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ANALYSIS AND DESIGN OF MULTI STORED BUILDING FOR VERTICAL AND HORIZONTAL LOADING WITH AND WITH OUT DAMPERS

[*] DULLA TRIVENDRA, [**]A.RAVI KUMAR
[*]MTech student, Dept of CIVIL, A.M.Reddy memorial college of Engineering and Technology, AP, India.
[**] Assistant Professor, Dept of CIVIL, A.M.Reddy memorial college of Engineering and Technology, AP, India.

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 lake 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.

Keywords: Single column, symmetrical, eccentric loads, Staad Pro.

1. INTRODUCTION:

Tuned mass dampers have been widely used for vibration control in mechanical engineering systems. In recent years, Tuned Mass Dampers 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.

Tuned Mass Dampers 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 when that frequency is excited, the damper will resonate out of phase with the structural motion. The mass is usually attached to the building via a spring-dashpot system and energy is dissipated by the dashpot as relative motion develops between the mass and the structure. Usually 5% of critical damping can be assumed for buildings, and an

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increase of the damping ratio causes a reduction of the stress or acceleration.

A tuned mass damper is a device consisting of a mass, spring and a damper that is attached to a structure in order to reduce the amplitude of undesirable motion. Tuned mass control systems can be used to control the displacements, accelerations and internal stress variables of a structure in case of earthquakes. 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.

1. Tuned mass damper systems are widely used for the reduction of vibration caused by wind and traffic like pedestrians or railway trains. Typical structures like slender bridges, stacks, high and slender buildings possess low levels of damping and may therefore undergo unacceptable vibration. Tuned Mass Dampers cause control effects which are similar to the increase of damping. Depending on the mass ratio, the tuning frequency and the damping capability the amplitude reduction can be very significant and achieve values of about 10 to 20% of the figures without Tuned Mass Dampers. The mass, stiffness and damping ratio has chosen according different criteria. Here, a multistory building is equipped with a tuned mass system on the rooftop.

2. LITERATURE SURVEY:

Den Hartog [7]. The TMD concept was first introduced by frahm in the year1909 to reduce the rolling motion of ships as well as ship hull vibrations. A theory for the TMD was presented later in the paper by Ormondroyd and followed by a detailed discussion of optimal tuning and damping parameters in Den Hartog's book on mechanical vibrations **[8].** The initial theory was applicable for an un-damped SDOF system subjected to a sinusoidal force excitation. Extension of the theory to damped SDOF systems has been investigated by numerous researchers.

Hrovat *et al*.[11]. Active control devices operate by using an external power supply. Therefore, they are more efficient than passive control devices. However the problems such as insufficient control-force capacity and excessive power demands encountered by current technology in the context of structural control against earthquakes are unavoidable and need to be overcome. Recently a new control approach-semi-active control device, which combines the best features of both passive and active control devices, is very attractive due to their low power demand and inherent stability. The earlier papers involving SATMDs may trace to 1983. presented SATMD, a TMD with time varying controllable damping. Under identical conditions, the behavior of a structure equipped with SATMD instead of TMD is significantly improved. The control design of SATMD is less dependent on related parameters (e.g, mass ratios, frequency ratios and so on), so that there greater choices in selecting them.

Clark [2]. The concept of multiple tuned mass dampers (MTMDs) together with an optimization procedure was proposed by Clark. The first mode response of a structure with TMD tuned to the fundamental frequency of the structure can be substantially reduced but, in general, the higher modal responses may only be marginally suppressed or even amplified. To overcome the frequency-related limitations of TMDs, more than one TMD in a given structure, each tuned to a different dominant frequency, can be used., then, a number of studies have been conducted on the behavior of MTMDs a doubly tuned mass damper (DTMD), consisting of two masses connected in series to the structure was proposed (Setareh 1994). In this case, two different loading conditions were considered: harmonic excitation and zero-mean white-noise random excitation, and the efficiency of DTMDs on response reduction was evaluated. Analytical results show that DTMDs are more efficient than the conventional single mass TMDs over the whole range of total mass ratios, but are only slightly more efficient than TMDs over the practical range of mass ratios (0.01-0.05).

