Analysis of A Tall Structure Considering Two Different Type of Dampers Using Analysis Tool

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ABSTRACT

Vibrations are one of the major environmental factors that act on buildings and mechanical structures, potentially reducing their lifetime. Current trends in construction industry demand taller and lighter structures with more flexibility, yet they have a quite low damping value. This increases failure possibilities and also create problems from serviceability point of view. Many building structure and bridges fall because of vibration, if frequency of excitation coincide with one of the natural frequency of system. Now-adays several techniques are available to minimize vibrations of a structure. Out of these, concept of using tuned mass damper is a recent trending innovation.

This study is conducted to research the effectiveness of using tuned mass damper for controlling vibration of a structure. The report proposes a comparative analysis of passive vibration control system with inclined damper system and tuned damper system in G+15 structure where the modelling and analysis was done using ETABS.

Keywords : Vibration control, Tuned mass damper (TMD), High rise buildings, Structural design, Structural Analysis, Tuned Dampers.

I. INTRODUCTION

Structural passive control systems primarily include energy dissipation devices. Damping is an impact inside or upon an oscillatory framework that has the impact of lessening, limiting or keeping its oscillations. In physical frameworks, damping is created by procedures that separate the intensity put away in the oscillation. Seismic earthquake in the least complex terms can be characterized as Shaking and vibration at the outside of the earth coming about because of underground development along a flat plane. The vibrations created by the tremors are because of seismic waves. Seismic waves are the saddest one. The recent development in the application of passive energy absorption systems for seismic resistance of structure. Multi-storey scale model building structures are tested in shaking table, it subjected to controlled semi-active fluid damper control system. Viscous damper, visco-elastic damper and steel damper are the seismic effect of 8-story RC building seismic energy dissipation device application in China. High capacity friction dampers are installed in tall structures based on rotational friction concept. The frictional dampers are resists the seismic response in single-story structures. Based on complex damper theory to determine the seismic response by viscous damper. Seismic vibration can control to use fluid viscous dampers is desired to control the shock vibration. The mathematically modeling of viscous damper and dynamic analysis. The preservation and application of any structure are in this manner endangered with the expanding rise. According to the standard codes, a structure that can oppose the most elevated shaking that could happen in that specific zone can be called as a quake-safe structure. Be that as it may, the most effective method for planning a trembling safe structure is limit the passing's just as limit the decimation of the usefulness of the basic component. From the past and few present records, the world has encountered a number of destroying seismic earthquakes, causing in the number of increment the loss of individual because of basic crumple and extreme harms to structure.

Types of Seismic Dampers

Damper systems are designed and manufactured to protect structural integrities, control structural damages, and to prevent injuries to the residents by absorbing seismic energy and reducing deformations in the structure. Seismic dampers permit the structure to resist severe input energy and reduce harmful deflections, forces and accelerations to structures and occupants. There are several types of seismic dampers namely viscous damper, friction damper, yielding damper, magnetic damper, and tuned mass damper.

Viscous Dampers

In viscous dampers, seismic energy is absorbed by silicone-based fluid passing between piston-cylinder arrangement. Viscous dampers are used in high-rise buildings in seismic areas. It can operate over an ambient temperature ranging from 40°C to 70°C. Viscous damper reduces the vibrations induced by both strong wind and earthquake.

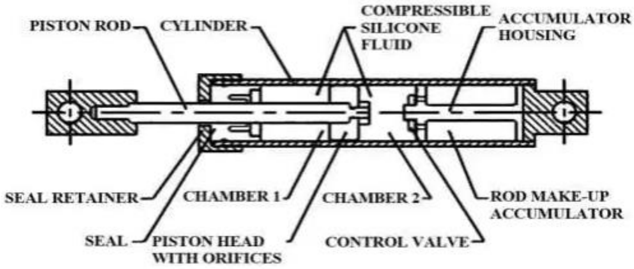


Fig 1 Schematic Detailing of Viscous Damper Components

Viscoelastic Dampers

Another type of damper is viscoelastic dampers that stretch an elastomer in combination with metal parts. This type of damper dissipates the building's mechanical energy by converting it into heat. Several factors such as ambient temperature and the loading frequency affect the performance and consequently the effectiveness of the damper system. Viscoelastic dampers have been successfully incorporated in a number of tall buildings as a viable energy dissipating system to suppress wind-and earthquake-induced motion of building structures.

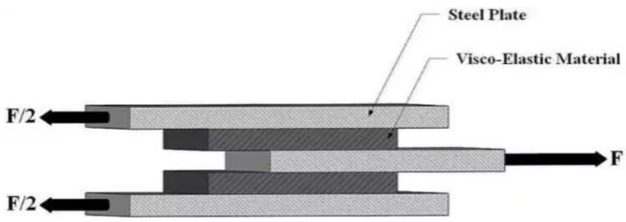


Fig 2 Viscoelastic Damper

Fig 3 Installed Viscoelastic Damper

Friction Dampers

Generally, a friction damper device consists of several steel plates sliding against each other in opposite directions. The steel plates are separated by shims of friction pad material. The damper dissipates energy by means of friction between the surfaces which are rubbing against each other. It is also possible to manufacture surfaces from materials other than steel.

Fig 4 Friction Damper

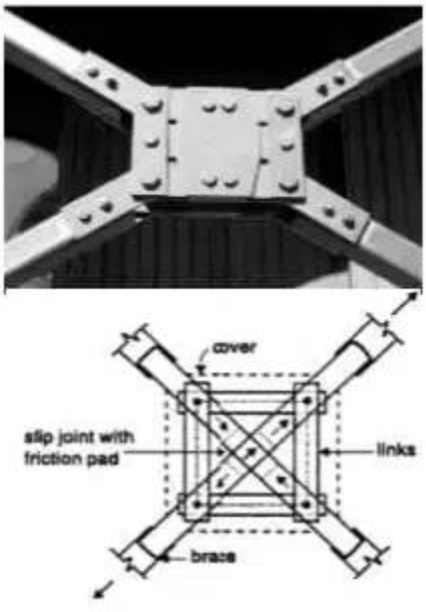


Fig 5 Friction Damper Working Mechanism

Tuned Mass Damper (TMD)

Tuned Mass Damper (TMD), also known as vibration absorbers or vibration dampers, is a passive control device mounted to a specific location in a structure so as to reduce the amplitude of vibration to an acceptable level whenever a strong lateral force such as an earthquake or high winds hit. The application of tuned mass damper can prevent discomfort, damage, or outright structural failure. They are frequently used in power transmission, automobiles and tall buildings.

