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A Review on Response of Seismic Loading on Regular High Rise Building With and Without Damper Using ETABS

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Abstrasct - *The main objective of this study is to carry out the analysis of G+10,G+15,G+20 against earthquake as per Indian standard codes of practice IS 1893(Part 1):2002. Basically the earthquake loads on the building are calculated assuming the building to be located at zone II. The member forces are calculated with load combinations for Limit State Method given in IS 456: 2000 and the members are optimized for the most critical member forces among them. With the help of ETAB software. The building is subjected to self weight, dead load, live load as per IS 875(Part 1, Part 2):1987. The structure is design in accordance with seismic code IS-1893:2002 under seismic zone II analysis with the help of the ETAB software. By using TMD we can control the vibration of structure while Earthquake occurs. So, now the interesting part is for the Structural engineer's that the design of high rise building includes a lot of parameters involve in it. From structural engineer's point of view, high rise multi-storied building is the one that by virtue of its height is affected by lateral forces to an extent that they play an important role in the structural design. In this type of Multi-storey buildings (i.e.,G+10,G+15,G+20), wind and seismic loads play a vital role. Hence the lateral stability is most important for high rise building.*

Key Words: *ETAB software, TMD, seismic. Dampers, Multistories, Dynamic Analysis,etc*

1. INTRODUCTION

1.1 General

Conventional design for seismic loads on a structure has to ensure the safety of the inhabitants of the building. This has always historically been, and always should be, the focus of design for all structures. But a structure under seismic loads may be severely damaged following a seismic event due to the demand on the structure. If properly designed, when the structure were subjected to large earthquakes it did not topple, but required significant repair to be deemed reusable. Since this was very costly, engineers began to develop ways of reducing the demand that affect buildings in order to reduce the damage. The main focus was to reduce the accelerations and displacements generated by the structure. There are many innovative ideas as to how to do this. Many are used in practice now. Many are still in development. There are two broad methods used to achieve this. One was the use of tuned mass dampers to dissipate energy and reduce acceleration. The second was base isolation which un-couples the structure from its foundation, thus reducing displacements and stresses. Initially, this literature review investigates seismic loading on structures. It then investigates the details of base isolation followed by tuned mass dampers. To complete the literature review, the focus shifts to mathematical concepts and processes that were used to derive and solve the equations that govern the response of these systems.

4. LITERATURE REVIEW

Haitham Mohamed Khalaf,et.al

The models created as regular and symmetrical models with 15 storey (45m) ,25 storey (75m) and 35 storey (105m).analytical models created by SAP 2000 program with and without Tuned mass damper

Parameters/Model/Software:

Tuned Mass Damper, SAP 2000. The following parameters to be used in the following discussion.

Natural Frequency of TMD, Damping Ratio of TMD , Natural Frequency of Main Structure ,Damping Ratio of Main Structure .

Conclusion: Base shear reduction after used TMD as following:

In 15 storey building the reduction 24%. ,In 25 storey building the reduction 28%. ,In 35 storey building the reduction 31%.

Lateral deflection (displacement) reduction after used TMD as following:

In 15 storey building lateral deflection decrease between (23.8-24.9)%. , In 25 storey building lateral deflection decrease between (28.5-28.9)%. , In 35 storey building lateral deflection decrease between (29.4-30.9)%.

My Conclusion: The conclusion that while using TMD base shear is decreases with increases rise of building.

Displacement after using TMD is decreases with increasing height.

In this paper SAP-2000 software is used and we are using ETABS instead of SAP-2000.

Response spectrum method is used to analyze the building and obtain the result are satisfied i.e we are also using RSM

Mr. Ashish A. Mohite,et.al

The wind-induced response of a structure with a damper system and to estimate the suppressing effects of dampers under earthquake loadings.

Analysis of symmetrical moment resistance frame (MRF) 10th,12th,14th,16th,18th, and 21th storey three – dimensional model with tuned mass damper and without tuned mass damper by using software ETABS

Parameters/Model/Software:

Tuned Mass Damper, TABS. The following parameters to be used in the following discussion.

The optimum natural frequency of the damper (fd), and the optimum damping ratio of damper (ζopt) are given by equation (1) and (2) respectively.

Conclusion:The seismic behavior of 10th, 12th, 14th, 16th, 18th, and 21th storey building with tuned mass damper and without tuned mass damper was investigated.

TMD is effective in reducing displacement and acceleration and, thereby, can be used for structures under earthquake.

This study is aimed as tuned mass dampers in reducing structural (storey drift, storey displacement and base shear) of seismically excited 10th, 12th, 14th, 16^{th},18th, and 21th storey building.

