A Study of Effect of Various Damping Systems on RCC Structures Subjected To Specified Ground Motion

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Abstract-*Current trends in construction industry demands taller and lighter structures, which are also more flexible and having quite low damping value. In the present study finite element modelling of RCC structure with TMD, Base Isolation is proposed using STAAD-Pro. Furthermore storey drift along X and Z direction, Base shears are compared using various damping systems using specific ground motion data(El-centro).*

From the study it was found that, Base isolation can be effectively used for vibration control of structures for present models.

Keywords-Rcc, Damping system, Staad.Pro

I. INTRODUCTION

Vibration control is having its roots primarily in aerospace related problems such as tracking and pointing, and in flexible space structures, the technology quickly moved into civil engineering and infrastructure-related issues, such as the protection of buildings and bridges from extreme loads of earthquakes and winds.

The number of tall buildings being built is increasing day by day. Today we cannot have account of number of low-rise or medium rise and high rise buildings existing in the world. Mostly these structures are having low natural damping. So increasing damping capacity of a structural system, or considering the need for other mechanical means to increase the damping capacity of a building, has become increasingly common in the new generation of tall and super tall buildings. But, it should be made a routine design practice to design the damping capacity into a structural system while designing the structural system.

The control of structural vibrations produced by earthquake or wind can be done by various means such as modifying rigidities, masses, damping, or shape, and by providing passive or active counter forces. To date, some methods of structural control have been used successfully and newly proposed methods offer the possibility of extending applications and improving efficiency.

The selection of a particular type of vibration control device is governed by a number of factors which include efficiency, compactness and weight, capital cost, operating cost, maintenance requirements and safety.

Tuned mass dampers (TMD) have been widely used for vibration control in mechanical engineering systems. In recent years, TMD theory has been adopted to reduce vibrations of tall buildings and other civil engineering structures. Dynamic absorbers and tuned mass dampers are the realizations of tuned absorbers and tuned dampers for structural vibration control applications. The inertial, resilient, and dissipative elements in such devices are: mass, spring and dashpot (or material damping) for linear applications and their rotary counterparts in rotational applications. Depending on the application, these devices are sized from a few ounces (grams) to many tons. Other configurations such as pendulum absorbers/dampers, and sloshing liquid absorbers/dampers have also been realized for vibration mitigation applications.

Aim:-

Earthquake Analysis of RCC Building with Tuned Mass Damper & Base Isolation to study effects of different types of damping systems on structure.

Objectives:-

1. A tuned mass damper (TMD) is placed on its top and through it to study its effects on Storey drift, storey displacement and base shear and analysis with and without the tuned mass damper (TMD) and using base isolation in STAAD.PRO.

In model 2 base isolators are added at plinth level as a spring mass model.

1.1. Analysis of symmetrical moment resistance frame (MRF) Without Tuned Liquid Damper three-dimensional model by using software STAAD.PRO.

1.2. Analysis of symmetrical moment resistance frame (MRF) With Tuned Liquid Damper three -dimensional model by using software STAAD.PRO.

2. To find the seismic response (storey drift, storey displacement and base shear) of a symmetrical MRF building with Base Isolation using STAAD.PRO.

3. A friction damper is used to study the energy dissipation capacity of dampers and find out effective position to setup.

4. The result obtained from software analysis of building with and without tuned mass damper and from base isolation and friction damper and comparison of result with each other.

II. TMD CLASSIFICATION

2.1 Passive Energy Dissipation:

All vibrating structures dissipate energy due to internal stressing, rubbing, cracking, plastic deformations, and so on; the larger the energy dissipation capacity the smaller the amplitudes of vibration. Some structures have very low damping of the order of 1% of critical damping and consequently experience large amplitudes of vibration even for moderately strong earthquakes. Methods of increasing the energy dissipation capacity are very effective in reducing the amplitudes of vibration. Many different methods of increasing damping have been utilized and many others have been proposed.