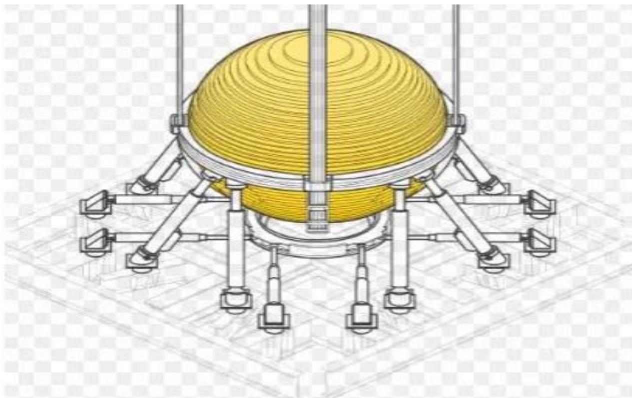


Fig 6 Tuned Mass Damper

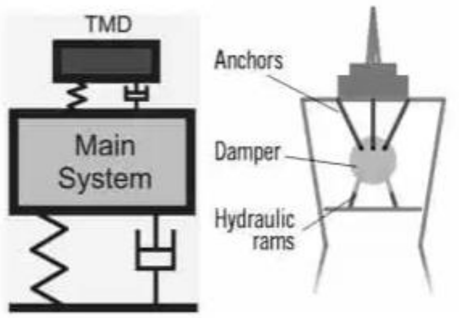


Fig 7 Working Mechanism of Tuned Mass Damper

Yielding Dampers

Yielding damper or metallic yielding energy dissipation device or passive energy dissipation device is manufactured from easily yielded metal or alloy material. It dissipates energy through its plastic deformation (yielding of the metallic device) which converts vibratory energy and consequently declines the damage to the primary structural elements.

yielding dampers are economical, effective, and proved to be a good energy dissipator.

Fig 8 Metallic Yielding Damper Installed in Multistory Building

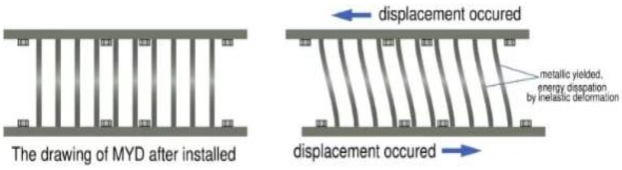


Fig 9 Working Mechanism of Yielding Damper

Magnetic Dampers

Magnetic Damper consists of two racks, two pinions, a copper disk and rare-earth magnets. This type of damper is neither expensive nor dependent on temperature. Magnetic damping is not strength that is why it is effective in dynamic vibration absorbers which require less damping.

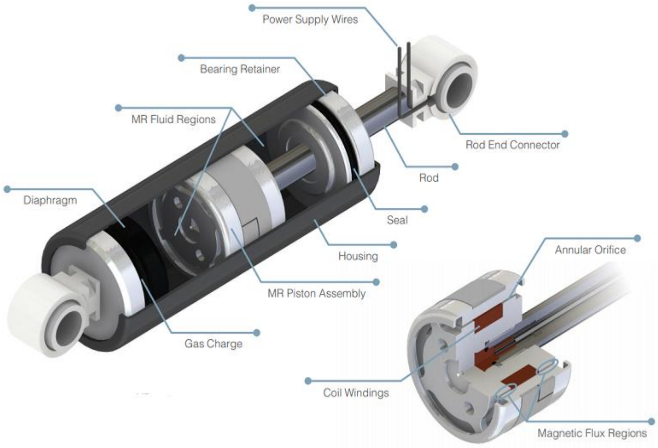


Fig 10 Magnetic Damper

II. Objectives of the research

The main objective of this work is to find out the effect of tuned mass damper and metallic yielding damper of a multi-story building with different bay sizes. Some other objectives of study are as follows:-

- To study the comparison of performance of Tuned Mass Damper and metallic yielding damper using public work as a reference and understand the behavior aspect.
- To do a literature review that covers different forms of tuned mass dampers as well as the behavior of systems that use tuned mass dampers.
- To do a literature review that covers different forms of metallic yielding damper as well as the behavior of systems that use metallic yielding damper tuned.
- To study the comparison of performance of building with and without damper using different bay size of structure.

III. LITERATURE REVIEW

Daniel C et al (2019) research paper conducted dynamic analysis for 5 Storey RC Structure with various seismic intensities using analytical application SAP 2000 for the purpose of modelling and analysis. Six ground acceleration for various intensities on MMI Scale to relate seismic response and seismic intensities.

The time history method for static and dynamic values, the scale factor fixed from the various Time histories the base shear obtained has decreased to the percentage of 50 for X-axis and 61.3 for Y-axis. The Roof displacement with VFD in X-axis decreased to a percentage of 50.65 and in Y-axis 51.35. There was a slight difference in the shear value when the damper was attached. When eventually introducing viscous dampers to the building, its behaviour was different under the earthquake force observed from the results.

Sunitha V et al (2019) research paper investigated the effectiveness of different bracing systems on the structural performance of buildings. 10 storied commercial RC building was designed and analyzed under lateral loading. The structural performance of the RC building was investigated using different types of bracing system such as crossed bracing, V-type bracing, and eccentric bracing and a comparative study were done on story displacement, story drift and storey shear.

Results stated that cross diagonally braced structure shows better structural performance among all the structures considered here under similar circumstances, and then compared with X bracing RC building with friction damper. Hence, the conclusion stated that the displacement of RC building with X Bracing and friction damper decreases by 63% compared to RC building with X bracing and story drift is decreased by 70%. Base shear also increases by 20% using building with X bracing and damper.

Yogesha A V and Dr. Jagadish G. Kori (2018) research paper was concerned with the comparative analysis of symmetrical and unsymmetrical building using different dampers like Fluid viscous and Visco-elastic dampers. Using codal provisions IS 1893 (Part I): 2002, the structures are analyzed by Equivalent static and Response spectrum method. The modeling and analysis was done with using software ETAB 2016, results that is seismic parameters such as displacement, storey drifts and storey shear was tabulated and comparative study of structure with and without dampers and combination of Fluid viscous and Visco-elastic dampers was performed.

Using fluid viscous dampers in equivalent static and response spectrum method of analysis the displacement, storey drift and Storey shear reduce 40 to 50 % in the both symmetrical and unsymmetrical building model as compared to building without dampers. Using the combination of two different dampers also reduces Displacement, storey drift and Storey shearup to 35 to 45 % in both symmetrical and unsymmetrical building as compare to building without damper. The performance of fluid viscous, visco-elastic and combination of two different dampers is much better for the tall buildings with slender design. Hence, results concluded that the fluid viscous dampers can be effectively used as one of the better alternatives for the conventional ductility based design methods of earthquake resistant design of structures.

Javed Shaikh and Girish Joshi (2016) research paper described the seismic and wind analysis of an R.C.C high rise structure with added viscoelastic dampers. The primary objective of the research was to perform quasi-static analysis according to response spectrum curves and wind analysis with and without the use of viscoelastic damper where the modeling of viscoelastic damper was done in ETABS software and results were valuated in terms of storey displacement, storey drift, storey acceleration and accessed the variation of placement of dampers affect the seismic response of the building.

Results stated that response of the structure can be greatly reduced by using viscoelastic dampers. Properties of dampers i.e stiffness and damping coefficient are highly sensitive to temperature changes but comparatively less sensitive to frequency change. The best suited position for damper placement is at the point of maximum inter-storey drift than at the point of maximum absolute displacement. The base shear of the structure reduces considerably by using viscoelastic dampers. Instead of providing dampers to all over the structure,one can obtain overall reduction in the displacement of the structure by providing dampers at point of maximum inter-storey drift.