It has been found that the TMDs can be successfully used to control vibration of the structure.

For the regular building frame, 5% TMD is found to effectively reduce top storey displacement. The reduction of 10th storey building is 38.13, reduction of 12th top storey building is 36.36, reduction of 14th top storey building is 35.16, reduction of 16th top storey building is 33.34, reduction of 18th top storey building is 31.96, and reduction of 21th top storey building is 30.46. And base shear by about 2%.Therefore, the TMD should be placed at top floor for best control of the first mode.

For the regular building, TMD with damping exponent (n) value 0.2 is found to be better than TMD with damping exponent value 0.5.From analysis it can be seen that it is necessary to properly implement and construct a damper in any high rise building situated in earthquake prone areas.

Our Conclusion: In this paper the result of using TMD will be obtained successfully. From the research of above paper it has been found that the best result will be obtained when we provide the TMD on top of building to control vibration.

Mr. Khemraj S. Deore ,et.al

Time History Analysis and Response Spectrum Analysis is a vital technique for structural seismic analysis particularly once the structural is high rise. This thesis study of the damper effect in the frame (MRF) is an important factor for the analysis.

For Analysis purpose practical (G+16) storey building modeled with and without tuned mass damper by using software ETABS.

Constant loading parameters are used for both cases. Load combinations are taken from IS code 875 Part 5. A tuned mass damper (TMD) is placed on top floor of building and Response spectrum analysis has performed

Parameters/Model/Software:

Mass of damper, mass ratio, Frequency of damper , Optimum damping ratio

Conclusion: On the basis of present study and reviewed literature The following conclusions can be drawn:

Seismic performance of building after application of damper is much better when we provide to top of storey.

It has been found that the TMD can be successfully used to control vibration of the structure.

For story drift which is important behavior for finishes such as sliding windows, performance is better for building with TMD. Application of TMD damper reduces large amount of displacement of the structure. Due to absolute displacement reduction the structure have not require more ductility to resisting earth-quake forces.

With the using of TMD in the structure, the base shear slightly increases. With the using of TMD in the structure, the Fundamental Period of structure reduces.

Our Conclusion: We concluded that all the parameters give much better value while using TMD on top storey of building. The conclusion is obtained that TMD is good for reducing vibration

Muhammad Murad.K ,et.al

This paper is to study the comparison of shear wall and TMD for reducing vibration of tall buildings due to wind and earthquake loading by using SAP2000 software.

Shear walls and Tuned Mass Dampers are assigned in the structure alternatively.

Various arrangements of Tuned Mass Dampers in this 30 storey building are studied and the best arrangement among these is applied in a 50 storey building to study the effectiveness in controlling vibration. And also the characteristic of this 50 storey building is studied by applying Time History Analysis of El-Centro earthquake.

Parameters/Model/Software: Mass of damper, mass ratio, Frequency of damper , Optimum damping ratio, Frequency of building

Conclusion: The storey displacement of 30 storey buildings with TMDs are also very less when compared with building with shear wall. The maximum storey displacement obtained for building with shear wall is 0.088m and the maximum displacement of buildings with TMDs is 0.046m. It is almost just the half of that with shear wall. The minimum displacement obtained is 0.037m.

The joint acceleration obtained for 30 storey buildings with TMDs are also having a large difference between that of building with shear wall. Proved to be safe. The Base shear, Storey displacements, joint accelerations and frequency of the structure are very less. These storey displacements, joint accelerations and frequency of the 50 storey structure are less than that of 30 storey building with TMDs for the designed optimum parameters of TMDs,

The cost of TMDs is almost similar to that of shear wall in 30 storey's structure. But less base shear, storey displacement, joint acceleration, and frequency makes TMDs more applicable than shear wall. For 50 storey building the TMDs could be cost effective.

Our Conclusion

In this paper the comparison of TMD & base shear wall is done. The result is obtained that the TMD gives less value than shear wall in all direction. We concluded that from this mostly for tall buildings TMD is used instead of shear wall.

Thakur V.M

In this paper TMD is used as soft story which is considered to be made up of RCC, constructed at the top of the building. A six storied building with rectangular shape is considered for analysis.

Analysis is done by FE software SAP 2000 by using direct integration approach. TMDs with percentage masses 2% & 3% are considered. Three different recorded time histories of past EQ. are used for the analysis. Comparison is done between the buildings with TMD and without TMD.

Parameters/Model/Software:

Effective mass ratio (μ) and optimum frequency ratio (fopt), is given by following Equation.

