Use of Water Tank as a Tuned Liquid Damper for Seismic Vibration Control in Building – A Review

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Abstract- *over the past few decades, we can see that earthquake posses hazard to human life and also property. Structural vibration control especially the passive control can effectively reduce the earthquake damage. Tuned liquid dampers are providing at top of the building. This TLD is used to reduce the response of a structure, provide good performance in building. There for TLD gives positive effect is accomplished taking into account the oscillation of free surface of a fluid inside a tank. And check the seismic parameter such as displacement, acceleration, velocity.*

The efficiency of the TLD at different places in horizontal direction and show the improving the seismic response. And analysis is done with time history method in SAP 2000 software.

Keywords- Passive devise, Sloshing, Earthquake, Tuned liquid damper, Time history Analysis, Displacement, Storey Drift, Base Shear.

I. INTRODUCTION

The current seismic resistant design is based on the concept of the ductility of structures. The advantage of ductile response is that only some specified elements are allowed to have inelastic deformation and yield, while other members remain elastic. The ductile members can be achieved by yielding in tension or inelastic buckling in braces, or flexural hinging in beams or at the base of the columns.

Seismic isolation systems utilize isolators that are installed between the key supporting points of the structure and the foundation. The isolators are designed to have a much lower lateral stiffness relative to that of the structure. As such they dissipate more seismic energy and transfer less energy into the structure. In general, seismic isolation systems have three main types: laminated-rubber bearings, lead-rubber bearings and the friction pendulum systems.

Supplemental damping devices are introduced into the structure to dissipate some of the energy introduced during the vibration and thereby mitigate the damage to the structural and non-structural components. They can be classified in three categories as, active, semi-active and passive systems.

II. LITERATURE SURVEY

J. S. Love, M. J. Tait (ELSEVIER-2013) [1]:

In this paper three fluid models are considered: shallow water wave theory, a small depth multimodal model, and an intermediate depth multimodal model. A TLD consists of a tank, partially filled with water, which is located near the top of a structure. Damping mechanisms in the TLD tank dissipate the energy of the sloshing fluid; removing the energy from the structure-TLD system and reducing the structural response. TLDs are often designed with fluid depth to tank length ratios less than 25% . TLDs are simple and affordable to install, operate and maintain.

Result from The fluid models considered are capable of modelling the sloshing behavior in rectangular tuned liquid dampers under certain conditions. This study has indicated the suitability of three fluid models based on the fluid depth ratio, and the Ursell parameter, which considers both the fluid depth ratio and the fluid response amplitude. This information will be useful to TLD designers when considering which fluid modelling methods are appropriate for their analysis.

T.Novo, H. Varum, F. Teixeira-Dias, H. Rodrigues, M. Falcao Silva, Campos Costa, L. Guerreiro(Bull Earthquake Engineering -2013) [2]:

This paper is focused on the study of an earthquake protection system, the tuned liquid damper (TLD), which can, if adequately designed, reduce earthquake demands on buildings. The efficiency of the TLD in improving the seismic response of an existing building, representative of modern architecture buildings. A TLD consist on a rigid tank with a shallow fluid. This fluid, that can be water or another fluid, is inside the tank that is rigidly connected to the structure. The fundamental sloshing frequency of the fluid in the TLD should be close to the natural frequency of the structure if the TLD is to dissipate energy efficiently.

It can be concluded that TLDs can be adopted as effective measures for reducing building structural demands to earthquake input motions. The TLD is more effective in reducing the structural demands for structures with lower natural periods.

Junhee Kim, Chan-Soo Park, Kyung-Won Min (ELSEVIER-2016) [3]:

In this study, a novel and rapid vision-based sensing strategy is developed exclusively for dynamic wave height measurement of tuned liquid column dampers (TLCDs). Structural control is needed to reduce the dynamic responses of the structures and to maintain their functional performances. Prior to installation of a TLCD at a site, a factory test for verification and tuning of dynamic characteristics must be conducted with the pre-fabricated TLCD .

A combined approach of experiments and computer simulations, e.g., pseudo-dynamic testing of the TLCDs will be strategically pursued. Accuracy of the proposed vision-based sensing is confirmed through comparison with conventional contact measurement and dynamic characterization is successfully conducted including estimation of damped natural frequencies and damping ratio.

