Study of Fluid Viscous Dampers In Multi-Story Buildings

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Abstract- *At present large number of existing buildings which are severely deficient against earthquake forces are increasing day by day. The solution for this problem is Seismic retrofitting and it strengthen such existing building but it is a complex task and requires skill, retrofitting of RC buildings is particularly challenging due to complex behaviour of the RC composite material. During an Earthquake when structure has much absorbing capacity than the seismic energy then it can withstand the structural damage .At that time application of fluid viscous damper (FVD) can be used as a feasible means of decreasing the structural damage. Which helps to increase the strength ,resistivity and overall lifespan of the structure.*

Keywords- Fluid viscous damping (FVD); Earthquake; Seismic Retrofitting :Energy absorber.

I. INTRODUCTION

In India large number of existing buildings which are severely deficient against earthquake forces are increasing day by day. The solution for this problem is Seismic retrofitting and it strengthen such existing building but it is a complex task and requires skill, retrofitting of RC buildings is particularly challenging due to complex behaviour of the RC composite material .During an earthquake some energy is dissipate and this dissipation of energy can be achieved by providing supplementary energy dissipating devices like metallic dampers, friction dampers, viscous and visco elastic dampers amount of energy dissipates by these dampers is directly dependent on the material used and geometry of dampers.

Seismic Retrofitting

Retrofitting is technical interventions in structural system of a building that improve the resistance to earthquake by optimizing the strength, ductility and earthquake loads. Generally, the structures vulnerable to earthquakes are retrofitted by means of steel jacketing, concrete jacketing, and Galvanized steel mesh reinforcement, Inclusion of new Supporting walls / concrete shear walls, steel bracings or by any other suitable means .Currently, the most practical and reliable method of reducing seismic structural response is the use of active and semi-active control devices and passive response control systems.

II. DAMPING

It is defined as energy loss in the response over the time period. Energy dissipation involves factors such as materials, radiation of soil etc. Clear understanding of damping is required for incorporating its effect to the structure.

Supplemental Damping systems

The supplemental damping system can be categorized in three groups as passive semi active and active systems. These dampers are activated by the movement of the structure and decrease the structural displacements by dissipating energy via different mechanisms.

Active Device: It refers to energy dissipation from the system by external means such as controlled actuator etc.

Passive Device : It refers to energy dissipation within the structure by add-on damping device such as isolator by structural joints and supports or by structural members internal damping.

Types Of Dampers

Dampers are classified based on their performance of friction, metal (Flowing), Viscous, Visco elastic, shape memory alloys (SMA) and mass dampers. There are following different types of Dampers are as follows.

Types of dampers

- Tuned mass Damper (TMDS)
- Tuned liquid mass damper (TLDS)
- Friction Damper
- Metallic Damper
- Fluid Viscous Damper(FVD)
- Elasto Plaster Damper

III. HISTORY

Taylor Devices is the world leading manufacturer of seismic and other force control devices, with an unrivalled list of project references .More than 600 buildings and bridges now use Taylor dampers. Taylor products are made in the United States at two manufacturing facilities in North Tonawanda, New York. Taylor Devices has manufactured fluid dampers since 1955, giving extensive experience and a proven track record of quality and success.

Advantages

- At low displacement also these are activated
- It has minimal restoring force
- The properties largely frequency and temperature independent
- The performance in military application has made the record

IV. WORKING AND DETAILS OF FLUID VISCOUS DAMPER (FVD)

Most various dampers are fluid dampers, similar to the shock absorbers in automobiles. Viscous dampers of varieties of materials and damping parameters were proposed and developed for seismic protection. Viscous fluid dampers commonly used as passive energy dissipation devices for seismic protection of structures are principally composed of a piston rod, a piston head and a cylinder filled with a viscous fluid. Fluid viscous dampers which operate on the principle of fluid flow through orifices are installed in a number of structural applications. Example of construction of viscous fluid viscous damper is shown in Figure .

