USE OF VISCOUS DAMPERS FOR ENHANCEMENT OF SEISMIC RESPONSE OF RCC HIGH-RISE BUILDINGS - A REVIEW

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Abstract : There are many techniques available in the construction field to depreciate the vibration of the structure in case of earthquakes. Placing of dampers within the structure is one in every of them to deal with the problem of the industry. Type of dampers used as energy dissipating device changes the response of the building. The position, configuration and range of dampers has tidy result on the seismic response of a building. The form of building is additionally having consequences on the behaviour of the structure.

***Index Terms* - Earthquake, Fluid Viscous Dampers(FVD), Seismic response.**

1. INTRODUCTION

India includes a terribly high frequency of earthquakes. In fact, over sixty fifth of the country is at risk of earthquakes consistent with BIS 1893-2016. Earthquake - prone areas of the country are known on the concept of scientific inputs regarding seismicity, earthquakes occurred within the past and tectonic setup of the region. supported these inputs, Bureau of Indian Standards [IS 1893 (Part I):2016], has classified the country into four seismal zones, viz. Zone II, III, IV and V. Of these, Zone V is seismically the foremost active region, whereas zone II is that the least.

1.1 EFFECTS OF EARTHQUAKES

The effects of an earthquake are horrific and devastating. Many buildings, hospitals, educational buildings, etc are damaged due to it. Loads of individuals get killed and livid. Many of us lose their money and property. It affects the psychological health and emotional health of individuals. The first environmental effects of earthquakes are ground shaking, ground rupture, landslides, tsunamis and liquefaction. Fires are probably the single most vital secondary effect of earthquakes. The subsequent fig-1 shows the chain of possible disasters occur throughout an earthquake, with a conditional possibilities analysis **[6]**.

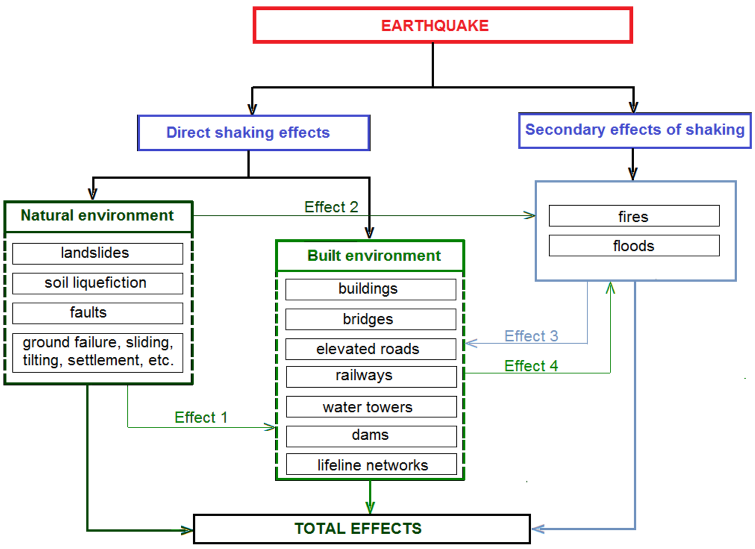

Fig-1 Possible Chain of Disasters during an Earthquake

1.2 TECHNIQUES OF EARTHQUAKE RESISTANT DESIGN OF STRUCTURES

There are several noted and practiced measures to guard unstable seismic threats. A number of **earthquake resistant techniques** utilized by the engineers world over to reduce the harm to structures due to earthquakes are Floating Foundation, Shock Absorption, Rocking Core-Wall, Pendulum Power, Symmetry, Diaphragms And Cross-Bracing and Energy Dissipation Devices.

1.3 DAMPERS

Dampers are mechanical systems that dissipate earthquake energy into specialized devices that deforms or yield throughout earthquake**[14]**. They intensify energy dissipation within structure in which they are lodged to scale back or resist the earthquake forces. Dampers don't seem to be supporting members for a structure. The seismic energy is applied in two forms i.e., kinetic and potential (strain) gets absorbed in them and damps the movement of the buildings. The dampers which are used for reduction in Earthquake forces are also called as SEISMIC DAMPERS.

