Dynamic Analysis of Tuned Mass Damper on Steel Structure: A Technical Approach

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Abstract: Seismic analysis is most important tasks to know the behavior of structure under action of earthquake loading. Different system is generated to reduce the effect of earthquake loading. TMD (tuned mass damper) arrangement is one which is used to decrease the sensations s of the steel structures. Further with the appearance of response spectrum analysis with better perceptive of seismic response. The significance of reduced the sensations and displacement of structure is realize in resisting even advanced seismic loads than the design load. The base shear force is decreases by introducing a response reduction factor to consider an inelastic displacement ability of ductile structure in dissipating the energy of structure. In this review paper studied the conduct of TMD on a steel frame structure under the action of dynamic loading with irregularity in vertical dir. The TMD is evaluated by means of response decrease coefficient. Which are generating from the proportion of the structure rejoinder with or without tuned mass damper. The response spectrum analysis of TMD structure shows the more accurate results against the seismic loading based on IS code depends on nonlinear performance of material.

Index Terms **- Earthquake Loading, Seismic Analysis, Spectral Acceleration, Storey Displacement, Storey Shear, Tuned Mass Damper**

I. INTRODUCTION

The concept of seismic design move towards has become the future dir. for design codes. In response spectrum analysis systems become significant in deciding the patterns and extent of damage to assess the structure response against the seismic event. Response spectrum method is a simplified procedure which is steered on SDOFS (Single Degree of Freedom System) to analyze structure frame until collapse mechanism is formed.

This undying journey for tallness has spread out unfathomable open doors for structure profession. From early minute edges to the present ultra-productive mega propped structures, the auxiliary designing has progressed significantly. The ongoing improvement of auxiliary investigation and plan programming combined with advances in limited component strategy has permitted the making of numerous basic and compositionally creative structures. In any case, increment dependence on computer analysis isn't the answer for the difficulties that lie ahead in the calling. The fundamental comprehension of basic conduct while utilizing on registering instruments are the components that will change the manner in which structures are planned and fabricated. the plan of structures is constrained by three overseeing components strength, stiffness and workability, created by the activity of earthquake loading, for example, seismic and wind.

II. LITERATURE REVIEW

A concise review of previous studies on the tuned mass damper on different structural configuration. This literature review also comprises past studies on diverse application of sensations of tuned mass damper. This literature review on new contribution associated to sensations investigation of building structure with tuned mass damper.

The study of conduct of Passive TMDs is an extremely effective answer for the control of sensations s in structures exposed to long-length, narrowband arousal. In this investigation, a Bidir.al and Homogeneously Tuned Mass Damper (BH-TMD) is proposed. The pendulum mass is bolstered from links & connected to a unidir.al contact damper with its pivot opposite to the heading of movement. A few points of interest of the proposed BH-TMD are:

(1) Its unidirectional Nature that permits thermostat of sensations s in both important ways;

(2) The ability to tune the gadget every central way autonomously;

(3) Its vitality dissemination limit that is corresponding to the square of the uprooting adequacy,

(4) Its low support cost. Numeric outcomes demonstrate that, under either unidirectional earthquake excitations, the dimension of reaction decrease accomplished by the stated BH-TMD is like that gotten from a "perfect" straight gooey gadget (Jos´e L. Almaz´an).

