Seismic response control of a non-linear structure using magneto-rheological dampers

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Abstract. Structures implemented in high seismicity areas are usually subjected to strong earthquake motion. Hence, high peak ground acceleration values characterize such seismic events. Under such excitations, the structures undergo non-linear behavior, leading to irreversible damage and eventually collapse. To prevent such hazards, seismic dampers are implemented in the structures. This study implements a magneto-rheological (MR) damper in a structure submitted to seismic excitations. The structure is modelled to undergo non-linear behaviour beyond a certain quantity of deformations. The non-linear behaviour of the structure is captured using the Bouc-Wen hysteresis model. The obtained results show a good performance of the magneto-rheological in reducing the response quantities of the structure. The investigated dynamical parameters are the top floor displacement, the inter-story drift and the hysteresis behaviour of the structure.

Introduction

Earthquakes are considered the most destructive natural events. They usually cause damage and loss in lives and materials. Throughout the existence of humankind on the earth, constructing aseismic structures was a relevant and continuously evolving challenge. Nowadays, structures constructed in high seismicity areas are designed and equipped with vibration control devices to reduce seismic-induced motions. It is well established that most structures submitted to seismic excitations will undergo non-linear deformations [1]. However, most of the studies in the literature involving vibration control devices consider that the structures remain in the elastic range leading to an overestimation of the structures and devices' performances. To overcome this lacunas, various models were introduced to represent the non-linear behaviour of structures. One of the most representative models of non-linear hysteresis behaviour is the Bouc-Wen model [2]. This model was used to represent the non-linear behaviour of multi-story buildings, and the results obtained by the approach were correlated using a pushover approach [3]. In this study, a multi-degrees of freedom structure was modelled to undergo non-linear behaviour. The structure is then equipped with four magneto-rheological dampers optimal set to obtain the best response reduction. This study's primary purpose is to investigate the performance of semi-active devices in the non-linear response reduction of structures submitted to earthquakes.

Results and discussion

A multi-degrees of freedom building modelled to express non-linear behaviour is equipped with four magneto-rheological dampers located on the first, second, third and fourth floors, respectively. The structure is submitted to earthquake excitations. The MR damper parameters are optimized using a genetic algorithm (GA) with a single objective function, defined as the reduction of the top floor displacement.

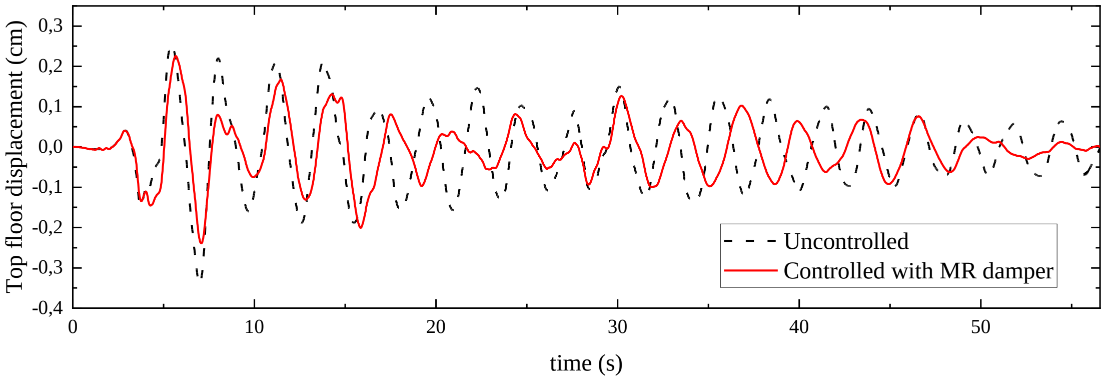

Figure 1: top floor displacement time history of the controlled and uncontrolled structures

The results show a good response reduction using MR dampers, especially in top flor displacement as shown in Figure 1. The MR dampers also reduce the hysteresis behaviour. Hence, reducing the damage induced to the structure by the ground acceleration. It was found that using purely elastic models to calculate the seismic response will lead to an overestimation of the devices' performance. Non-linear models are more accurate and representative of the actual case scenarios.

References

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