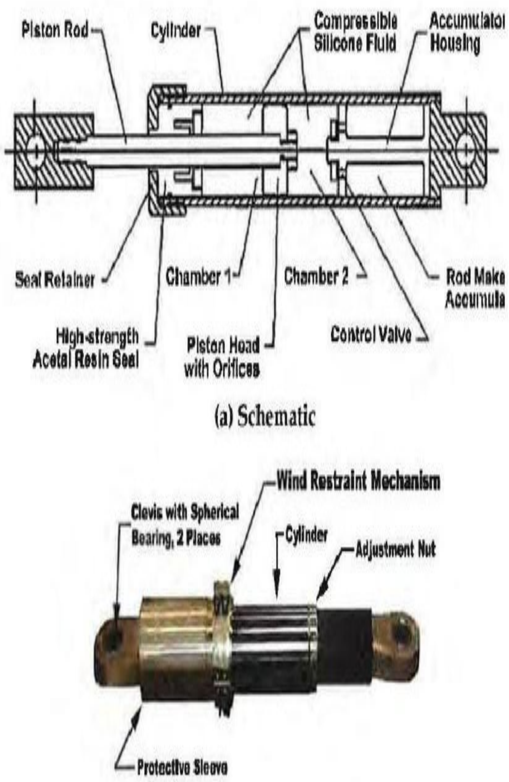


Figure 1. Fluid Damper

Major part descriptions are as follows, using Figure 1. as reference:

Piston Rod – Highly polished on its outside diameter, the piston rod slides through the seal and seal retainer. The external end of the piston rod is affixed to one of the two mounting clevises. The internal end of the piston rod attaches to the piston head. In general, the piston rod must react all damping forces, plus provide a sealing interface with the seal. Since the piston rod is relatively slender and must support column loading conditions, it is normally manufactured from high-strength steel material. Stainless steel is preferred as a piston rod material, since any type of rust or corrosion on the rod surface can cause catastrophic seal failure. In some cases, the stainless steel must be chrome plated for compatibility with the seal material.

Cylinder – The damper cylinder contains the fluid medium and must accept pressure vessel loading when the damper is operating. Cylinders are usually manufactured from seamless steel tubing. Welded or cast construction is not permissible for damper cylinders, due to concerns about fatigue life and stress cracking. Cylinders normally are designed for a minimum proof pressure loading equal to 1.5 times the internal pressure expected under a maximum credible seismic event.

Fluid – Dampers used in structural engineering applications require a fluid that is fire-resistant, non-toxic, thermally stable, and which will not degrade with age. This fluid must be classified as both non-flammable and non-combustible, with a fluid flashpoint above 90°C. At present, the only fluids possessing all of these attributes are from the silicone family. Typical silicone fluids have a flashpoint in excess of 340°C, are cosmetically inert, completely non-toxic, and are thermally stable. Since silicone fluids are produced by distillation, the fluid is completely uniform and no long-term settling will occur. The typical silicone fluid used in a damper is virtually identical to the silicone used in common hand and facial cream cosmetics.

Seal – The seals used in a fluid damper must be capable of a long service life; at least 25 years without requiring periodic replacement. The seal materials must be carefully chosen for this service life requirement and for compatibility with the damper's fluid. Since dampers in structures are often subject to long periods of infrequent use, seals must not exhibit long-term sticking nor allow slow seepage of fluid. Most dampers use dynamic seals at the piston rod interface, and static seals where the end caps or seal retainers are attached to the cylinder. For static seals, conventional elastomer o-ring seals have proven to be acceptable

Piston Head – The piston head attaches to the piston rod, and effectively divides the cylinder into two pressure chambers. As such, the piston head serves to sweep fluid through orifices located inside it, thus generating damping pressure. The piston head is usually a very close fit to the cylinder bore; in some cases the piston head may even incorporate a seal to the cylinder bore.

Seal Retainer – Used to close open ends of the cylinder, these are often referred to as end caps, end plates, or stuffing boxes. It is preferable to use large diameter threads turned on either the exterior or interior surface of the cylinder to engage the seal retainer. Alternate attachment means, such as multiple bolts, studs, or cylinder tie rods should be avoided as these can be excited to resonance by high frequency portions of either the earthquake transient or the building response spectra.

Accumulator – The simple damper depicted in Figure 11 utilizes an internal, in-line rod make-up accumulator. The accumulator consists of either a block of closed cell plastic foam, a moveable (and gas pressurized) accumulator piston, or a rubber bladder. The purpose of the accumulator is to allow for the volumetric displacement of the piston rod as it enters or exits the damper during excitation. A second purpose is to compensate for thermal expansion and contraction of the fluid. The damper in Figure 1 uses a control valve to meter the amount of fluid displaced into the accumulator when the damper is being compressed. When the damper extends, the control valve opens to allow fluid from the accumulator to freely enter the damper pressure chambers. Although the damper in Figure 1 has an in-line, internal accumulator, some older damper types use an external accumulator tank with connecting hoses or piping.

