

# NONLINEAR SEISMIC PERFORMANCE OF A BUILDING USING BASE ISOLATION METHOD

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**Abstract:** Researches in past reviewed for base isolation analysis using response spectrum it is found that the design in ancient time are not sure and safe due to lack of technology and lesser software analysis availabilities. Some countries applied base isolation these days and the building response constructed with base isolation performed better at practical ground. The response of base isolated building is lesser in terms of amplitude and the cost of the building can also be optimized. Many researchers studied for this subject and they concluded that base isolation must be applied in critical seismic zones and the isolators must be used to save lives and properties. It is seen that Indian construction practices are lacking to apply use of base isolation in building design. It is suggested in the end that it must be motivated to study and research base isolation in Indian constrains and conditions.

## 1 Introduction

In mechanical engineering systems, to control the vibration, Tuned mass dampers are used. In order to minimize the vibrations of high storey building and engineering structures, Tuned Mass Dampers are widely adopted. Structural vibration control applications such as dynamic absorbers and Tuned Mass Dampers are of Tuned absorbers and Tuned dampers. The Linear uses and the rotary equivalent in rotational applications of inertial, resilient, and dissipative elements of the tools were mass, spring and dashpot. Accordingly, the tool of the application is sized. Vibration mitigation applications of pendulum absorbers/dampers and sloshing liquid absorbers/dampers configuration have been realized. To minimize the dynamic reaction to a structure, tuned mass dampers are attached. When the frequency is high, the damper vibrates with the building's motion. Usually the mass connected to the building through a spring-dashpot system and the friction energy by the dashpot will relatively develops the motion between the mass and the structure. As in increasing of damping ratio causes a reduction in the stress and acceleration. For buildings, it can be assumed 5% of damping. A TMD is a tool consisting of a mass, spring and a damper that is connected to a structure in order to min. the amplitude of unwanted motion. In case of earthquakes to control displacements, accelerations and internal stress can be done by tuned mass damper. The location on the structure where the Tuned Mass Dampers are attached is vital. There are different types of methods of control for large modern structures. This system is usually used to reduce vibration occurred by the wind and traffic like pedestrians/railway trains. Some vibrations may be

acceptable for structures like slender bridges, stacks, high, and slender buildings has low levels of damping. Tuned mass dampers control the effect which is same as enlarge of damping. Without tuned mass dampers the figures achieve values of about 10% to 20% and the tuning frequency and the damping capability, the amplitude reduced based on the mass ratio. The mass, stiffness and damping ratio has chosen according different criteria. Here, a multistory building is assembled with a Tuned Mass System on the top of the roof.

## 2 Need of Work

Tremors on the earth's surface the triggered underground stress release along fault lines it is an earthquake. The earthquake force different types of dynamic loads. The biggest dynamic load is the inertia load created by the response of the concrete mass to ground accelerations. The behavior of structure depends on its energy absorption which is transmitted during an earthquake and its sustainability. The need for exploring various control devices which help in controlling the seismic response of buildings has come due to the damage and collapse of numerous concrete structures during recent earthquakes.

## 3 Objective

1. To study the seismic load carrying capacity that ascertained by using ETABS for framed structures.
2. To analyze the several qualities like time periods, Amplitude, base shear in x-axis and y-axis.

- To know the seismic response of a ten storied building with reinforced cement concrete frame using ETABS in Zone IV with non linear time history analysis.

#### 4 Scope of the Study

The scope of this project is as follows:

- In the present study two different structures of each 10 stories (i.e. Rectangular and L-Shape in plan), of 3mts floor height located in Seismic Zone IV have been considered for this analysis. The plan and the design properties of the structures are shown below.  
 Self weight of the Structure-25,000N/ m<sup>3</sup>  
 Live load -3,500N/ m<sup>3</sup>  
 Thickness of Outer wall -230mm  
 Grade of Concrete -M40  
 Grade of Reinforcement -Fe415
- At the rooftop of the structure with damping ratio of 5 percentage using ETABS, steel dampers are used as Tuned Mass Damping Device on an R.C.C framed structure with Non linear Dynamic Time History analysis.

