CHAPTER 4

ENERGY DISSIPATING DAMPING DEVICES

The general principles for the design of a damping system are

- It should be accessible
- It should have a low maintenance
- Its design must take into account corrosion
- Where high amplitude oscillations exist, buffers should be associated
- It should allow a later adjustment
- Its design must be accompanied with experimental tests

4.1 INTRODUCTION

The function of energy dissipation system is to reduce structural response due to earthquake, wind and other dynamic loads. These devices are also known as motion control system, can absorb part of the energy induced in the structure, reducing energy dissipation demand on the primary structural members, and thus reducing the structural deflection and non-structural deformations. There are many types of energy dissipation devices. The types of passive energy dissipation devices are:

1. Viscous fluid dampers
2. Friction dampers
3. Metallic dampers
4. Viscoelastic solid dampers
5. Tuned mass dampers
4.2 FRICITION DAMPERS

Friction damper is a passive energy dissipation device. Friction dampers consist of moving parts that will slide over each other during a strong earthquake. When the parts slide over each other they create friction which uses some of the energy from the earthquake that goes into the building. It consists of series of steel plates specially treated to develop friction. The plates are clamped together with high strength steel bolts.

During severe seismic excitations, friction dampers slip at a predetermined optimum load before yielding occurs in other structural members and dissipate a major portion of the seismic energy. This allows the building to remain elastic or at least yielding is delayed have to be available during maximum credible earthquakes. Another feature of friction damped buildings is that their natural period varies with the amplitude of vibration. Hence the phenomenon of resonance is avoided. Several frictional dampers are being used. They are available for tension cross bracing, single diagonal bracing and chevron bracing. Friction dampers exhibit rigid-plastic behaviour and force response is modeled by Coulomb friction.

The friction dampers have rectangular hysteresis loop compared to the other types of dampers and thus, it dissipates high energy from the structure during seismic action. The friction dampers are simple and less expensive. The connections and design are simple compared to the other types of dampers. Therefore, the friction dampers are widely used for new and retrofitting of the existing structures. The following are the various types of viscous fluid dampers:

- Pall Friction Damper
- Uniaxial Friction Damper
- Slotted Bolt Connection
4.2.1 Pall Friction Damper

The Pall cross-bracing friction damper consists of cross-bracing that connects in the center to a rectangular damper as shown in the Figure 4.1. The damper is bolted to the cross-bracing. Under lateral load, the structural frame distorts such that two of the braces are subjected to tension and the other two to compression. This force system causes the rectangular damper to deform into a parallelogram, dissipating energy at the bolted joints through sliding friction (Avtar & Cedric 1982).

![Figure 4.1 Pall Friction Damper (Avtar & Cedric 1982)](image)

4.2.2 Uniaxial Friction Damper

The device consists of copper pads impregnated with graphite in contact with the steel casing of the device. Figure 4.2 shows the uniaxial friction damper. The load on the contact surface is developed by a series of wedges which act under the compression of Belleville washer springs. The graphite serves the purpose of lubricating the contact and ensuring a stable coefficient of friction and silent operation. The dampers were not installed diagonally as braces. Rather, they were placed parallel to the floor beams, with
one of their ends attached to a floor beam above and the other end attached to a chevron brace arrangement which was attached to the floor beam below. Figure 4.3 shows the installation of uniaxial friction damper in steel frame.

![Figure 4.2 Uniaxial friction damper](image1)

![Figure 4.3 Installation of uniaxial friction damper in steel frame](image2)

This damper allows slip to occur in slotted bolted connections. The connection consists of gusset plate, two back to back channels, cover plates, and bolts with washers. The sliding interface consists of steel (Fitz Gerald et al 1989).
4.2.3 **Slotted Bolted Friction Damper**

This damper allows slip to occur in slotted bolted connections. The connection consists of gusset plate, two back to back channels, cover plates, and bolts with washers. The sliding interface consists of steel slotted bolted connections as shown in the Figure 4.4. (Fitz Gerald et al 1989).

