

SEISMIC STRENGTHENING OF HIGH RISE STRUCTURES BY PASSIVE DISSIPATING SYSTEMS (DAMPER): A Review

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Abstract— *In recent years, the concept of structural control has taken a critical role in the sector of seismic design of civil structures. Because of urbanization and industrialization there is not a single space to construct the structures. So, human are showing keen interest to buy sky rather than the land. For the construction of high rise building a safer and more economical design needs to be done by adding the systematic innovative devices which reduce the forces and deformations in structure mostly caused by the earthquake ground motion, wind and sometimes tsunami. In order to enhance the capability of structure to with stand earthquake or wind load, installation of passive energy dissipating devices are widely used in the engineering field. Use of dampers enhances the performance of the buildings during seismic and wind excitations. There are various types of dampers available now a day's which can be installed in high rise buildings depending on the need and requirement. This review paper investigates the usefulness of passive dissipating system (damper) in seismic strengthening of high rise structures.*

Keywords— *Earthquake, Rotational friction dampers (RFD), Vibration control, Natural frequency, Viscoelastic dampers (VEDs).*

INTRODUCTION

We know that, the entire lifetime of the Earth is continuous sequence of underground movement. The Earth is like a living body in permanent motion. There will be the tectonic plate movement and the chance of occurring of earthquake cannot be ignored. In fact, the prediction of ground motions is still far from a satisfactory level, due to both the complexity of the seismic phenomena and the lack of communication between seismologists and engineers.

In the last few years, the understanding of earthquake characteristics has considerably increased, due to the tragic experience from recent earthquake. The demand of human for sophisticated and luxurious life is also increasing day by day. Nowadays people are fascinated to buy a sky to live rather than a land for constructing building foundation. Today, the structural engineers are confident to have reached the stage where the actual structural performance during strong ground motions can be satisfactorily predicted, explained and quantified. The common method for protecting of structures against the destructive effects of earthquakes is to dampen the seismic energy by the structural elements, thus providing the resistance against the earthquake. Various response control methods have been implemented in the design procedures and can be generally divided into three groups:

- Passive control
- Active control
- Semi-active control.

Among them the passive damper are preferred because they require minimum of maintenance and need no external power to operate. Several passive energy dissipation devices are available and have been implemented worldwide for seismic protection of structures. Passive energy dissipation systems for seismic applications have been under theoretical development since the mid-1980s with a rapid increase in implementations starting in the mid-1990s. The most common examples of Passive energy dissipation devices are Metallic damper, friction dampers, Visco-elastic dampers, Viscous dampers, tuned mass dampers(TMD) and Tuned liquid dampers(TLD). As in Fig 1, the comparison between various types of passive energy dissipation devices are explained. Depending upon the requirement, suitability and expertise, any of the passive energy dissipation devices can be installed in the high rise buildings. All of the mentioned devices are useful in reducing the seismic energy generated on the building due to earthquake.

