Analysis of A Building Considering Tuned Liquid Damper Using Analysis Tool ETABS : A Review

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Abstract- *The present development in construction Industry resulting in construction of tall and high rise buildings, which should be stable and have low damping value. Such constructions are required where all safe design criteria's should be fulfill need some resisting members or techniques, which can help in resisting lateral load effects on the structure.*

In this survey paper we are presenting literature survey related to seismic analysis of tall structures considering different lateral load resisting members.

Keywords- Analysis, review, literature, lateral load, damping, forces, displacement.

I. INTRODUCTION

The investigation of the working of tuned liquid dampers to minimize vibrational loading utilizing examination programming (ETABS) which is a customary kind use structural analysis. The writing identified with selected area. A writing survey goes past the look for data and incorporates the distinguishing proof and future scope of connection between the writing and field of research. While the type of writing audit may be shift with different kinds of studies. We have distinctive writing survey from papers, diaries, sites and google researcher.

II. LITERATURE REVIEW

Bhattacharya et. al. (2016) The authors paper dealt with evolution of the various numerical codes so as to signify the effectiveness of tuned sloshing dampers considering fluid structure interaction effects. The case study included a five storey structure under harmonic ground excitation maximum percentage reduction of 47.7% in response of the structure as top floor displacement was observed for mass proportioning of 90% at fifth floor and 10% at the fourth floor. It was likewise seen that tuned water tank performed adequately as a damper notwithstanding for the mass proportioning of 60% at fifth floor and 40% at the fourth floor giving a rate decrease of 44.4 in the structure highest floor displacement.

The paper concluded that noteworthy execution of profound water TSD with shifting mass extent inferred that if enough highest floor space was not accessible for the establishment of TSD one can do the proportioning of the damper mass in the upper stories for multi-storeyed structures. Likewise from the structure configuration perspective as opposed to lumping the mass at the top story proportioning of damper mass in the upper stories will lessen the expansion in the loads in the basic membranes because of the expansion of the damper mass.

Mondalet. al. (2014) The primary objective of the author was to present the effectiveness of a tuned liquid damper (TLD) which is used in building structures to damp structural vibrations. The experiment apparatus included building model with beams and truss where the base was made movable using an electronic motor so as to stimulate similar to an earthquake. The apparatus used several sensors in form of an accelerometer which was used to measure the acceleration generated at the top most part of the structure when subjected to earthquake vibrations and readings were recorded in absence and presence of Tuned Liquid Damper. Vernier DAQ related to LabVIEW was utilized for information procurement from the accelerometer. The recurrence extends around the full recurrence (first normal recurrence) was considered for excitation in both the cases. The outcomes displayed that the TLD viably hosed the vibrations (up to 80% decrease in vibration) when energized and the hosing impact was observed to be greatest around the reverberation recurrence. The hypothetical model was fruitful in displaying the conduct of the structure yet missed the mark in demonstrating the conduct of water. This was because of utilizing a low precision model for displaying water and improvement in such a manner.

T P Nguyen et. al. (2018) This research paper considered a multi tuned Liquid dampers which included slat screens (M-TLDWSS) so as to analyze a detailed dynamic response of multi storey structures because of earthquake. Furthermore, the gravity equation of structure motion and M-TLDWSS underground acceleration of earthquake was established which

was based on dynamic balance and a numerical time based method was adopted.

Research was further sourced on the general effects of specifications of M-TLDWSS on dynamic response of the structure.

The generated results lead to the conclusion thatM-TLDWSS was quite efficient in reduction of structures dynamic response. Further, the proportion of profundity per length was influenced emphatically on the dynamic character of the M-TLDWSS, it expanded tuning proportion which was one of the most significant parameters for execution of the MTLDWSS on lessening dynamic reaction of the structure. In this genuine issue, the viability of the M-TLDWSS for diminishing structure reaction was increasingly huge in the scope of estimation of the proportion from 0.6 to 0.8 than others on a condition that the exhibition of the M-TLDWSS likewise relies upon TLDWSS number.