Types of Dampers

Dampers are classified on their performance **[2]** like as follows:

1.Friction Dampers: These absorb energy by surfaces with friction between them moving against each other.These dampers can avoid fatigue caused by service loads due to being non reactive under loads and advantageous for their performance independence to loading rates and surrounding temperature.

2.Tuned Mass Dampers(TMD): These comprises of a mass and a spring system clamped to the structure. It works on principle of harmonic motion. It reduces mechanical vibrations by outlasting resonance frequency. It includes of large oscillating mass, Spring and Viscose-damper.

3.Yielding Dampers (Hysteretic, Metallic, X-plate): In this, transferred energy to the structure is spent to submission and non-linear behavior in used element in damper. In these dampers, metal inelastic deformation is used such as for form-ability metals such as steel and lead for energy dissipation.

4.Magnetic Dampers: Generally, in these Neodymium Iron Boron NdFeB magnets are used. Electromagnetic damping with quad NdFeB magnets is not an expensive and independent to temperature mechanism. As this system is not that strong, used only where less damping is required. The damper consists of two racks, two pinions, a copper disk and rare–earth magnets.

5.Fluid Viscous Dampers(FVD): Viscous dampers are a way to feature energy dissipation to the lateral position of a building. In this, energy dissipation happens by pushing fluid through an orifice, that produces a damping pressure and successively creates a force. This dispense a notable reduction in seismic energy. It is a similar model of an shock absorber in an automobiles but functions at a higher force level. The position of viscous dampers within structure can reduce horizontal floor accelerations and lateral deformations by 50 percent or more sometimes. It is made up of steel so it is a sturdy material(fig-2). The damping fluid is silicone oil, which is inert, non-flammable, non-toxic, and stable for extremely long periods of time. Due to ease of installation, adaptability also diversity in their sizes, viscous dampers have several applications in designing and retrofitting.

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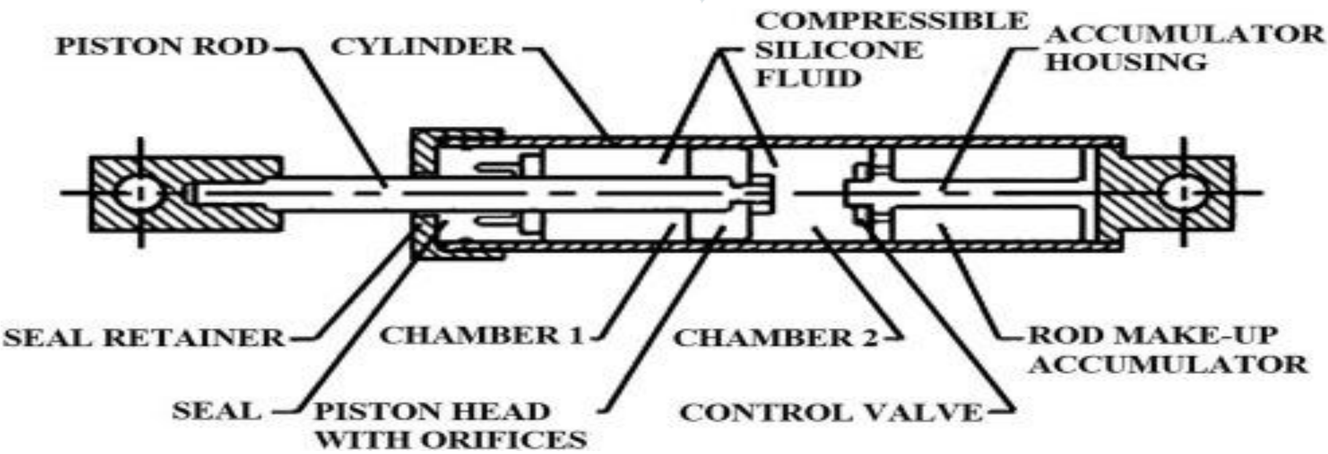

Fig-2 Fluid Viscous Damper system

2. RELATED RESEARCH STUDIES

The relevant research studies are reviewed in this section.