![Figure 4.4 Slotted Bolted Connections (Fitz Gerald et al 1989)](image)

4.3 **METALLIC DAMPERS**

Two major types of metallic dampers available are buckling-restrained brace (BRB) dampers and Added Damping And Stiffness (ADAS) dampers. A BRB damper consists of a steel brace having low-yield strength with a cruciform cross section that is surrounded by a stiff steel tube. The region between the tube and brace is filled with a concrete-like material and a special coating is applied to the brace to prevent it from bonding to the concrete. Thus, the brace slide with respect to the concrete-filled tube. The confinement provided by the concrete-filled tube allows the brace to be subjected to compressive loads without buckling. Since buckling is prevented, significant energy dissipation occurs over a cycle of motion (Black et al 2004).
BRB dampers are installed within a chevron bracing arrangement. In this case, under lateral load, one damper is in compression and the other is in tension, and hence zero vertical loads are applied at the intersection point between the dampers and the beam above. A second type of metallic damper is the ADAS damper; it consists of a series of steel plates in which the bottom of the plates are attached to the top of a chevron bracing arrangement and the top of the plates are attached to the floor level above the bracing. The X-Shaped plate metallic dampers as shown in the Figure 4.5 (Whittaker et al 1991).

![Figure 4.5 X-Shaped plate metallic dampers (Whittaker et al 1991)](image)

**4.4 VISCOELASTIC SOLID DAMPERS**

Viscoelastic solid dampers consist of solid elastomeric pads viscoelastic material bonded to steel plates. The steel plates are attached to the structure within chevron or diagonal bracing. As one end of the damper displaces with respect to the other, the viscoelastic material is sheared resulting in the development of heat which is dissipated to the environment. Due to this nature, they exhibit both elasticity and viscosity i.e., they are displacement and velocity dependent (Chang et al 1995).
Viscoelastic (VE) damper is one of important kind of passive energy devices these have been used as energy dissipation devices in many structures where the damper undergoes shear deformations. Viscoelastic materials exhibit combined features of viscous liquid and elastic solid when deformed. In other words they dissipate a certain amount of energy as heat and return to their original shape after every cycle of deformation. Viscoelastic shear damper is described by (Mahmoodi 1969) and he also mentioned that it can be efficient in decreasing the dynamic response of buildings. Viscoelastic dampers made of bonded acrylic polymers (Viscoelastic) layers. The extension of Viscoelastic shear damper to seismic applications is more recent. For seismic applications, more effective use of viscoelastic materials is required since large damping ratios than those for wind are usually required. Figure 4.6 shows a typical viscoelastic shear damper consists of viscoelastic layers bonded to steel plate. When these dampers are mounted to a building structure shear deformations occur, as a result energy dissipation take place when relative motion occurs between the outer steel flanges and central plate.

4.5 TUNED MASS DAMPERS

A Tuned Mass Damper (TMD) is a device consisting of a mass, a spring, and a damper that is attached to a structure in order to reduce the
dynamic response of the structure. The frequency of the damper is tuned to a particular structural frequency so that when that frequency is excited, the damper will resonate out of phase with the structural motion. Energy is dissipated by the damper inertia force acting on the structure. Figure 4.7 shows a typical tuned mass damper and Figure 4.8 shows a primary structure with tuned mass damper.

Figure 4.7 Tuned Mass Damper Pendulum Type

Figure 4.8 Primary structure with TMD
4.5.1 Tuned Liquid Mass Dampers (TLDs)

Tuned liquid mass damper basically consists of liquid sloshing tanks and liquid mass depth. Due to liquid sloshing, the damper response of TLDs is highly nonlinear in nature and also frequency dependent device. The effectiveness of TLD is increased by using multiple tuned mass dampers (MTLDs) in which number of liquid sloshing tanks are increased to reduce the dynamic response of the structures. These MTLDs can be used for high rise buildings to reduce the wind and earthquake vibrations. Advantages of TLDs are low initial and maintenance cost, easy to install as compared to TMDs. Experiments were performed to make out the characteristics of TLD and the interaction between the TLD and structure using the shake table test with a harmonic external loading. The Liquid Column Vibration Absorber (LCVA) is modeled as a SDOF system as shown in Figure 4.9 which consists of stiffness of $k_0$, mass of $m_0$, structural damping $c_0$, length of horizontal portion $B_h$ and length of vertical portion $L_e$, $x(t)$ & $y(t)$ are horizontal and vertical displacements and $b(t)$ base acceleration due to earthquake ground motion. Results show that LCVA tends to reduce the level of uncertainty. It was also observed that neglecting the effect of system parameter uncertainty may overestimate the damper performance.

