Semi-active control of a fluid viscous damper for vibration mitigation

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SUMMARY
In this paper the results of a study to evaluate the performance of several control algorithms for a hybrid system constituted by a base isolated structure plus a semi-active device are presented. A variable fluid damper at the base level is considered aiming to reduce earthquake induced vibrations. The performance of the algorithms is compared using a two degree of freedom dynamical model subjected to two different artificial accelerograms. The performance is evaluated by measuring the reduction in relative displacements and accelerations and comparisons are also made with passive and active systems. The results show that a semi-active sky-hook damper can be a viable option for structural vibration mitigation when the input has varying frequency content.

Keywords: Semi-active control, viscous damper, sky-hook damper, optimal control, vibration mitigation.

1. INTRODUCTION

Earthquakes have proven to be one of the most destructive natural disasters in the world. The traditional design methods for earthquake resistance of structures allow the occurrence of damage by using the inelastic deformation capacity of some elements. This kind of approach could be troublesome for structures that should be operational during and immediately after the occurrence of those events, such as: hospitals; energy power stations; communication centres; civil protection and fire station buildings. It is intended that structural relative displacements (inter-storey drifts) and accelerations are small in order to avoid damage and protect sensitive equipments from induced vibrations. The use of passive, semi-active (SA), active and hybrid control systems are typical ways of dealing with this problem; Soong and Spencer Jr. (2002). The semi-active control of seismically excited structures seems to be a promising proposal for civil engineering structures. The advantages of these systems compared with the others are: the capacity of adapting its characteristics in real time; the better overall performance when compared with passive devices; and lower power requirement, thus allowing for battery operation under proper conditions. A typical type of device that can be used for semi-active control is the fluid viscous variable damper. This type of devices consists typically of a hydraulic cylinder containing a piston which separates the two chambers that are connected by a hydraulic link. A control valve, like a solenoid valve or a servovalve is installed in the link to control the amount of fluid that flows from one chamber to the other. The control of the fluid through the valve can be performed in a continuous or in an on-off way; Symans and Constantinou (1999). In order to control the behaviour of those devices several control strategies have been proposed; Dyke (1996); Preumont (2002); Sadek and Mohraz (1998); Yoshida and Dyke (2004). One way to isolate the whole structure from ground motions and reduce both accelerations and inter-storey drifts is by using the base isolation concept; Kelly (1999). However, under near field actions increase in isolation displacement can lead to structural damage. An alternative solution is making use of hybrid systems (base isolation with active or semi-active devices); Shook *et al.* (2007).

In this paper the hybrid system is explored for controlling civil engineering structures subjected to earthquakes. Different control algorithms are presented and formulated for use with the SA device. Numerical simulations are made considering a two degree of freedom (2DOF) dynamic model employing an SA device with different control strategies and excited by two different input actions. Comparisons between the control algorithms and with passive and active systems are presented.