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Applications of Dampers for Vibration Control of Structures: An Overview

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Abstract: **-- For the seismic design of building structure, the traditional method, i.e., strengthening the stiffness, strength, and ductility of the structure has been in common use for a long time. Therefore, the dimensions of structural members and the consumption of material are expected to be increased, which leads to higher cost of the buildings as well as larger seismic responses due to the larger stiffness of the structures Thus, the efficiency of the traditional method is constrained. To overcome these disadvantages associated with the traditional method, many vibration-control measures, called structural control, have been studied and remarkable advances in this respect have been made over recent years. Structural Control is a diverse field of study. Controlling the response of the structure is one important aim of researcher these days. Dampers are one of the popular vibration control devices of structures, because of their safe, effective and economical design. This paper presents an overview of literature related to the behavior of different dampers in the seismic event. The review includes different types of dampers like the metallic damper, viscous damper visco-elastic damper, and friction damper.**

I. INTRODUCTION

The vibration control method can be classified into active control, passive control, hybrid control, semi-active control. Among these The passive control is more studied and applied to the existing buildings than the others due to its advantages like , a passive vibration control system that does not require any external power source for its operation and utilizes the motion of the structure to develop the control forces. Dampers are placed throughout a structure to absorb either kinetic or strain energy transmitted from the ground into the primary system. Damping in structures can significantly reduce the displacement and acceleration responses, and decrease the shear forces, along the height of buildings. Energy dissipation in buildings can be confined mainly to supplemental dampers. Damage to the building can be limited to supplemental dampers which are easier to replace than structural components.

II. LITERATURE REVIEW

A. METALLIC DAMPER

Metallic damper also called as the metallic yielding energy dissipation device resist the imposed loads act on the structure during seismic event. The structural response can be reduced when subjected to wind and earthquake by mounting metallic yield damper into the buildings, thereby reduces energy-dissipating demand on primary structural members and minimizes possible structural damage. Its effectiveness and low cost are now well recognized and extensively tested in the past in civil engineering. The MYDs are mainly made of some special metal or alloy material and is easy to be yielded and have good performance of energy dissipation when it services in the structure which suffered by seismic events.

Fig. 1 Metallic yield damper

The metallic yield damper is one type of displacement-correlated and passive energy dissipation damper. First hysteric damper were implemented by Skinner et al, (1980) the metallic dampers are made up of mild steel plates. The vast study is going on different metallic damper and many

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on them are currently in application. X- Plate damper is one type of metallic damper made up of group of plates, its mechanism is more useful during earthquake, Pujari and Bakre, (2011) investigated the seismic effectiveness of an XPD as a seismic protective system for industrial piping systems. They studied seismic performance of a piping system under important parametric variation of the damper properties for an industrial piping system under real earthquake ground motions and the effect of X-plate damper to control the seismic response. There exist optimal combinations of the properties of an XPD for which maximum energy is dissipated by the XPD in the controlled piping system. The energy dissipated in the piping system is dependent on the thickness of the XPD and the input ground motion.

F.Nateghi-E et al, (2008) Investigate the behaviour of filled accordion Metallic damper FMAD, as a supplemental passive energy absorption device for seismic design and seismic retrofitting of structures. Application of the FMAD in base isolation and chevron bracing in frame stories. A hysteretic system including of accordion thin-walled metallic tube has been suggested for this damper. Finite elements model and nonlinear dynamic analysis have been used in their studies; they found that Accordion metallic damper can be used for retrofitting the existing structures against the earthquake. Raul Oscar Curadelli and Jorge Daniel Riera (2004) investigate the effectiveness of metallic dampers in building under seismic excitation. It proved that seismic retrofitting and new design of frame building structure, external energy dissipation system may be advantageously used. In 1977 first time Robinson W.H. and Tucker A. G. did the experimental study on lead extrusion damper. There after (1993) W. J cousins and T.E. Porritt suggest some improvement in lead extrusion damper. The lead extrusion damper proved efficient at different temperature. The characteristic of lead extrusion damper have not been affected with the increased number of cycle. C. C. Patel (2017) investigate the response behaviour of two parallel structures coupled by lead extrusion damper and found effective in seismic response reduction of adjacent structure.

