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Vibration Control of Framed Structure Using Tuned Mass Damper

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***Abstract*—The current and modern constructions demands taller structures but these taller structures should have the adequate self weight because at the time of Earthquake the self weight of structure plays the essential role. Due to which structure should design and built with minimum possible weight but still we can't minimize the sections to reduce the self weight as it will affect the safety criteria of sections therefore the alternative to control the vibration while Earthquake and wind excitation is by installing damper in the structure, to minimize the vibration and stabilize the structure under the dynamic condition. The passive tuned mass damper is widely used to control the harmonic and wind excitation. This paper represents the vibration control of framed structure using tuned mass damper by using Etabs 2015. The study deals with the analysis of G+51 storey structure without damper and with tuned mass damper and the comparison of the displacement and drift values under the dynamic condition.**

***Index Terms*- Earthquake, Wind Excitation, Tuned Mass Damper, Response Spectrum Analysis, Etabs**

I. INTRODUCTION

The most of structural system designed to carry vertical load may not have the capacity to resist lateral load or even if it has, the design of lateral load will increase the structural cost substantially with increase in number of storey. As the seismic load acting on a structure is a function of the self-weight of the structure these structures are made comparatively light and flexible which have relatively low natural damping. Results make the structures more vibration prone under wind, earthquake loading. New generation high rise building is equipped with artificial damping device for vibration control through energy dissipation. The various vibration control methods include passive, active, semi-active, hybrid. Various factors that affect the selection of a particular type of vibration control device are efficiency, compactness and weight, capital cost, operating cost, maintenance requirements and safety [2]. A Tuned mass damper is a passive damping system which utilizes a secondary mass attached to a main structure normally through spring and dashpot to reduce the dynamic response of the structure. The secondary mass system is designed to have the natural frequency, which is depended on its mass and stiffness, tuned to that of the primary structure. When that particular frequency of the structure gets excited the TMD will resonate out of phase with the structural motion and reduces its response. Then, the excess energy that is built up in the structure can be transferred to a secondary mass and is dissipated by the dashpot due to relative motion between them at a later time. Mass of the secondary system varies from 1-10% of the structural mass. As a particular earthquake contains a large number of frequency content now a day's multiple tuned mass dampers has been used to control earthquake induced motion of high rise structure where the more than one TMD is tuned to different unfavorable structural frequency [3].

The Etabs 2015 is a finite-element-based structural program for the analysis and design of civil structures. It offers an intuitive, yet powerful user interface with many tools to aid in the quick and accurate construction of models, along with the sophisticated analytical techniques needed to do the most complex projects. Etabs 2015 has proven to be the most integrated, productive and practical general purpose structural program on the market today. Complex models can be generated and meshed with powerful built in templates. Etabs 2015 is an easiest and most productive solution for our structural analysis and design needs.

II. METHODOLOGY

A tuned mass damper (TMD) is a device consisting of a mass, a spring, and a damper that is attached to a structure in order to reduce the dynamic response of the structure. The frequency of the damper is tuned to a particular structural frequency so that frequency is excited, the damper will resonate out of phase with the structural motion. Energy is dissipated by the damper inertia force acting on the structure.

A G+51 RCC multistorey building has been considered for analysis. Analytical modelling of structural components has been done. The effect of soil structure interaction has been ignored in analysis. The columns are considered fixed at the base. Beams and Columns are modelled as frame element and joined node to nodes. Tuned mass damper is designed and installed in the building to combat the wind forces and acceleration forces due to earthquake. The building has been modeled using E-TABS basic modeller. Trial and error method has been carried out to find the mass attach to tuned mass damper in the building.

III. Modelling details

Structural Details

Grade of Concrete	M 45 For Columns and M40 For Beams
Grade of Reinforcing Steel	HYSD 415
Dimension of Beam	250×600 mm
Dimension of Column	1 to 20 storey: 500 X 2000 mm 20 to 34 storey: 500 mm X 1800 mm 35 to 51 storey: 500 mm X 1600 mm
Thickness of Slab	Floor Slab :- 150mm Staircase Slab :- 200 mm
Height of Typical Storey	4 m
Dead Load	Dead load according to IS 875 part I
Live Load	Live load according to IS 875 part II
Wind Load	Wind load according to IS 875 part III
Earthquake Load	Criteria as per IS 1893: 2002 Zone IV Site Type III
Density of Concrete	25 KN/m^3
Seismic Intensity	Very Severe
Response Reduction Factor	5
Zone Factor	0.36
Damping Ratio	5%
Structural Class	C
Wind Speed Zone	5
Basic Wind Speed	55 m/s
Risk Coefficient	1.00
Wind Design Code	IS 875:1987 (Part 3)
RCC Design Code	IS 456:2000
Steel Design Code	IS 800:2007
Load Combinations	As per IS 1893:2002 (part 1) and IS 456:2000
Location of Damper	For Top 8 Storey's (From 43 to 51)

For the analysis work ,model of concrete frame building (G+51) floors are made to know the realistic behaviour of building during earthquake. The length of the building at ground is 27 m and 26 m. The typical storey height is 4 m.