Figure 4.9 LCVA-SDOF Systems
4.6 VISCOUS FLUID DAMPERS

Viscous fluid dampers are commonly used as passive energy dissipation devices for seismic protection of structures. It consists of a hollow cylinder filled with fluid, the fluid typically being silicone based. As the damper piston rod and piston head are stroked, fluid is forced to flow through orifices either around or through the piston head. The resulting differential pressure across the piston head with very high pressure on the upstream side and very low pressure on the downstream side can produce very large forces that resist the relative motion of the damper (Lee & Taylor 2001). The fluid flows at high velocities, resulting in the development of friction between fluid particles and the piston head. The friction forces give rise to energy dissipation in the form of heat. The associated temperature increase can be significant, particularly when the damper is subjected to long-duration or large-amplitude motions (Makris et al 1998).

A fluid damper is a device which dissipates energy by applying a resisting force over a finite displacement. The damper’s output force is resistive; therefore it acts in a direction opposite to that of the input motion. Because the damper behaves in accord with the laws of fluid mechanics, the value of the resisting force varies with respect to the translational velocity of the damper at any point in time. The energy dissipated by the damper is equal to:

$$ED = \int |F| \, dx$$  \hspace{1cm} (4.1)

Where $F$ is the damper output force function and $x$ is the displacement.

The means of energy dissipation is that of heat transfer, i.e., the mechanical energy dissipated by the damper causes a heating of the dampers
fluid and mechanical parts, and this heat energy is harmlessly transferred to the environment by transport mechanisms, usually convection and conduction.

The fluid inertial damper as tested produced a linear damping output, where output force is proportional to velocity of displacement. Other versions of this damper have been produced which provide non-linear damping, where force is proportional to velocity raised to a power given by the following expressions:

\[ F \alpha V^K \]  \hspace{1cm} (4.2)

Thus, \[ F = CV^K \]  \hspace{1cm} (4.3)

Where, K has a value in the range of 0.1 to 1.2, as specified for a given application. A fluid damper has several inherent and significant advantages compared to other types of energy dissipaters, such as hysteretic (friction), visco-elastic (rubber), tuned masses, and elasto-plastic (yielding metal) types (Douglas & Taylor 1996).

4.6.1 Operation of Viscous Fluid Dampers

Fluid viscous dampers operate on the principle of fluid flow through orifices. A stainless steel piston travels through chambers that are filled with silicone oil as shown in the Figure 4.10. The silicone oil is inert, non-flammable, non-toxic and stable for extremely long periods of time. The pressure difference between the two chambers cause silicone oil to flow through an orifice in the piston head and seismic energy is transformed into heat, which dissipates into the atmosphere.
4.6.2 Salient Features of Viscous Fluid Dampers

1. In a typical un-damped structure, the inherent damping is merely 1-5% of critical. With the introduction of dampers, structural damping of 20-50% of critical can be easily achieved. As the dampers dissipate a major portion of the seismic energy, forces and deformations on the structure are significantly reduced.

2. Their performance is independent of velocity and hence exerts constant force for all future earthquakes, design-based earthquake (DBE) or maximum credible earthquake (MCE).

3. A much greater quantity of energy can be dissipated in viscous fluid than any other method involving the yielding of steel plates, viscoelastic dampers and friction dampers.

4. A fluid damper is self-contained, no auxiliary equipment or power is required.

5. Relatively easy to retrofit into existing buildings.

6. Thus, installation of viscous dampers is beneficial for reducing the seismic response of a structure.

7. Effect of enhancing energy dissipation by viscous dampers are done by the seismic response of a structure can be computed for any system subjected to arbitrary ground motion by varying
damping ratio based on computer analysis. As damping ratio increases, response acceleration, velocity and displacement generally decrease.

4.6.3 Design Requirements of Viscous Fluid Dampers

- Amount of energy dissipation, or equivalent damping ratio.
- Damping coefficient to determine on linear type dampers or nonlinear type dampers.
- Stroke of dampers.
- Maximum damping forces of dampers.