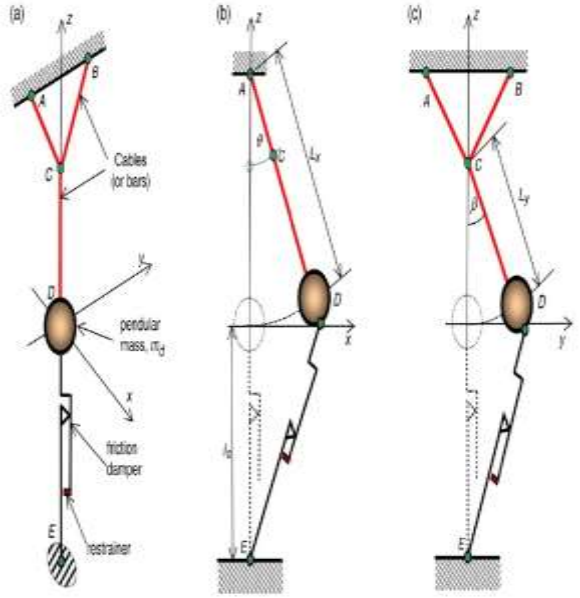

Figure 1: Representation of a BH-TMD

The analysis investigates the moderating impacts of a TMD on the auxiliary powerful reactions of Taipei 101 Tower, underneath the action of winds and remote (long-separate) seismic excitation. In the first place, the ideal limitations of the TMD in Taipei 101 Tower are first decided. At that point a limited component model of this tall structure, outfitted with a TMD framework, is built up. A point by point dynamic examination is directed as needs be, to assess the conduct of the structure-TMD framework. The reproduction results acquired are contrasted and the breeze passage test information and the documented ground estimations. The exactness of the set up computational structures is then confirmed. Discoveries of this investigation exhibit that the utilization of the TMD in this structure is tangibly compelling in decreasing the breeze incited sensations s. Nonetheless, it isn't as compelling in relieving remote seismic sensations s reactions (Alex Y. Tuan and G. Q. Shang).

The Tuned Mass Damper (TMD) has been observed to be best for controlling the basic reactions for symphonious and wind excitations. In the contemporary paper, the viability of TMD in controlling the earthquake reaction of structures and the impact of different ground movement parameters on the seismic adequacy of TMD have been examined. The structure considered is an admired single-level of-opportunity (SDOF) structure portrayed by its normal time of sensations and damping proportion. Different structures exposed to various real recorded seismic tremor ground movements and falsely created ground movements are considered. It is seen that TMD is viable in controlling tremor reaction of daintily damped structures; both for real recorded and falsely produced seismic tremor ground movements. The viability of TMD for a given structure relies upon the recurrence substance, data transmission and term of solid movement; anyway the seismic adequacy of TMD isn't influenced by the force of ground movement (Dr. Mohan M. Murudi).

The crucial parametric examination the earthquake presentation of Tuned Mass Dampers (TMDs) is explored. Quake energized ambiances inclined structures are established as versatile single-level of-opportunity oscillators and they are equipped with a solitary TMD. The TMD execution is surveyed by approaches for response decrease coefficients, which are produced from the proportion of the elementary response with and without TMD joined. It is discovered that TMDs are compelling in lessening the dynamic reaction of seismic animated structures with light basic damping. The aftereffects of the displayed examination depend on a lot of 40 recorded customary ground movements (Christoph Adam and Thomas Furtmuller).

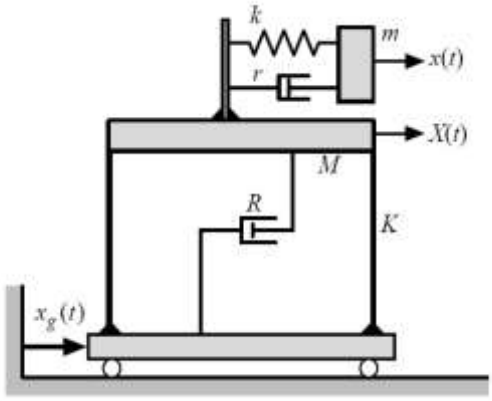

Figure 2: Mechanical model of structure TMD system subjected to seismic loading.

The use of tuned mass damper cultivating the reaction of structure is measured. At preliminary, three casings of 3, 9 and 20 stories are evaluated in that time history investigation is finished by EL–Straw seismic tremor. The greatest extreme decrease of among the three referenced coverings has a place with a 20-stories structure in that the rate of story uprooting decrease is around 25 to 45%, and

this shows by mounting the tallness of the structure, the exhibition of TMD enhanced. In the second part, the influence of semi-dynamic TMD is contemplated on a 10-stories outline. Studies demonstrated that utilizing a TMD formwork with thick damper with controller power diminishes the normal of most extreme uprooting of rooftop story down to 39.91 % and this measure of decrease is 22.81% for semi-dynamic tuned mass damper. At former, the presentation of Single tuned and diverse mass Damper is assessed on a 20-stories outline, and the outcomes demonstrate that solitary and numerous dampers diminishing structures' reactions and the exhibition of tuned numerous dampers relies upon the mass and repetition proportion and furthermore reasoned that the presentation of tuned multiple mass dampers is diminished by change to centre of the framed stories (Kourosh Talebi Jouneghani).

