Performance Based Seismic Design of Shape Memory Alloy Reinforced Concrete Bridge Pier

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Abstract

Recent advancements in numerical analysis and computational power have pushed the current bridge design specifications towards a more descriptive performance-based seismic design (PBSD) approach as compared to the conventional force-based method. Shape memory alloy (SMA), with its distinct superelasticity, shape memory effect and hysteretic damping, is a promising material for the application in bridge piers to attain the objectives of PBSD. Despite few experimental testing to demonstrate the efficacy of SMA as reinforcement in bridge pier, there has been a lack of comprehensive guidance for potential designers of SMA-RC bridge piers. This paper proposes a performance-based design methodology for SMA-RC bridge piers, which consists of defining the performance objectives, developing performance based damage states and formulating a performance based design guideline considering maximum and residual drift. The procedure anticipates the allowable residual drift based on target performance level, calculates the maximum allowable drift, and ensures that those deformation demands remain below the allowable residual and maximum drift. Guidelines to determine the target drift and effective damping properties for SMA-RC bridge piers are also provided. The proposed procedure and guidelines are used in a trial application to design a SMA-RC bridge pier and analysed using a suite of selected earthquake records. The nonlinear analyses showed that the designed pier behave according to design expectations and provided very promising results in terms of the effectiveness and applicability of the proposed design method.

Keywords: Performance-based design, Shape memory alloy, Residual drift, Damping, Ductility.

1 Introduction

In the last decade, seismic design of bridges has transitioned from the conventional force-based method towards a more descriptive performance-based seismic design (PBSD) approach. Recent developments in PBSD and assessment approaches have emphasized the importance of properly assessing and limiting the residual (permanent) deformations that are typically sustained by a structure after a seismic event [1]. Observations from recent earthquakes (Kobe 1995, Northridge 1994) and a desire to develop innovative structural systems with improved post-earthquake functionality have motivated researchers to pioneer and test different novel

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