2.2 Types of Passive Control Devices

2.2.1 Metallic Yield Dampers
2.2.2 Friction Dampers
2.2.3 Viscoelastic Dampers
2.2.4 Viscous Fluid Dampers
2.2.5 Tuned liquid damper
2.2.6 Tuned Mass Dampers

2.3 Classification of Control Methods

2.3.1 Active Control

An active control system is one in which an external power source the control actuators are used that apply forces to the structure in a prescribed manner. These forces can be used to both add or dissipate energy from the structure. In an active feedback control system, the signals sent to the control actuators are a function of the response of the system measured with physical sensors (optical, mechanical, electrical, chemical, and so on).

2.3.2 Passive Control

A passive control system does not require an external power source. Passive control devices impart forces that are developed in response to the motion of the structure. Total energy (structure plus passive device) cannot increase, hence inherently stable.

2.3.3 Hybrid Control

The term "hybrid control" implies the combined use of active and passive control systems. For example, a structure equipped with distributed visco elastic damping supplemented with an active mass damper near the top of the structure, or a base isolated structure with actuators actively controlled to enhance performance.

2.3.4 Semi-active Control

Semi-active control systems are a class of active control systems for which the external energy requirements are less than typical active control systems. Typically, semi-active control devices do not add mechanical energy to the structural system (including the structure and the control actuators), therefore bounded-input bounded-output stability is guaranteed. Semi-active control devices are often viewed as controllable passive devices.

III. METHODOLOGY

3.1 General

In this chapter the method used for analysis and designing RCC building is discussed. Also it focus on how modeling is done in finite element software.

3.2 Finite element model in Staad Pro.V8i software

The step-by-step procedure in Staad Pro.V8i software is given below.

1. Modelling
2. Pre-processor
   2.1 Define element type
   2.2 Define material properties
   2.3 Define support condition

  - 2.4 Define load and load combination
- 3. Solution
  - 3.1 Perform analysis
  - 3.2 Run analysis
- 4. General postprocessor
  - 4.1 Displacement
  - 4.2 Reaction
  - 4.3 Stresses
  - 4.4 Bending Moment

3.3 Time History Analysis

- Dynamic analysis shall be performed to obtain the design seismic force, and it's distribution to different levels along the height of the building and to the various lateral load resisting elements.
- Dynamic analysis may be performed either by the Time History Method or by the Response Spectrum Method.
- Time History Method of analysis shall be based on an appropriate ground motion and shall be performed using accepted principles of dynamics.
- After applying the load combinations ,TIME HISTORY ANALYSIS has been defined, While defining the time history EL-Centro earthquake data is used for analysis of result. And top nodal results are studied.

IV. PROBLEM STATEMENTS

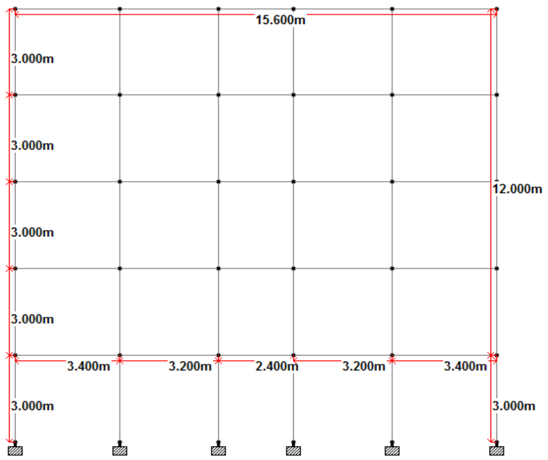
Design of frame structure in software(STAAD.PRO).
The following data are taken for analysis of the frame:

1)Grade of concrete	M30
2)Grade of steel	Fe415
3)Type of the structure	Multi-storey rigid jointed plane frame.
4) Size of columns	0.230 m × 0.450m
5) Size of beams	0.230 m × 0.450m
6) Depth of slab	0.150 mm
7) Modulus of elasticity	200×10³ N/m²
8)Water Pressure	-20KN/m²(for G+3 frame with damper)(loading applied in -X direction)
9)Water Tank Dimension	Length:-5.2m,width:-2.4, Height:-2m

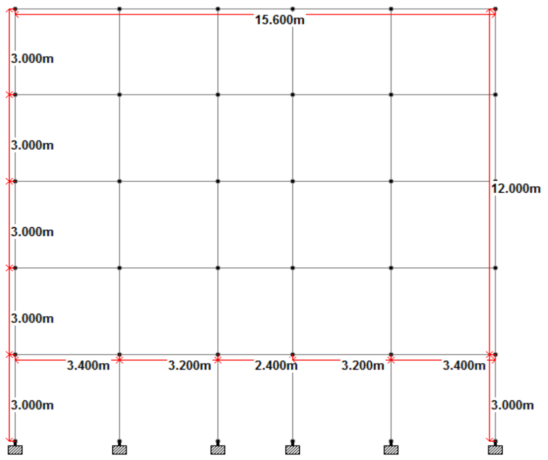
Parameters	**Details**	
No. of floors	G+3	G+10
Each Floor Height	3 m	3 m
Total height of building	12 m	33 m
Zone	III & V	
Type of Structure	SMRF	SMRF
Response Reduction Factor	5	5
Importance Factor	1	1
Soil Type	Hard Soil	Hard Soil
Soil Site Factor	1	1
Damping Ratio	5%	5%