Hao Luo, Ruifu Zhang, Dagen Weng (Soil Dynamics and Earthquake Engineering -2016) [4]:

In this study, an ovel hybrid method is proposed to control Sloshing in arigid circular-cylindrical tank under ground motions Induced by earthquakes. Generally, the use of obstacles, such as baffles, has been considered as an alternative method to prevent the sloshing of liquid in moving containers. To safeguard the liquid storage tank under earthquakes, both the liquid sloshing and hydrodynamic pressure need to be effectively controlled, and a new method is urgently required for seismic protection of liquid storage tanks.

Generally, for the controlled tank using the proposed method, The sloshing height decreases as the mass of the VMD increases, while the damping of the VMD is found to have a Limited effect on the sloshing height. For both slender and broad tanks, the sloshing heights are found to be reduced by a large extent using the proposed hybrid control method.

Aditee S. Patil, N.G. Gore, P.J. Salunke (IJESC-2016) [5]:

This study was made to study the effectiveness of using TLD for controlling vibration of structure. Current trends in construction industry demands taller and lighter structures, which are also more flexible and having quite low damping value. This increases failure possibilities and also, problems from serviceability point of view. Several techniques are available today to minimize the vibration of structure, out of which concept of using of TLD is a newer one. Only TLD which were properly tuned to natural frequency of structure was more effective in controlling the vibration.

A study has been conducted to find out the effect of TLD size in structural damping while keeping the mass of TLD constant.

Roshni. V. Kartha, Ritzy.R (IJERA-2015) [6]:

In this research paper Damping is a phenomenon in which the energy of the system is gradually reduced and finally the vibration of the system is completely eliminated and the system is brought to rest. TLD is essentially a liquid filled tank which is rigidly connected to the top of the structure. It relies on the sloshing wave developing and breaking at the free surface of the liquid to dissipate a portion of the energy released during the dynamic event and therefore increases the equivalent damping of the structure.

A study has been conducted to find out the damping effect of the TLD increases with mass ratio. It has been found that TLD is capable of controlling vibration of structure effectively.

A. Samanta and P. Banerji. (World Conference on Earthquake Engineering -2008) [7]:

This paper presents a numerical study for structural control using a modified configuration of the tuned liquid damper (TLD), which is a passive damper consisting of a solid tank filled with water used for controlling vibration of structures. In this present investigation, rectangular TLDs have been taken and liquid sloshing has been modeled using shallow water theory.

The results show that a properly designed TLD can significantly reduce response of structures. It is found that the shallow water theory used for modeling the TLD liquid sloshing is good in predicting actual structural response. The effectiveness is definitely dependent on the stiffness of the rotational spring.

Mohtasham Mohebbi, Hamed Rasouli Dabbagh, Kazem Shakeri (Periodica Polytechnica Civil Engineering -2015) [8]:

This paper proposes a systematic optimization method to design optimal multiple tuned liquid column dampers (MT LCDs) for improving the seismic behaviour of structures. The results of numerical simulations show the simplicity and effectiveness of the method. Also it has been found that the performance of MT LCDs has been affected by its mass ratio and earthquake characteristics.

The results of designing optimal MTLCDs for different mass ratio and TLCD numbers show that increasing the mass ratio leads to improvement in the performance of MTLCDs. According to the results it can be said that the proposed method for designing optimal MT LCDs has been effective regarding the simplicity and convergence behavior of the method.

Nishant Kishore Rai, G. R. Reddy and V. Venkatraj (ISSN-2013) [9]:

In this paper The medium height, RC framed structures, constructed before 1970 were not designed for seismic forces due to lack of provisions in the then prevailing building codes. The seismic retrofitting of such structures can be accomplished by displacement response control method with tuned sloshing water dampers. The real life applications of TSWDs in tall structures have exhibited the response reductions up to 70% against wind loads.

For well-defined structures subjected to resonant harmonic excitations TSWD based retrofitting systems are efficient and more suitable. The TSWD based retrofitting systems can be incorporated in the ESs in multi-layered clustered configuration without interfering with the architectural, structural features and occupancy, hence conveniently adoptable.

III. CONCLUSIONS

From this study we conclude that due to seismic force in structure are damage so reduce this lateral force, vibration effect, displacement in building.

We use tuned liquid dampers in past time TLD use at a only centre of the building. In Present study TLD used at different places in horizontal direction with different water depth and different time history and check % reduction in vibration and displacement.

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