SELF-CENTERING CAPABILITY OF SHAPE MEMORY ALLOY (SMA)-BASED SUPERELASTICITY-ASSISTED SLIDER (SSS)

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Keywords: Aseismic Isolation, Sliding Systems, Shape Memory Alloys, Superelasticity, Self-centering

ABSTRACT

The self-centering capability, emphasized in design codes as a fundamental feature of aseismic isolation systems, is investigated for the Shape memory alloy (SMA)-based Superelasticity-assisted Slider (SSS).

Restoring force in SSS is associated with austenitic SMA wires in order to properly re-center flat sliders. Energy considerations are examined first as an insight into the problem, revealing also the governing parameters. The self-centering capability is then investigated through an extensive parametric study of the isolated structures idealized as single-degree-of-freedom systems subjected to a large group of recorded earthquakes. According to the results obtained from extensive nonlinear time-history analyses,residual displacement after an earthquake and the cumulative build-up of displacements after a series of successive earthquakes depend on both structural properties and ground motion characteristics. SSS exhibits an acceptable self-centering capability, satisfying code provisions.

INTRODUCTION

The self-centering capability is identified by the current design codes as a fundamental requirement for seismic Isolation Systems (ISs). Systems with sufficient self-centering capability demonstrate a tendency to return towards the origin during the seismic event. Insufficient restoring capability is manifested by: (a) substantial residual displacements after the end of the seismic event, (b) accumulation of displacements during a sequence of seismic events, and (c) increased maximum and residual displacements for earthquake input histories containing substantial one-sided pulses. The self-centering capability of the ISs is increased by restoring forces that always act towards the origin, such as the rubber stiffness force of elastomeric bearings and the restoring force due to the concave sliding surface of spherical sliding bearings (e.g. the friction pendulum system or FPS). The self-centering capability of the ISs is decreased by forces that can act away from the origin, such as hysteretic forces (hysteretic dampers, yielding of lead in lead rubber bearings) and friction forces in sliding bearings. The balance of these counteracting components defines the self-centering capability of an IS (Katsaras et al., 2008).

The restoring force in SMA-based sliding ISs is provided by superelastic SMA devices, while the friction reduces the self-centering capability.

Most of the previous researches on the self-centering capability of nonlinear systems have been focused on the residual displacements of low-ductility systems that are not typical for ISs (Cardone, 2012). Riddell and Newmark (1979) showed that the magnitude of the residual displacement may be strongly affected by the hysteresis loop shape of the nonlinear system. Mahin and Bertero in a paper in 1981 (as cited in Cardone, 2012) found that, for some elasto-plastic systems, the residual displacement averaged more than 40% of the peak displacements with significant scatter. Kawashima et al. in a paper in 1998 (as cited in