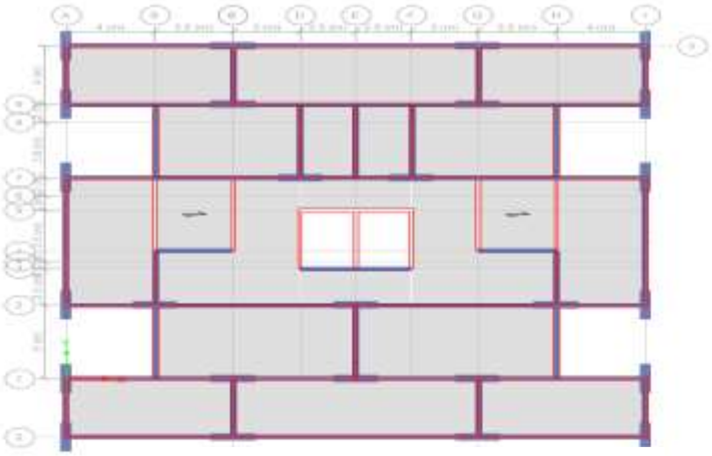


Fig 1: 1 to 20 Storey's plan

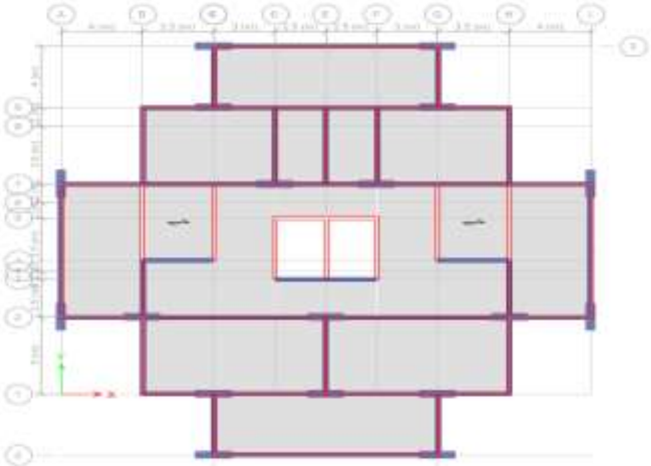
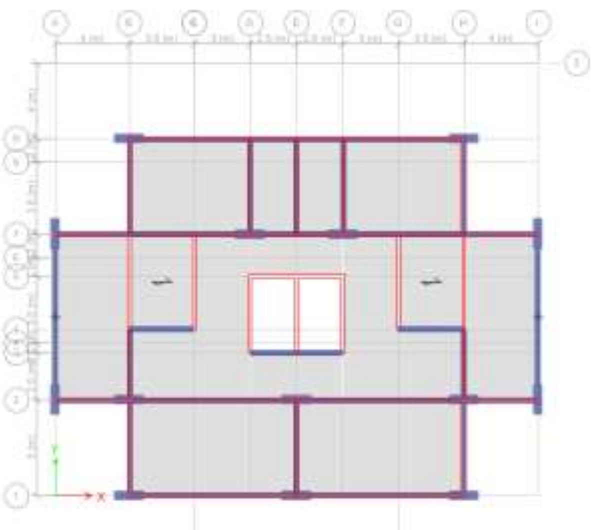


