are drawn.

KEYWORDS: *Equivalent Static Analysis, Time History Analysis, Wind Analysis, ETABS*

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I. INTRODUCTION

An addition to primary gravity loads, in the seismic prone areas the buildings and other structures are subjected to seismic forces. The damages caused to the structures depend on the intensity and magnitude of the earthquake. During earthquake steel structure behaviour is different and its behaviour switches from elastic to in elastic nature. The strength and stiffness in steel structures are ensured by dissipating large amount of energy during seismic effects.

It is important to increase the stiffness of the structure than increasing the strength of high-rise structure. The stiffness can be mainly increased by providing some lateral load resisting systems. The more frequently used bracing systems, moment resisting frame are effectively increases the stiffness of the structure. However, these system decreases the flexibility of the structure.

ADVANTAGE AND DISADVANTAGE

A. Advantages

The advantages of Steel structures are listed below:

- Since, most of the parts can be easily built at site, this can be fast in construction.
- It is having very good lateral load resisting property due to its flexible nature.
- Ready sections are available in the shape of I, C and other forms of structural steel.
- It can be moulded easily to any shape and any form, and hence the desired shape can be easily availed.
- One and other members can be easily connected by welding and bolting.

B. Disadvantages

Steel structure is having few disadvantages,

- It will lose its property, when it is subjected to fire or blast. Since it is having lower melting point than concrete.
- During exposure to water and air, it is susceptible to corrosion.

OBJECTIVES AND METHODOLOGY

A. Objectives

1. To Study the behaviour of Steel Structure subjected to lateral loadings.
2. To understand the performance of steel structure for bracing system and damper.
3. Study is carried out to observe the behaviour of Structure dynamic time history and wind loadings.
4. The parameters such as base shear, displacement, storey drift, and time period are compared and discussed in detail.

B. Methodology

- The various journals are referred and objectives are finalized.
- The basic modelling is carried out using ETABS software.
- The models are provided with X bracings and Viscous Dampers and analysed.

- The analysis is carried out for static (Equivalent Static Analysis), dynamic (Time History Analysis) and wind analysis.
- The results are extracted and discussed in detail. The conclusions are drawn based on the study

II. MODELLING

In the modelling a 15 Storey steel structure modelling has been discussed. The basic models are created using the below steps and the remaining models are prepared using similar way.

Model 1 : Multi level Steel Structure.
Model 2 : Multi level Steel Structure with X Bracing System at Corner.
Model 3 : Multi level Steel Structure with X Bracing System at Middle.
Model 4 : Multi level Steel Structure with Viscous Damper at Corner.
Model 5 : Multi level Steel Structure with Viscous Damper at Middle.

The below steps explain the modelling procedure carried out for modelling.

- Finalizing Grid data & Storey data.
- Defining - Materials
- Defining Frame sections & area Sections.
- Defining Load Cases.
- Defining Mass source.
- Draw Columns, slabs & drop slab.
- Assigning support restrains.
- Assigning Loads.
- Analysis
- Result Extraction.
- The above procedure holds good for other models and results are extracted in the same way as explained below. Few of images are presented in the below section, which are self-explanatory.

