SEMI-ACTIVE VISCOUS DAMPER FOR CONTROLLING CIVIL ENGINEERING STRUCTURES SUBJECTED TO EARTHQUAKES

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Abstract: This paper presents the results of a study to evaluate the performance of several control algorithms for a semi-active fluid damper aiming to reduce earthquake induced vibrations. The performance of each algorithm is compared considering a single degree of freedom dynamical model subjected to three alternative input actions: two time series of filtered white noise and a synthesized seismic action. The performance of the system is evaluated by measuring the reduction in relative displacement and acceleration. Comparisons are also made with the passive and active systems. The results demonstrate that semi-active devices can be an option for structural vibration mitigation.

Keywords: Semi-active viscous dampers, Sky-Hook damper, Linear Quadratic Regulator, Vibration mitigation, Seismic protection, Control applications.

1. INTRODUCTION

The design of civil engineering structures has always been a challenge for the humanity. In our modern era resources are often limited and efficient designs must be sought. The protection against environment loads like strong winds and earthquakes, which are characterised by non-stationary processes, has been also of main concern for the designers; (Soong and Dargush, 1997). As a result new innovative concepts of structural protection have been developed: passive, semi-active (SA), active and hybrid systems; (Soong and Spencer Jr., 2002). Recent solutions based on the principle that passive devices can be adjusted in real-time and the associated advantages like the power required for operation and the operability during an event (input loads), led to the research and development of energy dissipation systems employing SA devices. During the last decade the scientific community has been devoted to Magneto-Rheological type devices for earthquake structural vibration mitigation; (Zapateiro *et al*. 2010). Although very attractive in terms of energy consumption and generated forces its behaviour is highly non-linear. An alternative way is the variable fluid viscous damper. In this paper the viscous damper device is investigated for semi-active control of civil engineering structures subjected to earthquakes. Different control algorithms are presented and formulated for use with this device. Numerical simulations were made considering a single degree of freedom (SDOF) dynamic model employing an SA device with different control strategies and excited by three alternative input actions. Comparisons with the passive and active systems are also presented.

2. STRUCTURAL SYSTEM

The model considered in this study is a SDOF system subjected to earthquake loads at the base, which has an SA device (variable damper) connected between the base and the mass (Fig. 1).

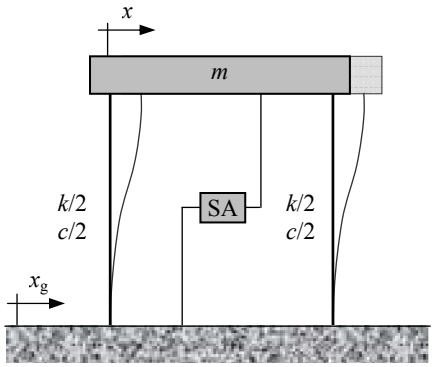

Fig. 1. Single degree of freedom model employing a variable damping semi-active device; properties are represented by mass m, elasticity k, viscous damping c; x_g is the input displacement and x is the system displacement response.