Fig 2: 20 to 34 Storey's plan



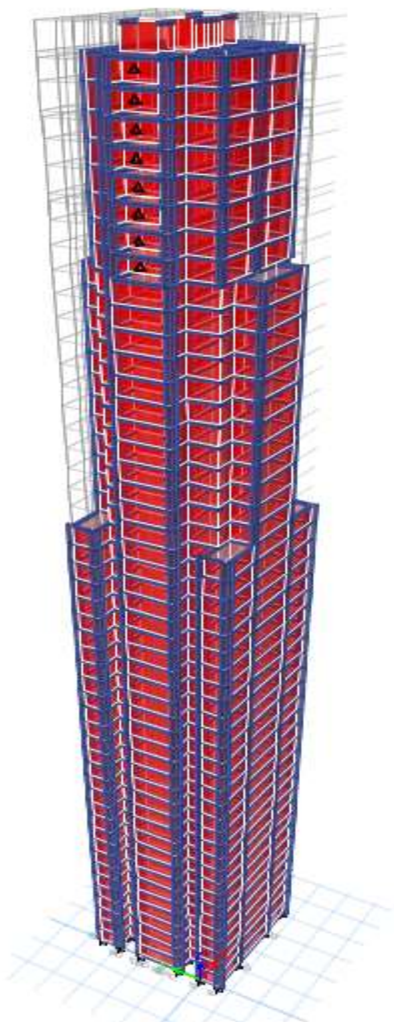


Fig 4: 3D sketch of the structure

Damper Details

The tuned mass damper used is the distributed type of tuned mass damper i.e. instead of using long pendulum with huge mass, tuned mass damper is divided into small distributed pendulum mass damper each of having mass of 100 kg , installed for top eight storey at outer face on both side of building.

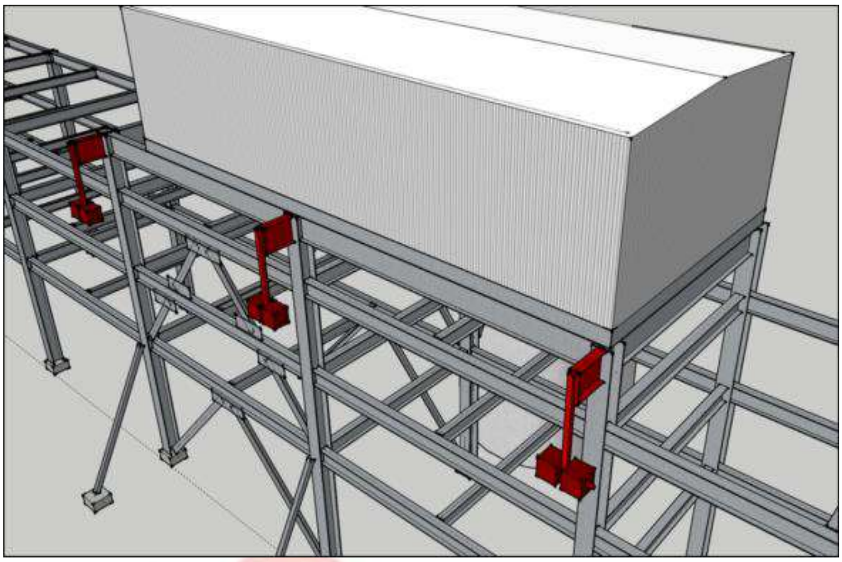


Fig 5: Design of Tuned mass Damper [5]

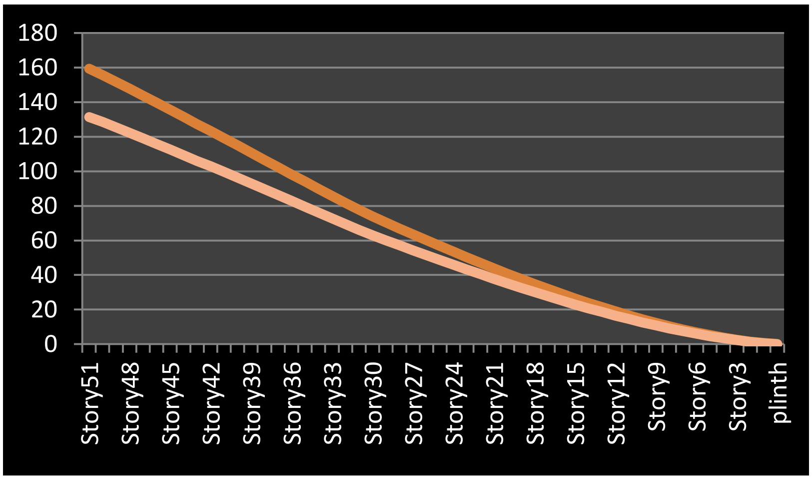
Properties of Tuned Mass Damper:-
Length of Damper = 0.9 m
Mass Attach to the Damper =100 kg
Location of Damper = for top eight storey's indicated by black in Fig 4: 3D sketch of the structure

IV. RESULT AND DISCUSSION

The results have been shown for most critical condition and for the critical load combination. Considering the wind speed as 55 m/s, therefore wind is found to be governing factor.