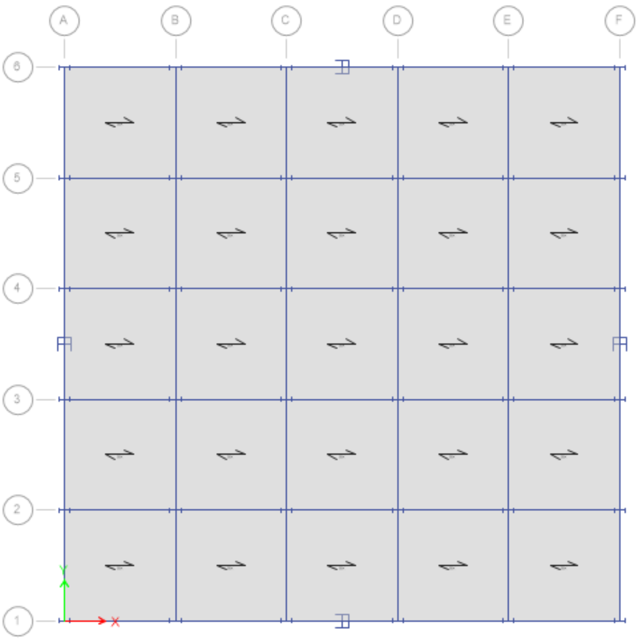


Fig 1: Plan View

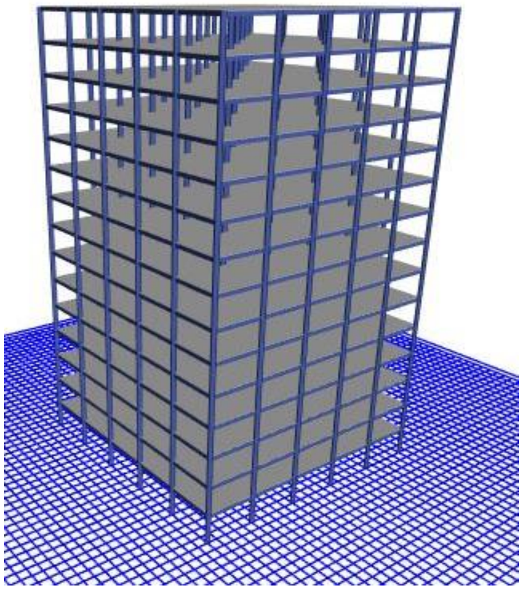
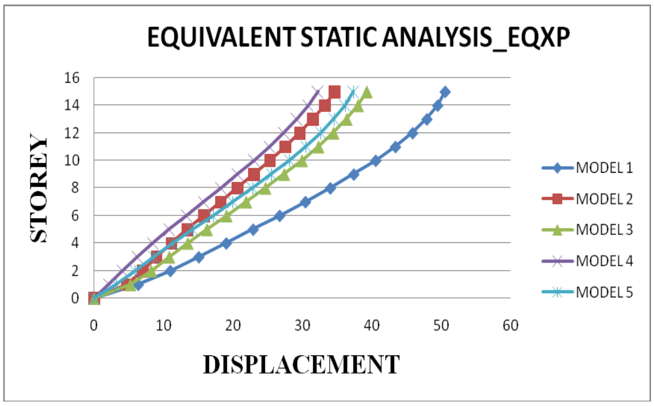


Fig 2:3D View

Table 1-Material Properties and Design Parameters

Sl. No.	Description	Data
1.	Seismic Zone	III
2.	Seismic Zone Factor (Z)	0.16
3.	Importance Factor (I)	1.5
4.	Response Reduction Factor (R)	4
5.	Damping Ratio	0.05
6.	Soil Type	Hard Soil (Type II)
7.	Height of the building	45m(15 Storey)
8.	Story to story Height	3.0 m
9.	Span Length	5m
10.	Column Size used	ISMB500
11.	Thickness of Slab	125mm
12.	Floor Finish	1.5KN/m^2
13.	Live Load	4.0KN/m^2
14.	Grade of Concrete (f_{ck})	M35
15.	Grade of Structural Steel (f_{ys})	Fe 350
16.	Grade of Reinforcing Steel (f_{yr})	Fe 500