IV. Methodology

Step 1: numerous research papers were reviewed which used different damping system for passive control as structural stability.

Step 2: Defining the grid system as per ETABS in x and y direction and preparing the plan of the structure.

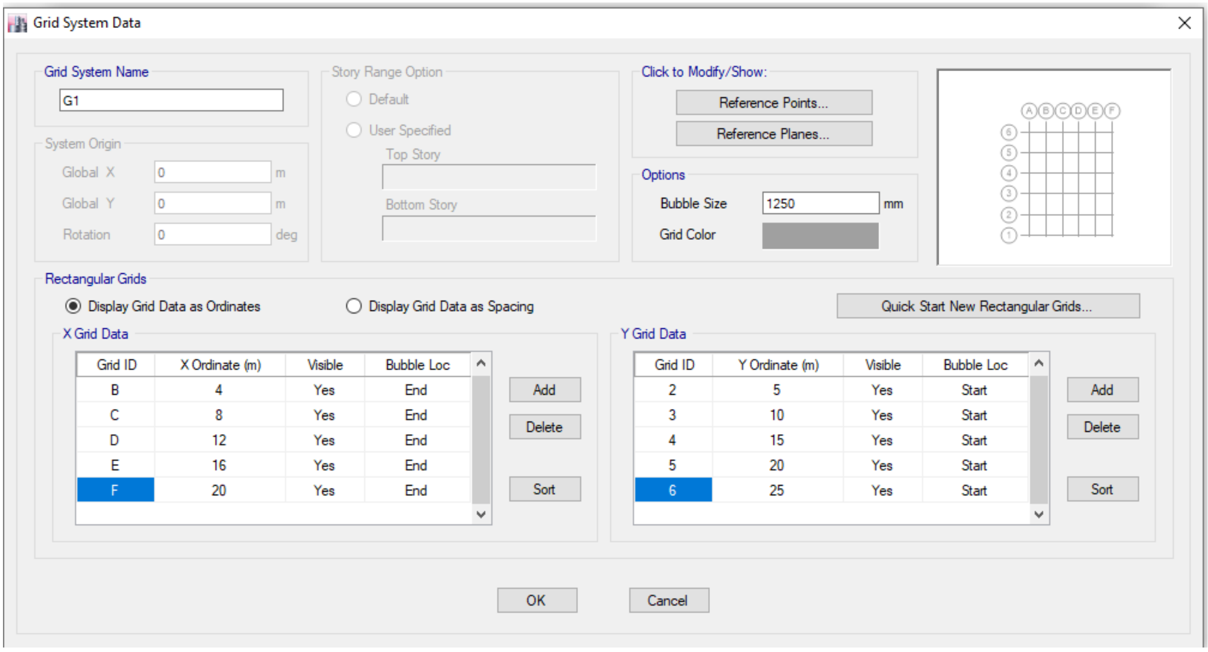


Fig 11 Defining Grid Data System

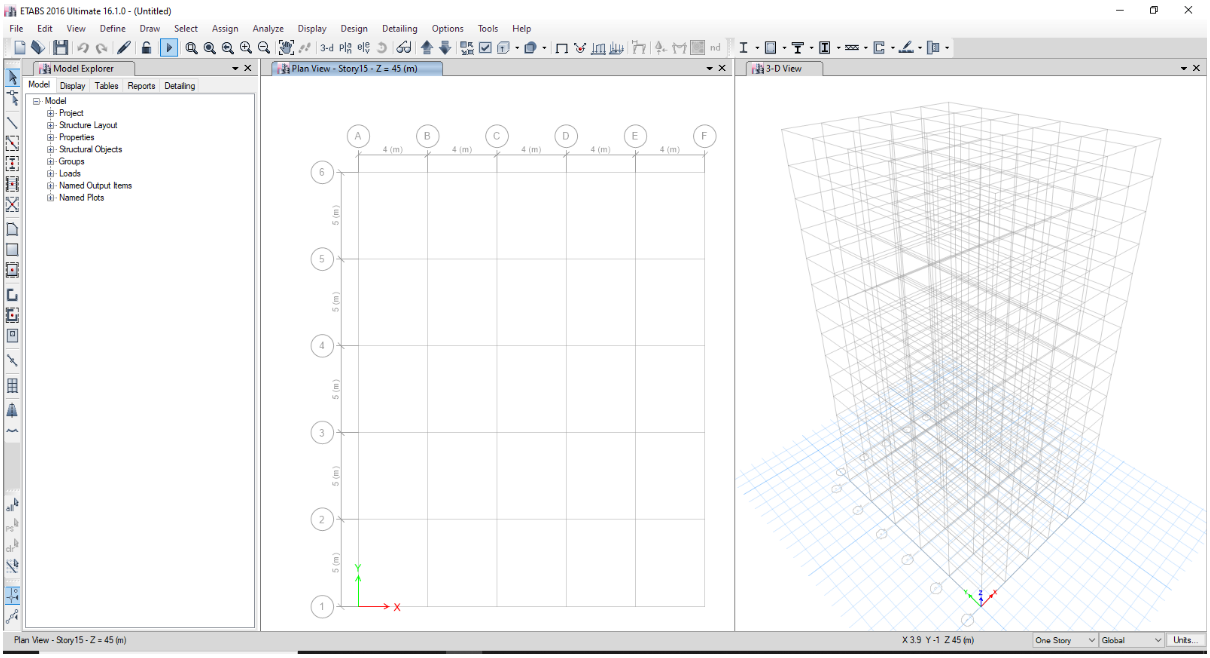


Fig 12 Plan of the structure

Step 3: Defining material properties of column, beam and slabs.