4.6.4 Advantages of Viscous Fluid Dampers

- Use of viscous damping to control and improve building performance is a mature technology.
- The output of a fluid damper is essentially out of phase with primary bending and shearing stresses in a structure. This implies that a fluid damper can be used to reduce both internal shear forces and deflection in a structure.
- A viscous fluid damper is self-contained, no auxiliary equipment or power is required.
- A modern viscous fluid damper operates at a fluid pressure level of significant magnitude, thus making the damper small, compact, and easy to install.
- Viscous Fluid dampers are generally less expensive to purchase, install, and maintain than other types. They can economically reduce the overall cost of a structure, especially when used at high damping ratios in the 15% - 40% critical damping range.
- Viscous fluid dampers have been proven by the test of time, with over 100 years of successful large scale use, in the most severe environments, most notably by the military and aerospace industries.

- Improve building performance without adding stiffness (and therefore accelerations).

- Application of viscous dampers in elastically/near elastically responding steel moment resisting frames will achieve a very high level of seismic performance.

- Relatively easy to retrofit into existing buildings.

- Out-of-phase response of viscous dampers is such that when used for building retrofit the need for strengthening of existing foundation and super structure elements is often mitigated.

- While not as good as base isolation offers many similar advantages and is significantly cheaper.

- Suitable for flexible structures.

- Effective retrofit option which can eliminate, or significantly reduce, the need for strengthening of existing foundation and super structure elements.

- Practical design methodologies are available for viscous damped buildings.

4.6.5 Disadvantages of Viscous Fluid Dampers

- Temperature dependence of viscosity

- Build-up of damping force at high velocity range (over design level velocity). This is dangerous for both devices and structures.
Generally viscous dampers are expensive compared to other types of dampers such as steel dampers.

In this present study, we are using viscous fluid dampers because of greater advantages and easy availability in market and also cost effective while comparing with other types of dampers. The practical implementations of viscous fluid dampers installed around the world are listed in Table 4.1.