The M-TLDWSS connected for diminishing the dynamic reaction of the structure can be appropriate for different ground increasing acceleration in this genuine issue. It is more decreasing significantly structure response than without damper.

RijuKuriakose and Lakshmi P.(2016) Author proposed TLD tanks for a 40storey building situated in Kerela, India, where the structure was firstly modelled and then its fundamental natural frequency was found out by carrying out free vibration analysis. Second stage was to model TLD into the structure and monitored changes in natural frequencies. The structure was subjected to an earthquake loading (El-Centro Earthquake) and its frequency response was compared without TLD's and with TLD's.

The results derived after carrying out the normal mode analysis of the structure with TLD tanks stated that the structural frequency increase with increasing mass ratios, making it less vulnerable to exciting forces. The reduction in amplitude was found as 28.73 %. Eight tanks were proposed with 5 x 4.25 x 3 m dimensions with a water depth in each tank to be maintained was 0.985 m.

Nanda and Biswal (2011) Authors studied the effectiveness of tuned liquid damper for controlling the seismic vibrations of the structure and generated a computer code. The numerical and test investigation of a SDOF structure exposed to both symphonious and recorded ground movements demonstrates that an appropriately planned TLD can considerably lessen structural response. While considering several excitation frequency ratios varying from 0.5 to 1.5, it was observed that the performance of TLD structure was quite effective in reducing the response of the structure when excitation frequency ratio is near to unity. For other excitation frequency ratios inertial and sloshing components of the TLD interface force interferes with each other, the TLD was observed to be ineffective in dissipating the energy. While considering different water depth ratios varying from 0.05 to 0.3 for TLD to evaluate the performance at resonant condition, it was seen there existed an ideal water depth proportion related to the base reaction sufficiency. The ideal water depth proportion was observed to be 0.125. On account of the higher water depth proportion, no huge decrease accordingly abundancy was found for higher depth proportions. The energy absorbed and dispersed by TLD depended for the most part on the sloshing and wave breaking.

Pradipta (2004) Author presented various numerical simulations and experiments which took place in last few years which were broadly able to present the effectiveness of TLD's which is able to control the structure response in case of earthquake of long duration. It was demonstrated that a TLD water molecule motion formulation dependent on a shallow-wave hypothesis proposed by researchers in the past were sensible for anticipating the reaction of a structure with a TLD connected to it and exposed to enormous plentifulness seismic tremor type movements at its base. It was significant that examinations demonstrate that the above hypothesis reliably under-predicts the decrease in structural response for a wide assortment of structures and ground movements. This research even presented the TLD parameters namely water depth ratio to tank length and water mass ratio against the structure mass so as to prove the effectiveness of TLD.

Results demonstrated that the reaction of a typical single-degree-of-freedom (SDOF) structure was commonly diminished by about 30% if a TLD has a depth proportion of 0.15 and a mass proportion of 4%.

Venkataweshwar Rao (2013) Here the author considered a non Linear TLD model and developed a numerical algorithm so as to investigate the response of the frame model, fitted with a TLD while applying five different loading conditions at the structure base.

Author conducted a series of research tests on SDOF structure tuned liquid damper systems to evaluate their performance under harmonic excitation. The effect of the different parameters such as frequency ratio, depth ratio and mass ratio on the behavior was further studied. The effectiveness of the TLD was calculated in terms of percentage of reduction of amplitude of displacements of the structure.

Ruiz (2015) Author introduced a new type of liquid mass damper and named it Tuned Liquid Damper with Floating Roof (TLD-FR) which contains combinative characteristics of both TLDs and liquid column dampers. The TLD-FR constituted of a traditional TLD (liquid tank filled with liquid) with the addition of a floating roof.