RESULTS AND DISCUSSIONS

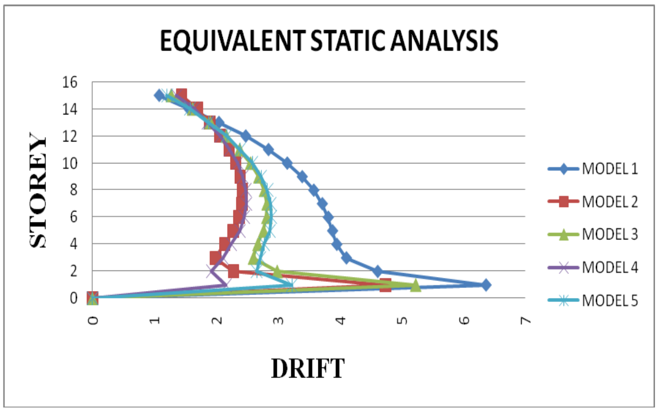


Graph1: Displacement vs. Storey in X Dir._ EQX

From the graph above, it is seen that model 1 is having highest displacement compared to all other models.

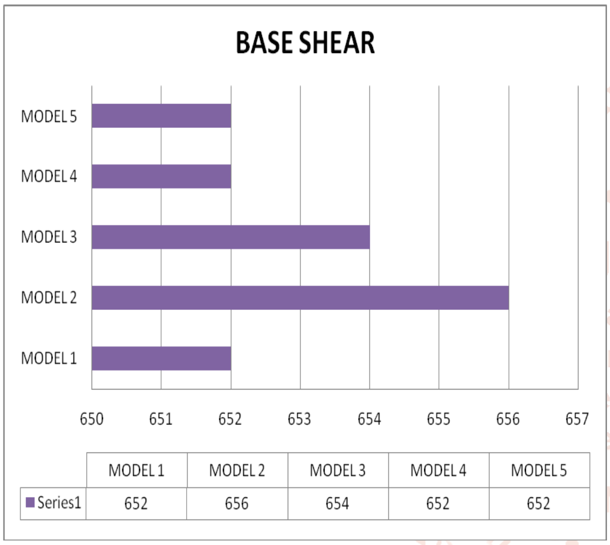
However, the displacement reduced drastically after the introduction of dampers and bracings.

The model M4 is showing least displacement than other models.



Graph2: Storey Drift vs. Storey in X Dir._ EQX

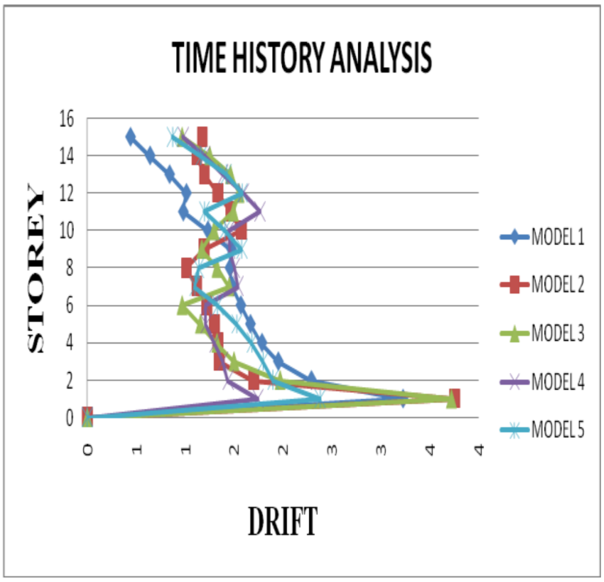
Drift values are found more in model M1. However, other models possess same drift values