V. MODELLING

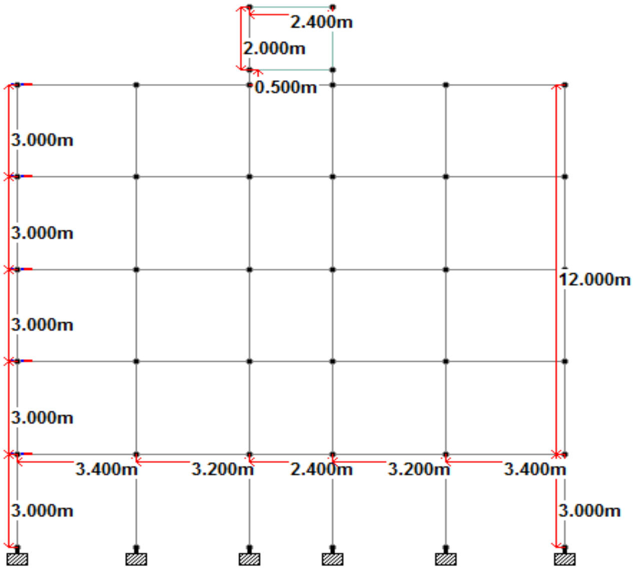
1. Frame Structure Without Damper



2. Frame Structure With Base Isolation

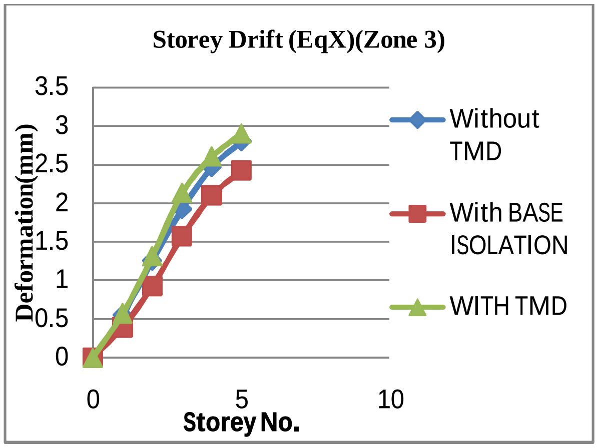


3. Frame Structure With Tuned Liquid Damper

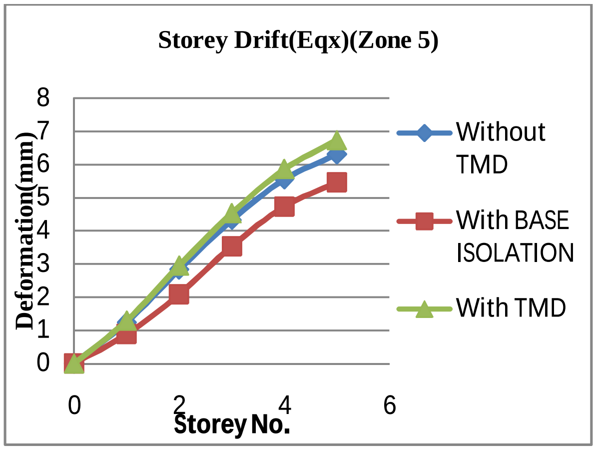


VI. RESULTS AND GRAPHS

6.1 Static Analysis



Graph No.1



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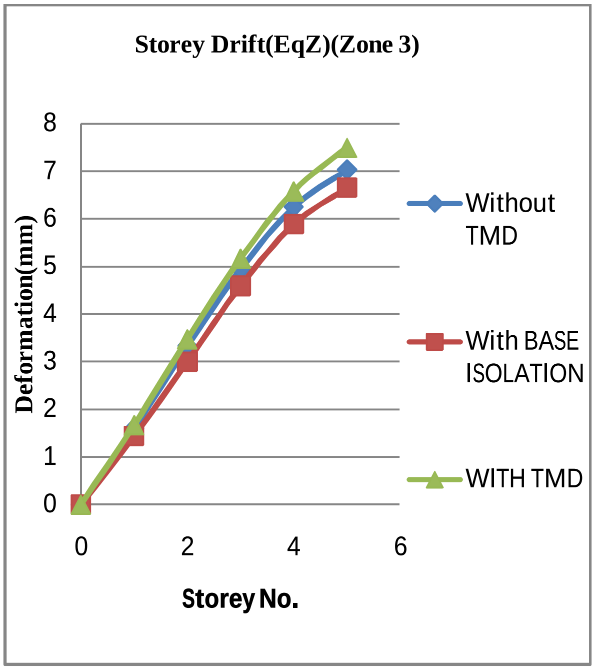

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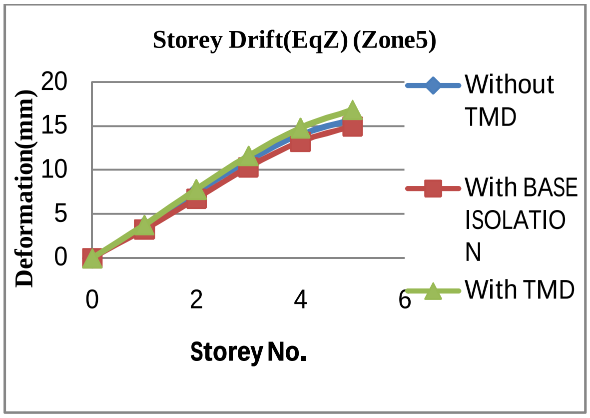

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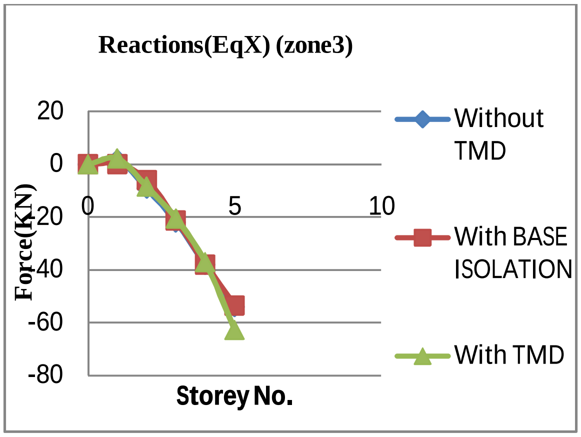