During this process the efficiency of mass dampers for seismic applications in Chile is also examined by comparing the performance across different types of ground motions, representing different regions around the world. Finally, a versatile life-cycle assessment and design of the new device is established considering risk characterizations appropriate for the Chilean region, so that the cost-benefits from its adoption can be directly investigated. This involves the development of a multi-criteria design approach that considers the performance over the two desired goals: (i) reduction of the total life-cycle cost considering the upfront damper cost as well as seismic losses and (ii) reduction of the consequences, expressed through the repair cost, for low likelihood but high impact events. Through this approach the financial viability of the TLD-FR (competitiveness against TMDs) for enhancing seismic performance is demonstrated.

This exposition set up and approved numerical apparatuses for examining the execution of TLDs-FR set up productive plan forms for them and analyzed their life-cycle seismic execution. It displayed their preferences over (I) TLDs as they have basically direct conduct (no weaving breaking or amplitude dependence), and (ii) over fluid section dampers as they can encourage higher proficiency list esteems and demonstrated that they are a monetarily aggressive alternative to TMDs for the upgrade of seismic execution as long as legitimate structure (evasion of low-productivity records for them) can be cultivated.

A. Samanta and P. Banerji (2008) The author research paper introduced a numerical report for basic control utilizing a changed arrangement of the tuned fluid damper (TLD), which was a latent damper comprising of a strong tank loaded up with water utilized for controlling vibration of structures. In this present examination, rectangular TLDs have been taken and fluid sloshing was demonstrated utilizing shallow water concept. This shallow water model of fluid sloshing was utilized to research the reaction of the structure under harmonic base motions, with the standard TLD setup.

Results demonstrated that for a given structure TLD setup, there exists an ideal estimation of the rotational spring solidness, which was sensibly excitation independent, for which the adequacy of the adjusted TLD was highest.

This exploration paper proposed a changed TLD design, where the TLD was associated with the structure through a rotational spring and inflexible pole framework. The viability of such a setup was additionally read for symphonious base excitations. This altered design was observed to be more successful as a basic control gadget than the standard setup, where the TLD is inflexibly associated with the structure. The adequacy was certainly subject to the firmness of the rotational spring. For sinusoidal excitation, the proposed adjusted TLD arrangement with an ideal rotational spring solidness has been observed to be altogether more successful than the standard TLD design for generally adaptable structures and for the recurrence proportions ($\beta<1.1$) that gave the real commitment to response of the structure, with the TLD attributes being the equivalent for the two setups.

Srinivasaet. al. (2015) Here the author presented the performance of a tuned mass damper (TMD) under wind and earthquake loads (multi-hazard loading) considering a 76-story benchmark building for the analysis under multi-hazard loading. The research paper adapted the use of pounding tuned mass damper (PTMD) and performance of the structure was analyzed and obtained results were later compared with a conventional TMD. Along with the comparison, the performance of viscous dampers in reducing earthquake effects was further investigated with a primary objective to further, the comprehension of the effect of multi-peril loading, brought by wind and seismic tremors, on the conduct of tall structures, to apply such information to plan.

The analytical results demonstrated that The TMD was compelling in diminishing the maximum displacements of the top the floors of the structure by 28.6% and then speeding up the reaction by 31.25% under wind loadings. The most extreme shear force at the ground floor was diminished by 27.2% and the standard deviation of shear forces was decreased by 41.6%, with the expansion of the TMD. Thus, the most extreme and standard deviation of the general bending moment at the ground floor was diminished by 20% and 40%, individually. The TMD demonstrated to be powerful in decreasing the impacts of wind on structures. Not at all like breeze loadings, which for the most part energize lower methods of vibrations, seismic tremors will, in general, energize higher modes, and delayed quakes can make critical harm the inward individuals (non-basic segments) of the structure. Under seismic tremor loadings, TMD decreased the most extreme relocation of the highest floor by 25% and the standard deviation of removal by 11%. The TMD has no huge impact in diminishing the absolute acceleration, base shear force, and the overall turning moment of the building. At the point when the TMD was supplanted by a PTMD, under quake

loads, there was no critical decrease in the greatest removal at the highest floor, however, there was a 14.7% decrease in the highest floor increasing speed. Not at all like most extreme the decrease in the increasing speed, there was no critical change in the standard deviation of acceleration at the highest floor.

