In-Plane Seismic Performance of Plain and TRM-Strengthened Rammed Earth Components

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Abstract

Raw earth is one of the most widely used building materials and is employed in different techniques, among which adobe and rammed earth are the most common. The respective structural systems, like in masonry buildings, acceptably withstand against gravity loads, though they are significantly vulnerable to earthquakes. Moreover, a great percentage of the World's population is still inhabited in such environments, which are endangered by future earthquakes. The current article investigates the seismic in-plane performance of an I-shaped rammed earth component by means of advanced nonlinear finite element modelling. In this regard, conventional pushover analyses were conducted to evaluate load/displacement capacities and to assess probable failure modes. It was observed that the component fails mainly due to detachment of the wing walls from the web wall and due to occurrence of diagonal shear cracks at the web. Subsequently, the application of Textile Reinforced Mortar (TRM) strengthening solution to the component was studied and shown to be able to maintain the integrity of the component for larger lateral load levels. Finally, the reliability of the pushover analyses to predict the seismic response was evaluated by comparison with outcomes from incremental nonlinear dynamic analysis.

Keywords: Rammed Earth; TRM; Seismic Behaviour; Pushover Analysis; Dynamic Analysis.

1. Introduction

Raw earth is probably the most naturally available building material around the world. Thus, extensive earth architecture is found worldwide (see Figure 1) in the form of a variety of techniques developed through time. Among them, adobe and rammed earth are the most common. Despite nowadays raw earth being rarely used in new constructions from developed countries, a significant percentage of the World's population still inhabits earth buildings, while numerous historical buildings were built using this material.

Considering the aforementioned facts, the need for investigating the different damaging agents affecting these buildings and developing efficient intervention solutions becomes evident. Under service conditions, earth constructions can be damaged by several agents, such as rainwater, soluble salts and temperature oscillations [1]. Regarding the structural performance, it is expected that earthen structures easily withstand gravity loads. However, they can be severely damaged under earthquake excitations due to their low tensile strength, weak connections between structural elements and high inertial forces. Such catastrophic failures have been reported in past earthquakes, namely in Turkey (Erzinkan 1992), Iran (Bam 2003), Peru (Pisco 2007) and Chile (Concepción 2010). Despite this limitation, a significant percentage of these buildings were built in regions with moderate to high seismic hazard (see Figure 1). Thus, the millions of inhabitants continuously exposed to

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