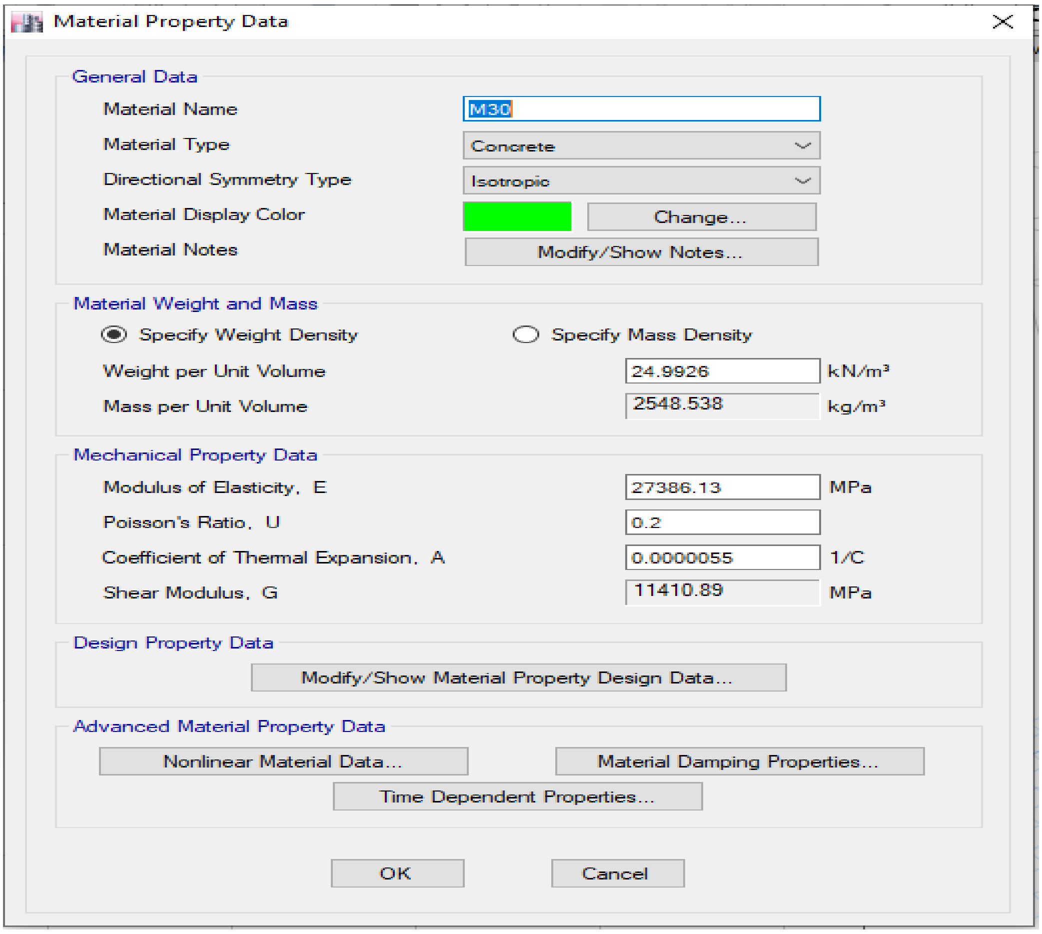
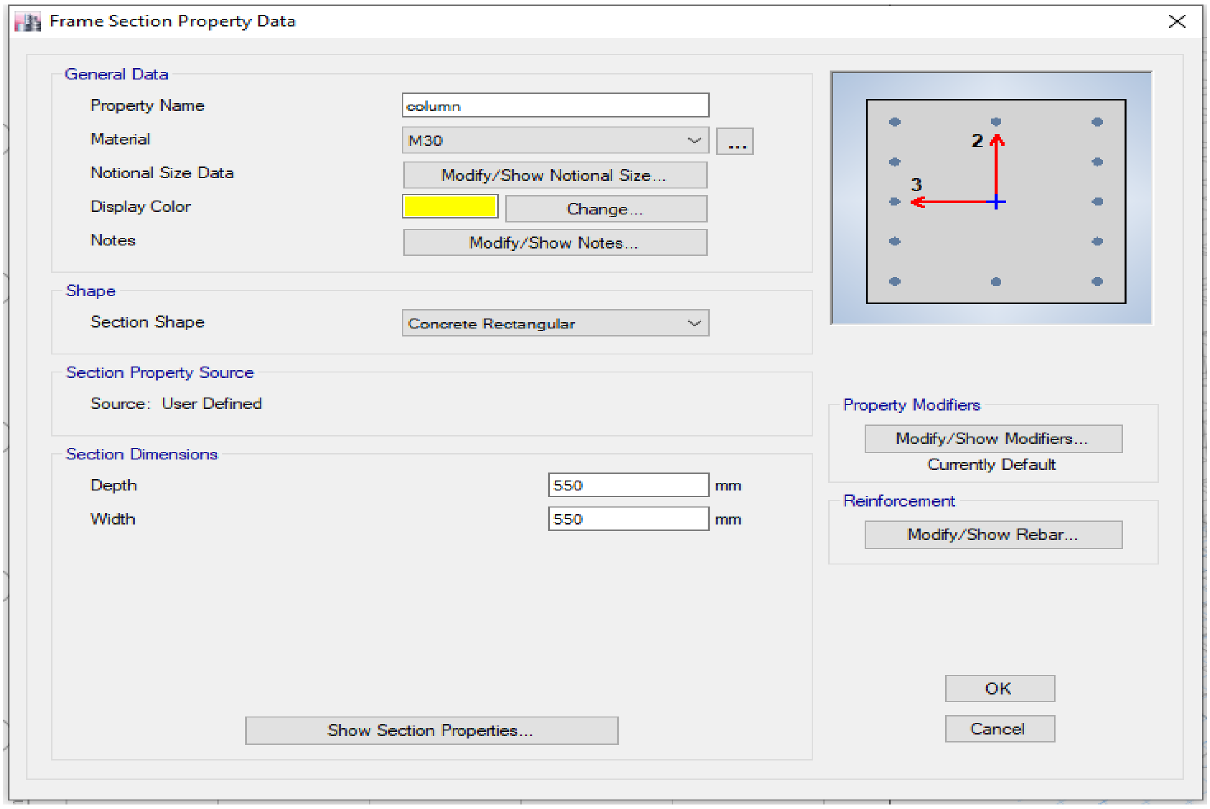


Fig 13: Material Properties

Step 4 Defining sections properties for the size of column, beams and slab.



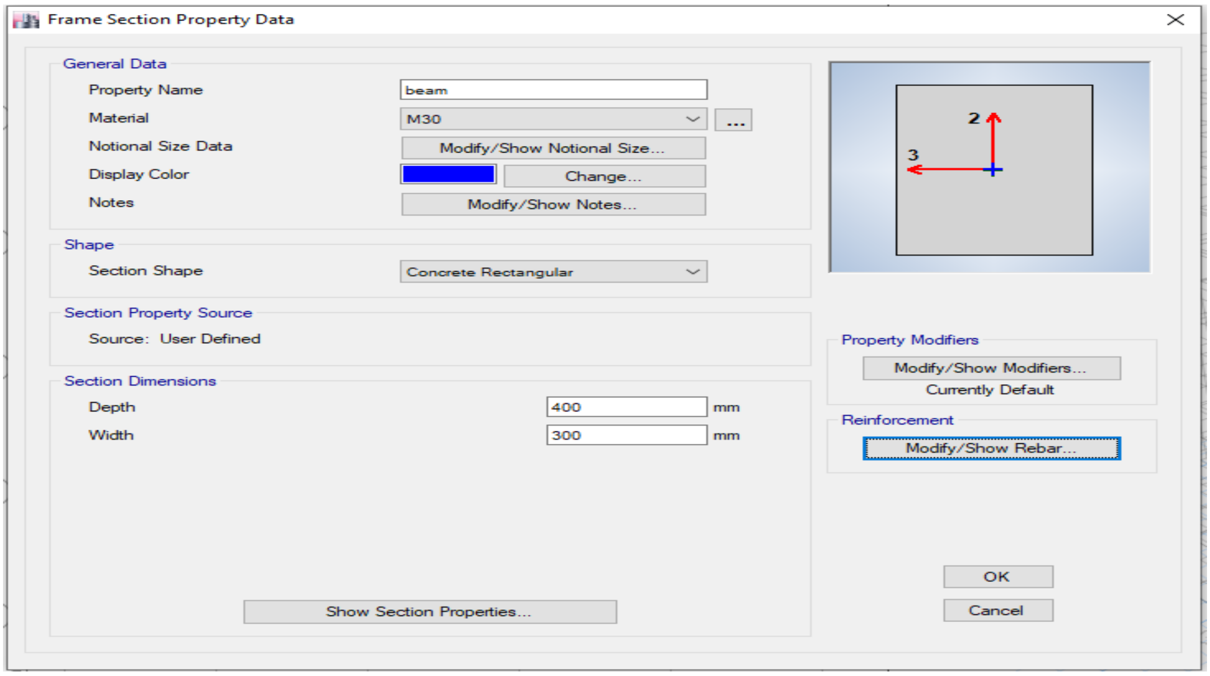


Fig 14: Defining section properties of beam and column.

