

## ANALYSIS AND DESIGN OF MULTISTORIED BUILDING FOR DYNAMIC LOADINGS WITH AND WITHOUT DAMPERS AND ISOLATORS USING SAP2000

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### Abstract

Earthquakes are the most unpredictable and destructive of all catastrophic events, and it is exceedingly difficult to protect people and property against them as they are being built. The quick transitory shaking of the ground caused by the release of energy in a matter of seconds causes them to be the most dangerous natural risks to human life. A vibrating force is produced by an earthquake at its base, which is a prevalent issue nowadays. To avoid such critical damage structural engineer has been working on various structural systems that can help in without resistance, provide strength to the buildings to withstand the natural hazards.

The tuned mass damper was proposed as energy dissipation device for buildings subjected to structure lateral forces. Dampers are one of the earthquakes effective systems. They are used for column buckling, beam deflection and to improve structural rigidity. It helps in eliminating or reducing the damage due to earthquake loads, the tuned mass damper is sufficiently flexible to reduce the response of acceleration. Isolators are the new structural earthquake resistant device to reduce the potential damage caused by the earthquakes. It is the flexible approach for the structure to isolate from the ground reducing seismic shock propagation to the structure.

In this response spectrum analysis and time history analysis are used to investigate the effect of tuned damper at various levels of a building. SAP2000 is a software which is widely used an extremely versatile and powerful program with many functions with different building and damper configurations. A TMD system using spring and visco-elastic damper scan reduce vibration in a building, and it becomes more safety during the earthquakes by confirming the seismic safety in India.

**Keywords:** Tuned Mass Damper, Isolators, Earthquake, Response Spectrum Method, Time History Analysis, andSAP2000.

### I. INTRODUCTION

In order to keep away from structural failure, the lack of lives and economic investments, structural engineering ought to do not forget how such systems face up to the acute occurrence of various herbal and earthquake forces. Engineers' ought to make correct predictions and meticulous plans for homes with the intention to face up to a number of forces to be able to keep lives and shield investments. Correct base isolation structures and unique concentrically braced metal frames because the primary lateral force-resisting system (LFRS) in low- to mid-upward push systems are crucial key infrastructures to be designed while designing structural engineering.

They stand out because of the reality that they could meet layout necessities for stiffness and electricity with the least quantity of metal mass because of their excessive elastic stiffness to weight and electricity to weight ratios. The behaviour and structural metal layout of traditional, seismic absorbing, and seismic damping systems were the situation of giant studies over an extended time period on traditional metal homes, lead rubber bearings, and fluid viscous dampers. This research turned into done in a number of methods. Many humans agree that Steel braced frames (SBF) are

some of the structural answers which might be the maximum effective, affordable, and adaptive withinside the face of seismic excitations.

However, while uncovered to intense earthquake stresses, the bulk of conventional metal braced structures now not carry out magnificently. The shape reports untimely dynamic instability because of the awareness of deformations in a Storey, which makes this in particular true. In earthquake engineering, an isolation tool is a device that actions a shape to part of the layout spectrum with decrease spectral acceleration and prolongs the herbal length of the shape being remoted there.

The lower in spectral acceleration reasons the superstructure to revel in much less of an inertia force, which additionally lessens structural damage. However, the power will bring about a better displacement in appreciate to the ground of the remoted shape at some point of an earthquake. The reality that lead rubber bearing modifies the modal homes of the remoted constructing such that large modes make contributions much less to the remoted constructing's reaction to horizontal seismic excitation is a vital issue.

With the realization of the Cold War within side the past due 1980s, the absolutely evolved fluid viscous damping (FVD) technological expertise turned into as soon as mentioned because the maximum notably used passive damping system. However, the primary fluid viscous dampers have been touchy to temperature and running environment. The fluid's viscosity, which modifications notably with temperature, controls the damping effects. In 1897, a fluid viscous damper (FVD) turned into used to lessen the cringe of an artillery rifle. Dampers product of excessive-capacity fluids and viscous fluids performed some of vital industrial roles in civil systems and bridges that have been jolted via way of means of earthquakes and buffeted via way of means of winds.

## II. LITERATURE REVIEW

[1] **N. Lin, et.al and H. W. Shenton III (1992)**. The seismic results of traditional systems and base isolation have been analysed, and the advent of unique concentrically brace metal frames and second frames became counselled as a result. When designing a base isolation machine and a framework with a set base, discuss with diverse codes. In 1990, the Structural Engineering Association of California (SEAOC) conceived of the concept for the constant basis body, and that they used it as the premise for the encouraged layout basis shear. The lateral pressure that the SEAOC recommends the primary isolation constructing be capable of face up to is a hundred percentage, fifty percentage, and twenty-5 percentage of what its miles designed for. For the functions of research, a complete of fifty-4 specific floor movement information are used. In addition to those yield frames, yield units, and overall relative roof displacements have been discovered after appearing a nonlinear time records evaluation dynamic on loads of specific consequences which includes roof displacement and the collapsed body. The findings that have been acquired on this way beneath neath loads of situations imply that 50 percentage of the lateral forces encouraged via way of means of SEAOC are well matched to a more volume than sure combinations. The traditional shape and the isolation moments of the helping brace metal body have been each subjected to a comparative evaluation so that it will generate the height reaction completed via way of means of the traditional shape.