The examination demonstrated that viscous dampers can essentially diminish the increasing acceleration response of tall structures under tremors, with a commitment to construct stronger structures that can oppose multi-danger loadings.

Abhinavet. al. (2011) The authors research paper emphasized on modeling of a tuned mass absorber to suppress the vibrations of a single degree of freedom system operating at its fundamental natural frequency. The analysis of the model was done using ANSYS which is basically a commercial finite elements package. ANSYS harmonic analysis was effective in predicting safe operating frequency range for the modified structure which was also verified experimentally.

A solitary Degree of Freedom framework was picked for examination. The framework was at first worked at its regular recurrence. A tuned mass safeguard framework was so picked as to stifle the vibration of the essential framework at the working recurrence. It was seen that after presenting the tuned mass framework the vibration sufficiency had been smothered essentially. The framework was likewise displayed in ANSYS 10.0 a business FEM bundle and observed to be solid in anticipating the characteristic frequencies. The working scope of frequencies could likewise be anticipated by the investigation. Thus tuned mass safeguards could be successfully used to stifle vibrations at reverberation frequencies. Limited components investigation can help in an ideal plan of structures from a vibration perspective. The adaptability of the structure to adjust to varying external frequencies was another key part of the plan.

Mohan Murudi and PradiptaBanerji (2012) The author's exploration paper displayed an extensive investigation of the impacts of different ground movement parameters on the capacity of a TLD to diminish auxiliary reaction for quake base movements. It was displayed that the recurrence component and data transfer capacity of the ground movement don't fundamentally influence the viability of the TLD. Since TLD was a nonlinear framework, its adequacy increments with an expansion in the forces of the ground movement. Besides, since TLD acts as a viscous damper, it can't lessen the reaction in an initial couple of cycles of vibration. Along these lines, TLD was increasingly effectively for the far-field ground movements, where the solid movement stage and thus the pinnacle reaction of the structure happen after an initial couple of cycles of vibration.

An exhaustive report on the adequacy of a TLD in controlling the seismic reaction of structures was completed considering various kinds of ground movements. It was discovered that however, the TLD adds damping to the structure, it wasn't viable in diminishing the reaction of structures for the extremely short-duration pulse-type motions. If the duration of the pulse was long enough for the peak response to happen after in any event two cycles of structural vibration, the TLD turns out to be dynamically increasingly compelling. For the more extended span ground movements, the TLD was quite viable. It has likewise been demonstrated that the artificially generated ground motions considered in the investigation precisely mirror the attributes of recorded ground movements. At long last, by shifting the parameters of the misleadingly created ground movements, the impact of ground motion parameters on the viability of a TLD in decreasing the structure reaction has been examined. An intriguing point that requirements restatement here was that a TLD turns out to be progressively increasingly compelling as the ground-movement power increments. In this manner, a TLD is one uninvolved vibration control gadget that is progressively successful for the more exceptional ground movements.

Kartha and Ritzy. R (2015) the authors primary objective was to study the adequacy of TLD in diminishing seismic vibration of a 2 storey structure outline when it is exposed to even excitations. An analytical examination of the undamped casing was done in ANSYS WORKBENCH programming. In light of modes and frequencies acquired from the expository examination, measurements of the steel building frame were fixed and analytical results were completed by shake table examinations.

The outcomes presented that there was an expansion in incapable damping of the joined framework when the fundamental framework was combined with tuned liquid damper. Damping lessens as the profundity of fluid in the TLD increments as the fluid sloshing and wave improvement and breaking diminishes since the whole mass of water in the damper does not add to sloshing. It was even discovered that TLD was equipped for controlling the vibration of structure successfully. The characteristic recurrence acquired from the finite element analysis and exploratory examination presented great understanding for the undamped structural model.