**Table 4.1 Practical implementation of Viscous fluid dampers**

<table>
<thead>
<tr>
<th>Name and type of structure</th>
<th>Country/city</th>
<th>Type and number of dampers</th>
<th>Date</th>
<th>Load</th>
<th>Additional information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barwon Heads Bridge</td>
<td>Australia/Victoria</td>
<td>Taylor Fluid Dampers Total: 10 405kN ± 50mm stroke</td>
<td>2010</td>
<td>Seismic</td>
<td>Lock-up devices used to limit bridge deck displacements for a new highway bridge with timber piers.</td>
</tr>
<tr>
<td>Meguro Gajoen Extension Project</td>
<td>Japan/Tokyo</td>
<td>Taylor Fluid Dampers Total: 72 1000kN ± 50mm stroke 1500kN ± 50mm stroke 2000kN ± 50mm stroke</td>
<td>2010</td>
<td>Seismic</td>
<td>New construction, 16-story steel and concrete frame office/hotel/parking structure uses dampers to dissipate earthquake energy</td>
</tr>
<tr>
<td>Kasumigaseki 3 Chome Project</td>
<td>Japan/Tokyo</td>
<td>Taylor Fluid Dampers Total: 64 1000kN ± 50mm stroke 1500kN ± 50mm stroke</td>
<td>2010</td>
<td>Seismic</td>
<td>New construction, 17-story steel frame office/parking structure uses dampers to dissipate</td>
</tr>
<tr>
<td>Location</td>
<td>City/State</td>
<td>Taylor Fluid</td>
<td>Seismic/Wind</td>
<td>Total Load Capacity</td>
<td>Description</td>
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<tr>
<td>250 West 55th Street</td>
<td>USA/New York, NY</td>
<td>Taylor Fluid Dampers Total: 7 1690 kN ± 100 mm stroke</td>
<td>Wind</td>
<td>2009</td>
<td>Custom high capacity metal bellows dampers used as part of an outrigger system in a new 39-story all glass exterior office building to reduce wind motion.</td>
</tr>
<tr>
<td>US Dept. of Interior Bureau of Reclamation - Utah Projects Office Complex</td>
<td>USA/Provo, UT</td>
<td>Taylor Fluid Dampers Total: 9 445kN ± 100mm stroke 245kN ± 75mm stroke</td>
<td>Seismic</td>
<td>2009</td>
<td>Retrofit of an office complex. Dampers and lock-up devices used in diagonal braces to dissipate earthquake energy and reduce displacement.</td>
</tr>
<tr>
<td>LAX Theme Building</td>
<td>USA/Los Angeles, CA</td>
<td>Taylor Fluid Dampers Total: 8 555 kN ± 15mm stroke</td>
<td>Seismic</td>
<td>2009</td>
<td>Retrofit of an elevated restaurant supported by four curved legs. Dampers used as part of a mass damper system to control movement of the mass block during an earthquake.</td>
</tr>
<tr>
<td>100 International Drive - Steel warehouse</td>
<td>USA/East Hartford, CT</td>
<td>Taylor Fluid Dampers Total: 2 330 kN ± 100 mm stroke</td>
<td>Seismic</td>
<td>2009</td>
<td>Single-story steel framed warehouse building with plan dimensions of 676’ x 450’. Dampers transfer loads</td>
</tr>
<tr>
<td>Location</td>
<td>City, State</td>
<td>Taylor Fluid Dampers Total:</td>
<td>Year</td>
<td>Seismic Type</td>
<td>Details</td>
</tr>
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<tr>
<td>T.F. Green Airport Parking Garage</td>
<td>USA/ Providence, RI</td>
<td>64 135 kN ± 32 mm stroke 270 kN ± 75 mm stroke</td>
<td>2009</td>
<td>Seismic</td>
<td>Located in Warwick, near Providence, RI, this airport parking garage uses dampers to transfer loads across expansion joints, thereby reducing the large seismic expansion joint/gap requirements.</td>
</tr>
<tr>
<td>Aircraft Hanger</td>
<td>USA/ Hawthorne, CA</td>
<td>160 900 kN ± 100 mm stroke</td>
<td>2009</td>
<td>Seismic</td>
<td>Voluntary seismic upgrade of an aircraft hangar building using dampers in double-diagonal braces to provide seismic energy dissipation.</td>
</tr>
<tr>
<td>865 Market Street - San Francisco Centre</td>
<td>USA/San Francisco, CA</td>
<td>50 2000 kN ± 125 mm stroke 2000 kN ± 165 mm stroke</td>
<td>2009</td>
<td>Seismic</td>
<td>Voluntary Seismic upgrade of existing multi-story Nordstrom Store in a San Francisco downtown shopping center mall. Dampers in diagonal braces provide seismic energy dissipation.</td>
</tr>
<tr>
<td>3300 Hyland Ave –</td>
<td>USA/ Costa Mesa, CA</td>
<td></td>
<td>2009</td>
<td>Seismic</td>
<td>Seismic upgrade of 3-story existing</td>
</tr>
<tr>
<td>Location</td>
<td>City, Country</td>
<td>Type</td>
<td>Dampers Details</td>
<td>Year</td>
<td>Application</td>
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<tr>
<td>Abraxis Biosciences</td>
<td>CA</td>
<td>Structure</td>
<td>44 1000 kN ± 100 mm stroke` structure containing offices on the first and third floors and a state-of-the-art upgraded laboratory on the second floor. Dampers in double-diagonals provide seismic energy dissipation.</td>