[2] **Donato Concellara et.al (2013)**. Based at the findings of his research, a contrast of the (LRBs) and became defined (FS). This kind of seismic isolator, additionally called a high-damping hybrid seismic isolator, consists of an LRB coupled with an FS. A high-damping hybrid isolator's reaction to an earthquake is as compared with that of a traditional (LRB). Investigate the conduct of the identical constructing withinside the presence of various earthquake occupations, each in phrases of frequency and intensity. This article focuses by and large at the (HDHSI) and compares it too diverse different (LRB). A nonlinear evaluation of the constructing's time records has been performed, and those extra vibration isolators had been completely mounted withinside the constructing. There are loads of seismic sports to take into attention. The basis shear pressure, backside movement, and base shear of the structural frames are as compared so that it will

examine the consequences. The findings of a contrast display that HDHSI is advanced to different procedures in phrases of defensive towards excessive seismic pastime.

- [3] **Abdelouahab Ras et al (2013)**. In the research, a three-dimensional, twelve-tale metal shape constructing became built via way of means of numerically watching and studying data. The non-linear FVD is inserted into the body in a diagonal orientation. A contrast of specific fashions may be performed with the assist of the SAP2000 software program. The first version does now no longer have any bracing, whilst the second one version has braced FVD. For the motive of evaluation, a fast non-linear time records became performed. Create a version of FVD via way of means of the use of mathematical expressions with loads of specific speed exponent values. It became found that for alpha values which might be much less than one, a discount withinside the price of the amplitude will bring about a growth withinside the price of the damping ratio. In end, it may be said that the diagonal will now no longer transmit any undesirable axial pressure, however it'll lessen the damping whilst as compared to the version that doesn't have any braces.
- [4] **D.Lee et al (2001)**. Viscous dampers had been discovered to be able to protective the shape from wind, explosions, and seismic pastime. (FVD) generation became first of all advanced to be used withinside the navy and withinside the aerospace industry. People made the invention someplace round ten years ago. It is feasible that the identical kind of generation, called FVD, that protects missiles from nuclear moves and submarines from underwater close to explosions also can shield homes, bridges, and different sorts of systems from dangerous shocks and vibrations. As a result, a complete precis of the FVD's operating method, set up method, and destiny scope has been supplied. In this paper, the feature of nonlinear dampers and their connections are investigated. It is usually recommended that loads of damping modelling software program be applied, which includes SAP2000 and ETABS, so that it will deliver the seismic reaction right all the way down to an appropriate level. Additionally defined right here are loads of bracing assist strategies that may be applied whilst putting in dampers.

### III. METHODOLOGY USED

Because in their excessive strength, exact flexibility, and simplicity of fabrication, metallic systems are regularly used within side the production of buildings. In this specific scenario, however, the modelling of metallic systems locations an emphasis on evaluating 3 wonderful metallic shape fashions of constant base, (LRB), and (FVD) within side the occasion of resistances from earthquake excitation forces with stiffness and ductility behaviours. The SAP2000 v20 software program turned into used to carry out the evaluation at the version. Kocaeli, Turkey, on August 17, 1999, served because the vicinity for the time records evaluation of the earthquake's epicentre. Nonlinear analyses are advanced as a reaction to the dynamic conduct of the shape, which could extrude over the path of time and in reaction to the loading layout parameters. To begin, the shape version consists of the homes of the materials, the metallic details, and the burden combinations. Second, the structural modelling has been described with a non-linear time records evaluation, and it's been showed that the constructing will behave in a solid way while subjected to vibration and seismic forces because of the incorporation of rubber bearing and fluid viscous dampers into the shape.

### DAMPERS

One of the lateral pressure discounts brought on by earthquakes is the discovery of dampers. Excessive electricity is applied to the form during an earthquake. This electricity is used to create shapes and is either absorbed or amortized as kinetic and potential (strain) energy. If a form is not dampened, it may vibrate continually; but, because of the damping provided by the fabric, vibration is diminished. Input energy caused by earthquake to structure is presented in the following equation:

$$E = E_k + E_s + E_n + E_d \quad (1)$$

In this equation, E stands for earthquake front energy,  $E_k$  for kinetic energy,  $E_s$  for reversible strain energy within the elastic range, E for energy misplaced because of inelastic deformation, and  $E_d$  for energy amortized with the aid of using including extra damper. Strength dissipation structures have

been utilized in seismic isolation structures to offer themselves a unique zone. The use of many approaches, along with the go with the flow of a sensitive metal, metal friction on every other, a piston motion internal a slimy material, or viscoelastic behaviour in materials like rubber-like materials, makes damping increase possible.