T P Nguyen et. al. (2018) Here the author considered a the multi-tuned liquid damper with slab screens (M-TLDWSS) in detail so as to analyze the unique reaction of multi-degrees of free structure because of seismic tremor and later settled the

general condition of movement of the structure and M-TLDWSS underground increasing speed of quake dependent on powerful parity of standard and understood by numerical technique in the time area. The impacts of trademark parameters of M-TLDWSS on the dynamic reaction of the structure was further examined.

The derived conclusion from the analytical results stated that the depth proportion per length was influenced firmly on the dynamic character of the M-TLDWSS, it expands tuning proportion which was one of the most significant parameters for execution of the MTLDWSS on diminishing powerful reaction of the structure. In this genuine issue, the viability of the M-TLDWSS for decreasing structure reaction was progressively critical in the scope of estimation of the proportion from 0.6 to 0.8 than others. The exhibition of the M-TLDWSS additionally relies upon TLDWSS number. The impact of the TLDWSS number was additionally unique relating with each the proportion. In any case, a general gauge demonstrates that the viability of the M-TLDWSS does not have very contrasts with different estimations of the proportion relating with different estimations of the TDWSS number. The M-TLDWSS connected for decreasing the dynamic reaction of the structure was appropriate for different ground increasing speeds in this genuine issue. It was more diminishing altogether structure reaction than without damper.

Mahesh M Pardeshiet. al. (2014) The exploration paper surveyed new sort of TLD introduced with rigid baffle divider and depth of water profundity, for example, 50mm, 70mm, 90mm and 110mm. Initial analytical tests were led on the scaled model (G+5 story) exposed to sinusoidal excitations utilizing shaking table trial. The primary goal behind introducing such a baffle wall was to diminish the structural vibrations exposed to seismic tremor excitation. From this examination, it was discovered that TLD with 90mm water profundity and single confuse demonstrated to be increasingly successful prompting 80% decrease in speeding up. It was additionally discovered that just TLD which was appropriately tuned to the common recurrence of the structure was progressively viable in controlling the vibration. The damping impact of TLD strongly diminishes with the mistuning of TLD.

The results stated that TLD can be successfully used to control vibrations of the structure, TLD was found to be more effective at the top storey of the structure. From experimental analysis it is concluded that energy dissipation achieved is maximum when TLD is used and it is more effective with the use of one baffle placed at centre of tank. It is also observed that maximum reduction in acceleration was found to be at 90mm water depth and one baffle wall. There was about 85% reduction in the acceleration at the top storey with the use of one baffle and water depth 90 mm. Considerable decrease in the acceleration were observed up to a 90mm depth and gradually increased at the 110mm depth.

III. CONCLUSION

- Authors presented numerical calculation and decrement of vibrations and damping due to liquid dampers
- Authors presented implementation of analysis tool for analyzing tuned liquid damper structures but none of them explain its variation in comparison to general structures.
- In past researchers explained the importance of risk analysis in a construction project due to lateral forces which we are resolving in our study.

REFERENCES

[1] JitadityaMondal, HarshaNimmala, Shameel Abdulla, Reza Tafreshi (2014), Tuned Liquid Damper, Paper No. 68, Proceedings of the 3rd International Conference on Mechanical Engineering and Mechatronics

[2] T P Nguyen, D T Pham and K T Ngo(2018), Effectiveness of multi tuned liquid dampers with slat screens for reducing dynamic responses of structures, IOP Conf. Series: Earth and Environmental Science 143 (2018) 012023.