Villaverde. Recently, numerical and experimental studies have been carried out on the effectiveness of TMDs in reducing seismic response of structures [for instance, Villaverde(1994)]. In three different structures were studied, in which the first one is a 2D two story shear building the second is a three-dimensional (3D) one-story frame building, and the third is a 3D cable-stayed bridge, using nine different kinds of earthquake records. Numerical and experimental results show that the effectiveness of TMDs on reducing the response of the same structure during different earthquakes, or of different structures during the same earthquake is significantly different; some cases give good performance and some have little or even no effect. This implies that there is a dependency of the attained reduction in response on the characteristics of the ground motion that excites the structure. This response reduction is large for resonant ground motions and diminishes as the dominant frequency of the ground motion gets further away from the structure's natural frequency to which the TMD is tuned. Also, TMDs are of limited effectiveness under pulse-like seismic loading.

Allen J. Clark [2]. Multiple passive TMDs for reducing earthquake induced building motion. In this paper a methodology for designing multiple tuned mass dampers for reducing building response motion has been discussed. The technique is based on extending Den Hartog work from a single degree of freedom to multiple degrees of freedom. Simplified linear mathematical models were excited by 1940 El Centro earthquake and significant motion reduction was achieved using the design technique.

K. C. S. Kwok *et al* [14]. Performance of tuned mass dampers under wind loads The performance of both passive and active tuned mass damper (TMD) systems can be readily assessed by parametric studies which have been the subject of numerous research.. Few experimental verifications of TMD theory have been carried out, particularly those involving active control, but the results of those experiments generally compared well with those obtained by parametric studies. Despite some serious design constraints, a number of passive and active tuned mass damper systems have been successfully installed in tall buildings and other structures to reduce the dynamic response due to wind and earthquakes.

T.Shimazu and H.Araki [26]. "Survey of actual effectiveness of mass damper systems installed in buildings". In this paper the real state

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of the implementation of mass damper systems, the effects of these systems were clarified based on various recorded values in actual buildings against both wind and earthquake. The effects are discussed in relation with the natural period of buildings equipped with mass damper systems, the mass weight ratios to building weight, wind force levels and earthquake ground motion levels.

Fahim Sadek *et al* [8]. A method of estimating the parameters of tuned mass dampers for seismic applications. In this paper the optimum parameters of TMD that result in considerable reduction in the response of structures to seismic loading has been presented. The criterion that has been used to obtain the optimum parameters is to select for a given mass ratio, the frequency and damping ratios that would result in equal and large modal damping in the first two modes of vibration. The parameters are used to compute the response of several single and multi-degree of freedom structures with TMDs to different earthquake excitations. The results show that the use of the proposed parameters reduces the displacement and acceleration responses significantly. The method can also be used for vibration control of tall buildings using the so-called ‗mega-substructure configuration', where substructures serve as vibration absorbers for the main structure.

G. W. Housner *et al* [9]. Structural control: past, present, and future This paper basically provides a concise point of departure for those researchers and practitioners who wishing to assess the current state of the art in the control and monitoring of civil engineering structures; and provides a link between structural control and other fields of control theory, pointing out both differences and similarities, and points out where future research and application efforts are likely to prove fruitful.

3. MATERIALS AND METHODOLOGY

A high-rise framed building has been modeled using ETABS package. The framed structure was analysed using dynamic analysis and the time period, magnitudes of displacements at critical locations were recorded. Thereafter, a suitable TMD system was designed. The weight of the TMD will be 3% to 5% of the total weight of the building. The TMD was first analyzed separately and its natural frequency was obtained. Keeping the TMD so designed on top of the building, the structure was once again analyzed using dynamic analysis and the time period, displacement at the corresponding locations was compared with the results obtained without TMD to illustrate the utility of the study.

The methods of dynamic analysis are as follows:

1. Response spectrum analysis: This method is applicable for those structures where modes other than the fundamental one affect significantly the response of the structure. In this method the response of multi-degree of freedom system is expressed as the superposition of modal response, each modal response being determined from the spectral analysis of single degree of freedom systems, which are combined to compute the total response. The method used is usually used in conjunction with a response spectrum.
2. Pushover analysis: The pushover analysis of a structure is a static non-linear analysis under permanent vertical loads and gradually increasing lateral loads. The equivalent static loads appropriately represent earthquake induced forces. A

plot of total base shear and roof displacement in a structure is obtained by the analysis that would premature failure and weakness. The analysis is carried up to failure, thus it enables determination of collapse load and ductility capacity.