**Figure 1: Using rotational friction dampers in retrofitting.**

### **Damping Effect on Structural Response**

Damping developing reduces structural response (acceleration and displacement) damping effect at low frequency (close to zero) haven't any effect on spectrum amount and at immoderate frequency, it has low effect on response acceleration. The biggest impact of damping boom in the frequency variety of 0.3 to 2.5 seconds is visible in Figures 1 and 2.

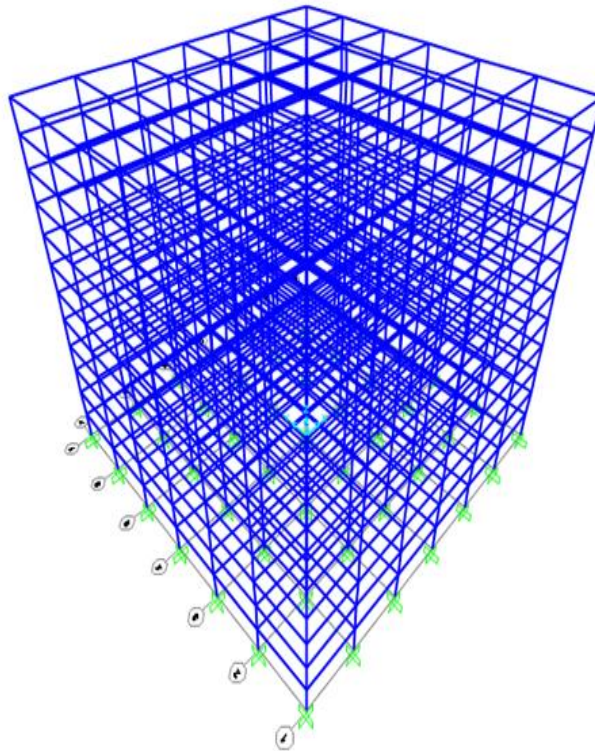
### **Building description**

In order to perform the reason of the research, 4 fashions of 3d metallic homes with twelve storeys were chosen. These fashions constitute the constant base, tuned mass damper, and unfastened vibration damper of the metallic structures. They have a rectangular picture of forty-five\*forty-five meters. The distance among every gridline spacing is 7.5 meters on each side. The storeys of the shape stand at a top of 3.5 meters. The whole top of the shape is forty-two meters. The identical structural structures have been used for each metallic homes designed and analysed for this observe the use of SAP2000 v20 software. The metallic structural device featured the lateral device created from Special Moment Frames (SMF) withinside the x-axis, and y-axis, and the identical structural structures have been used for each metallic home.

### **Building framing and elevations 3D plan**

The following are the plan and elevation views of the frames of the project models for four distinct types of structures:

- 1 The floor plan is in the shape of a square, which makes it possible to have a fully symmetrical layout, meaning that the frame can be designed exactly the same way in both directions.
- 2 The standard floor plan layout, as well as the layout for the roof plan, have been put into service.



**Figure 2:3-dimensional rendering of the building's steel-frame structure**

ISHB 350 and ISMB 250 are used to model a column and a beam, respectively. However, in light of the information provided, I-profiles, which are selected frame section property types in order to define the cross-sectional properties of structural elements, are described as follows

**Analysis procedure**

When it involves the evaluation, the inter-Storey drifts, and Storey accelerations of 4 fashions—the traditional structure, base-isolated, Tuned Mass and fluid viscous damper metal structures, Non-linear (THA)—are used to offer records at the (DBE), and (MCE) degrees. These fashions are the traditional structure, Tuned Mass, and fluid viscous damper metal structures, Non-linear (THA). In addition, the overall performance degrees of the constructing had been analysed with the aid of using recording the rotations of the plastic hinges that had been established withinside the constructing frames according with the IS code

The following is an overview of the analysis procedure:

1. To simulate damping, a lead rubber bearing, and a fluid viscous damper were used.
2. The following are the stages involved in defining building models with the SAP2000 programme.
3. Methods of earthquake resistance research and analysis.
4. An examination of the response spectrum
5. Using the PEER website (ngawest2.berkeley.edu), select the ground motions record data level.
6. An examination of the course of time (non-linear dynamic analysis).
7. Specifications from ASCE 41-06 were utilized in the modelling of the structures, loads, and analysis criteria.