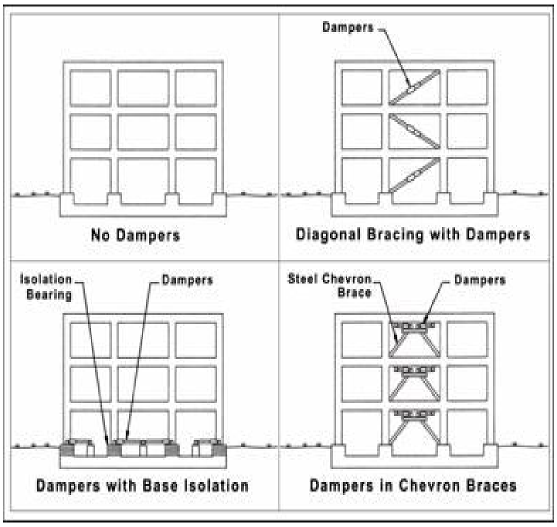
Orifices – The pressurized flow of the fluid across the piston head is controlled by orifices. These can consist of a complex modular machined passageways, or alternately, can use drilled holes, spring loaded balls, poppet's, or spools. Relatively complex orifices are needed if the damper is to produce output with a damping exponent of less than two. Indeed, a simple drilled hole orifice will follow Bernoulli's equation, and damper output will be limited to varying force with the square of the damper velocity. Since "velocity squared" damping is of limited use in seismic energy dissipation, more robust and sophisticated orifice methods are usually required

V. IMPLEMENTATION OF FLUID DAMPERS

One of the most beneficial aspects of using fluid dampers in a structure is that they are essentially a "bolt-in" item, of a relatively compact size. If used as part of a structural bracing system, the fluid dampers usually will have a smaller cross-sectional envelope than a conventional steel brace.

Fluid dampers are connected to the structure in three ways:

- Damper installation in the floor or foundation (in the method of seismic isolation).
- Connecting dampers in chevron braces.
- Damper installation in diagonal braces



Basic Mounting Attachment Styles

VI. FABRICATION ISSUES: SIZE VS. COST

If a given structure requires certain total macroscopic damping, to implement this damping will involve dividing the total damping by the number of dampers used. The end result is a maximum force and damping function for each individual damper. The question is Should the engineer select a large number of small dampers, or a lesser number of large dampers? The rather large number of available dampers sizes tends to compound the problem even further.The structural engineer normally starts out with multiple dampers of the same size, dispersed uniformly throughout the structure. This usually results in many dampers in the relatively small force range of 5 tonnes to 25 tonnes output. If the structure is small enough to require less than 32 pieces of a 5 tonnes to 25 tonnes output damper, than this will probably be the most effective size, since quantities smaller than 32 pieces tend to become costly, due to set-up, engineering, and test charges being amortized over a small quantity. The 32 piece number was obtained strictly from the past experience of the author.

The next step is to reduce the number of dampers by using the next larger size, and continuing this process until:

1. The quantity of dampers goes below 32 pieces.
2. The force rating of the damper goes over 300 tonnes.
3. The structure begins behaving less efficiently because the dampers are not distributed well enough.

This is an interactive process, and thus damper sizes will vary from project to project.Currently available damper sizes from manufacturers range from 5-800 tonnes of force output. In terms of relative cost, the least expensive sizes on a force basis are usually in the 100-250 tonnes range, i.e., one piece of a 150 tonnes force damper costs less than 10 pieces of a 15 tonnes force damper. In most cases, dampers larger than 600 tonnes output are used only on large bridges, since the point loading into a building structure from such a large device requires that special design considerations be made to the structure’s beam to column connections. Also, note that just as 15 tonnes force dampers are relatively expensive compared to the 150 tonnes size, dampers larger than 250 tonnes also tend to become costly. In this case, the problem relates to a general lack of available high-strength steel in the very large sizes, requiring special orders to the steel mill.

VII. CONCLUSIONS

The use of fluid dampers for seismic and wind protection of commercial and public structures has occurred widely throughout the 1990's and into this century. Implementation has occurred rapidly, compared with other technologies. When fluid dampers are used for seismic or wind protection, the end result is a predictable reduction of both stress and deflection in the structure. This simultaneous stress and deflection reduction is unique to fluid dampers. Optimal performance is dependent on the type of structure and the level of performance required. Damping levels for optimal use of this technology range from 10% critical to 45% critical.Today, more than 240 major buildings are using fluid dampers as a primary design element. Damper sizes being used range from as little as 5 tonnes force to more than 800 tonnes force, with deflections as low as25mm and as high as 1.5 m. Indeed, it can be said that the use of supplemental fluid dampers will be one of the primary solutions for seismic and wind protection in the structures of the 21st century.

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