SHAPE MEMORY ALLOY (SMA)-BASED SUPERELASTICITY-ASSISTED SLIDER (SSS)

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Base isolation is the most effective demand reducing technique for aseismic control of structures. The objective of this paper is to introduce a practical isolation system based on friction and superelasticity. The most attractive features of sliding isolators are further elongation of the natural period, insensitivity to the frequency content of excitation, and lower transmission of the ground motion accelerations into the superstructure. Flat Sliding Bearings (FSBs) are known as the simplest sliders. FSBs, however, require a proper restoring mechanism. Friction Pendulum System (FPS) is a typical solution. There are, at the same time, some limitations with the FPS (Calafell et al., 2010). Shape Memory Alloy (SMA)-based recentering is a relatively modern approach in order to provide an alternative restoring mechanism for FSBs. Large strain plateau and acceptable energy dissipation capacity are the most favorable characteristics of austenitic SMAs for using in aseismic ISs. A practical system with simple structures is, however, required due to the nonlinear nature of sliding phenomenon and the specific phase-dependent behavior of superelastic SMAs. Shape memory alloy (SMA)-based Superelasticity-assisted Slider (SSS) is proposed in this regard. SSS is practically made up of FSBs allowing isolation displacements and austenitic SMA wire ropes (Reedlunn et al., 2013) providing proper self-centering capability. The layout of SSS is schematically depicted in Figure 1.

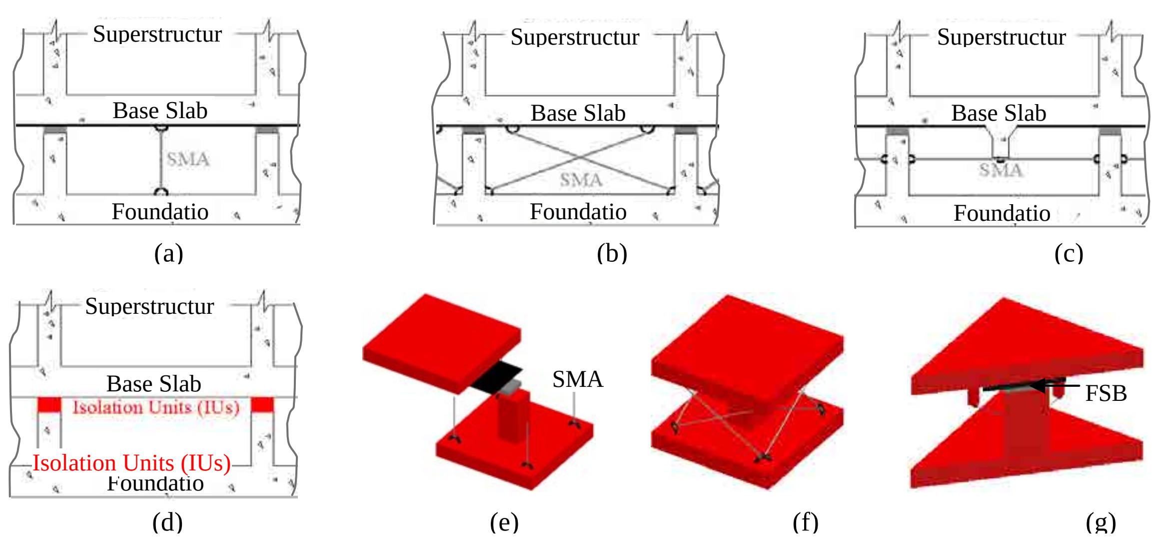

Figure 1. SSS: (a) Vertically arranged SMAs, SSS-v; (b) Diagonally arranged SMAs, SSS-d; (c) Horizontally arranged SMAs, SSS-h; (d) SSS-IUs: (e) SSS, IU-v; (f) SSS, IU-d; (g) SSS, IU-h

As shown in Figure 1, the application of SSS is possible directly or by means of space-saving Isolation Units (IUs), being also suitable for retrofitting purposes. Three alternative configurations can also be considered based on the vertical, diagonal or horizontal arrangement of SMA wire ropes.