The purpose of this research is to determine the behaviour of regular steel structures when they are subjected to horizontal earthquake excitations. The peer database was consulted in order to acquire the earthquake records that were utilized for this investigation. They show that the peak ground acceleration (PGA) is 0.390 g, while the magnitude (M) of the ground motions range is 7.51.

**LOAD COMBINATION**

The list of design load combinations that follows is as follows:

- ✓ 1.4DL
- ✓ 1.2DL+1.6LL
- ✓ 1.2DL+LL+WL
- ✓ 1.2DL+LL-WL
- ✓ 1.5DL+LL+EX
- ✓ 1.5DL+LL-EX
- ✓ 1.5DL+LL+EY
- ✓ 1.5DL+LL-EY
- ✓ 1.5DL+LL+LX
- ✓ 1.5DL+LL-LX

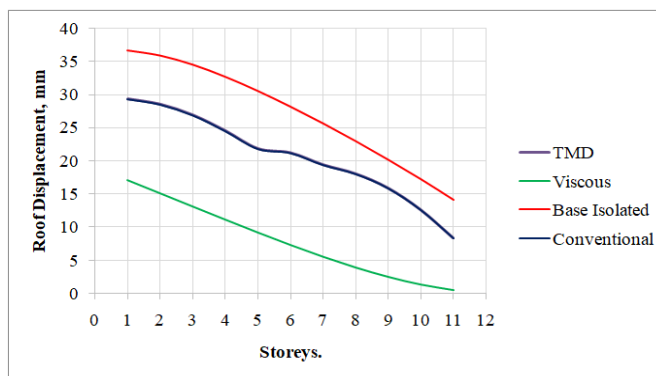


Figure 3: Storey displacement in x-direction due to earthquake conventional structure, (LRBs), and fluid viscous damper

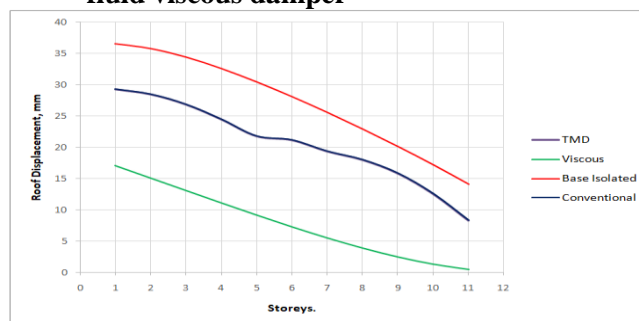


Figure 4: Storey displacement in y-direction due to earthquake fixed base, lead rubber bearing, and fluid viscous damper (FVD)

Model Shape

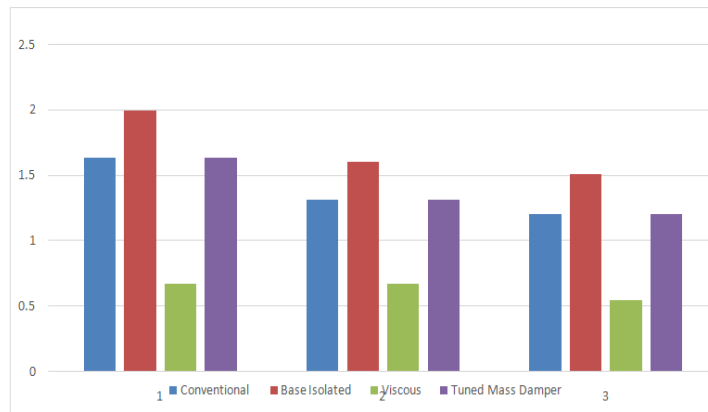


Figure 5: Mode shape for the conventional structure, (LRB), and (FVD)

Base Shear

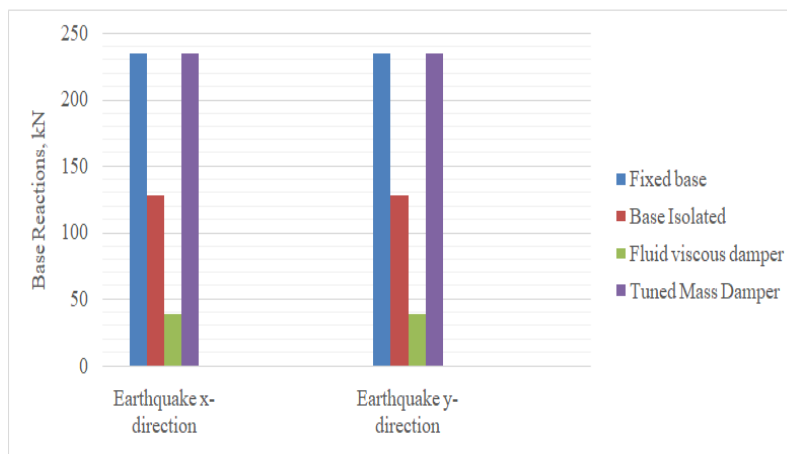


Figure6: Base shear for the conventional structure, (LRB), and (FVD)

