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ENHANCEMENT OF CONCRETE MOMENT FRAMES SEISMIC BEHAVIOR USING SMA/ECC MATERIALS

Gholamreza GHODRATI AMIRI
Professor, School of Civil Engineering, Iran University of Science and Technology, Tehran, Iran
Ghodrati@iust.ac.ir

Rasoul NOURBAKHSH
M.Sc. Student, School of Civil Engineering, Iran University of Science and Technology, Tehran, Iran
r_noorbakhsh@civileng.iust.ac.ir

Ehsan DARVISHAN
PhD Student, School of Civil Engineering, Iran University of Science and Technology, Tehran, Iran
darvishan@iust.ac.ir

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During a severe seismic action, structural elements of reinforce concrete moment frames tolerate large lateral deformations which yields considerable inelastic rotations in beam-column members.

For decades, the aim of seismic design codes was to enhance deformation capacity and provide ductility under seismic excitations for safety reasons. However, higher damage tolerance is obtained by large plastic deformations in concrete and yielding of reinforcement in order to dissipate imposed earthquake energy. Such permanent residual plastic strains in Conventional reinforced concrete (RC) structures not only question the post-earthquake serviceability of such structures, but also significantly increases the repair costs (Park and Paulay, 1975). For this reason, there is a need for enhanced structural members that present lower residual deformations. One approach is to concentrate damage in a limited number of elements. Another methodology, however, is to recover permanent deformations.

Shape memory alloys are unique materials with a capability to recover plastic deformations after large deformations via heating or removal of load. In addition, their energy dissipation characteristics makes superelastic shape memory alloys desirable for seismic design purposes (McCormick and Delemont, 2004; Sahria et al., 2009; Saiidi, 2010).

The cost of producing and machining of SMA is very high and thus should be considered as a factor when planning on using it for seismic applications. For this reason, we used the SMA only in plastic hinges of the beams that include a small part of the structure reinforcement. In addition, there has been a significant reduction in the price of Ni–Ti over the last ten years, from more than 1000 USD/kg to below 100 USD/kg at the present , and is expected to decrease further with more uses.

Moreover, Engineered Cementitious Composites (ECC) (Li, 2003), catagorized as HPFRCC (High-Performance Fiber-Reinforced Cementitious Composite), are able to undergo large damage conditions while possesing favorable durability for normal service conditions. In contrast to conventional concrete, ECC represents post-crack strain hardening. This, in conjunction with an improved tensile resistance is comparable to ductile behavior of metals under monotonic or cyclic loading conditions.

In this study, seismic performance of SMA/ECC concrete moment frames is investigated. SMA and ECC are utilized as substituted for reinforcement and concrete, respectively. Three structures including 4, 8, and 12 story moment frames are analytically modeled. For each building, three different detailing are considered: (i) steel reinforcement (steel only), (ii) SMA rebar used in the plastic hinge region of the beams and steel rebar in other regions (Steel-SMA), and (iii), SMA rebar and ECC used in the plastic hinge region of the beams and steel rebar in other regions (SMA-ECC). For each case, columns were reinforced with steel rebar. Nonlinear static pushover and nonlinear dynamic time history analyses were carried out using OpenSEES finite-element software package.

The obtained results indicate that utilization of SMA can lead to increase in maximum story drift ratios, since SMA materials possess lower modulus of elasticity than steel, as depicted in Fig 1. However, a considerable improvement can be observed in residual drift ratios in SMA case, which is mainly due to inherent self-centering behavior of SMA. Also, ECC reduces earthquake damage and seismic response of structures compared to the conventional reinforced concrete.

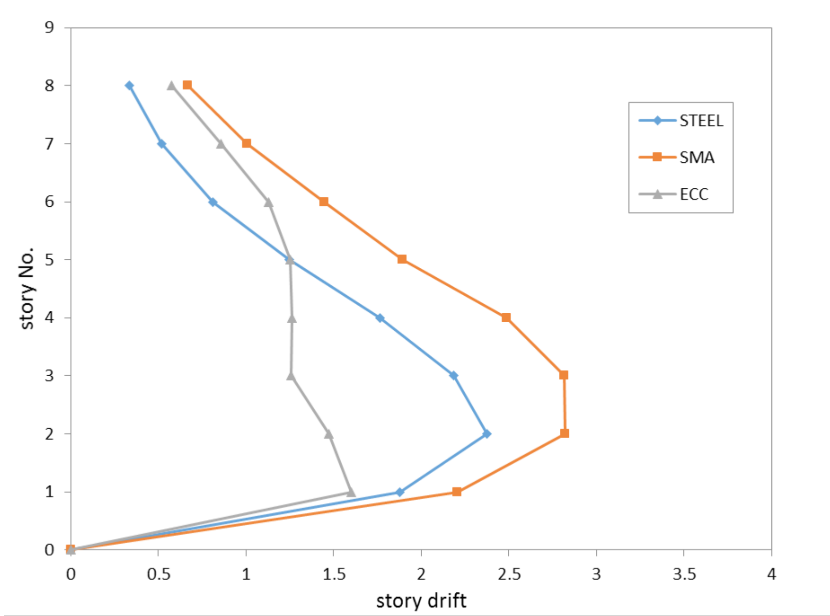

Figure 1. Story drift profile

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