Step 5 Defining the two cases with structure using two different dampers

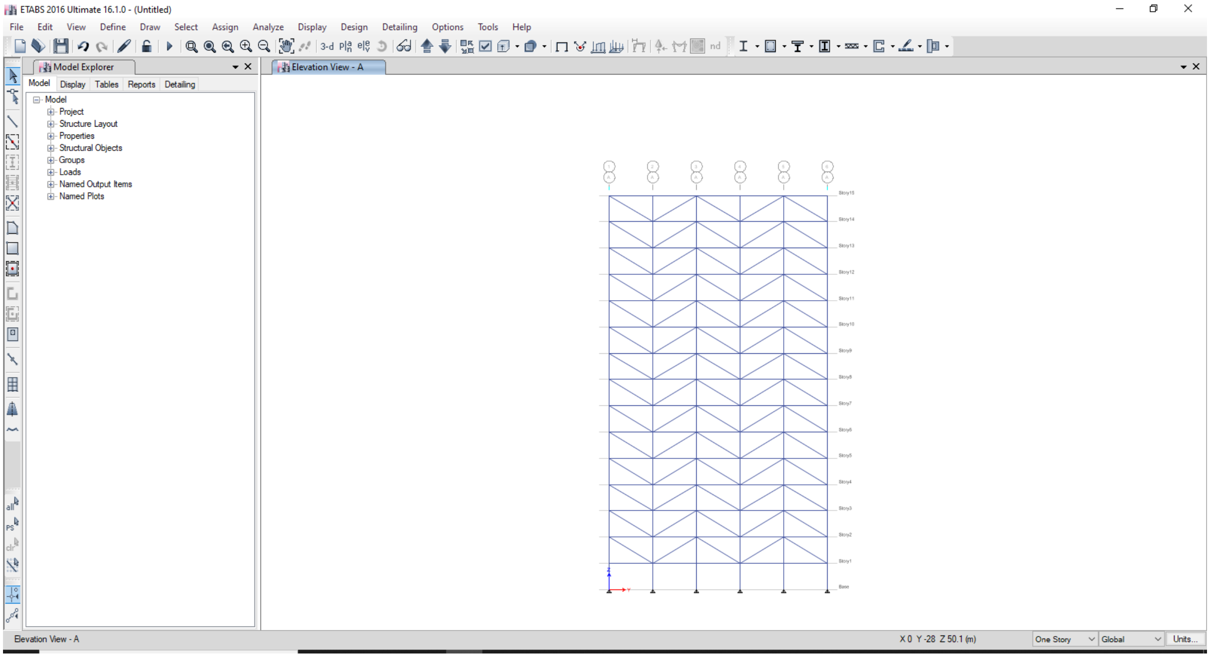


Fig 15 Case I Tuned Mass Damper

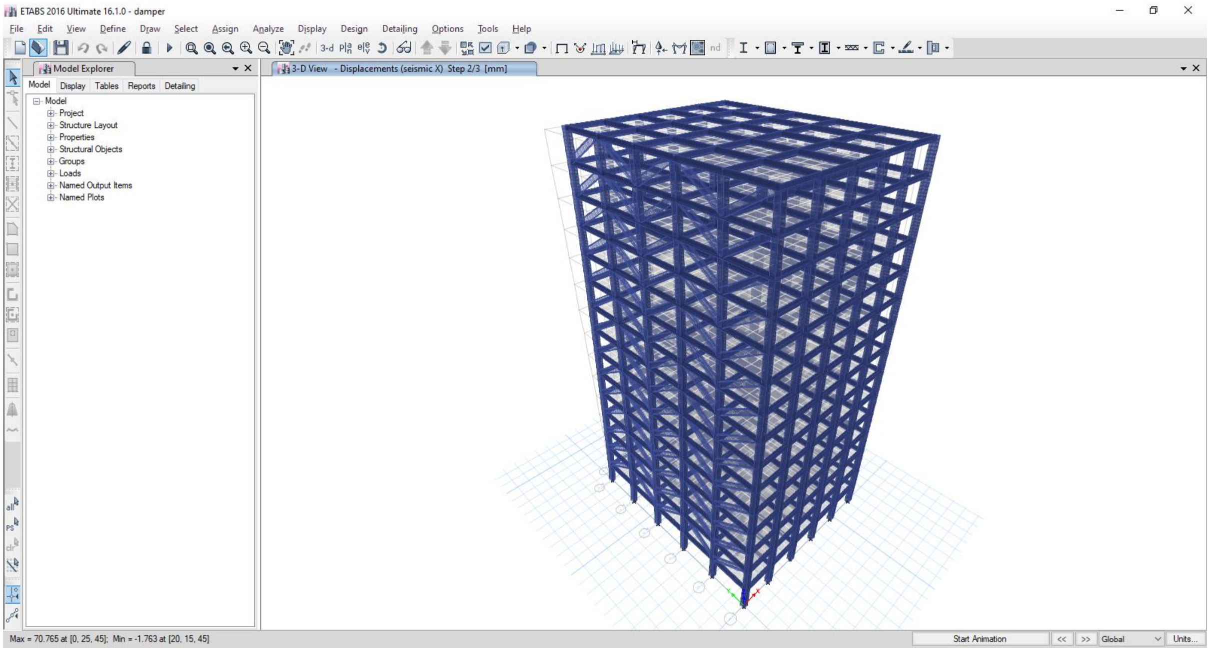


Fig 16 Case II Yielding Damper

Step 6: Defining Loading condition on the structure

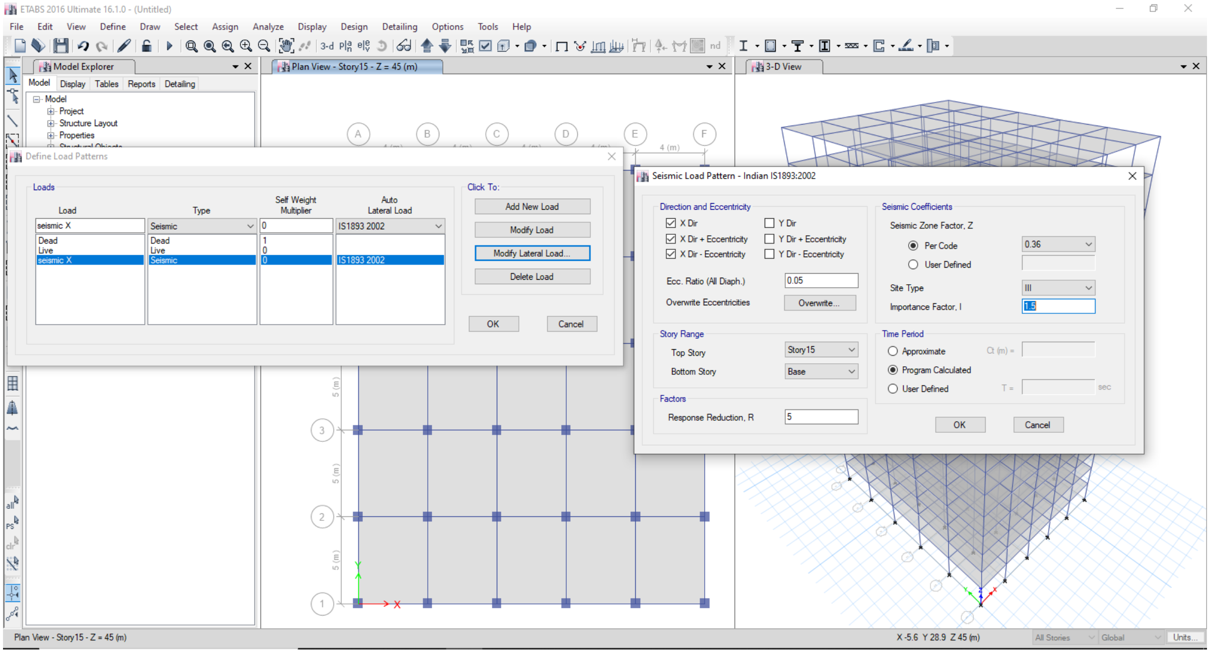


Fig17: Load combinations

Step 7 Defining Properties of Mass Tuned Damper

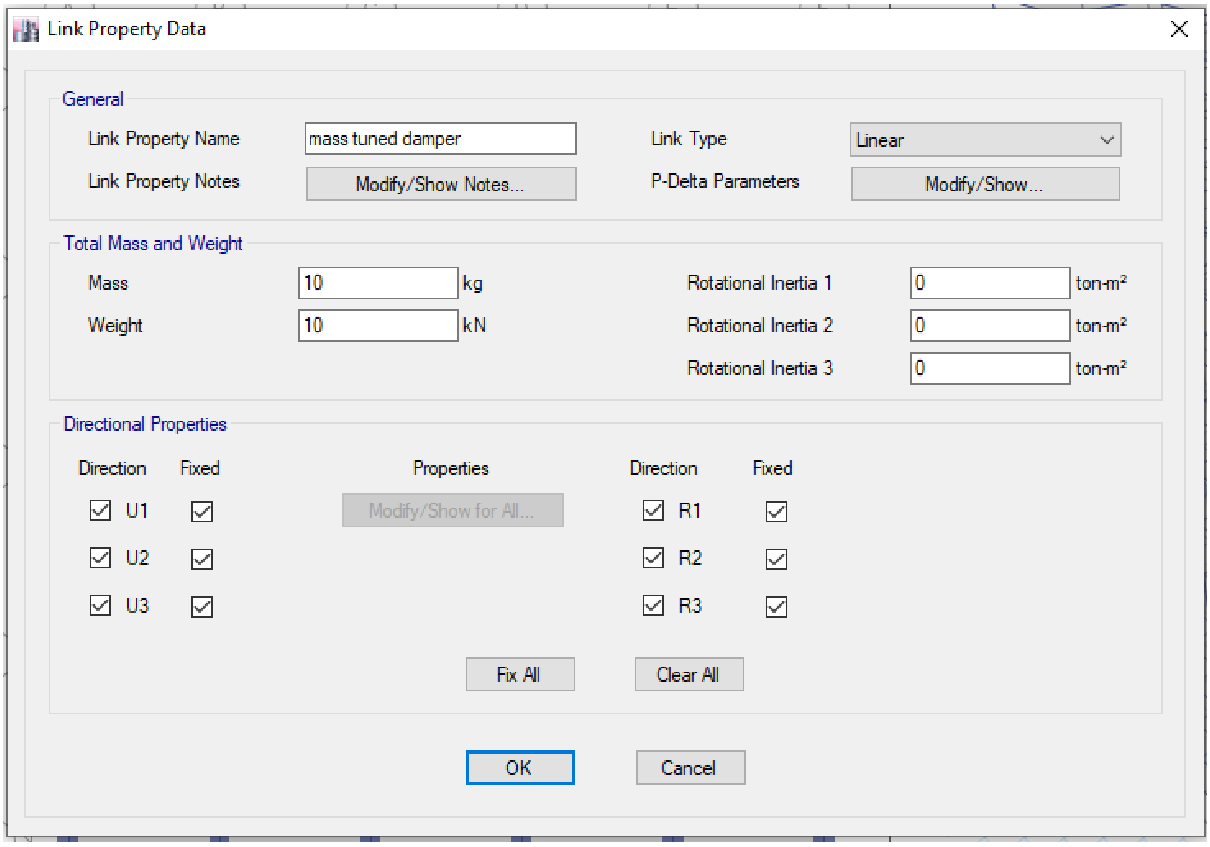


Fig 18:Properties of Mass Tuned Damper

Step 8 Analysing the structure on states of displacement, drift and stiffness

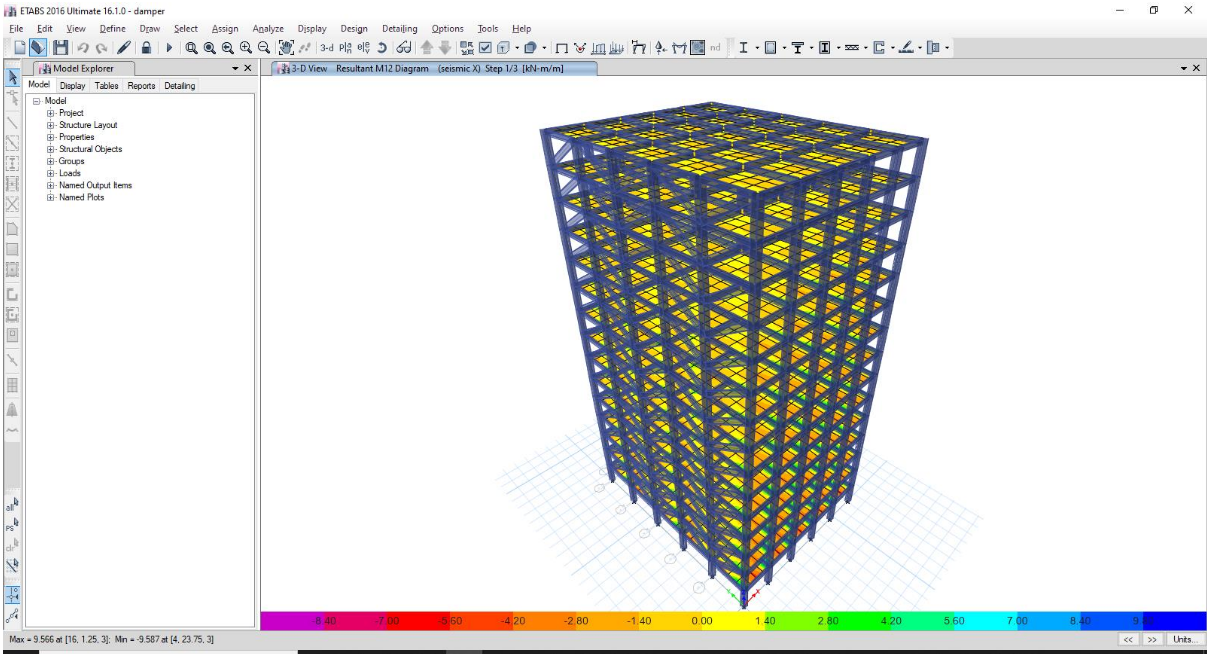


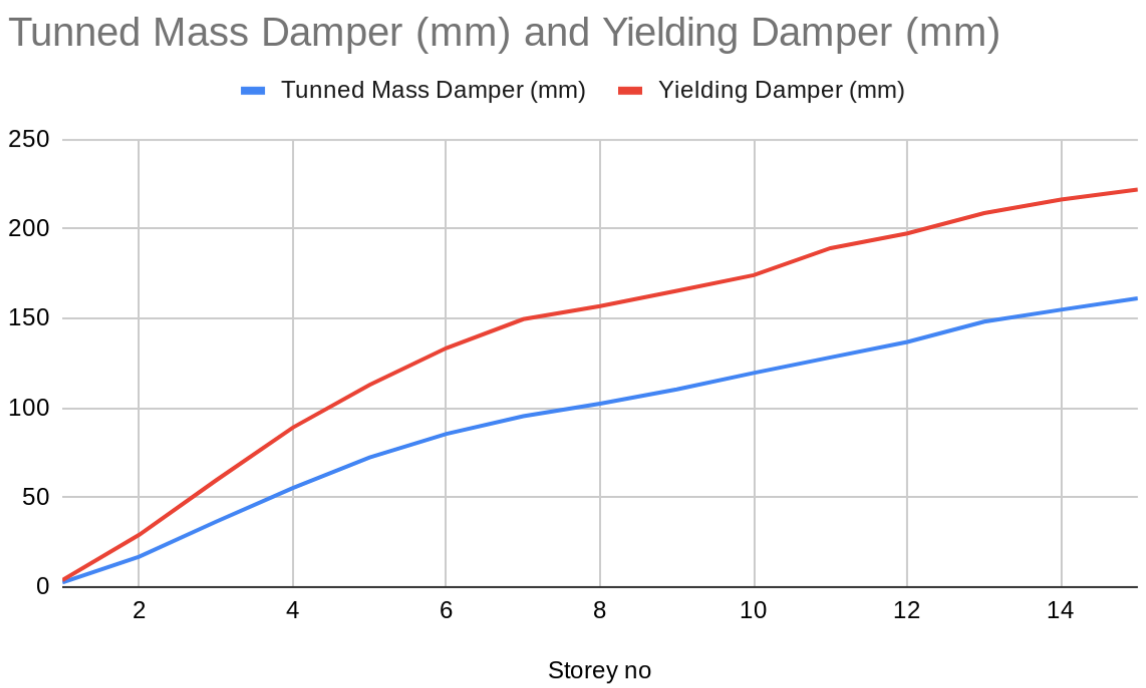
Fig 19: Values of Displacement

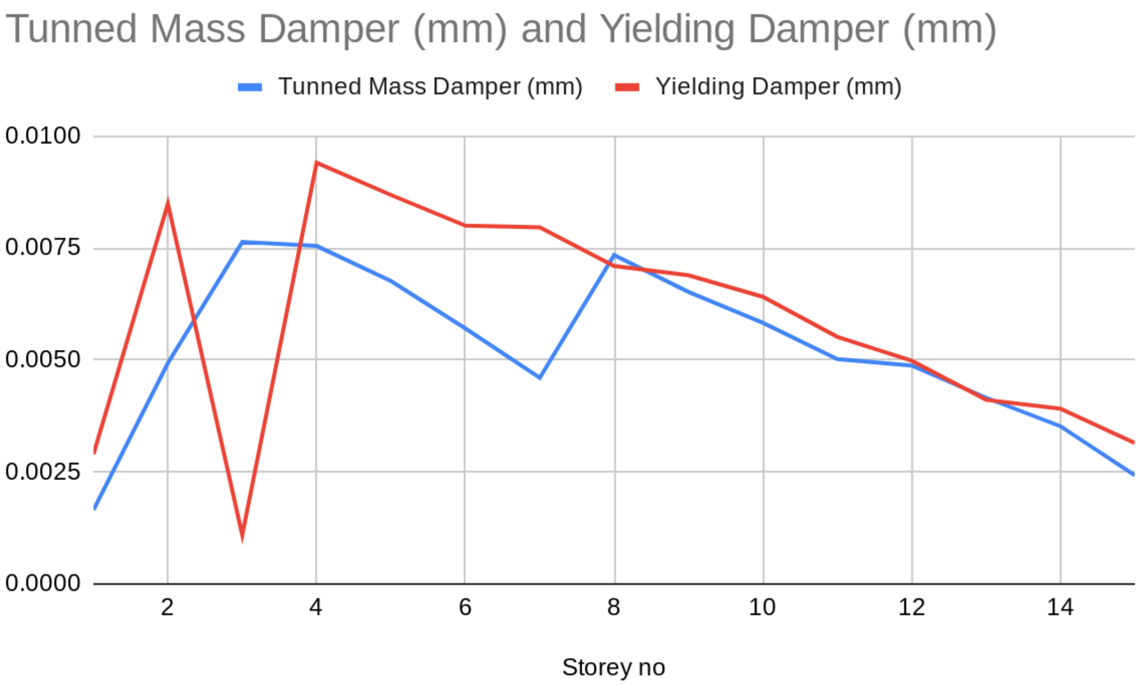
Table 1: geometrical data

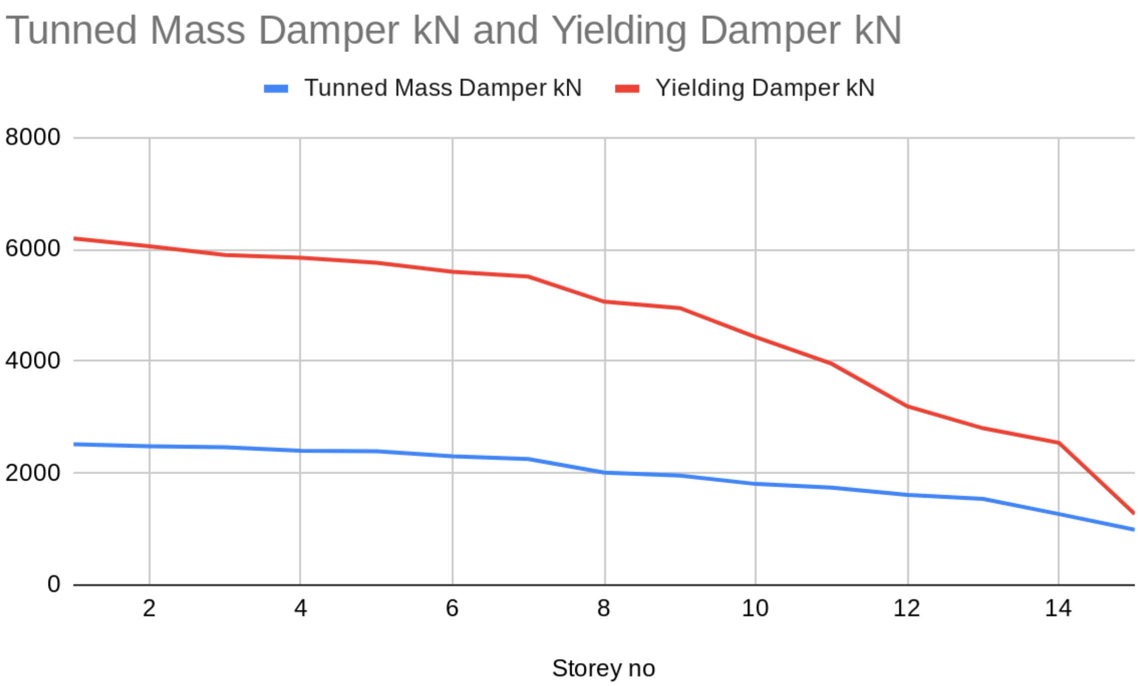
S.no	Specifications	Size
1	Plan Size (X x Y)	18m x 18m
2	Two bay size	6m x 6m
3	Floor to floor height (m)	3.0m
4	Total Height of Building G+15	48.0m
5	Types of structure	SMRF
