Taylor Devices, Inc.

Building Today

For Tomorrow

Since 1955
Why Use Viscous Dampers?

Viscous Dampers dramatically decrease earthquake induced motion . . .

- Less displacement . . . over 50% reduction in drift in many cases
- Decreased base shear and inter-story shear, up to 40%
- Much lower “g” forces in the structure. Equipment keeps working and people are not injured
- Reduced displacements and forces can mean less steel and concrete. This offsets the damper cost and can sometimes even reduce overall cost
Why Fluid Dampers?

- Only fluid dampers reduce both stress and deflection in a structure during a seismic event, at damping levels to 40% of critical
- Successfully used since 1897, originated by the military
- Predictable at all times
- Relatively small size, self-contained
- Easily produced in forces of 10 mt to 800 mt, displacements to plus or minus 1.2 meters
- Easily installed in a structure as diagonal braces or as part of a base isolation system
- Stable, predictable performance at any temperature
- Long life, no maintenance
Fluid Damper Design

Diagram showing the components of a fluid damper design:
- Piston Rod
- Cylinder
- Compressible Silicone Fluid
- Accumulator Housing
- Seal Retainer
- High-strength Acetal Resin Seal
- Chamber 1
- Piston Head with Orifices
- Chamber 2
- Control Valve
- Rod Make-up Accumulator
Dampers for U.S. Navy
Airborne Laser (ABL)
Taylor Devices, Inc.

- Located in North Tonawanda, NY - In business since 1955
- All dampers we ship are dynamically tested. The test report comes with each damper
- Dampers made 48 years ago are tested every few years to prove their integrity
- 35 year warranty. Leak proof, zero maintenance.
- Quality Control is per Aerospace standards
- Used on over 100 structures so far and many more pending
Project Overview ~
Large Dampers in Commercial Structures

~ 106 Buildings, 34 Bridges to Date ~

- 9 Airport Structures
- 8 Hospitals
- 7 Stadiums
- Los Angeles and Hayward City Halls in California
- San Francisco Civic Center
- Tokyo-Rinkai Hospital
- Jimbo-Cho Office Building, Tokyo
- San Francisco-Oakland Bay Bridge
- Millennium Bridge Retrofit in the U.K.
- 9 Tall Buildings, including the Torre Mayor Project in Mexico City
Project Examples ~ Base Isolation

Arrowhead Regional Medical Center
Colton, California

Five Buildings, 79,000 Meters$^2$ Area
186 Dampers Installed
Damper Force  =  145 mt
Damper Stroke  =  +/- 600 mm
Seismic Damper for base isolation of Arrowhead Regional Medical Center in Southern California and Los Angeles City Hall in Los Angeles, California
Force = 320,000 lbs., Stroke = +/- 24 inches, Production = 238 pieces
THE SAN BERNARDINO COUNTY MEDICAL CENTER
LOCATED IN COLTON, CALIFORNIA
184 DAMPERS USED WITH BASE ISOLATION
ENGINEER: KPFF CONSULTING ENGINEERS

Base Isolators, top photo, in another building are inspected after 10 years' service.
Douglas P. Taylor, President of the company that manufactures viscous dampers

Above - Horizontal Fluid Dampers extend between a steel truss and the foundation. A 48-in. stroke provides a 320,000-lb. damping force at 60 in. per sec.

Hospital isolated from Big One
Taylor Devices’ Testing Capabilities

- **Vertical Drop Testing**
  - Seven separate drop rails, 10 lbs. – 60,000 lbs. weight
  - Test forces of 50-4,000,000 lbs.
  - Velocity to 45 ft/sec.

- **Hydraulic Test Stands**
  - Four separate test stands, 10,000-1,500,000 lbs. output force
  - Velocity to 6 ft/sec.

- All instruments calibrated traceable to NIST

- Digital data acquisition, processing via LabVIEW software
Testing of Seismic Damper in Taylor Devices' hydraulic test machine
Test Force = 1,500,000 lbs.
Damper Testing Capabilities

HYDRAULIC STAND TESTING
Maximum Force: 1,500,000 lbs.
Maximum Velocity: 70 in/sec.
Damper Testing Capabilities

DROP TESTING
Maximum Force: 2,000 kips
Maximum Velocity 450 in/sec.
Power Rating: 130,000 hp
Damper Tests in a Building
3-Story *With* and *Without* Dampers
UBC RESPONSE SPECTRA (SCALED 0.4g)
SOIL TYPE S2

SPECTRAL ACCELERATION (g)

PERIOD (Sec)

5% DAMPED
10% DAMPED
15% DAMPED
20% DAMPED
F = CV^n

where

F = Force in Pounds
C = Damping coefficient, a constant that is specific for each damper
V = Velocity in inches per second
n = Damping exponent, a constant that is specific for each damper

n can be set to any value from .3 to 1.95. In general, the lower this value, the greater the energy dissipation per cycle for a given maximum stress in the structure. n = 1 is easiest to analyze. A value of n = .5 for the San Bernardino Medical Center resulted in 13% fewer dampers than using n = 1.
OUTPUT OF THREE 300 KIP DAMPING DEVICES, HAVING DIFFERENT EXPONENTS

\[ F = C V^2 \]

\[ F = C V \]

\[ F = C V^5 \]
Viscous damping acts 90° out of phase with structural bending. It fattens the hysteresis loop.

Optimum values for C & n must be found. (n = .5 for San Bernardino Medical Center, .75 for Golden Gate) and the best number of dampers and locations must also be found.

The initial model should be fairly simple, and could use modal analysis with dampers represented as modal damping (n = 1.0). We know that 20% to 30% works well. This initial model can determine the optimum "n".

A later model should be a finite element detailed model with discrete damper elements. It should permit non-linear damping (“n” that is other than 1.0). This model will provide an estimate of the number and location of dampers as well as their force and velocity requirements. At this stage a two dimensional model should be sufficient.

Later, if the structure is torsional, it may be necessary to proceed with a three dimensional finite element model.
Damping Function vs. Temperature

![Graph showing the relationship between force (lbs) and velocity (in/sec) with temperature as a parameter. The graph indicates a curve that increases as velocity increases.]
Chevron Brace
Diagonal Brace
Project Example ~ Historic Building

Los Angeles City Hall
Los Angeles, California

32-Story, 85,000 Meters$^2$ Area, Historic Structure

52 Base Isolation Dampers Installed

Damper Force = 180 mt

Damper Stroke = +/- 650 mm
LOS ANGELES CITY HALL
Located in Los Angeles, California
54 - 315 kip & 14 - 225 kip Dampers
Engineer: Nabih Youssef & Associates Engineers
TOKYO RINKAI HOSPITAL
LOCATED IN TOKYO, JAPAN
45 - 200 KIP DAMPERS USED WITH BASE ISOLATION BEARINGS
ENGINEER: TOKYO-KENCHIKU STRUCTURAL ENGINEERS
Tillamook Hospital
Tillamook Hospital
Fluid Dampers ~ The Bottom Line

- New Structures will be better, and will cost less
- Lifelines will be more survivable
- Historic structures can be preserved
- Existing structures can be simply upgraded
- Soft soil structural problems greatly reduced