2.1 M.C. Constantinou et. al (1992)

This paper is one of the foremost researches done on using Fluid Viscous Dampers as Seismic energy dissipation device on buildings and bridges. The authors studied the application of these devices as part of seismic energy dissipating systems for buildings and bridges experimentally and analytically. The experimental models included the 3-story steel structure and the bridge structure on which tests were constructed with and without dampers. The isolation system was based on the seismic input specified for design of bridges in Japan. Experimental results have been presented that fluid dampers are very effective in reducing the seismic response to which they are attached also insensitive to significant temperature changes.

2.2 Amy Hwang (1997)

The author has focused on the practical issues for the structural engineer for using Viscous dampers in a structure. Incorporated the available guidelines for design, other energy dissipation alternatives, and procedures being followed for FVD design and analysis. Author compared various types of dampers with FVD and also configured different patterns of dampers in a building. The author discussed the then situation for effective application of these dampers between design engineers and researchers, software engineers, and architects. Ultimately, author emphasize that the use of FVD within the buildings can be used to define the architectural purpose of building design, rather than just to re-mediate its structural problems.

2.3 A.A.Seleemah et. al (1997)

Authors performed experimental study of non-linear viscous damping devices for earthquake simulation tests on one-storey and three-storey model structures without and with linear and non-linear viscous dampers. These demonstrated results of significant reductions in response when dampers, whether linear or nonlinear, are added to the structural frame. The addition of dampers resulted in drift reduction by 30% to 90% and shear force reduction by 20% to 65%. Non-linear dampers produced more drift response reduction than linear dampers. The applicability of this procedure to the case of nonlinear dampers has not been previously confirmed.This study produced a modification of the Linear Static procedure that is applicable to the case of nonlinear dampers and is sufficiently accurate floor design purposes.

2.4 T.T. Soong et. al (2002)

In this, authors emphasized the wind and seismic response of buildings and bridges by various structural control devices like Active systems and Passive systems. The focus was on the passive and active structural control systems. Passive systems embrace a variety of materials and devices for enhancing structural damping, stiffness and strength. While active systems were comprising active, hybrid and semi-active systems, which are employed with controllable force devices integrated with sensors, controllers and real-time information processing. This paper resulted in brief historical outline of these systems development and an assessment of evolving technology. Also discussed the advantages and limitations in the context of seismic design and retrofit of civil engineering structures.

.2.5 Mohsen Kargahi et al (2004)

This paper explores the employment of viscous dampers as an alternate methodology for the seismal rehabilitation of non-ductile concrete buildings. Additionally states the Optimization technique of viscous damper properties for reduction of seismic risk in concrete buildings. In such analyses, the impact of external dampers is enclosed by an iterative procedure that modifies the overall building damping to match that from the expected response in the dampers. The optimization ensures that the dampers are highly effective, even at relatively small displacements, by choosing properties for dampers at different stories that result in overall minimum cost. An existing building is utilized as an illustration. The study resulted in nearly 50% reduction in displacements.

2.6 Carolina Tovar et. al (13th World Conference on Earthquake Engineering, 2004)

This paper elaborates evaluating the influence of the number and placement of dampers on the dynamic response. Major objectives were affect of variation of placement and number of dampers on seismic response of a framed structure and simplified method to analyze frame structures that have non-classical damping. Five-story frames with two values of the fundamental period are subjected to earthquake ground motions were used. Various distributions of dampers in number and locations were considered while maintaining the same amount of damping in each case. The results showed that large number of dampers placement do not always leads to the benefit in terms of drift reduction for all stories.

2.7 Samuele Infanti et. al (2008)

The Authors describe the behavior of high-rise buildings in seismic areas with the technology of Viscous Dampers installed in them during both wind storms and earthquakes. They considered 3 high-rise buildings in Asia for the above analysis, the Taipei 101 in Taipei, Taiwan, and the twin St. Francis Shangri-La Towers in Manila, Philippines. The results show that viscous dampers can be effectively used in different configurations to reduce the response of high-rise buildings to wind and earthquake. The addition of Viscous dampers, alongside the use of performance based seismic design, on the St Francis Towers has also enabled a reduced superstructure, making a net saving on the structure of approximately $4 Millions of USD. Further, Taipei 101 TMD was observed to behave as the design intended during some major earthquakes.