Conclusion: Simple TMD with optimum frequency ratio, provided in the form of soft storey at building top is found to be effective in reducing seismic response of building. In general, a soft storey at the top of building reduces top building deflection by about 10 to 50%. Tuned mass damper in the form of soft storey of RCC is found to be effective in reducing seismic forces at critical locations like footing level and first floor level. Among 2% & 3% TMDs, 3% TMD is found better than 2% and 3% TMDs in reducing axial force, bending moment and displacement. Soft storey's presence also reduces the designing forces in the columns at all the floor levels.

Our Conclusion: In this paper while using TMD on top the deflection is reduces. From above we concluded that TMD is provided on top of building for better results.

Sadek, F

In this paper TMD is used as soft story which is considered to be made up of RCC, constructed at the top of the building. A six storied building with rectangular shape is considered for analysis.

Analysis is done by FE software SAP 2000 by using direct integration approach. TMDs with percentage masses 2% & 3% are considered. Three different recorded time histories of past EQ. are used for the analysis. Comparison is done between the buildings with TMD and without TMD.

Parameters/Model/Software:

effective mass ratio (μ) and optimum frequency ratio (fopt), is given by following Equation.

Conclusion: Simple TMD with optimum frequency ratio, provided in the form of soft storey at building top is found to be effective in reducing seismic response of building. In general, a soft storey at the top of building reduces top building deflection by about 10 to 50%. Tuned mass damper in the form of soft storey of RCC is found to be effective in reducing seismic forces at critical locations like footing level and first floor level. Among 2% & 3% TMDs, 3% TMD is found better than 2% and 3% TMDs in reducing axial force, bending moment and displacement. Soft storey's presence also reduces the designing forces in the columns at all the floor levels.

Our Conclusion: In this paper while using SAP 2000 software analysis is done. Analysis is done by FE software SAP 2000 by using direct integration approach we have to use ETAB instead of SAP 2000.

The TMD concept was first applied by Frahm in 1909 (Frahm, 1909) 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 Den Hartog(1928),followed by a detailed discussion of optimal tuning and damping parameters in Den Hartog's book on mechanical vibrations (1940).Hartog's book on mechanical vibrations (1940). The initial theory was applicable foran undamped SDOF system subjected to a sinusoidal force excitation. Extension of the theory to damped SDOF systems has been investigated by numerous researchers.

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 devices, which combine 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 traced to 1983. Hrovat *et al*.(1983) presented SATMD, a TMD with time varying controllable damping. Under identical conditions, the behaviour 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.

Multiple passive TMDs for reducing earthquake induced building motion. Allen J. Clark (1988). In this paper a methodology for designing multiple tuned mass damper 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.

Performance of tuned mass dampers under wind loads K. C. S. Kwok *et al*(1995).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.

Structural vibration of tuned mass installed three span steel box bridge. Byung-Wan Jo *et al* (2001).To reduce the structural vibration of a three span steel box bridge a three axis two degree of freedom system is adopted to model the mass effect of the vehicle; and the kinetic equation considering the surface roughness of the bridge is derived based on Bernoulli-Euler beam ignoring the torsional DOF. The effects of TMD on steel box bridge shows that it is not effective in reducing the maximum deflection ,but it efficiently reduces the free vibration of the bridge. It proves that the TMD is effective in controlling the dynamic amplitude rather than the maximum static deflection.

Optimal placement of multiple tuned mass dampers for seismic structures. Genda Chen *et al*(2001). In this paper effects of a tuned mass damper on the modal responses of a six-story building structure are studied. Multistage and multimode tuned mass dampers are then introduced. Several optimal location indices are defined based on intuitive reasoning, and a sequential procedure is proposed for practical design and placement of the dampers in seismically excited building structures. The proposed procedure is applied to place the dampers on the floors of the six-story building for maximum reduction of the accelerations under a stochastic seismic load and 13 earthquake records. Numerical results show that the multiple dampers can effectively reduce the acceleration of the uncontrolled structure by 10–25% more than a single damper. Seismic effectiveness of tuned mass dampers for damage reduction of structures. T. Pinkaew *et* *al***(2002).**The effectiveness of TMD using displacement reduction of the structure is found to be insufficient after yielding of the structure, damage reduction of the structure is proposed Structural vibration of tuned mass installed three span steel box bridge. Byung-Wan Jo *et al* **(2001).**To reduce the structural vibration of a three span steel box bridge a three axis two degree of freedom system is adopted to model the mass effect of the vehicle; and the kinetic equation considering the surface roughness of the bridge is derived based on Bernoulli-Euler beam ignoring the torsional DOF. The effects of TMD on steel box bridge shows that it is not effective in reducing the maximum deflection ,but it efficiently reduces the free vibration of the bridge. It proves that the TMD is effective in controlling the dynamic amplitude rather than the maximum static deflection

Mr. K.Lova Raju et al (2015) He studied the effective location of shear wall on performance of building frame subjected to earthquake load. In this paper, four types of structures with G+7 are considered in which one of the frame without shear wall and three frames with shear wall in various positions. The Non Linear Static analysis is done using ETABS v9.7.2 software.