	MODEL 1	MODEL 2	MODEL 3	MODEL 4	MODEL 5
Series1	652	656	654	652	652

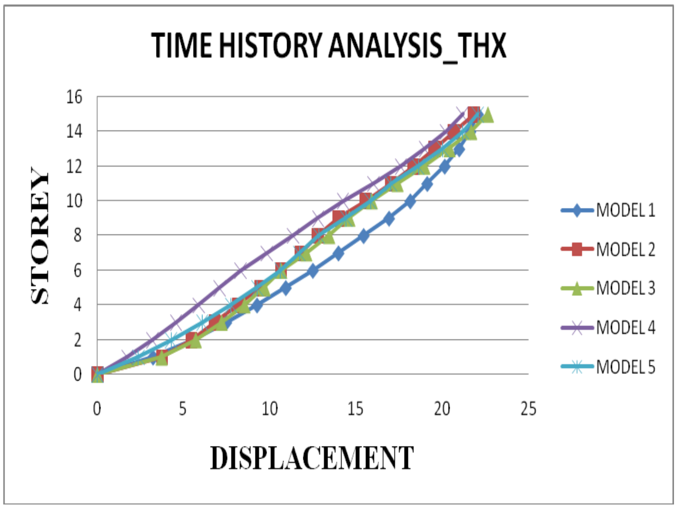
Graph 3: Base Shear_ EQX

All the base shear values are same. However, the model M2 is having little higher base shear values comparatively. The base shear mainly depends on the mass of the structure. The Additional mass of the structure is mainly due to bracings only



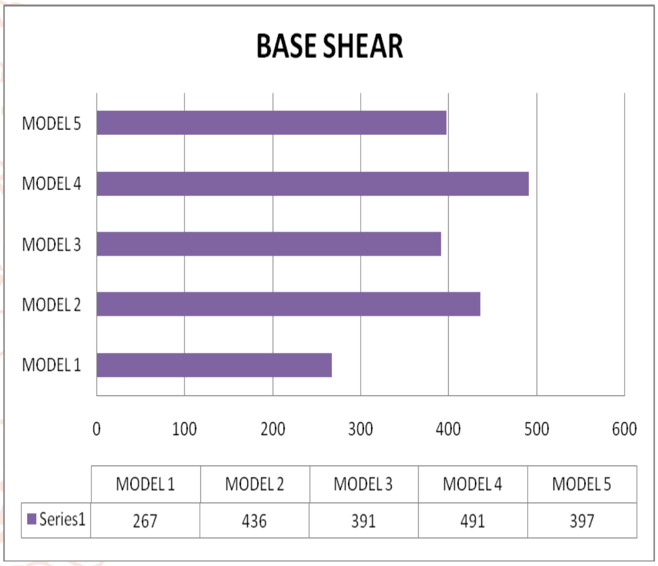
Graph 5: Storey Drift vs. Storey in X Dir.-THX

The drift values of all the models are within limiting range and equal approximately



Graph 4: Displacement vs. Storey in X Dir._ EQX

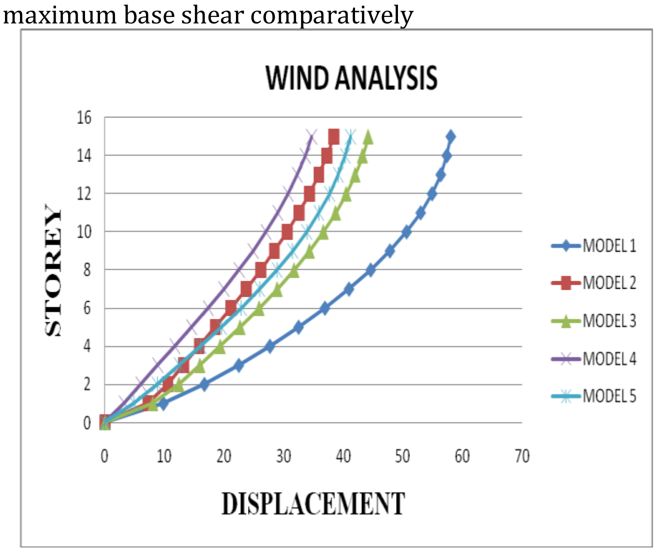
From the graphs, time history results show similar displacement for all the models. This is due to fact that, the dynamic analysis works better for super tall structures