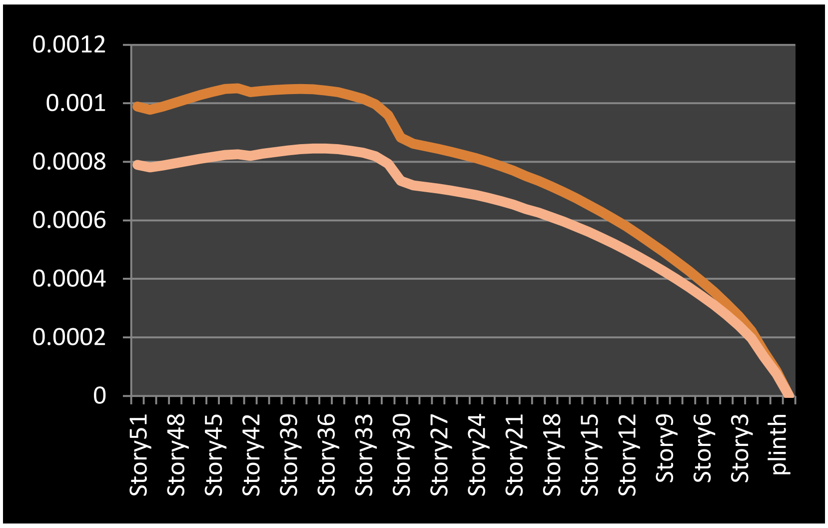
1. Comparison of Displacement and Drift values without Damper and with Damper

Load Case :-EQX



Displacement Graph

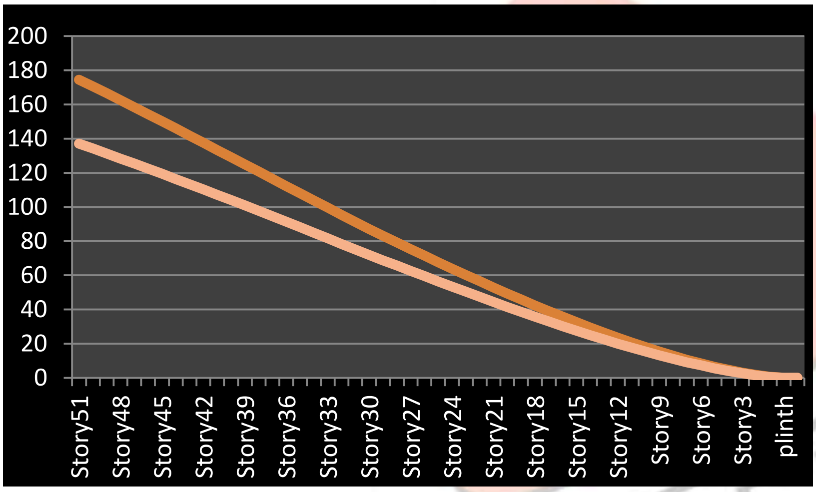
Displacement Graph for Eqx (mm)
Maximum Displacement without Damper:-159.295
Maximum Displacement with Damper: - 131.434
% Reduction: - 17



Drift Graph

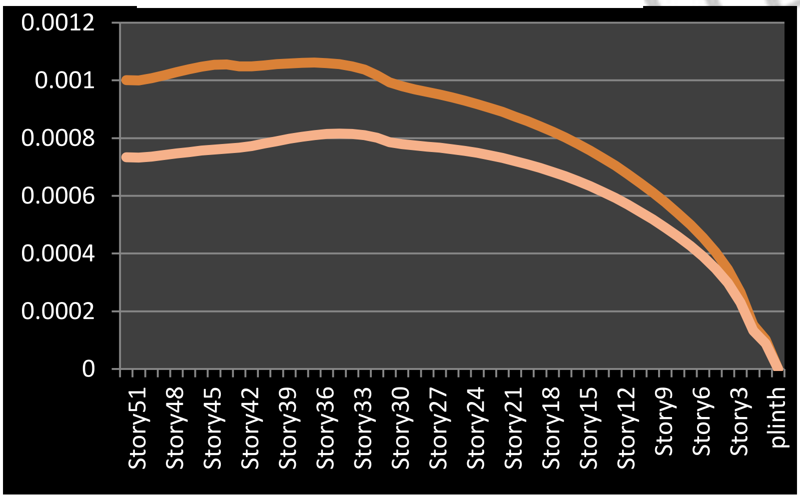
Drift Graph for Eqx (mm)
Maximum Displacement without Damper: - 0.000989
Maximum Displacement with Damper: - 0.00079
% Reduction: - 20