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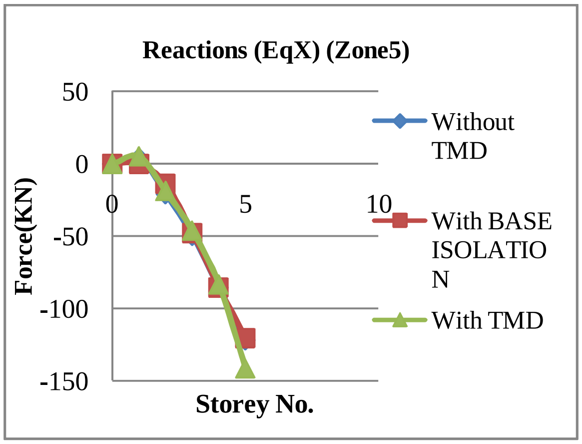
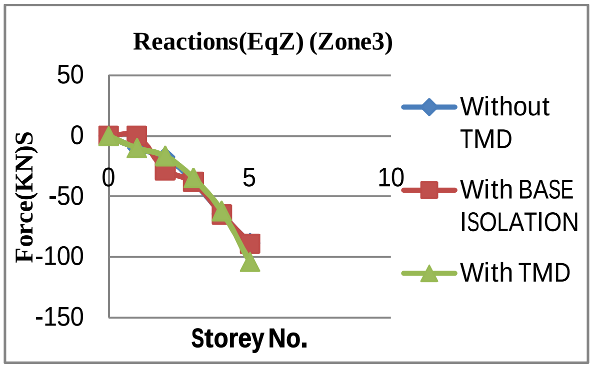
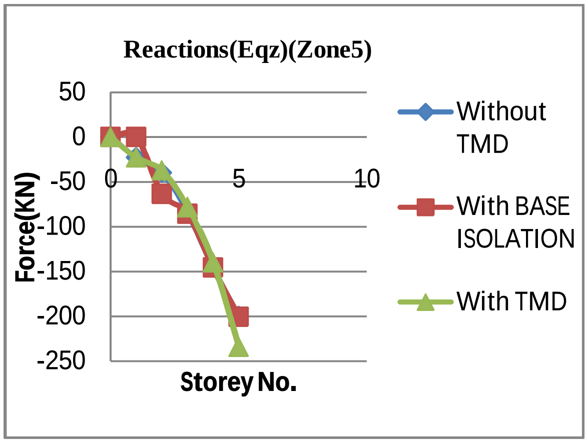