The investigation of cutting edge aloof and semi-dynamic tuned mass damper (PTMD and SATMD) building frameworks for diminishing the seismic reaction of tall structures and alleviating harm. The proposed basic arrangement isolates the upper storey(s) of a structure to go about as the 'tuned' mass, either latently or semi effectively. In the view purpose of conventional TMD framework hypothesis, this elective methodology abstains from including unreasonable excess mass that is seldom utilized. Specifically, it is proposed to supplant the inactive spring damper framework with a semi dynamic resettable gadget based framework (SATMD). This semi-dynamic methodology utilizes criticism control to modify or control the response powers, viably re-tuning the framework relying upon the auxiliary reaction. In this exchange off parametric examination, the viability of spreading solidness between resettable gadgets and elastic heading is outlined. Ghostly investigation of rearranged 2-DOF model investigates the adequacy of these changed basic control frameworks and the general legitimacy of the ideal determined parameters is illustrated. The final product of the otherworldly investigation is an ideally based beginning structure approach that fits into acknowledged plan procedures. (Min Ho Chey.)

III. Gap Of Study

Tall structure development has been quickly increases in India introduce new challenges that require to be met through engineering judgment. Selection of the proper structural scheme for a tall building subjected to earthquake loads is very difficult task. The used of tune mass damper system has been very effective and efficient structural system used in decreasing the horizontal displacement and storey drift. However, when height of the structure increases, the structure does not have the adequate stiffness to keep the storey drift down to acceptable limits. For such tall structures, a structural system known as TMD (tuned mass damper) were introduced. This system helps in reducing the movement of structure and reduces the storey drift as well as lateral displacement.

Although various analysis is carrying out in the past years but the advancement in technology and analysis procedures of structure give as more precise result. Therefore, there is need of performing structural analysis with some advance tools. In this study ETABS software is used to analysis and study the various aspect of performance of structure. In previous studies researchers considered only regular geometry of structure by placing TMD (tuned mass damper) at different storey level under earthquake load to get optimum position of structure.

IV. Results and Discussion

The analysis conducted on models by seismic loading done with the help of IS 1893 2002 code (design of earthquake resisting structure) with zone factor equal to 0.36, building importance factor equal to 1, response reduction factor equal to 5 and soil type 2 is used in analysis. Story shear and story displacement is calculated in X and Y-direction are as follows.

Lateral displacement refers to the lateral movement of stories from each other from its original position by the action of story shear on the structures. As per IS 456:2000 displacement should not be greater than the ratio of height of structure to 500.