2.8 Kasra Bigdeli et. al (2011)

This paper stated the optimal arrangement of a limited number of dampers to minimize inter storey drift. Five approaches to resolution the ensuing bi-level optimisation downside area unit introduced and examined (exhaustive search, inserting dampers, inserting floors, locations of most relative rate and a genetic algorithm) and the numerical efficiency of each method is examined. The results revealed that the inserting damper method is the most efficient and reliable method, particularly for tall structures. It was also claimed that increasing the number of dampers does not necessarily increase the efficiency of the system in fact increasing the number of dampers can worsen the dynamic response of the system.

2.9 Daniela Dobre et. al (2013)

The authors emphasized the effects of earthquake on various constructions like buildings, roads, bridges, water towers, utility lines, pipelines etc and also on environment. The effects are classified as short-term(immediate) or long-term impacts. The paper presented some aspects like why do buildings collapse in earthquakes and how to make them resistant to earthquakes. The authors concluded that seismic data of few decades need to be collected for future research and design field to avoid failures.

2.10 H. Kit Miyamoto et. al (2013)

A Cost-Effective Solution with Enhanced Performance for Retrofit and New Construction was carried by using Seismic Viscous Dampers. Steel Moment Reduce Frames (SMRFs) were used to provide strength, dampers were used to control story drifts. Stated that Performance Based Engineering(PBE) design using dampers is superior to the conventional design. The demand on both structural and non-structural components is reduced. When a damper issue of safety is enclosed in style, further protection for the structures and dampers is provided. This approach followed by authors provides pertinent information for the designers to assist in seismic design.

2.11 Liya Mathew et. al (2014)

In this, authors assessed effect of Fluid Viscous Dampers in Multi-storeyed buildings for seismic forces. The buildings location is considered as Zone-V region and loadings are according to IS-875 and IS-1893-2002. The provided results are for maximum effectiveness in reducing the dynamic responses, a structure with FVD should be designed for damping ratio of 20% and the velocity exponent, α of the FVD as 0.5. For effective FVD along width of buildings, the dynamic floor responses of the buildings, it can be concluded that, placing FVD at the external corners on all four sides of the building is effective for square plans. Also for effectiveness of FVD along the height, The peak displacements and inter storey drifts are minimized most effectively by placing the FVD along the first three floors alone. But whereas considering more dynamic responses like the ground rate and floor acceleration, placement of FVD all throughout the peak is found to be effective.

2.12 Alireza Heysami (2015)

This paper discusses about the types of dampers and their seismic performance during an earthquake. Author investigated the tall buildings in the world and satisfactory level of damper performance. The results show that no solely dampers have a suitable unstable behavior against lateral forces like wind and earthquake forces. But it's reduced construction limitations of multi-storey building.

2.13 Naziya Ghanchi et. al (2015)

In this, authors performed response spectrum analysis in ETABS on a 25 storey RCC building with and without viscous dampers which is situated in earthquake zone III according to IS code. Multiple Damper properties has been used which resulted in significant amount of reduced building response in terms of story drift and story displacement and story shear. These parameters has been compared with the conventional buildings for the response reduction.

2.14 Felipe Saitua (2017)

This paper considered the optimization of viscous dampers in multi-storey buildings along the height-wise distribution. Five cost functions that account (with different sophistication levels) for different relationships between cost and damper force capacity, strengthening of columns, and maximum possible damper force capacity were considered. The performance function was defined in terms of the inter-storey drift response, and was used as a constraint function by imposing a target reduction of the response in comparison with the uncontrolled structure. This research shows the advantages of damper distributions optimized considering, in a particular manner, practical (and relevant) design issues. In particular, cost functions outlined in terms of damper force capacity and bracing schemes anchored at non-consecutive floor levels are of special relevance. Proper consideration of damper non linearities may also be of importance.

3. CONCLUSION

After going through the various works related to dampers by different researchers, it may be concluded that:

Dampers can be used as energy dissipating devices in the buildings against seismic devices effectively. These studies essentially provide comprehensive performance of provision of dampers in structures for seismic forces. The position, configuration and number of dampers also affects the behavior of structures. Different types of devices have respective responsive character for the forces applied on it. Damper properties have considerable effect on the results of structural behavior of building. Shape of building also has enough impact on the seismic response of building.

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