#### 5 Methodology:

With the help of ETABS package a framed building modeled with higher rise. Recorded critical locations of framed structure were analyzed by using dynamic analysis, time period, magnitudes of displacements and then a TMD system has designed. TMD weights will be 3% to5% of the total building weight. TMD was firstly examining individually and its natural frequency can be found. The structure was once again analyzed by keeping TMD on top of the building using dynamic analysis and the time period, displacement at the locations to illustrate the utility of the study, the comparison of the resultants are done without Tuned Mass Damper.

The methods of dynamic analysis are as follows:

- Response spectrum analysis: A method which is relevant for the structures where modes, apart from fundamental one affect the reaction of multi-degree of freedom significantly. The reaction of multi-degree of freedom system show as the superposition of modal response, each modal reaction have been regulated from the spectral analysis of single degree of freedom systems, were combined to compute the total response. It is usually used in a response spectrum with conjunction.
- Pushover analysis: It is a test to a structure which is a static non-linear analysis under permanent vertical loads and thereafter slowly increasing lateral loads. The equivalent static loads appropriately act for seismic induced forces. A plot of total base shear and roof displacement in a structure is acquired by the analysis for premature failure and weakness.

The test is carried up to failure, thus it shows measurement of collapse load and ductility capacity.

- Inelastic time history analysis: During earthquake motion, an earthquake inadequate structure will be inelastic action. The inelastic time history analysis of the structure under strong motion earthquake brings out the regions of weakness and ductility demand in the building. It is an accurate method for assessing building performance.

#### Preliminary data :

1	Structure type	Rigid frame multi-storied (SMRF)
2	Earthquake zone	IV( Table 2, IS 1893-2002)
3	No. of stories	10
4	Floor height	3m
5	Self weight of the structure	25,000N/m <sup>3</sup>
6	Live load	3,500N/m <sup>3</sup>
7	Slab depth	0.15m
8	Column (size)	0.6mx0.6m
9	Beam (size)	0.45mx0.45m
10	Thickness of outer wall	230mm
11	Thickness of inner wall	115mm
12	Grade of concrete	M40
13	Reinforcement Grade	Fe 415
14	RCC's specific weight	25KN/m <sup>3</sup>

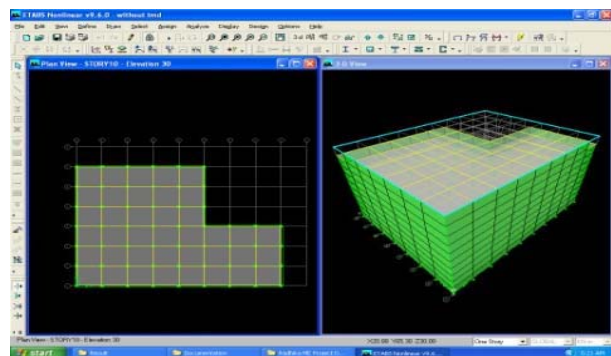
15	Brick's specific weight	20KN/m <sup>3</sup>
16	Imposed load	4KN/m <sup>2</sup>
17	Type of soil	Rock
18	Time history	As per IS 1893(part 1):2002
19	Young's Modulus	=5000 √f <sub>ck</sub> = 5000 √40 = 31622.6
20	Moment of Inertia of column	0.0108 m <sup>4</sup>
21	Each column stiffness	12EI/l <sup>3</sup> = (12x31622.6 x 10 <sup>3</sup> x 0.0108)/(3.0 <sup>3</sup> ) =151788.48 Kn/m
22	Total stiffness of column	total of each stiffness column x no. of columns = 72 x 151788.48 = 10928770.56
23	Weight of dampers	521 KN
24	Mass of dampers	527KN
25	Stiffness of damper	570KN/m
26	Damping	123 Kn.S/m

Calculation of weight at each floor:

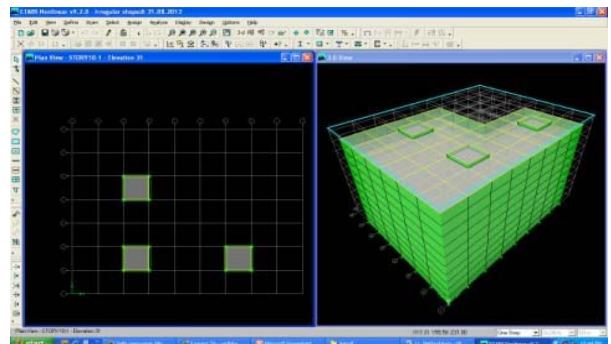
- a) Slab weight :Slab thickness in meter x Area of Slab x concrete unit concrete= [42x48] x 0.15 x 25 = 7560KN

- b) Beam weight: c/s Area of beam x total length x concrete unit weight =[(42x8)+(48x9)] x 0.45 x 0.4 x 25 = 3456KN
- c) Columns weight: C/s of column x height number of columns x concrete unit concrete= 0.6 x 0.6 x 3 x 72 x 25 = 1944KN
- d) Outer walls weight= [ ( 42x2) + (48x2) ] x 0.23 x 3.0 x 20 = 2484KN
- e) Inner walls weight= [ ( 42x6) + (48x7) ] x 0.115 x 3.0 x 20 = 4057KN
- f) Imposed load = 42 x 48 x 4 = 8064KN
- g) Total weight at each floor = (beam+innerwalls+slab+columns+outerwalls+imposed load)weights = 27565KN

**L- Shape Building:**



**Figure : 5** Unsymmetrical Building Plan without TMD

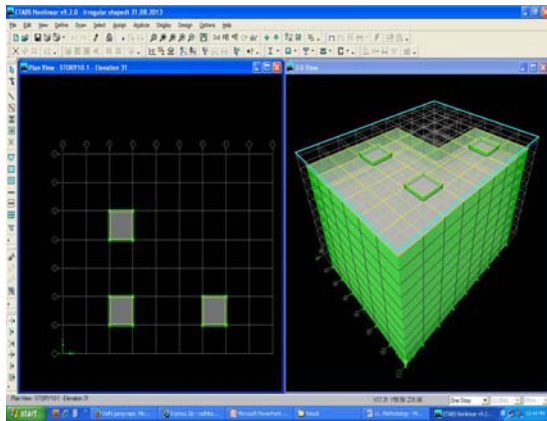


**Figure : 6** Unsymmetrical Building Plan with TMD.

**5 Results**

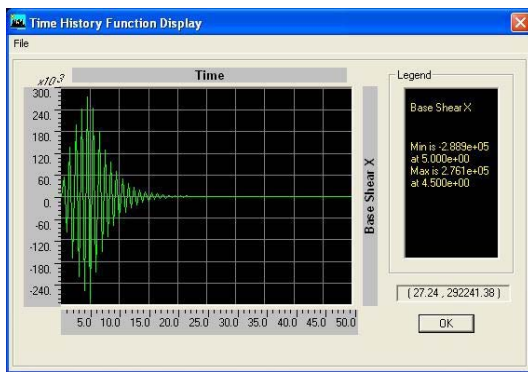
Non linear Dynamic Time History Cases studied 10 storied R.C.C. framed structure by applying TMD with damping ratio of 5percentage in ETABS at top of structure. In the present study two R.C framed models with ten stories i.e., rectangular in plan and the other is having L-shape in plan. At the centre of the grid the tuned mass damper was placed in plan.

**L- Shape Building:** Placing of Damper at top of the building in columns at three locations for unsymmetrical building.

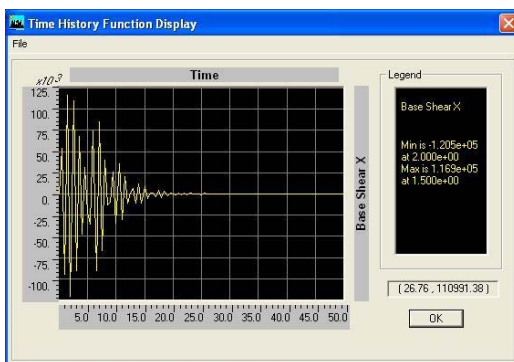


**Figure: 13** Plan showing the TMD placed at three different location of unsymmetrical section

Case I: Without TMD & With TMD: Time Period Vs Base shear x:

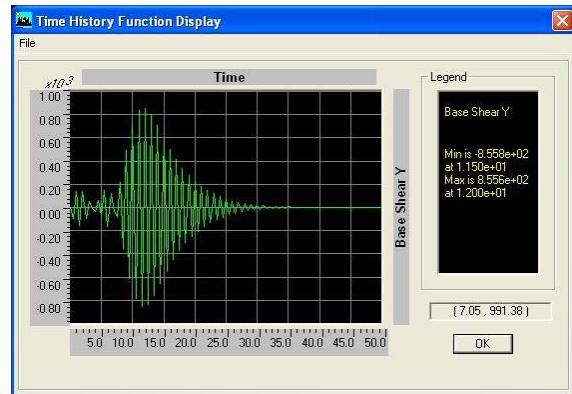


**Figure: 14** Time Vs Base shear x Without the TMD graph

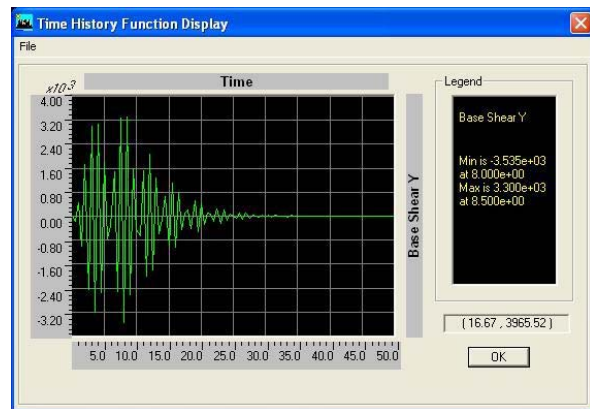


**Figure: 15** Time Vs Base shear x With TMD graph

Case II: Without TMD & With TMD: Time Period Vs Base Shear y:

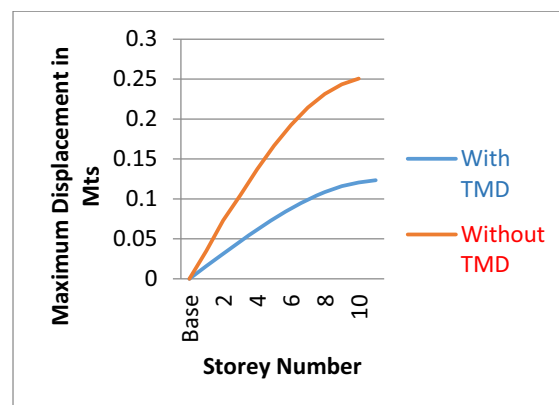


**Figure: 16** Time Vs Base shear y Without the TMD graph



**Figure: 17** Time Vs Base shear y with the TMD graph

CASE III: Storey Number Vs Max Displacement:



**Figure: 18** Storey number Vs Maximum displacements graph

## 6 Discussions

Based on the limited studies carried out it is observed that:

- 1) The steel damper provided to be an effective TMD mechanism in columns at top of the building.
- 2) Significant contribution from the TMD was noticed when the supports of the columns corresponding to the TMD were hinged.
- 3) The study was done on the mass of TMD approximately 4% - 5% mass of structure.
- 4) The sizing of the structural elements of the TMD was made so that the frequency of the TMD approx. matches that of the frequency of the structure.
- 5) From the study, it is observed that a suitable TMD has designed for a particular building using ETABS package.

## 7 Conclusions

As per IS: **1893:2002** (part-1) with 5 percentage of structural damping, based on the outputs from the ETABS package following conclusions are made.

1. Similarly for un-symmetrical buildings, the value of the amplitude of vibration could be brought down by 49% (page 58) using steel dampers.
2. Similarly for symmetrical Buildings, the value of the base shear is brought down by 56% (page 45 & 46) using steel dampers.
3. For un-symmetrical Buildings, the value of the base shear is brought down by 42% (page 54) using steel dampers.

## 8 Future Scope

1. Further studies have to be carried out for different TMD's i.e. Active, Semi active, etc.
2. With experimental studies the effects of TMD needs to be validated.
3. Further studies have to be carried out for finding the Stiffness Matrix and Mass Matrix of an element.

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