B. FRICTION DAMPER

Friction damper is one of the simple and inexpensive types of damper. Friction damper consist of series of steel plates which are specially treated to develop most reliable friction. Friction damper utilizes the mechanism of solid friction that develops between two solid bodies sliding relative

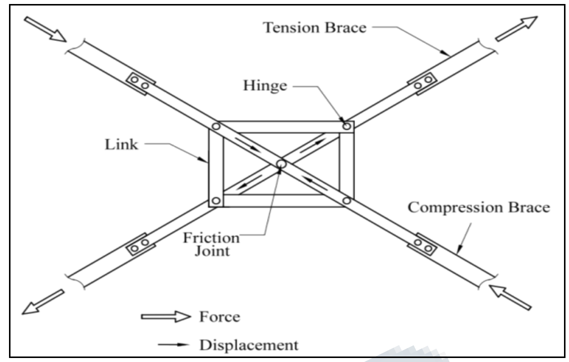

Fig 2. Friction damper

to one another to provide desired energy dissipation. Plates are clamped together with bolts and allowed to slip at predetermined load. The performance of friction damper is not affected by temperature, and stiffness degradation against aging. Pall et al (1979) conducted static and dynamic test on verity of sliding elements with different surface treatments. Friction damper slips at optimum load and dissipate major portion of seismic energy during the seismic event. In 1987 Filiatrault and Cherry states some limitation of Palls friction damper that Palls damper was only valid if slip during every cycle. They proposed a detailed macroscopic model using brake lining pads at intersection of cross braces which improve the physical properties of damper. Some alternate friction damper designs are proposed in some resent literature. Roik et al., (1988) investigate the use of three stage friction grip elements. The recent friction damper manufactured by Fluor Daniel known1 as EDR i.e. Energy Dissipating restraint. It consists of steel compression wedges and bronze friction wedges to transform the axial spring force into normal pressure acting outward on the cylinder wall. In 1992 Suzuki et al., investigated the performance of friction damper on piping system. In 2006 bi-directly interaction of friction force was suggested by Bakre et al., has significant effects on response of the piping on friction support. In 2001 Y. L. Xu et.al,. investigate the use of semi active friction damper in to control the response of wind exited truss tower. That was the first known attempt compared with passive friction dampers, the semi-active friction dampers are more robust and versatile for improving both serviceability and strength performances of wind excited large truss towers. In 2002 Imad H Mualla investigates the performance of steel frames with new friction damper during seismic event. The application of the new FDD presents a feasible alternative to the conventional ductility-based earthquake-resistant design both for new construction and for upgrading existing structures. A.V. Bhaskarao and R.S. Jangid (2005) did the seismic analysis of connected structure with friction damper. Ceredic Marsh (2000) investigated the application of friction in conjunction with rigid structural frames. Both in steel and concrete it gives the most economical protection against seismic activity for framed medium-rise buildings.. Continues study is going improvement of friction damper and their utilization.

C. VISCOELASTIC DAMPER

Viscoelastic damper includes viscoelastic solid damper and viscoelastic fluid damper. In 1969 Mahmoodi presented the concept of vicoelastic damper.

