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# Seismic Behaviors of Steel Structure with Bracings and Translational Tuned Mass Damper

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***Abstract*: In this work the dynamic response of steel structure with Bracings and Translational Tuned mass damper (TTMD) are studied. TTMD is a device that consists of a mass which is connected to the structure by means of a spring and a damper. The mass is tuned to vibrate at the different frequency as the structure, which allows it to cancel out the vibrations of the structure. Bracings are added to the structure to provide additional stiffness and strength. G+5, G+15 and G+25 storeyed steel structure models with the different combinations of bracings and TTMD are considered in this study. Following which the FE Analysis involving the modal, equivalent static and response spectrum analysis are performed and results are obtained in terms of Time period, Base Shear, storey displacement and storey drift all are discussed.**

***Keywords*: displacement, equivalent static analysis, modal analysis, response spectrum, time period.**

## 1. Introduction

Earthquakes induce complicated ground vibrations that are converted into dynamic loads which damage buildings and other structures by causing the ground and everything linked to it to oscillate. Civil engineers always try to find better ways to deal with this issue. Traditional methods of system strengthening need more resources and energy. Furthermore, greater seismic forces result from greater masses. Alternate methods, such passive control systems, have shown to be able to minimize the impacts of seismic activity and other dynamic factors on Civil Engineering Structures.

Steel structures perform differently during earthquakes and their behavior changes from being elastic to being inelastic in nature. Steel constructions' strength and stiffness are maintained by releasing a significant amount of energy during seismic effects. More emphasis should be placed on improving the structure's stiffness than its strength. The basic way to enhance stiffness is to install certain mechanisms that can withstand lateral loads. Moment resistant frames along with bracing systems efficiently improve the structure's rigidity. However, these systems limit the flexibility of the structure.

## 2. Objectives of the Project

1) To study the dynamic response of steel structure with bracings and tuned mass dampers.
2) To design the translational tuned mass dampers.
3) FE analysis involving modal, equivalent static and response spectrum analyses to be performed on steel structure with different bracing systems and translational tuned mass dampers.

## 3. Methodology

1) Detailed literature review is carried out on the seismic response of steel structure with different types of bracing and tuned mass damper.
2) Three types of Bracings consider for the study are namely X, V and Inverted V bracings.
3) The Design of translational tuned mass damper are carried out as per procedure adopted in Connor J and Laflamme S. (2014).
4) FE Analyses performed on G+5, G+15, G+25 Storey steel structure with three different types of bracings and Translational tuned mass damper to obtain Time period, Base shear, Storey displacement and Storey drift.

## 4. Modelling

Table 1
Nomenclature and description of the models

| Models | Nomenclature |
|---|---|
| BFS (G+5) | BF5 |
| BFS (G+5) + X-Bracing | X5 |
| BFS (G+5) + V-Bracing | V5 |
| BF5+Inverted V-Bracing | IV5 |
| BF5+Translational TMD | TD5 |
| X5 +Translational TMD | TDX15 |
| V5 +Translational TMD | TDV15 |
| IV5 +Translational TMD | TDIV15 |
| BFS (G+15) | BF15 |
| BFS (G+15) + X-Bracing | X15 |
| BFS (G+15) + V-Bracing | V15 |
| BF15+Inverted V-Bracing | IV15 |
| BF15+Translational TMD | TD15 |
| X15 +Translational TMD | TDX15 |
| V15 +Translational TMD | TDV15 |
| IV15 +Translational TMD | TDIV15 |
| BFS (G+25) | BF25 |
| BFS (G+25) + X-Bracing | X25 |
| BFS (G+25) + V-Bracing | V25 |
| BF25+Inverted V-Bracing | IV25 |
| BF25+Translational TMD | TD25 |
| X25 +Translational TMD | TDX25 |
| V25 +Translational TMD | TDV25 |
| IV25 +Translational TMD | TDIV25 |

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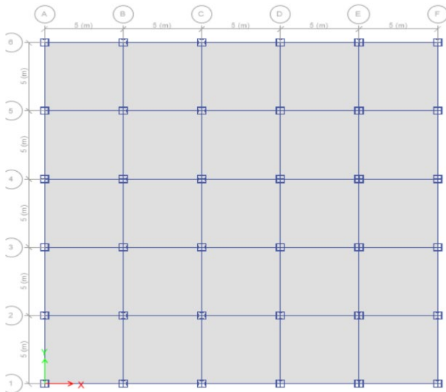
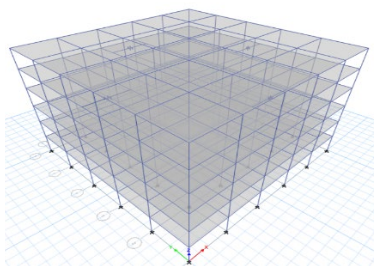
In the modelling a G+5, G+15, G+25 Storey steel structure modelling has been discussed Nomenclature and description of the model as shown in Table 1.