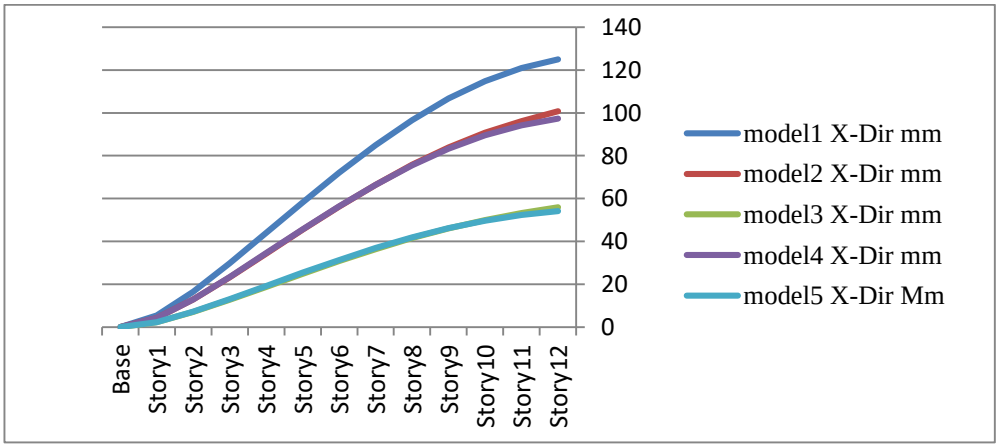

Figure 3: Story displacement of all models in X-direction

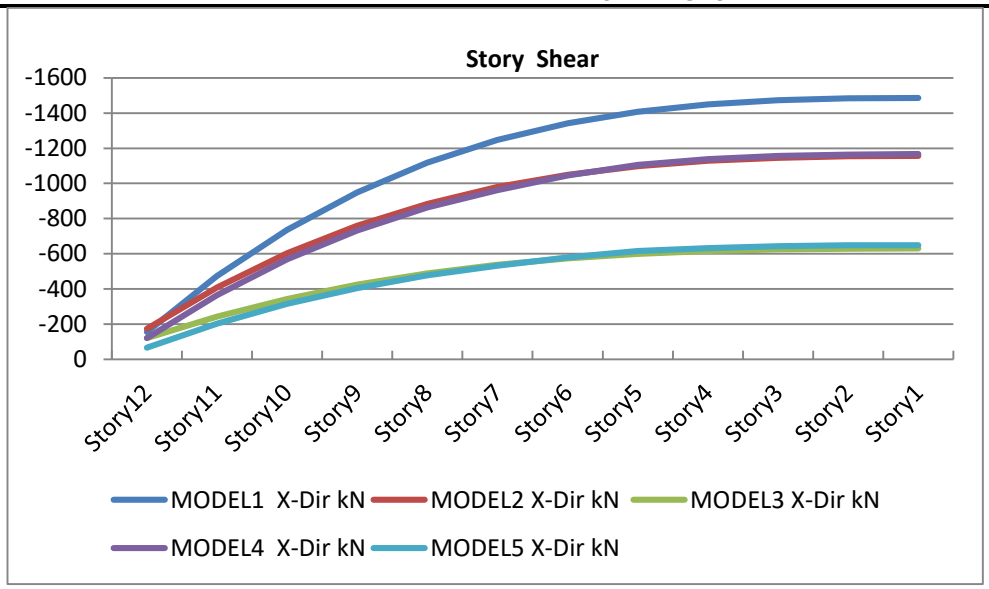

Figure 4: Story Shear of all models in X direction

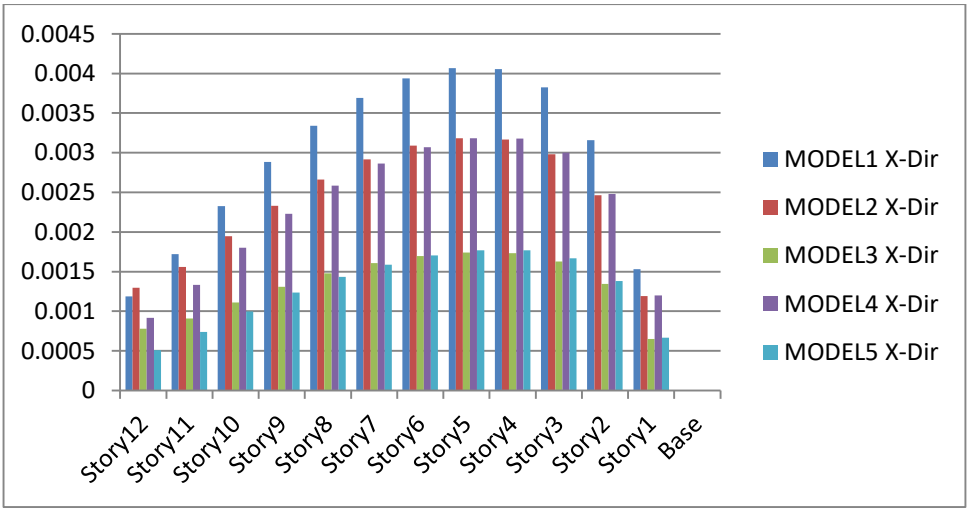

Figure 5: Story drift of all models in X direction

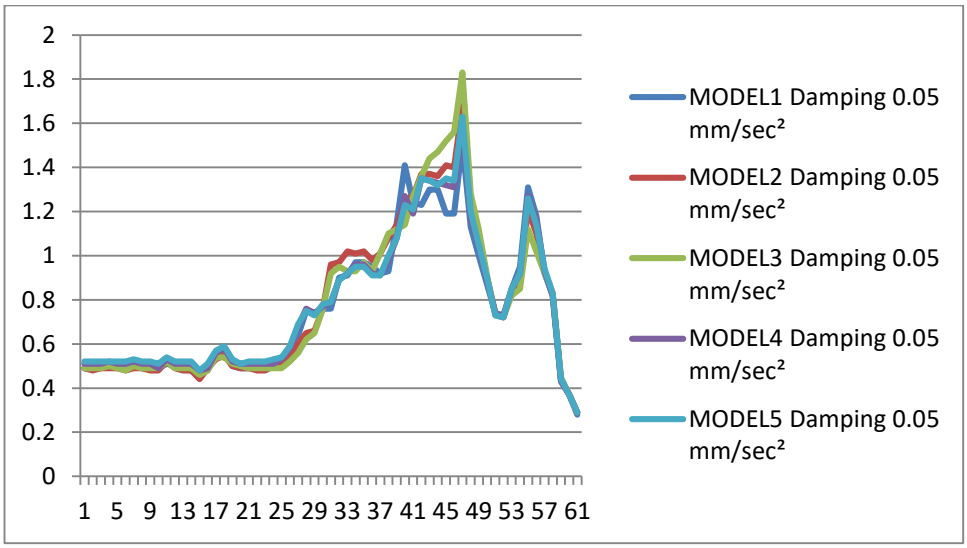

Figure 6: Spectral acceleration of all models in X-direction due to response spectrum