Graph No.6



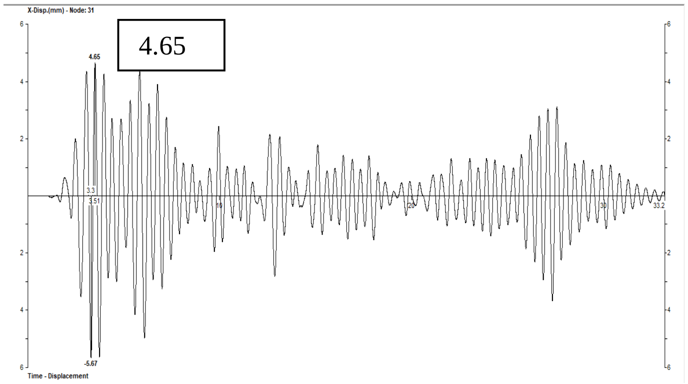
Graph No.7



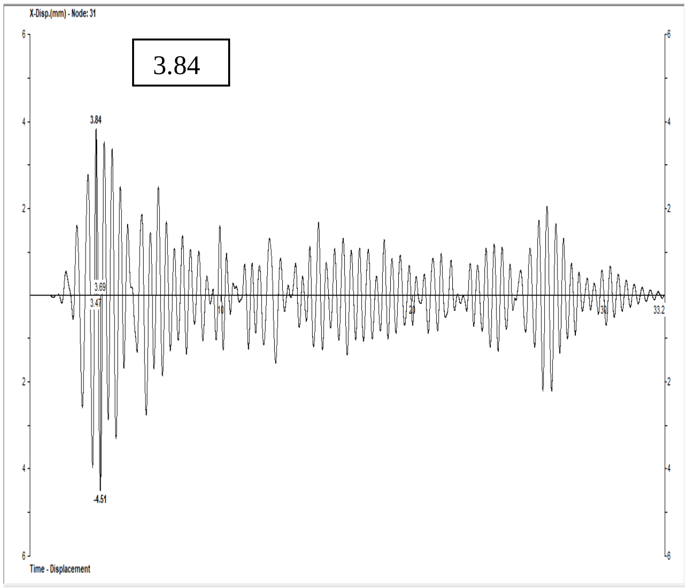
Graph No.8

6.2 Dyanamic Analysis

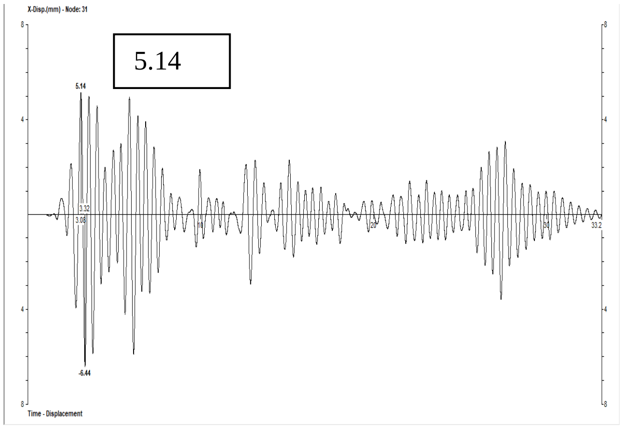
6.2.1 Time Vs. Displacement results:



a) Time Vs. Displacement graph for model 1



b) Time Vs. Displacement graph for model 2



c) Time Vs. Displacement graph for model 3

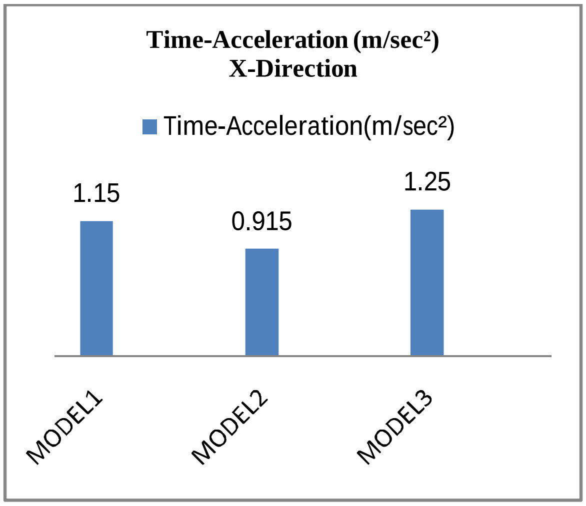
6.2.2 Values on top nodal points of all models in x and z direction are as below:

Table showing values of top nodal points

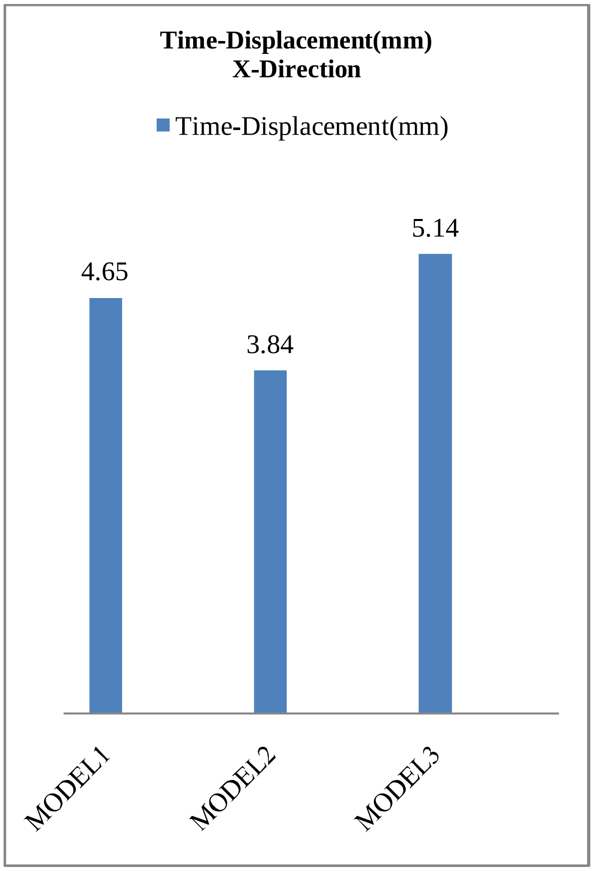
		Time Displacement (mm)	Time-Velocity (mm/sec)	Time-Acceleration (m/sec^2)
MODEL1	X-direction	4.65	85.6	1.15
	Z-direction	0.000286	0.00527	0.0000706
MODEL2	X-direction	3.84	71.1	0.915
	Z-direction	0.000342	0.00634	0.0000812
MODEL3	X-direction	5.14	87.8	1.25
	Z-direction	0.00151	0.0258	0.000366

6.2.3 Graphical Comparison Of Results From Time History Analysis For Models

We are comparing the results from the seismographs after applying the el-centro data on all the models using time history analysis. The Values which are obtained from dynamic analysis for Acceleration, Velocity & Displacement are compared below in graphical format.



Graph No.9



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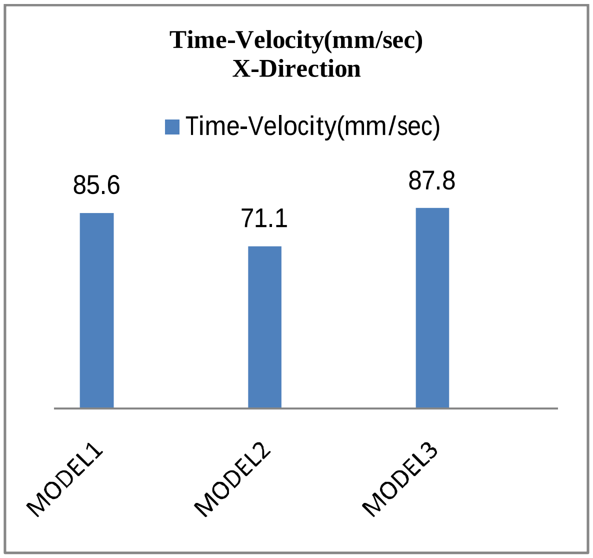

Graph No.11

VII. CONCLUSION

In the present study finite element modelling of RCC structure with TMD, Base Isolation is proposed using STAAD-Pro and it is concluded that

- The use of base isolation in RCC reduces the lateral deformation by 9% than Model1.
- However Maximum moments, shear force, bending moment does not change significantly the difference is observed up to 4-5% only.
- By graph no.2 it is concluded storey drift of all floors is 25-30% less in base isolator RCC as compared to RCC without base isolator.
- Liquid Mass Tuned mass damper does not contribute to reduction in displacement for present model.
- In time history analysis the values of Acceleration, Velocity & Displacement along Y & Z direction are approximately equals to zero.
- Values of Acceleration, Velocity & Displacement along X-direction are studied.
- From the graphs it is concluded that base isolation system having minimum values of Acceleration, Velocity & Displacement.

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