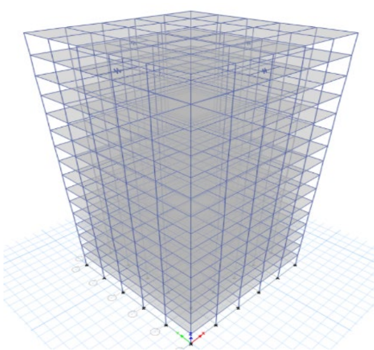
The below figure shows the creation of FE Modals.



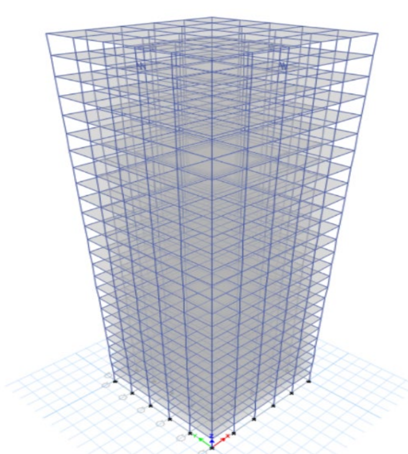
Plan of BF5, 15, 25



G+5 Storey



G+15 Storey



G+25 Storey

Fig. 2. Plan and 3D View of Bare Frame Structure model (BFS)

The below table shows the FE modal creation data.

Table 2
Structural configuration

| Description | Data |
|---|---|
| Number of storeys | G+5, G+15, G+25 |
| Seismic Zone | V |
| Seismic Zone Factor (Z) | 0.36 |
| Importance Factor (I) | 1.5 |
| Response Reduction Factor (R) | 4.0 |
| Damping Ratio | 0.05 |
| Soil Type | Medium Soil (Type II) |
| Span Length | 5m |
| Column Size used | ISMB600@122.6 Kg/m |
| Beam Size used | ISMB500@86.9 Kg/m |
| Thickness of Slab | 125mm |
| Floor Finish Load | 1.5KN/m² |
| Live Load | 3KN/m² |
| Story to story Height | 3.0m |
| Bottom story Height | 3.0m |
| Grade of Concrete ($f_{ck}$) | M25 |
| Grade of Structural Steel ($f_{ys}$) | Fe345 |
| Grade of Reinforcing Steel ($f_{yr}$) | Fe 500 |
| Load Combination | 1.5 (DL+LL)<br>1.2 (DL+LL$\pm$ EQ)<br>0.9DL $\pm$ 1.5EQ |