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</tr>
<tr>
<td>IETMC</td>
<td>USA/Fontana, CA</td>
<td>Taylor Fluid Dampers Total:</td>
<td>8 1500 kN ± 610 mm stroke 2009 Seismic New Caltrans District 8 Inland Empire Transportation Management Center with 24/7 Emergency traffic response and management facilities uses rubber isolators and Taylor dampers to meet immediate occupancy criteria in this 2-story steel structure</td>
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<tr>
<td>Dubai Racetrack Stadium</td>
<td>United Arab Emirates/Dubai</td>
<td>Taylor Fluid Dampers Total:</td>
<td>108 885 kN ± 50 mm stroke 1280 kN ± 50 mm stroke 1370 kN ± 50 mm stroke 2009 Wind New stadium utilizing 36 Tuned Mass Dampers for the reduction of wind vibrations in large cantilevered roof truss sections.</td>
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</tr>
<tr>
<td>Location</td>
<td>Region</td>
<td>Damper Type</td>
<td>Total Number</td>
<td>Stroke Details</td>
<td>Year</td>
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<tr>
<td>Meixihe Bridge</td>
<td>China/Chongqing</td>
<td>Taylor Fluid Dampers</td>
<td>4</td>
<td>1750kN ± 250mm stroke</td>
<td>2009</td>
</tr>
<tr>
<td>Nanping Mingjian Bridge</td>
<td>China/Fujian</td>
<td>Taylor Fluid Dampers</td>
<td>4</td>
<td>1400kN ± 500mm stroke</td>
<td>2009</td>
</tr>
<tr>
<td>Ningbo Yongjiang Bridge</td>
<td>China/Ningbo</td>
<td>Taylor Fluid Dampers</td>
<td>8</td>
<td>1800kN ± 550mm stroke</td>
<td>2009</td>
</tr>
<tr>
<td>Xinjiang Guozili Bridge</td>
<td>China/Xinjiang</td>
<td>Taylor Fluid Dampers</td>
<td>8</td>
<td>1100kN ± 400mm stroke, 1200kN ± 500mm stroke</td>
<td>2009</td>
</tr>
<tr>
<td>Nihonbashi Nomura Project</td>
<td>Japan/Tokyo</td>
<td>Taylor Fluid Dampers</td>
<td>52</td>
<td>1800kN ± 50mm stroke, 1500kN ± 50mm stroke</td>
<td>2009</td>
</tr>
<tr>
<td>Location/Project</td>
<td>Country/Region</td>
<td>Damper Details</td>
<td>Year</td>
<td>Seismic Description</td>
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<tr>
<td>Hydra Waves</td>
<td>Mexico/Mazatlan</td>
<td>Taylor Fluid Dampers Total: 18 680kN ± 50mm stroke</td>
<td>2009</td>
<td>New structure uses dampers to absorb earthquake energy and reduce deflection and stress.</td>
<td></td>
</tr>
<tr>
<td>Tauranga Harbour Link Bridge</td>
<td>New Zealand/Tauranga</td>
<td>Taylor Fluid Dampers Total: 21 980kN ± 175mm stroke 1470kN ± 175mm stroke 1750kN ± 225mm stroke</td>
<td>2009</td>
<td>New four lane highway bridge uses Lock-Up Devices with force limiting devices to control bridge deck movement during seismic events.</td>
<td></td>
</tr>
<tr>
<td>ASE I – Mihai Eminescu Project</td>
<td>Romania/Bucharest</td>
<td>Taylor Fluid Dampers Total: 142 1000 kN ± 100 mm stroke 100 kN ± 100 mm stroke</td>
<td>2009</td>
<td>Retrofit of a historic building with dampers in diagonal braces to provide seismic energy dissipation.</td>
<td></td>
</tr>
<tr>
<td>TSMC Fab #12 P5</td>
<td>Taiwan/Hsin Chu City</td>
<td>Taylor Fluid Dampers Total: 6 2000 kN ± 75 mm stroke</td>
<td>2009</td>
<td>Retrofit of a semiconductor processing plant uses dampers to dissipate seismic energy and micro vibrations.</td>
<td></td>
</tr>
<tr>
<td>Uni-President B8 Project</td>
<td>Taiwan/Taipei</td>
<td>Taylor Fluid Dampers Total: 336 600 kN ± 75 mm stroke</td>
<td>2009</td>
<td>Known as Taipei Hsin-Yi Project, this new 22-story reinforced concrete building uses dampers in chevron braces to dissipate...</td>
<td></td>
</tr>
<tr>
<td>Project</td>
<td>Location</td>
<td>Damper Details</td>
<td>Year</td>
<td>Seismic Details</td>
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<tr>
<td>FDS Project</td>
<td>Taiwan/Taipei</td>
<td>Taylor Fluid Dampers Total: 6 500 kN ± 75 mm stroke</td>
<td>2009</td>
<td>Dampers installed in RC supporting wall in a new reinforced concrete building.</td>
<td></td>
</tr>
<tr>
<td>Farglory H61</td>
<td>Taiwan/Taipei</td>
<td>Taylor Fluid Dampers Total: 12 500 kN ± 75 mm stroke</td>
<td>2009</td>
<td>Dampers installed in RC supporting wall in a new reinforced concrete building.</td>
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</tr>
<tr>
<td>Farglory H63</td>
<td>Taiwan/Taipei</td>
<td>Taylor Fluid Dampers Total: 52 500 kN ± 75 mm stroke</td>
<td>2009</td>
<td>Dampers used in chevron bracing elements in a new 15-story reinforced concrete building.</td>
<td></td>
</tr>
</tbody>
</table>