Load Case :- EQY



Displacement Graph

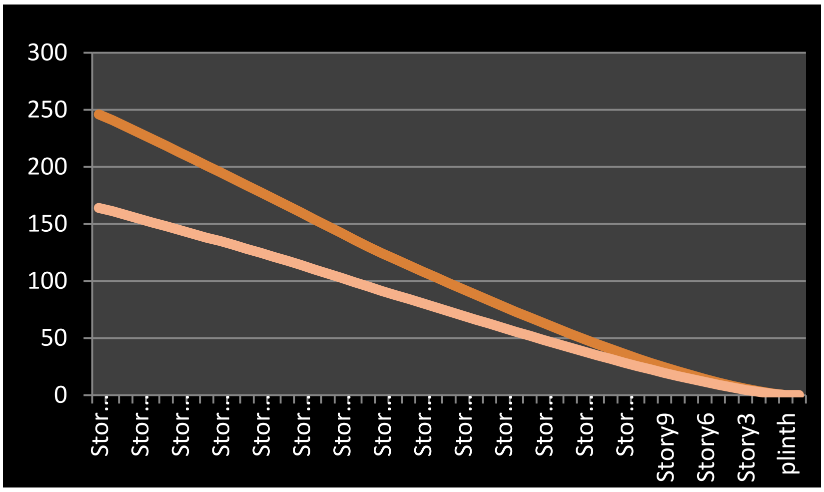
Displacement Graph for EqY (mm)
Maximum Displacement without Damper: - 174.578
Maximum Displacement with Damper: - 131.164
% Reduction: - 24



Drift Graph

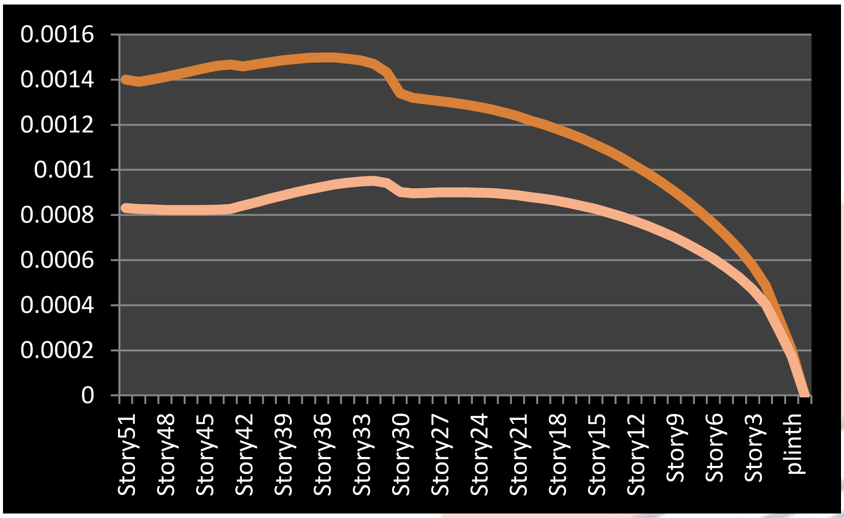
Drift Graph for EqY (mm)
Maximum Displacement without Damper: - 0.001
Maximum Displacement with Damper: - 0.000733
% Reduction: - 26

Load Case :- Wind X



Displacement Graph

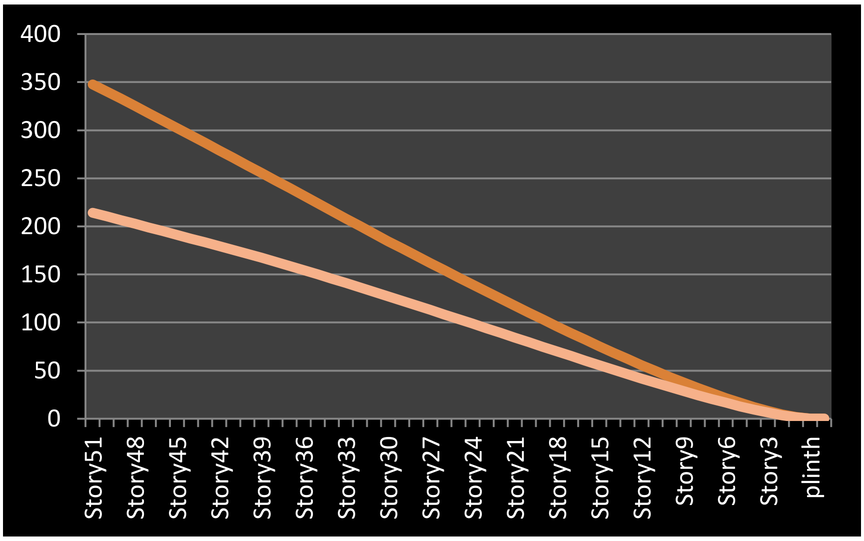
Displacement Graph for wind x (mm)
Maximum Displacement without Damper: - 246.063
Maximum Displacement with Damper: - 164.136
% Reduction: - 33