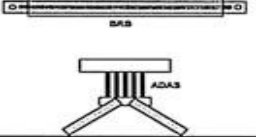
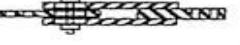
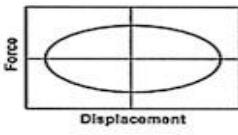
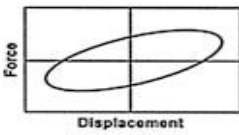
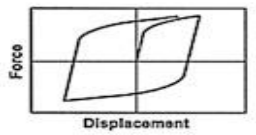
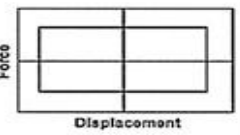
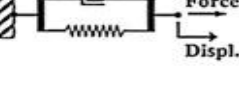
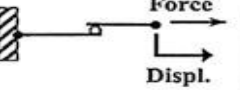
	Viscous damper	Viscoelastic damper	Metallic damper	Friction damper
<i>Basic Construction</i>				
<i>Idealized Hysteretic Behavior</i>				
<i>Idealized Physical Model</i>			Idealized Model Not Available	
<i>Advantages</i>	<ul style="list-style-type: none"> Activated at low displacements Minimal restoring force For linear damper, modeling of damper is simplified Properties largely frequency and temperature-independent Proven record of performance in military applications 	<ul style="list-style-type: none"> Activated at low displacements Provides restoring force Linear behavior, therefore modeling of damper is simplified 	<ul style="list-style-type: none"> Stable hysteretic behavior Long-term reliability Insensitivity to ambient temperature Materials and behavior familiar to practicing engineers 	<ul style="list-style-type: none"> Large energy dissipation per cycle Insensitivity to ambient temperature
<i>Disadvantages</i>	<ul style="list-style-type: none"> Possible fluid seal leakage (reliability concern) 	<ul style="list-style-type: none"> Limited deformation capacity Properties are frequency and temperature-dependent Possible debonding and tearing of VE material (reliability concern) 	<ul style="list-style-type: none"> Device damaged after earthquake; may require replacement Non-linear behaviour; may require non-linear analysis 	<ul style="list-style-type: none"> Sliding interface conditions may change with time (reliability concern) Strongly non-linear behavior; may excite higher modes and require non-linear analysis Permanent displacements if no restoring force mechanism provided

Fig. 1: Summary of passive energy dissipation devices for seismic protection applications

LITERATURE REVIEW

Roy T and Matsagar V(2019), investigated multi-hazard assessment in the (9-, 20- and 25-storey) steel building under earthquake and wind during design life. The governing differential equations of motion with and without the retrofitting devices were solved by Newmark's time marching scheme. It was found that the control devices of modified properties helped to reduce the wind response and was insufficient to reduce the seismic response, Judgment should be taken while retrofitting under lesser and larger parameter of wind load and seismic load .The investigation of the structures from the multi-hazard perspective needs to be done for proper retrofitting solution.

Wanga S, .Mahinb S A, et al (2018), conducted an investigation of viscous dampers for improving the seismic performance new and existing buildings. An existing 35-story steel moment incorporating pre-Northridge welded beam-to-column connections was selected. The frame 56m×41m in-plan and150m in height was selected as a case-study building for verification of the optimization design procedure following the framework of Performance Based Earthquake Engineering (PBEE) and automatic tool that incorporates an optimization engine and structural analysis software. Viscous damper was used at different location in the building. Dampers were considered more effective when located in the exterior four frames of the building. It was found that Level-2 retrofit relies on using supplemental fluid viscous dampers (FVDs) to avoid collapse under a BSE-2E event. It was also consulted that Computer aided automatic design gives efficient design parameter that helps in improving the seismic performance of structure.

Table 1 – ASCE 41-13 Basic Performance Objective for Existing Buildings (BPOE)

Risk Category	Tier 1 & 2	Tier 3	
	BSE 1E	BSE 1E	BSE 2E
I & II	Life Safety Structural Performance Life Safety Nonstructural Performance (3-C)	Life Safety Structural Performance Life Safety Nonstructural Performance (3-C)	Collapse Prevention Structural Performance Nonstructural Performance Not Considered (5-D)
III	Damage Control Structural Performance Position Retention Nonstructural Performance (2-B)	Damage Control Structural Performance Position Retention Nonstructural Performance (2-B)	Limited Safety Structural Performance Nonstructural Performance Not Considered (4-D)
IV	Immediate Occupancy Structural Performance Position Retention Nonstructural Performance (1-B)	Immediate Occupancy Structural Performance Position Retention Nonstructural Performance (1-B)	Life Safety Structural Performance Nonstructural Performance Not Considered (3-D)

Tabassum T and Ahmed K.S. (2018), conducted an analysis of the seismic behavior of a thirty story steel building (Bangladesh) with and without damper under different earthquake acceleration signals on the top three floors of the building. The various dampers that were installed in the building were as friction damper, bilinear damper and exponential damper. The time history analysis was done using ETABS. It was found that seismic performance of building by installing damper, parameter like base share, Joint acceleration, and story displacement reduces.