Md. Rashedul Kabir et al (2015) He has determined response of multi-storey regular and irregular buildings of identical weight under static and dynamic loading in context of Bangladesh. In this paper, a 15 storeyed regular shaped and irregular shaped buildings have been modelled using program ETABS 9.6 for Dhaka (seismic zone 2), Bangladesh. The effect of static load, dynamic load and wind load is analyzed. The mass of each building were considered to be same. Displacement due to wind load is maximum in all type of buildings.

5. METHODOLOGY

5.1 General

The main objective of this study is to carry out the analysis of G+10,G+15,G+20 against earthquake as per Indian standard codes of practice IS 1893(Part 1):2002.

Basically the earthquake loads on the building are calculated assuming the building to be located at zone II.

The member forces are calculated with load combinations for Limit State Method given in IS 456: 2000 and the members are optimized for the most critical member forces among them.

The building is subjected to self weight, dead load, live load as per IS 875(Part 1, Part 2):1987.

The structure is design in accordance with seismic code IS-1893:2002 under seismic zone II analysis with the help of the ETAB software

The present project deals with comparative study of seismic analysis of RC building by Response spectrum method using Structural Analysis and Design E-TAB software and considering Indian Standard code 1893(2002).

Physical parameters of buildings

Particulars	**Model-01**	**Model-02**	**Model-03**
Plan Dimension	25mx20m	25mx20m	25mx20m
No Of Story	10	15	20
Height Of Each Story	3	3	3
Total Height	32	47	62
Depth Of Footing	2m	2m	2m
Size Of Beam	230mmx 600mm	230mmx 600mm	230mmx 600mm
Size Of Column	300mmx 600mm	300mmx 600mm	300mmx 600mm
Slab Thickness	120	120	120
Dead Load	1kn/m^2	1kn/m^2	1kn/m^2
Live Load	2kn/m^2	2kn/m^3	2kn/m^4
Seismic Zone	II	II	II
Soil Condition	Medium	Medium	Medium
Response Reduction Factor	5	5	5
Importance Factor	1	1	1
Zone Factor	0.16	0.16	0.16
Grade Of Concrete	M25	M25	M25
Grade Of Reinforcing Steel	Fe500	Fe500	Fe500
Density Of Concrete	25kn/m^3	25kn/m^3	25kn/m^3
Density Of Brick Masonry	20kn/m^3	20kn/m^3	20kn/m^3
Damping Ratio	5%	5%	5%

The earthquake load is considered as per IS:1893 (Part I):2002, for the zone II and medium soil with importance factor 1.0 and Reduction factor 3.

Seismic zone factor Z for Zone II =0.16

The design horizontal seismic coefficient Ah for a structure shall be determined by the following expression:

$A_h = \frac{ZIS_a}{2Rg}$ (From IS-1893 (Part 1) :2002 Pg. No.14)

Provided that for any structure with T≤ 0.1 s, the value of $A_h$will not be taken less than *Z/2*whatever be the value of *I/R*

Where,

Z = Zone factor given in Table 2, is for the Maximum Considered Earthquake (MCE) and service life of structure in a zone. The factor 2 in the denominator of Z is used so as to reduce the Maximum Considered Earthquake (MCE) zone factor to the factor for Design Basis Earthquake (DBE).

I=Importance factor, depending upon the functional use of the structures, characterized by. Hazardous consequences of its failure, post-earthquake functional needs, historical value, or economic importance (Table 6).

R=Response reduction factor, depending on the perceived seismic damage performance of the structure, characterized by ductile or brittle deformations. However, the ratio (I/R) shall not be greater than 1.0(Table 7). The values of R for buildings are given in Table 7

S_a/g = Average response acceleration coefficient

Base shear $V_B = A_h$*W

For medium soil sites

$\frac{S_a}{g}$ =1+15T 0.00≤T≤0.10

=2.5 0.10≤T≤0.55

=1.36/T 0.55 ≤T≤4.00

6. Conclusions

1. Analysis can be done by using software ETAB in detail
2. Finding displacement by response spectrum method.
3. Analysis is to be done with different zones

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