Seismic performances of SSS are evaluated using SAP2000 program. The superelastic behavior of SMAs is phenomenologically modelled based on a combination of multi-linear elastic link element in parallel with Pivot-type Multi-linear Plastic (PMP) link element (Narjabadifam and Eradat, 2013). A typical 3-story building is assumed, with SMAs characterized in Figure 2 and μ assumed as 0.05.

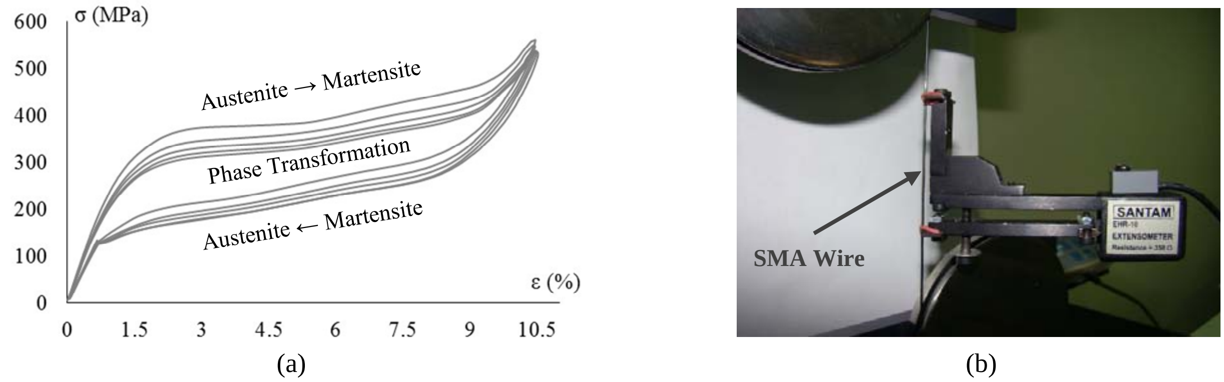

Figure 2. The hysteretic behavior of SMA wires tested for SSS (a); General view of the test setup (b)

Table 1 shows the average responses in terms of residual displacements (δ), maximum displacements (D_{max}), and maximum base shears as a fraction of building weight (V_{max} / W). Total lengths of required SMA wires (L_{SMAs}) are also reported for each configuration. The maximum base shears (reported as V_{max} / W) are almost same for all the configurations. The total length of SMA wires required in the vertical configuration is considerably less than the other two configurations. The recentering capability seems to be stronger in the horizontal and diagonal configurations.

Table 1. Seismic performances of the vertical, diagonal, and horizontal configurations of SSS under the same design assumptions (typical 3-story building, D_d = 0.3m, SMA behavior of Figure 2, μ = 0.05)

Configuration	L_{SMAs} *(m)*	**Seismic Performances**		
		Δ *(cm)*	D_{max} *(m)*	V_{max} / W
Vertical	*3570*	4.5	0.300	0.138
Diagonal	*7883*	2	0.272	0.135
Horizontal	*8196*	1.5	0.274	0.134

A comparison is also made to FPS and High Damping Laminated Rubber Bearing (HD-LRB). The vertical arrangement of SMA wire ropes is considered. The results are summarized in terms of maximum base shears (V^{max}), maximum story accelerations (a_i^{max}) and maximum story drifts (d_{ij}^{max}). SSS seems to be effective for the purpose of aseismic control, as well as FPS and HD-LRB.

Table 2. Seismic performances of SSS with vertical SMAs compared to those of FPS and HD-LRB under the same design assumptions (for a typical 4-story moment resisting concrete building)

IS	**Seismic Performances**		
	V^{max} *(kN)*	a_i^{max} *(m/s²)*	d_{ij}^{max} *(%)*
SSS	1713	3	0.23
FPS	2074	2.9	0.26
HD-LRB	2245	3.4	0.69

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