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PASSIVE CONTROL OF CIVIL ENGINEERING STRUCTURES

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ABSTRACT

Structural control has been a major research area in aerospace engineering aimed at solving very complex problems related with analysis and design of flexible structures. The efficiency of these strategies to improve the performance of several structural systems suggests its potential to reduce damage and control earthquake-induced response in civil structures. Therefore, this technology has been well accepted by structural engineers as a feasible approach to design improved earthquake resistant structures. The present paper provide a brief description of each control scheme describing the main properties of different anti-seismic solutions and presenting the most relevant developments in this area. Control methodologies and devices are highlighted identifying their advantages and limitations. The main focus of this paper is to present a comprehensive state-of-the-art of passive control system. Different passive techniques are described and the effectiveness in mitigating seismic hazard for structures is addressed.

Keywords: passive control, base isolation, energy dissipation.

INTRODUCTION

Passive control was among the first control scheme to mitigate vibrations in civil engineering structures such as buildings and long bridges with high level of seismic safety. This type of control do not require power to operate and therefore passive systems are non-controllable in the sense that is not possible to change the control forces or the device behaviour during the earthquake excitation.

Although the passive nature can be seen as a limitation to the adaptability of the control system, is also a source of reliability since passive systems are not affected by possible power outages during the seismic event but also because they have low maintenance requirements. Therefore, these systems are perceived as a reliable, economic and easy to realize technique to enhance structural safety and integrity allowing protecting not only structural and non-structural elements but also building contents for considerably large earthquakes.

Passive devices are designed to dissipate or transfer the seismic energy been transmitted to the structure and/or isolate the structure from external loadings in order to minimize structural and non-structural damage. Seismic isolation and passive energy dissipation/transfer are generally recognized as the most effective and relatively inexpensive anti-seismic protective systems.

This type of control systems are designed or tuned with uncontrollable and constant properties to protect the structure from a particular dynamic loading or response by dissipating the seismic energy using the structural vibration to convert kinetic energy to heat or by transferring energy among vibrating modes.

Passive dissipation devices take advantage of the mechanical properties of some materials such as rubber, steel, lead, viscous and viscoelastic materials or friction mechanisms to dissipate the seismic energy in order to reduce the plastic deformations in the structural elements, i.e., to reduce the inelastic dissipation demand of the structural elements (plastic hinges) and therefore limiting structural damage. Since they are designed to absorb or concentrate the input energy, some damage may occur in these devices, which require their substitution after the earthquake although the device replacement is usually easy to perform. Transferring energy among vibration modes is achieved with supplemental oscillators that operate as dynamic absorbers (Constantinou and Symans, 1993; Symans *et al.*, 2008).

The strategies based upon passive control are well known and accepted methodologies that have been applied successfully to civil engineering structures due to its effectiveness to enhance damping, stiffness and strength of new or existing structures for natural hazard mitigation (Soong and Spencer, 2002). Although their passive nature offers significant reliability compared to other control strategies since they do not require external energy to operate (they can operate during a power outages, no energy is injected into the system and they guarantee a stable response), the constant behaviour of passive devices is a significant limitation since the system does not perform with efficiency for other dynamic loading or structural configuration.

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