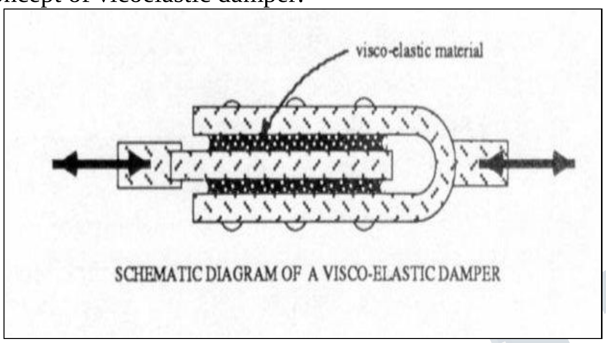

Fig 3 Visco Elastic Damper

Viscoelastic damper comprises two viscoelastic layers bonded between three parallel rigid surface. In 1970 this type of damper was used in New York for controlling wind vibration in twin towers of world trade centre. The experimental and analytical study of Zhang said that viscoelastic damper can reduce the response in steel structure effectively. Seismic application of VED begins in 1993 for a seismic retrofit project of 13-story Santa Clara County building in San Jose, A full scale vibration test was performed by Lai et al., (1995) design procedure for damper was developed by scaling up the size of viscoelastic material. Viscous damping walls were recently used for a seismic protection in newly constructed SUT- building in Shizuka city, Japan as described by Miyazaki and Mitsusaka (1992) . Total 170 damping walls are employed within the steel frame. Based on time history analysis the damping walls reduce response by 70-80%.. K.C. Chang et al., (1988) investigate on the seismic analysis and design of structure with viscoelastic damper. the design procedure used by them proves economic and safe alternative for seismic resistant structure under seismic design regulation. Lin and chopra in 2003 studied the response of one story system with viscoelastic damper attached to flexible braces and fluid viscous damper attached to rigid chevron braces. They showed that asymmetric system with this damper can be estimated with sufficient accuracy for design. B Samali et al,. (2006) investigated the uses of viscoelastic damper for reducing wind and earthquake forces. Examples of earlier installations were given some detail to clearly demonstrate the effectiveness and potential of viscoelastic damper as viable, cost effective and maintenance free damper system to control the motion of dynamically sensitive structures subjected to environmental loads. M. P. Singh et al,. did the seismic analysis of structure with viscoelastic damper on mathematical model. It seen that viscoelastic damper effective in control of seismic response of structure.

D. VISCOUS DAMPER-

Viscous damper works on fluid flow through orifice. By adding fluid viscous dampers, the energy input from a transient is absorbed. Fluid damping technology was validated for seismic use by extensive testing in the period 1990-1993.In 2003 Robert Mcnamara and Douglas Taylor investigate the application of fluid viscous damper in high rise structure to suppress the anticipated wind induced acceleration.

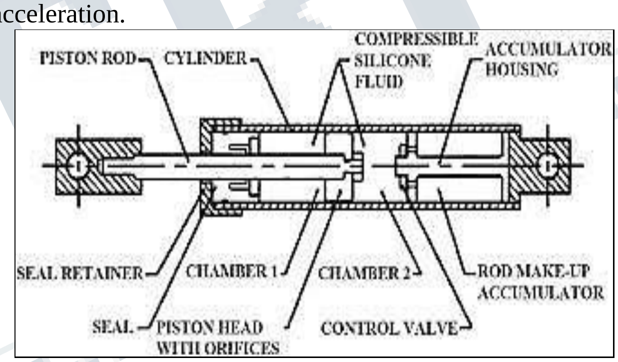

Fig 4 Viscous damper

The application of viscous damper proved very cost effective. Yukihiro Tokuda and Kenzo Taga (2008) worked on structure in which vicious damper installed in basement soft story. The paper introduce in practical use of viscous damper. In 2012 D Naarkhede and R. Sinha did the experiment to evaluate the performance of viscous damper for shock loads. They discuss the mathematical formulation and relative performance of structure subjected to short duration pulse excitation. Samuele Infanti et al,. Described the technology of viscous damper in high rise building. Their study show that viscous dampers can be effectively used in different configurations to reduce the response of high-rise buildings to wind and earthquake In 2015 Jinaxing chen et al,. investigated the use of viscous damper in high rise structure for seismic response control. The seismic responses of the structure with viscous dampers are studied by time-history analysis. The investigation result showed that viscous dampers substantially reduce the structural dynamic response.

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A Ravitheja (2016) investigated the seismic evaluation of multistory RC building with and without fluid Viscous Damper. The research show that viscous damper effectively reduce the building response by selecting optimum damping coefficient

III. CONCLUSION

The use of seismic control system has increased in these resent years but selecting the best damper for reducing vibration in structure in seismic event is necessary. The controlling reduces damage significantly by increasing the structural safety, serviceability and prevents the building form collapse during the earthquake. In this paper the basic concept of passive seismic response control devices is mentioned and their resent development and application are discussed. The experimental and analytical investigate carried out by various richer clearly demonstrate that the seismic control method has potential to improve the seismic performance of structure.

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