## 5. Results and Discussions

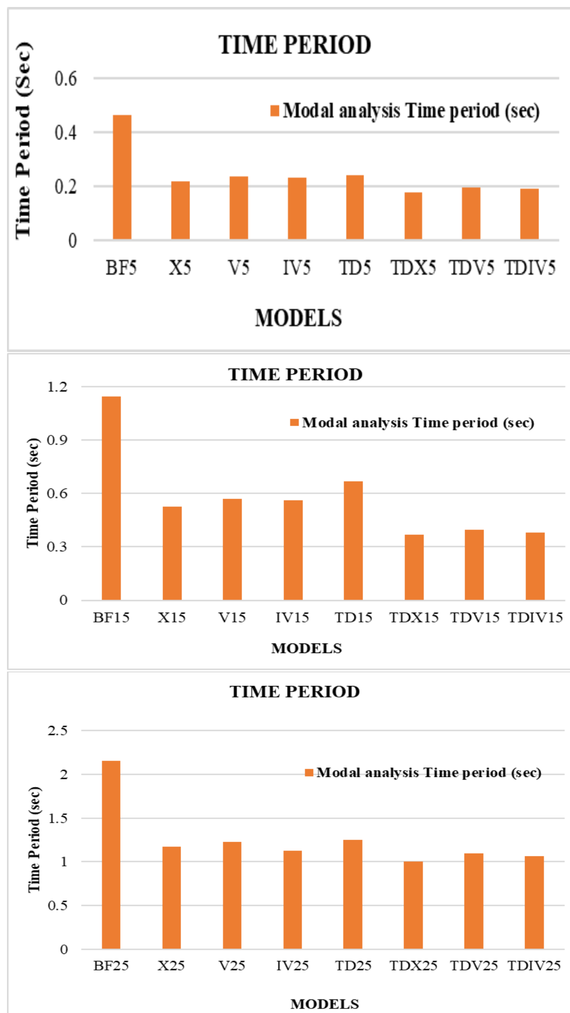



Fig. 3. Time period

1) The Time Period increases as the height of structure increases due to an increase in mass for all the models.
2) The Time Period is lowest in X-Bracings followed by IV-Bracings and V-Bracings for all the floor height due to the increase in stiffness by X-Bracings.
3) Excluding the Bare frame condition TDX is having the lowest Time Period due to the increase in stiffness by TDX and V-Bracing is having the highest Time Period for all the floor height due to the less stiffness in V-Bracing, when compare with all the models.

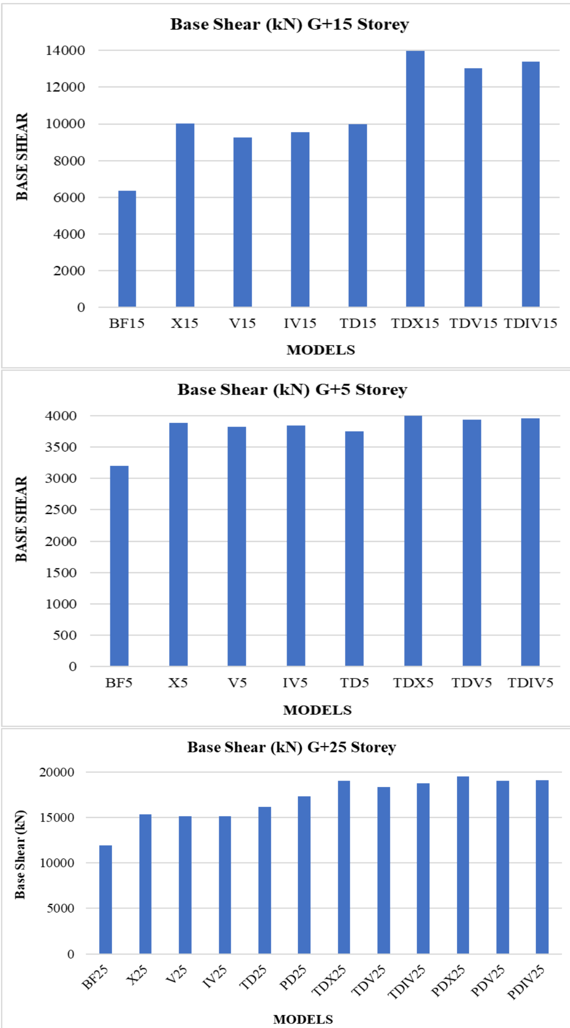



Fig. 4. Dynamic base shear

1) As height of the structure increases, Base Shear increases due to increase in self-weight of the structure for all the models.
2) The Base Shear is highest in X-Bracings followed by IV-Bracings and V-Bracings for all the floor height due to the increase in stiffness by X-Bracings.
3) Excluding the Bare frame condition TDX is having the highest Base Shear due to the increase in stiffness by TDX and V-Bracing is having the least Base Shear for all the floor height due to the lower stiffness in V-Bracing, when compare with all the models.