Time History Analysis

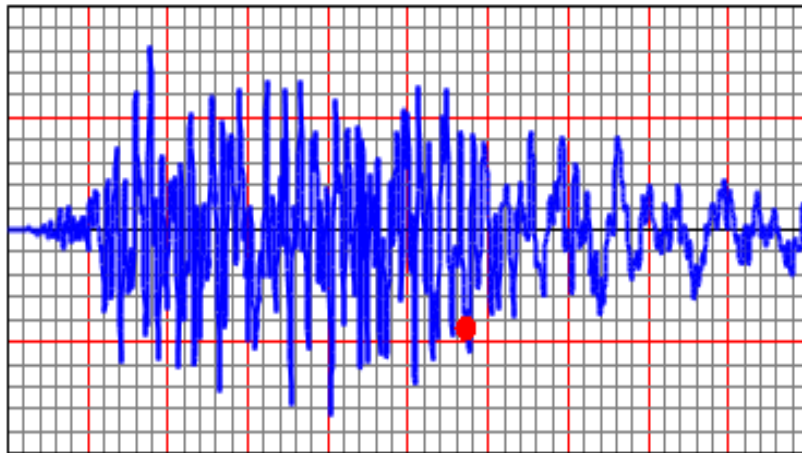


Figure 7: Kobe ground motion THA

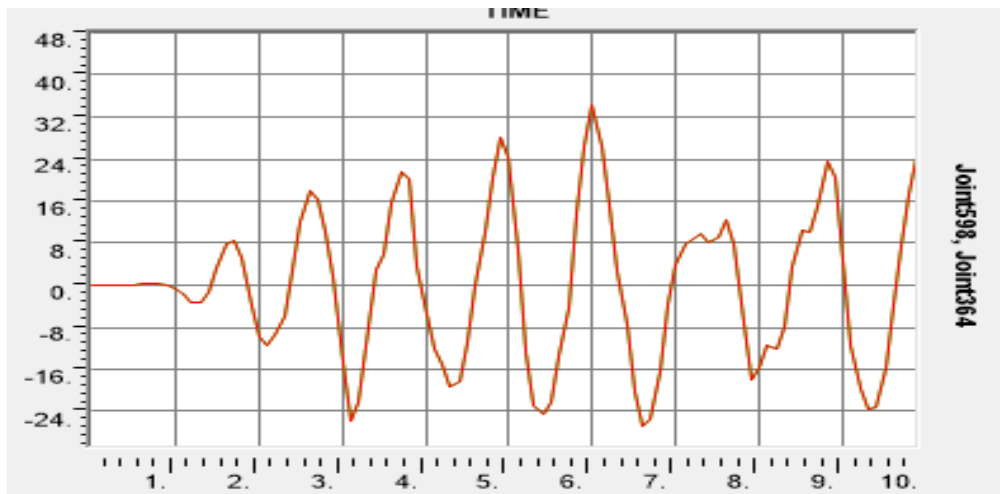


Figure 8: Conventional structure THA

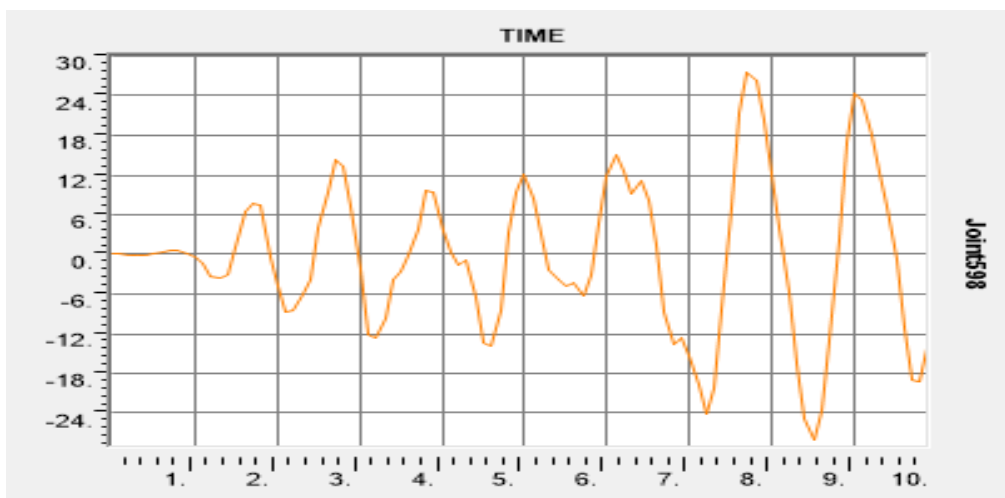