Drift Graph

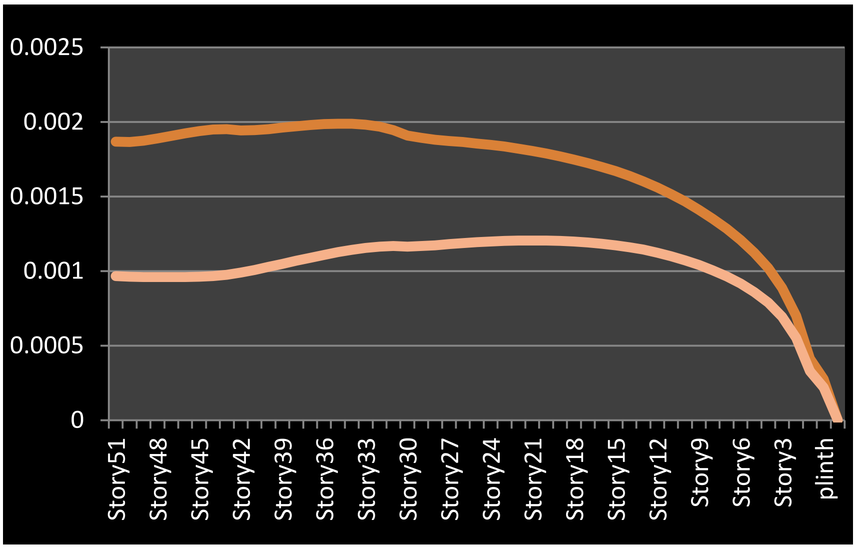
Drift Graph for wind x (mm)
Maximum Displacement without Damper:- 0.0014
Maximum Displacement with Damper: - 0.000831
% Reduction: - 40

Load Case :- Wind Y



Displacement graph

Displacement Graph for wind y (mm)
Maximum Displacement without Damper: - 347.821
Maximum Displacement with Damper: - 214.254
% Reduction: - 38.4



Drift Graph

Drift Graph for wind y (mm)
Maximum Displacement without Damper: - 0.0018
Maximum Displacement with Damper: - 0.00096
% Reduction: - 45

2.Results:-

Maximum Storey Displacement	**Without Damper(mm)**		**With Damper(mm)**	
Eqx	159.295		131.434	
Eqy	174.578		131.164	
Wind X	246.063		164.136	
Wind Y	347.821		214.254	
Maximum Storey Drift (mm)				
Eqx	0.000989		0.00079	
Eqy	0.001		0.000733	
Wind X	0.0014		0.000831	
Wind Y	0.0018		0.00096	
Maximum Storey Acceleration(mm/s^2)	**RES Y(UX)**	**RES Y(UY)**	**RES Y(UX)**	**RES Y(UY)**
Storey 51	885.88	811.72	765.18	737.93
Storey 50	866.7	730.87	749.8	661.46

RES Y:- Response of structure under Dynamic Condition in Y-Direction (Response Spectrum Method)
UX:- Acceleration along X-Direction UY:- Acceleration along Y-Direction

V. CONCLUSION

1. The values of displacement and drift are found to be more on structure when structure is acted upon by dynamic conditions without damper.

2. But by assigning Tuned Mass Damper to structure, the structure is going to more stable as the values of displacement and drift are reduced.

3. The acceleration also reduced significantly using tuned mass damper.

4. From the analysis and observations of graph we can conclude that , the percentage decrease in the displacement and drift values found to be reduced by 28% and 32% respectively.

5. Therefore the Tuned Mass Damper is highly useful in tall Structure as it is resist the structures motions under the dynamic conditions.

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