	MODEL 1	MODEL 2	MODEL 3	MODEL 4	MODEL 5
Series1	267	436	391	491	397

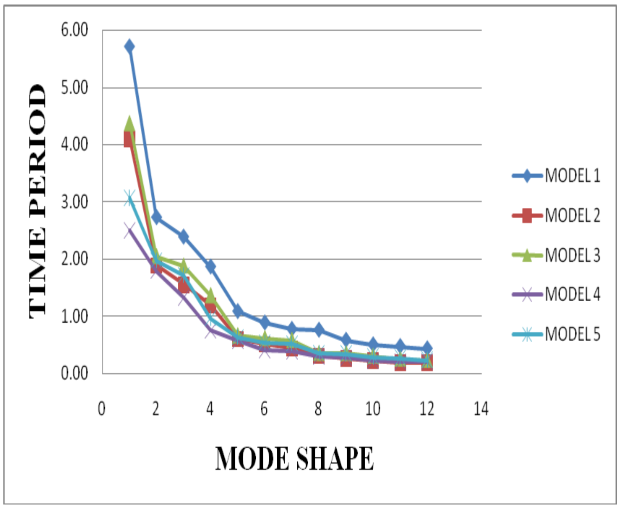
Graph 6: Base Shear_ THX

The base shear due to time history analysis shows the capacity-based distribution of forces. It indicates that the models having higher stiffness will attract higher base shear values. And hence, the model M4 and Model M2 having maximum base shear comparatively



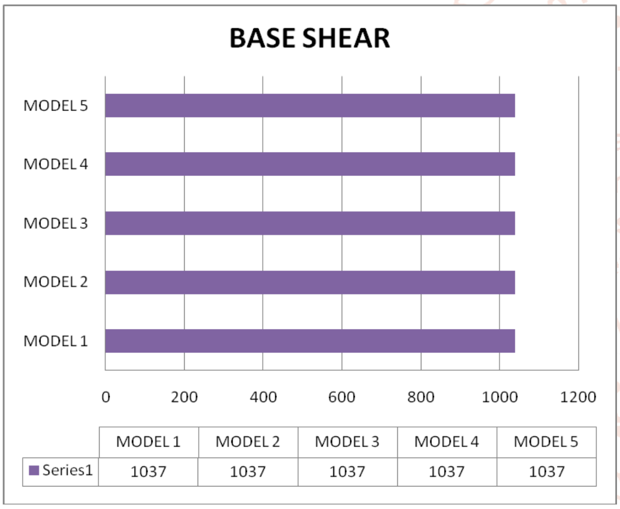
Graph7: Displacement vs. Storey in X Dir._ WINDX

From the graph above, it is seen that model 1 is having highest displacement compared to all other models. However, the displacement reduced drastically after the introduction of dampers and bracings. The model M4 is showing least displacement than other models.



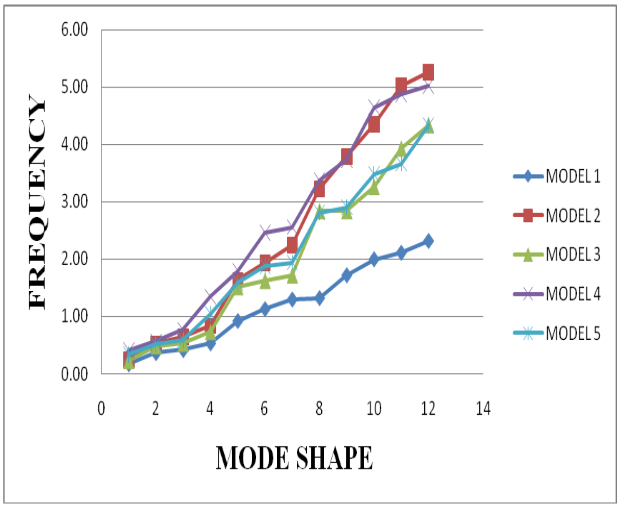
Graph 8: Time Period vs. Modes

The time period of the model 1 is more and found flexible compared to other models. However, model M4 is more rigid and exhibiting lesser time period values



