Application of Fluid Viscous Dampers to Earthquake Resistant Design

by Michael Constantinou

Abstract

Damping devices based on the operating principle of high velocity fluid flow through orifices have found numerous applications in the shock and vibration isolation of aerospace and defense systems.These previous uses include the attenuation of weapons grade shock, including airburst, water surface, and underwater detonations: with applications including individual weapons or electronic systems, ship decks, and command, control and communications equipment for all branches of the military. Other previous aerospace/defense uses include the attenuation of aircraft, spacecraft and ship vibration, plus wind and airblast isolation on large rocket launch gantries, such as the Space Shuttle.

In 1991, a cooperative effort between NCEER and Taylor Devices, Inc. of North Tonawanda, New York began to adapt this defense technology for hazard mitigation applications on buildings and bridges. After extensive technical interchange, a series of experiments was performed to demonstrate the benefits of fluid viscous damping devices as part of either a bracing arrangement or to augment existing design base isolation bearings. Steel moment frame and reinforced concrete building models and a steel bridge model were tested, and all exhibited improved resistance to a variety of seismic loads. For example, a three story steel building frame model without the dampers was found to be on the onset of yielding under an earthquake of only one-half the magnitude of the 1940 El Centro earthquake. With the bolt-on addition of six small fluid viscous dampers, the same structure withstood 150% of the El Centro earthquake, without any damage, for an overall three-fold enhancement of seismic capacity. The particular design of fluid viscous dampers used for this experiment was the same as that provided by Taylor Devices for use on the B-2 Stealth Bomber. Similar successful experiments on a reinforced concrete building model utilized damping devices used on the U.S. Navy's Tomahawk Cruise Missile.

A series of papers and reports published from October 1992 to August 1994 generated interest in the structural engineering community, many of whom had specific and immediate applications for this technology In late 1993,Taylor Devices received a $4,900,000 contract from the County of San Bernardino, California, to provide large damping devices for five buildings of a new medical center located close to two major fault lines This $680 million dollar project required a very high damping capacity isolation system, and the fluid viscous dampers were chosen as the most economical solution

At this time,Taylor Devices has several other projects pending for this technology, is in the process of a $1.3 million facilities expansion in Western New York, and has created 25 new full time jobs.

Collaboration

Michael Constantinou
Andrei Reinhorn
University at Buffalo

Douglas P. Taylor
Taylor Devices

Shunji Fujii
Susumi Okamoto
Daisuke Ozaki
Taisei Corporation