6	Size of beam	0.4m x 0.3m
7	Size of column	0.5m x 0.5m
8	Wall thickness	0.2m
9	Thickness of slab	0.150m
10	Grade of concrete and steel	M30, Fe415
11	Types of soil(as per IS1893(part 1): 2002	Type II Medium rocky soil
12	Response Reduction Factor (R)	5
13	Importance Factor	1
14	Seismic Zone Factor	0.36 (Zone V)

15	Load Combination	According to IS:1893 (part 1) : 2002
	Dead Load	Calculated as per Self Weight
	Live Load	3 KN/m2
	Seismic Load	As per IS 1893 (part I):2002
	Floor Finish	KN/m2

V. ANALYSIS AND RESULTS




Tunned Mass Damper (mm) and Yielding Damper (mm)
Tunned Mass Damper (mm)
Yielding Damper (mm)
0.0100
0.0075
0.0050
0.0025
0.0000
2
4
6
8
10
12
14
Storey no


Tunned Mass Damper kN and Yielding Damper kN
Tunned Mass Damper kN
Yielding Damper kN
8000
6000
4000
2000
0
2
4
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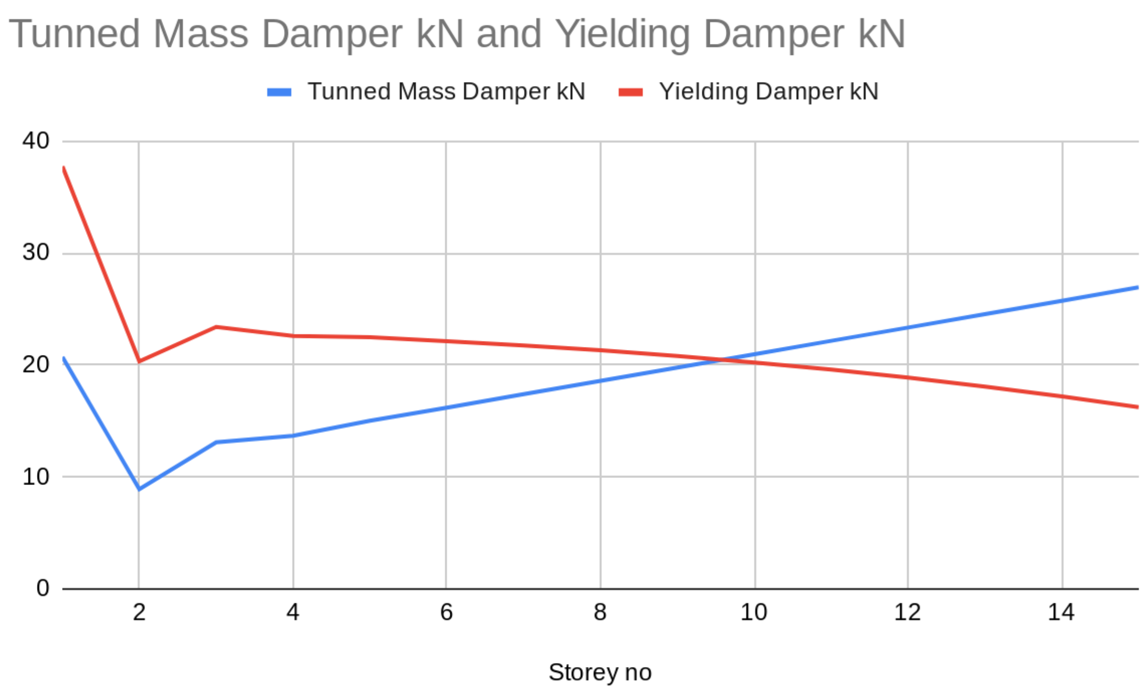
8
10
12
14
Storey no



VI. CONCLUSION

Maximum Displacement