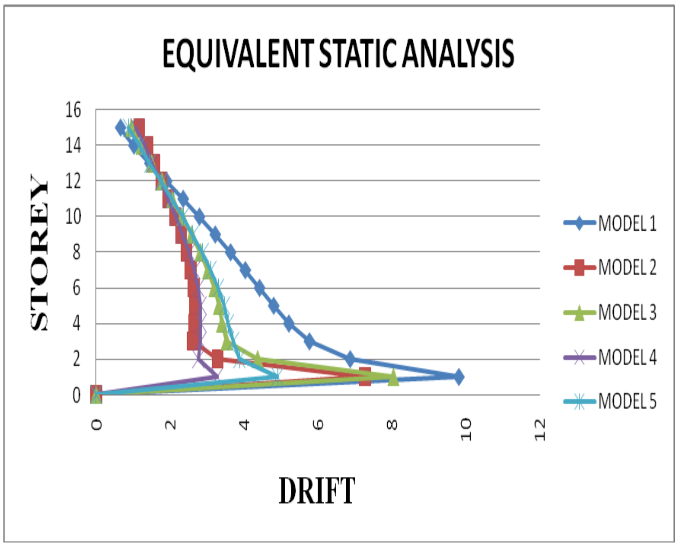
Graph 9: Base Shear_ WINDX

The base shear values are same for all the models. It is due to the fact that, base shear value depends on the amount of wind force applied. Unless seismic force, it won't depend on inertial force and stiffness of the structure.



Graph 10: Frequency vs. Modes

Since, frequency depends on time period and inversely proportional. The frequency value is found maximum in case of model M4 and least in case of model 1.



Graph 11: Drift vs. Storey in X Dir._ WINDX

Drift values are found more in model M1. However, other models possess same drift values

CONCLUSIONS

From the static Analysis, it is found that, the displacement values are higher in case of model M1 with bare frame, however, it is reducing up to 31% and 37% by providing bracings and dampers respectively.

- The drift values are higher for model M1. The drift values are reducing for other models with bracings and dampers. The drift values lesser in models with bracings and dampers located at ends and it is little more in case of drift values at middle.
- The base shear values are similar for almost all the models. However, the base shear of model 2 is more comparatively.
- Based on Time history analysis, the displacement of all the models are almost similar. The models are having very minor variations. Since, the structure is 15 Storeys, the effect of dynamic analysis is also less. Hence no much variation in difference in displacement among other models.
- The drift values are less for all the models and all models are having drift values lesser than limiting.
- The base shear values are higher in case of model 4 and model 2. This is due to fact that, these two models are having higher stiffness. In the time history analysis, the models having more stiffness attract maximum base shear values.
- The effect of displacement is similar for static and wind analysis. The maximum displacement is noticed In model 1. However, it is reducing for bracings and dampers system by 34% and 39.5% respectively.
- The drift values are maximum in case of Model M1. The values are reducing after the introduction of bracing and damper systems. However, dampers and bracings provided at exterior support at exhibiting better results comparatively.
- The base shear values of all the models in wind loading are same. Since, the base shear depends only on applied force in case of wind analysis.

- The modal analysis shows the models 4 is efficient, rigid and higher stiffness compared to other models. The time period value is more in model M1 than other models. And hence lesser stiffness and higher flexibility.
- The frequency of the structure is found maximum in model M4 than other models and model M1 is showing lowest frequency.
- From the overall results it is found that, the dampers provided at exterior end exhibits better performs than all other models. However, the next efficient is the model M2 with bracing at exterior location.
- From the results it also proves that, location of bracings and dampers matters. There is a difference in the results. Even though, the models provided with dampers at middle portion is exhibiting higher Displacement than bracing provided at exterior locations.

Future Scope:
- The Structures can be analysed for further high-rise structure and results can be interpreted
- Different time history files can be compared for better results.
- Pushover analysis can be adopted to assess the localized failures

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