The values of story displacement in X direction for different models are compared and it is observed that minimum roof displacement 54.1 mm and 55.9 mm is obtained in model 5 and model 3 because more stiffness is providing with the help of tuned mass damper having mass ratio equal to 0.04 to the building.

V. CONCLUSION

The results of 3-dimensional modeling of TMD structure from ETABS software with the help of response spectrum and time history analysis. Five different models having constant plan area equal to 256 m^2 and same plan section are prepared by software with the help of IS code and comparative analysis studied between them. This project has introduced TMD steel frame structure which analyzing to determine its structural performance.

- From earthquake analysis on all five models target displacement in **model 3** are44.72% of **model 1**due to the position of TMD in X-direction as compare to other models.
- The story shear of **model 1** is comparatively higher than **model 2, model 3, model 4,** and **model 5** because of no infill and TMD in **model 1** to resist the lateral load.
- From earthquake analysis on all models according to IS-1893 the story displacement in **model 3** are 34% of **model 2** and **model 4** due to the mass ratio of TMD is twice in model 3 and model5 as compare to other models of steel frame structure.

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REFERENCES

[1] Agarwal A. 2012, Seismic Evaluation of Institute Building, Bachelor of Technology Thesis, National Institute of Technology Rourkela.
[2] Applied Technology Council (ATC) 1996, Seismic Evaluation and Retrofit of Concrete Buildings, ATC-40, Redwood City, CA.
[3] ASCE 41-06, 2007, Seismic Rehabilitation of Existing Buildings, American Society of Civil Engineers.
[4] A. Kadid, A. Boumrkik 2008, "Pushover analysis of reinforced concrete frame structure". Asian Journal of Civil Engineering (building and housing) 9(1), pp. 75-83.
[5] Brown john, J. M.W., Pan, T. H., 2001, "Response of Tall Building to Weak Long Distance Earthquakes," Earthquake Engineering Structure Dynamic, 30, pp. 709-729.
[6] Computers and Structures Inc.; CSI. ETABS 2013, "CSI analysis reference manual". Berkeley, California, USA, 2008.
[7] Chang, C. C, 1999, "Mass Dampers and Their Optimal Designs for Building Vibration Control," Eng Struct., 21(5), pp. 454-463.
[8] Gerges, R. R. and Vickery, B. J., 2003, "Wind Tunnel Study of the Across-Wind Response of a Slender Tower with a Nonlinear Tuned Mass Damper," J Wind Eng Ind Aerod, 91(8), pp. 1069-1092.
[9] IS 456, Plain and Reinforced Concrete Code of Practice (fourth revision), 2000, New Delhi-110002: Bureau of Indian Standards.
[10] IS 875 (part1), 1987, Dead loads, unit weights of building material and stored and stored material (second revision), New Delhi 110002: Bureau of Indian Standards.
[11] IS 875 (Part2), 1987, Imposed loads (second revision), New Delhi 110002: Bureau of Indian Standards.
[12] IS1893-2002, Indian Standard CRITERIA FOR EARTHQUAKE RESISTANTDESIGN OF STRUCTURE, Bureau of Indian Standards, Fifth revision.
[13] Leung, A. Y. T. and Zhang, H. J., 2009, "Particle Swarm Optimization of Tuned Mass Dampers," Eng Struct., 31(3), pp. 715-728.
[14] Leung, A. Y. T., Zhang, H. J., Cheng, C. C. and Lee, Y.Y. 2008, "Particle Swarm Optimization of TMD by Non--Stationary Base Excitation during Earthquake," Earthquake Eng & Struct D, 37(9), pp. 1223-1246.
[15] Lee, C. L., Chen, Y. T., Chung, L. L. and Wang, Y. P., 2006, "Optimal Design Theories and Applications of Tuned Mass Dampers," Eng Struct., 28(1), pp. 43-53.
[16] Mwafy A.M., Elnashai A.S., 2001, "Static pushover versus Dynamic Collapse analysis of RC buildings", Journal of Engineering Structures, 23, pp. 407-424.