Both Yielding dampers and Tuned mass Damper are effective way to provide passive control in reducing the forces acting on strcuture. Here the results showed that Tuned mass damper was 37% more effective in comparison to yielding dampers as maximum vertical forces were seen in case II.

Maximum Storey Drift

Storey drift is the difference between the lateral displacements of two adjacent floors of the surface is called storey drift. In this analysis the time history method has been used. The storey drift values follow the code IS 1893-2016 clause 7.11.1 for storey drift limitations. Storey Drift was minimum in case I with tuned mass damper when compared to yielding damper where reduction of 13% was seen in the results.

Maximum Storey Shear

Storey shear is friction force from the total dead load and live load acting at the every floor level of the structure. The storey shear of the top floors is higher compared to bottom floors. Storey Shear was least by 21 % in case of tuned damper when compared to yielding damper.

Bending Moment

A bending moment (BM) is a measure of the bending effect that can occur when an external force (or moment) is applied to a structural element. This concept is important in structural engineering as it is can be used to calculate where, and how much bending may occur when forces are applied. The most common structural element that is subject to bending moments is the beam, which may bend when loaded at any point along its length. Failure can occur due to bending when the tensile stress exerted by a force is equivalent to or greater than the ultimate strength (or yield stress) of the element. However, although the mechanisms are different, a beam may fail due to shear forces before failure in bending. Bending moment was minimum with tuned mass damper when compared to yielding dampers.

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