Figure 9: Base Isolated structure THA



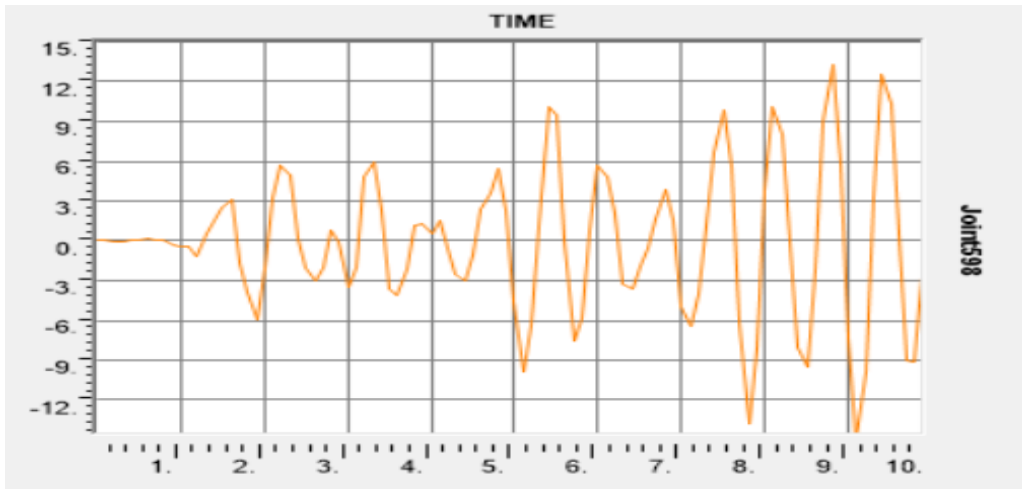


Figure 10:Viscous Damper THA

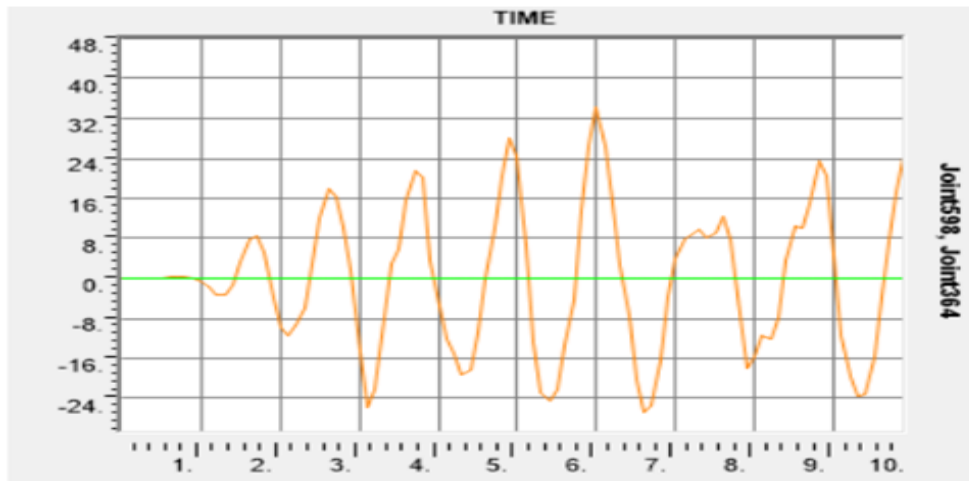


Figure 11:Tuned Mass Damper THA

Roof Acceleration:

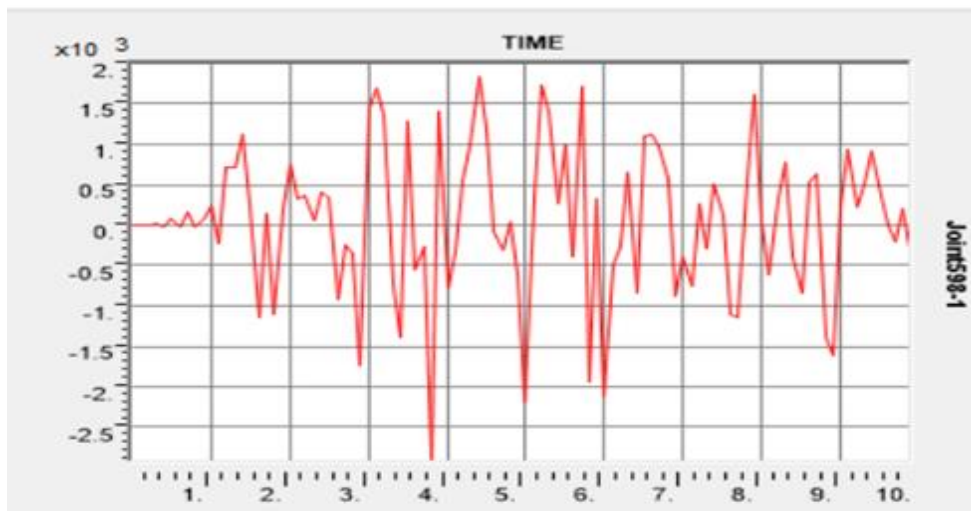


Figure 12: Conventional Building RA

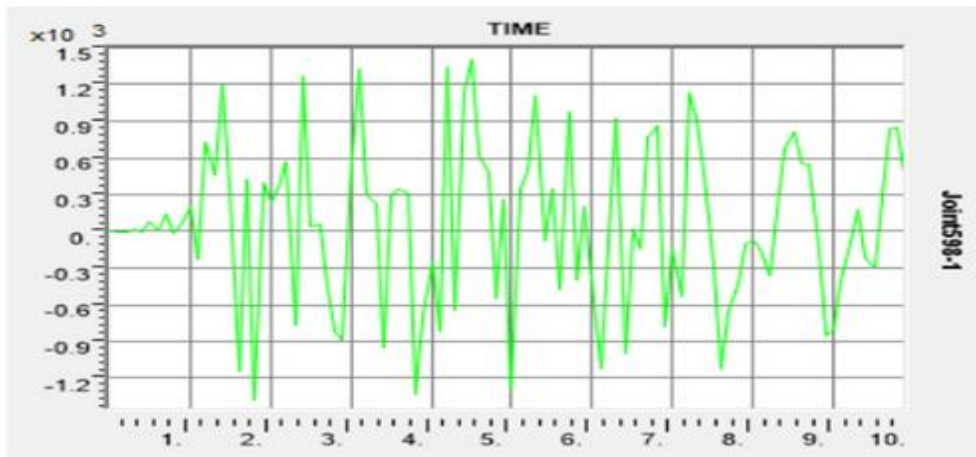


Figure 13:Base isolated RA

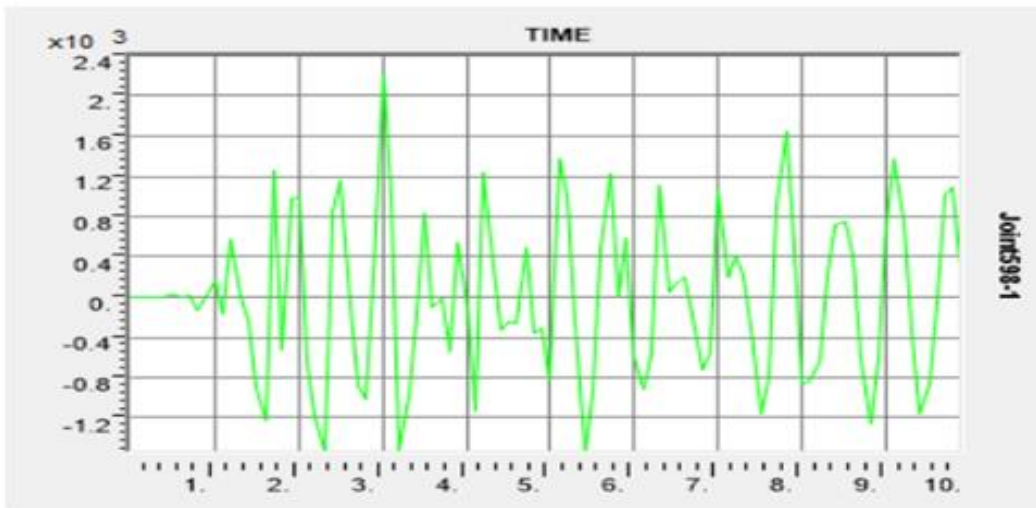


Figure 14: Viscous Damper RA

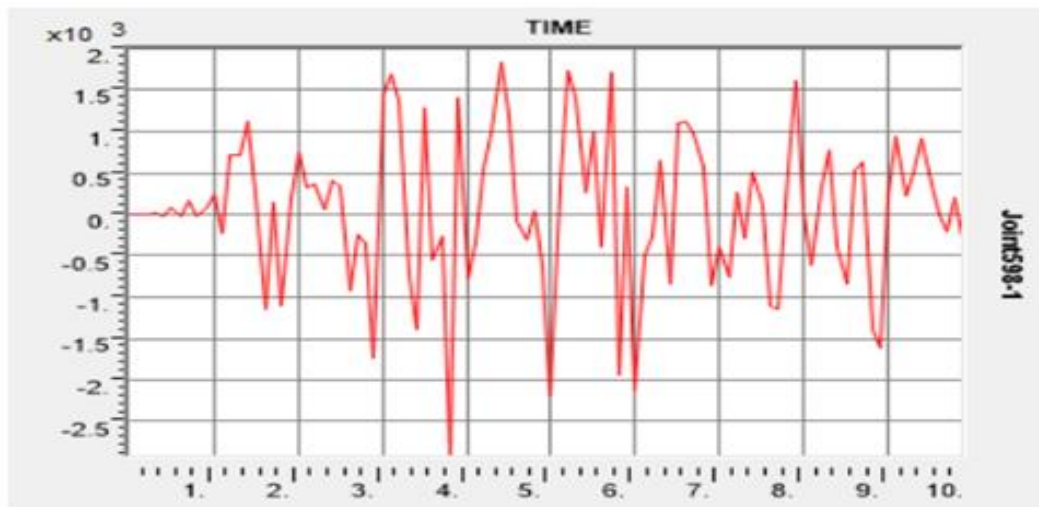


Figure 15:Tuned Mass Damper RA

## V. CONCLUSIONS

The evaluation looks at of the 3 metallic mission version systems has been carried out, designed, and analysed on how they behave towards seismic performances whilst geared up with and without electricity dissipation systems. The look at turned into conducted, designed, and analysed on how they behave towards seismic performances. After figuring out the essential term of numerous mode shapes, it turned into observed that the durations of the lead rubber bearing constructing have been longer than the ones of the constant base and the fluid viscous damper systems. In particular, it's been decided that the primary and 2d length of the constructing are about two times as huge because the lead rubber bearing's (LRB).

It shows that a base remoted shape has an extended time period in evaluation to a traditional shape, which gives the shape with time beyond regulation to react withinside the occasion of an earthquake. The Storey displacements of the evaluation mission fashions, which might be distinct storeys, are calculated the usage of an earthquake withinside the x-direction (SMF) Special Moment Frames and the y-direction (SCBF) special concentrically braced frame systems with a traditional shape, with a lead-rubber-bearing isolation gadget (LRB), and with a fluid viscous damper. As an end result, the analyses and designs of the numerous structural fashions produced various quantities of displacement. Both the traditional constructing and the shape that incorporates a fluid viscous damper have values which are nearly same possibilities of 15 percentage displacement. This displacement takes region at the pinnacle Storey withinside the x-axis (SMF), whilst the displacement on the lowest Storey is most effective 1 percentage. In the y-axis (SCBF), the proportion variety on the pinnacle ground is among sixteen and 17 percentage.