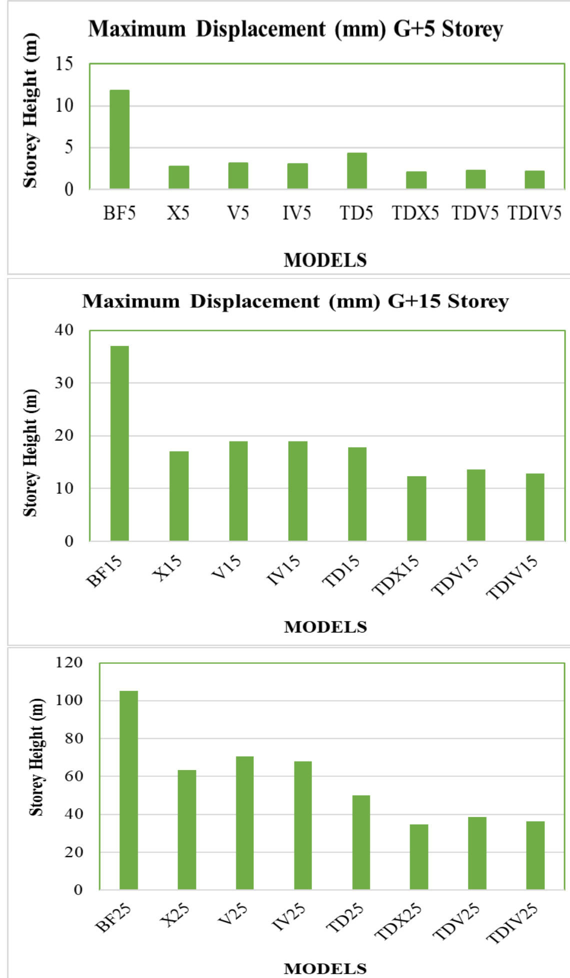
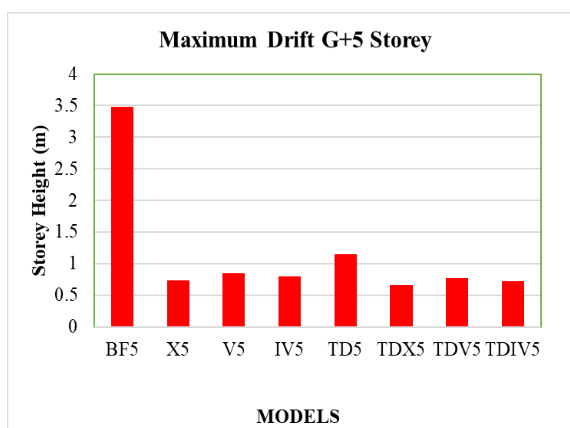



Fig. 5. Maximum storey displacement

1) The Displacement is lowest in X-Bracings followed by IV-Bracings and V-Bracings for all the floor height due to the increase in stiffness by X-Bracings.
2) Excluding the Bare frame condition TDX is having the lowest Displacement due to the increase in stiffness by TDX and V-Bracing is having the highest Displacement for all the floor height due to the lower stiffness in V-Bracing, when compare with all the models.



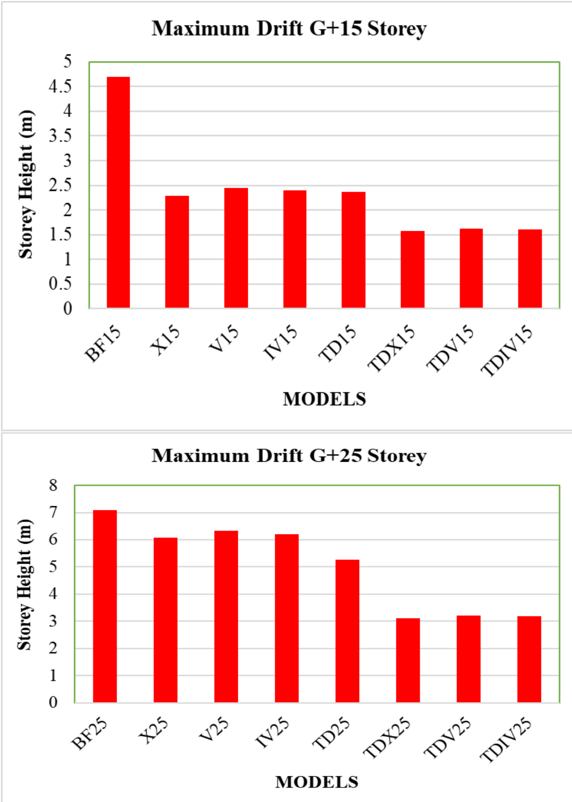



Fig. 5. Maximum storey drift

1) The Drift is lowest in X-Bracings followed by IV-Bracings and V-Bracings for all the floor height due to the increase in stiffness by X-Bracings.
2) Excluding the Bare frame condition TDX is having the lowest Drift due to the increase in stiffness by TDX and V-Bracing is having the highest Drift for all the floor height due to the lower stiffness in V-Bracing, when compare with all the models.

## 6. Conclusion

TDX is having the lowest Time period, Drift, Displacement and highest Base shear due to the increase in stiffness by TDX and V-Bracing is having the highest Time period, Drift, Displacement and lowest Base shear for all the models due to the lower stiffness, when compare with all the models.

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