Tchamo J M and Ying Z(2018), focused their research on alternative design method for structures with Visco-elastic dampers VEDs for a 7-story reinforced concrete (RC) structure and to check its reliability and effectiveness . Nonlinear time-history analysis was performed on the building. Dominantly inter-story shear forces were taken for damper design and compared with previous studies. It was concluded in three points, First one was under the minor earthquake level the VEDs can be designed using 30% inter-story shear forces. Second one the inter-story drift reduction was about 50%, the story force reductions under various earthquake level were around 39%, the roof acceleration, roof displacement and story displacement have reduced about 31%, 48%, and 47%, respectively. The last one was, if story stiffness of specific floor was too large than in the most of floor then this method was cost-effective and economical.

MuallaI and Koss H(2017), conducted a thorough study of damping systems developed by Damptech and based on a unique rotational friction concept and showed versatile application of rotational friction dampers (RFD). It shows that RFD used in the first high-rise building to be equipped with Damptech dampers in base isolation configuration was 144 tower in Osaka. The tallest building in Japan, the “Abeno Harukas” building, with a height of 300 m has 4 friction joints and several layers of steel plates and friction pads to have a large damper capacity of 1500- 2250 kN.. Another V-Bracing Configuration with RFDs was installed in the structure through the 300m building in which when top story get deflected towards right then right damper will be in compression while left damper will be in tension both damper dissipate the energy. It was concluded that the building could be efficiently protected against earthquakes. The dampers had successfully used in the tallest building in Japan and in many projects around the world.

A. Ras, N. Boumechra(2016), conducted investigation using 3D analysis on a 12-storey steel building moment frame with diagonal fluid viscous damper FVD. The analysis was done by SAP2000 software and comparisons were made between unbraced, braced and damped structure. The following conclusion were made that the fundamental period decreases by 220% compared to the unbraced structure .Value of shear force and time of loading were reduced by 37% of maximum acceleration. Undesirable force was transmitted not by the diagonal with the damping energy dissipation. According to the building height the damping ratio and number should be reduced for more efficient and economical use.

Khante S N, et al (2016), conducted research with L-shaped building where Tuned mass damper (TMD) is kept at the top of the building in three different location. Analysis was done by using SAP2000 and the response of the building was studied under EL Centro earthquake of 1940 and Bhuj earthquake of 2001. Five condition of water tank i.e. . Tank empty, 0.25h ,0.5h, 0.75h & full tank were considered. It was found that when water level, location of tank and mass ratio were tuned properly, water tank will act as (TMD). Further. TMD (tank + water) which lies near to the centre of mass and center of stiffness of L shaped irregular building shows maximum response reduction as compared to other two.

Dehghan M J, Soleymannejad M (2015), conducted a study of the seismic behavior of reinforced concrete special moment frames under different earthquake effect with viscous dampers. The performance of 10 and 16-story structures

was analyzed by 3D software (non-linear analysis). The primary model was designed by using ETABS. The viscous dampers was modeled as the diagonal bracing elements in the side spans. 20% to 30% earthquake damaged resistance was considered with and without viscous damper. It was found that the viscous damper act has a significant role in decreasing and controlling maximum drift of structure. According the study conducted 30% damping power was restrained 97% of earthquake that indicated the earthquake effect can be reduced by using viscous damper.

CONCLUSIONS

Based on the study done, it can be concluded that by the use of passive energy dissipating devices in a structure it can limit damaging deformations caused by earthquake and wind in structural components. When the structure is designed on the basis of how much priority can be given to strength and cost on the basis various type of passive dissipating damper can be used to reduce the structural response during dynamic excitation. Strengthening of the high rise structure depends on the properties of the device, the characteristics of the ground, the inherent properties of the basic structure, and its connecting elements, as well series of linear and non-linear response-history analysis. If all the parameter is well then passive dissipating system (damper) can be used in the strengthening of high rise building.

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