[3] RijuKuriakose and Lakshmi P.(2016), Effectiveness of Tuned Liquid Dampers on High Rise Buildings in Kerala, International Journal of Engineering Research & Technology (IJERT), Vol. 5 Issue 09, September-2016

[4] Bharadwaj Nanda And Kishore Chandra Biswal (2011), Application Of Tuned Liquid Damper For Controlling Structural Vibration Due To Earthquake Excitations, Modern Methods and Advances in Structural Engineering and Construction, ISEC-6, Zürich, June 21–26, 2011.

[5] PradiptaBanerji (2004), Tuned Liquid Dampers For Control Of Earthquake Response, 13th World Conference on Earthquake Engineering Vancouver, B.C., Canada, Paper No. 1666

[6] A. Samanta and P. Banerji (2008), Structural Control Using Modified Tuned Liquid Dampers,The 14 th World Conference on Earthquake Engineering October 12-17, 2008, Beijing, China

[7] Venkateswara Rao K (2013), Experimental And Numerical Studies On Tuned Liquid Damper, Department Of Civil Engineering National Institute Of Technology Rourkela, Orissa-769008

[8] S K Bhattacharyya(2016), Tuned Sloshing Damper in Response Control of Tall Building Structure, Proc Indian NatnSciAcad 82 No. 2 June Spl Issue 2016 pp. 223-231.

[9] SrinivasaAdithyaSaileshAbburu (2015), Vibration Control in High-Rise Buildings for Multi-Hazard, Louisiana State University and Agricultural and Mechanical College.

[10] EmiliBhattacharjee, LipikaHalder* and Richi Prasad Sharma (2013), An experimental study on tuned liquid damper for mitigation of structural response, International Journal of Advanced Structural Engineering 2013, 5:3

[11] Fujino Y, Pacheco BM, Chaiseri P, Sun LM (1988) Parametric studies of tuned liquid damper (TLD) using circular containers by free-oscillation experiments. StructEng/Earthquake Eng, JSCE 5:381–391

[12] Fujino Y, Sun L, Pacheco MB, Chaiseri P (1992) Tuned liquid damper (TLD) for suppressing horizontal motion of structures. Journal of Engineering Mechanics 118(10):2017–2030

[13] Koh CG, Mahatma S, Wang CM (1995) Reduction of structural vibrations by multiple mode liquid dampers. Engineering Structures 17(2):122–128

[14] Koh CG, Mahatma S, Wang CM (1994) Theoretical and experimental studies on rectangular liquid dampers under arbitrary excitations. Earthquake Engineering and Structural Dynamics 23:17–31

[15] M.A. Ozyildirim, Effect of polypropylene fiber content on flexural strength of lightweight foamed concrete at ambient and elevated temperatures, Adv. Appl. Sci. Res. 3 (5) (2012) 2837–2846.

[16] Parisio, D. Varagnolo, D. Risberg, G. Pattarello, M. Molinari, and K. H. Johansson, "Randomized Model Predictive Control for HVAC Systems," in Proceedings of the 5th ACM Workshop on Embedded Systems For Energy-Efficient Buildings, 2012.

[17] Hyunjoo Kim, Zhang, G.; Zhou, J.; Xu, F. The Influence of Wall's Insulation Thickness to Building Energy Consumption. In Proceedings of the International Conference on Mechanic Automation and Control Engineering (MACE), Wuhan, China, 26–28 June 2011; pp. 4241–4244.

[18] Khudhair, A. M. and Farid, M. M., 2004. A review on energy conservation in building applications with thermal storage by latent heat using phase change materials, Energy Conversion and Management, vol.45, no. 2, 263-275.

[19] Maile, T.; Frauke r, M.; Bazjanac, V. Building Energy Performance Simulation Tools—A Life-Cycle and Interoperable Perspective; CIFE Working Paper #WP107; Stanford University: Stanford, CA, USA, 2011.

[20] Muralitharan, Kaushal Kishore, Foamed Cellular Light Weight Concrete, Research Paper in Concrete Engineering as online access, ''Civil engineering portal", Indian Institute of Technology, Roorkee, ISSN 5654, Vol. 03, 2017, pp. 23-29.