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NONLINEAR ADAPTIVE CONTROL OF BUILDING STRUCTURES WITH ELASTO-PLASTIC BEHAVIOR OF ELEMENTS UNDER SEISMIC MOTION

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One of the main approaches for reducing the seismic response of civil infrastructures is the application of control strategy. There are some challenges in choosing control algorithms, such as the high degrees of freedom of structures and various uncertainties in mathematical model and control devices. Previous researches indicate that adaptive algorithms are very effective in controlling the seismic behavior of structures. SACM (Simple Adaptive Control Method) is a direct model-based adaptive algorithm which its main objective is approaching to ideal model responses (Bitaraf & Hurlebaus, 2011; Hosseini et al., 2017). For this purpose, the output responses of the plant and the reference model are compared with each other, and the control parameters are adjusted to reduce the differences between them (Kaufman et al., 2012).

In most researches, a linear model for structures is considered, and the likelihood of elasto-plastic behavior of members is neglected. Due to the unpredictable nature of the earthquake and control devices constraints, it is probable that structural elements go beyond elastic level and plastic hinges occur in both ends of columns and beams.

On the other hand, the SACM algorithm has a nonlinear extension which is practical for controlling nonlinear systems (Kaufman et al., 2012). A structure with nonlinear elements is a time-variant system because the stiffness matrix is not consistent and varies with time. It is possible to separate nonlinear changes of stiffness matrix in the dynamic equation, so the efficiency of SACM and Nonlin-SACM can be investigated in controlling such structures (Subbaraj & Dokainish, 1989).

In this paper, a 20 story nonlinear structure benchmark is chosen and a bilinear hysteresis model is considered for plastic hinges at the ends of each structural member (Ohtori et al., 2004). MR (Magneto Rheological) dampers are used as required control devices. These dampers use MR fluid characteristics to provide variable damping properties, and they have some restrictions such as force capacity and the input voltage (Casciati et al., 2006).

The efficiency of two adaptive algorithms is investigated when the structure is excited by Kobe's earthquake record at two different levels, 1xPGA and 3xPGA. It is concluded that both SACM and Nonlin-SACM algorithms have good results in controlling the seismic behavior of structure with elasto-plastic behavior of elements. However, the nonlinear algorithm shows better performance in controlling floors' acceleration (see Figure 1).

By increasing the ground motion level, the number of saturated dampers is increased, and more plastic hinges are formed in structural elements (Figure 1). In this case, since many dampers cannot perform properly, the efficiency of Nonlin-SACM is reduced, and its performance in controlling structure is approaching to SACM. A comparison is made between 10th story damper's forces in Figure 2. It is shown that when the amounts of input forces increase, both algorithms request the most resistant forces, so damper's output forces are closer.

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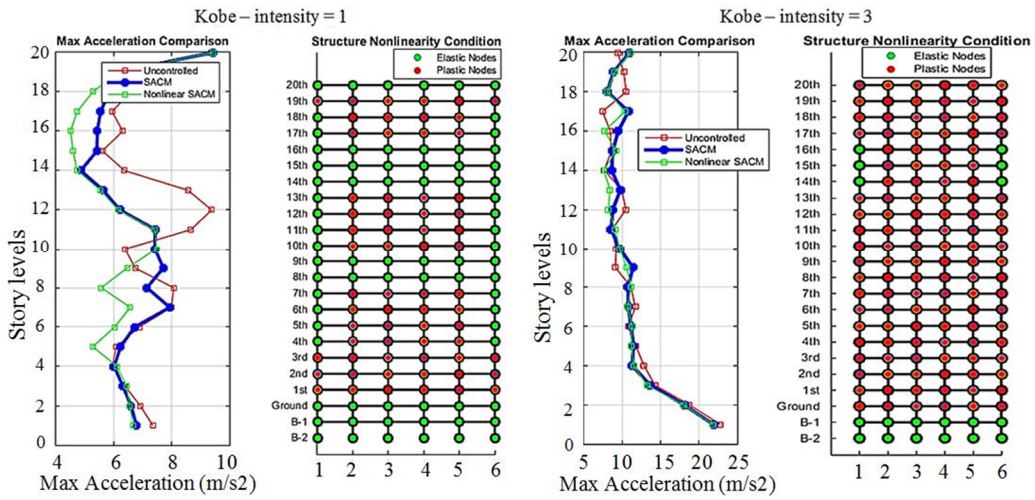

Figure 1. SACM and Nonlinear SACM results in controlling acceleration of stories and plastic hinges condition.

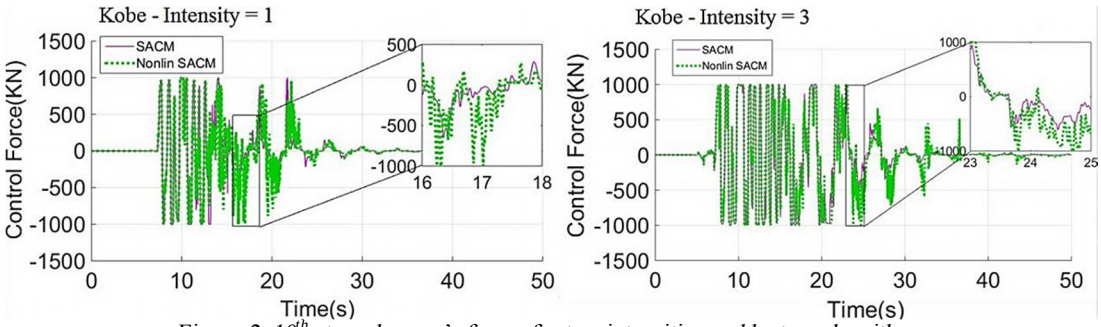

Figure 2. 10th story damper's forces for two intensities and by two algorithms.