When in comparison to the fee of the lead rubber bearing in each direction, relative equal-stage displacement takes place at an eight-percentage price withinside the x-axis (SMF), and the price of displacement withinside the y-axis (SCBF) is likewise eight percentage. On the alternative hand, the displacement at the bottom isolator (LRB) is decrease than the displacement on the traditional shape, and it additionally isn't always as huge (FVD), specifically because of the reality that lead rubber bearings withinside the base isolation have a higher manage impact on displacement. When it involves the evaluation of the Storey flow among numerous version systems of with lead rubber bearing, constant base, and with fluid viscous damper, the outcomes imply that the gadget with lead rubber bearing could increase the lowest Storey inter-flow via way of means of ninety-two percentage withinside the x-axis (SMF), and it might increase the lowest Storey inter-flow via way of means of ninety-five percentage withinside the y-axis (SCBF). The values are near for the constant-primarily based totally and fluid viscous damper, with five percentage withinside the x-direction (SMF) and four percentage withinside the y-direction, respectively (SCBF). It approaches that the highly huge Storey flow at the floor ground with lead rubber bearing reasons extraordinary flexibility and absorption stages whilst evaluating the inter-flow among traditional systems, lead rubber bearings, and fluid viscous dampers. This is due to the fact traditional systems, lead rubber bearings, and fluid viscous dampers all use fluids as their damping medium. Due to the reduced lateral hundreds at the shape, Storey inter-flow and Storey-displacement are decreased to a more volume in base-remoted homes with (LRB). Additionally, version in most displacement turns into notably low towards the storeys in base-remoted systems. Due to the ability life of viscous damper's higher manage impact on displacement, the shape with (FVD), inter-flow, Storey-acceleration, and Storey-displacement are anticipated to be minimized as much as a selected volume. On a cross-segment of the structural member, an axial pressure may be used to both anxiety or compress the material. The quit end result is that the axial pressure exerted via way of means of the outdoors onto the primary ground via way of means of the LRBs is elevated via way of means of 2% whilst in comparison to the pressure exerted via way of means of the metallic body geared up with a fluid viscous damper.

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