3. Inelastic time history analysis: A seismically deficient building will be subjected to inelastic action during design earthquake motion. The inelastic time history analysis of the building under strong motion earthquake brings out the regions of weakness and ductility demand in the structure. This is the most rational method available for assessing building performance.

Rectangular plan:

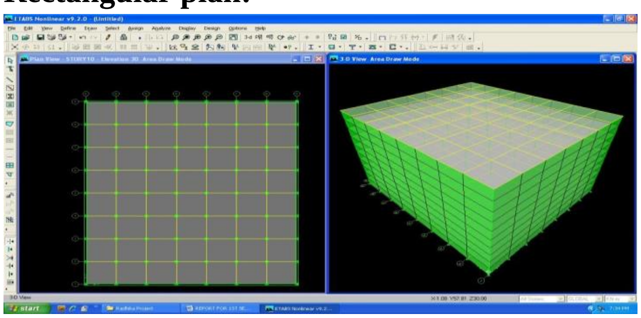

Fig.1. Symmetrical building Plan without TMD.

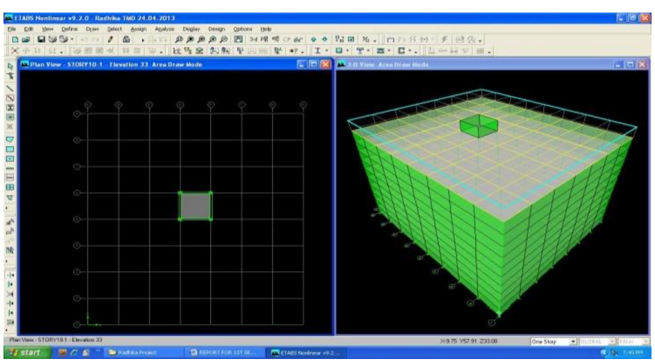

Fig .2. Symmetrical building plan with TMD.

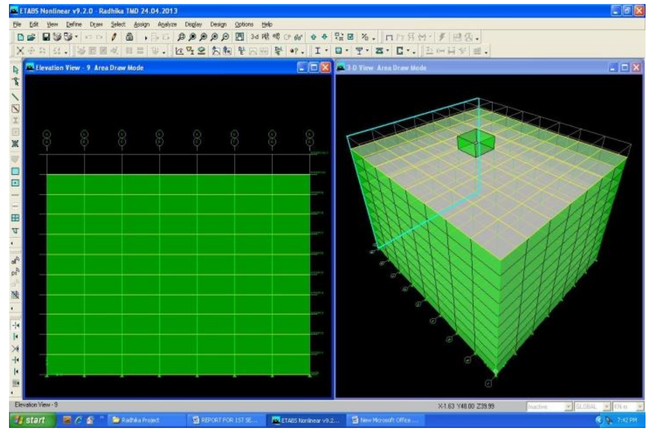

Fig.3. Shows elevation of symmetrical building.

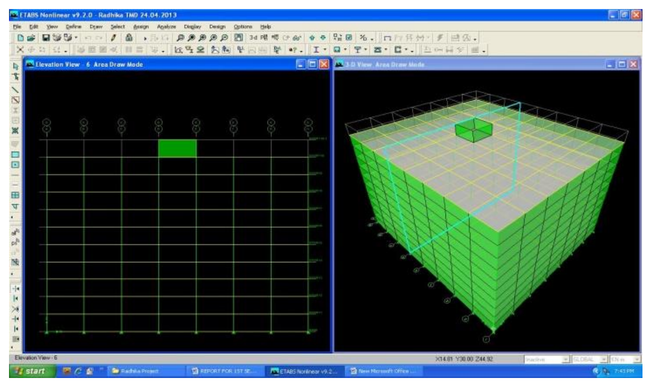

Fig.4. Shows elevation of symmetrical building.

L- Shape Building:

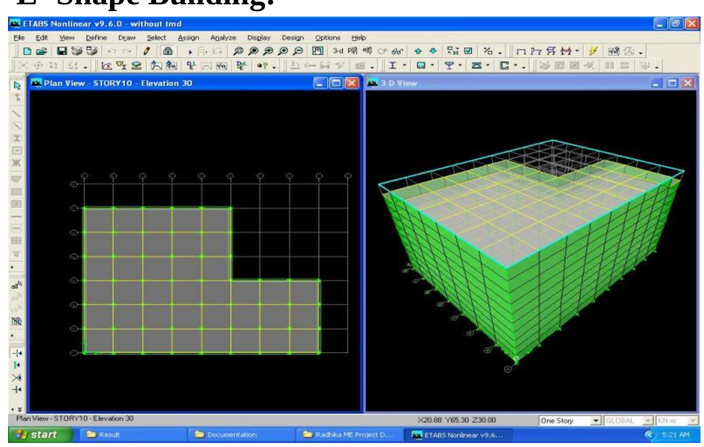

Fig.5. Unsymmetrical Building Plan without TMD.

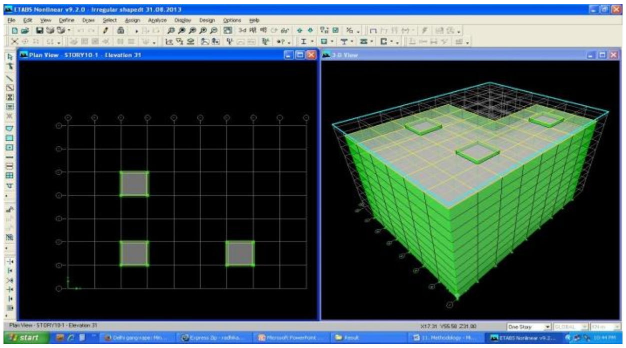

Fig.6. Unsymmetrical Building Plan with TMD.

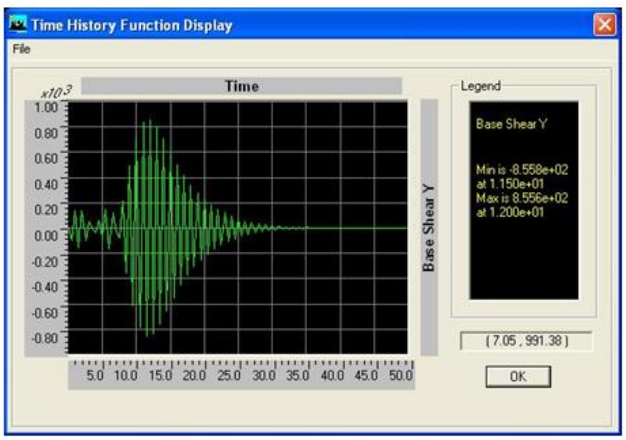

Fig.7. The Graph Showing between Time Vs Base shear y (Without TMD).

Fig.8. The Graph Showing between Storey Number Vs Max displacements.

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

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

CONCLUSION

Based on the outputs obtained from the ETABS package as per IS: 1893:2002 (part-I) with 5% of structural damping following conclusions are made.

1. With 5% mass of Tuned Mass Dampers the frequency of the Tuned Mass Dampers matches close to the fundamental mode of the structure. Due to this reason mass of the Tuned mass dampers is fixed close to 5% of the structural mass.

2. For Symmetrical Buildings, using of Tuned mass dampers in the form of steel dampers, the amplitude of vibration could be brought down by 51% (page 50).

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3. Similarly for un-symmetrical buildings, the value of the amplitude of vibration could be brought down by 49% (page 58) using steel dampers.

4. Similarly for symmetrical Buildings, the value of the base shear is brought down by 56% (page 45 & 46) using steel dampers.

5. For un-symmetrical Buildings, the value of the base shear is brought down by 42% (page 54) using steel dampers.

Scope of future work:

1. Further studies have to be carried out for different TMD's. i.e Active, Semi active, etc.

2. The effect of TMD needs to be validated with experimental studies.

3. Further studies have to be carried out for finding the Stiffness Matrix and Mass Matrix of an element.

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