Seismic risk assessment of a traditional rammed earth structure from Eastern Croatia

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1. Introduction

Traditional houses in Eastern Croatia were usually built using local earthen material [1, 2]. However, earthen architecture faded away when artificial stone (e.g. fired brick and concrete) replaced traditional building techniques (e.g. rammed earth and adobe). Today, earthen architecture in Slavonia and Baranja is in deteriorating state since there has been minimal concern for reparation and preservation. With no guidelines or standards for building and preserving earthen structures in Croatia, it is easy to presume that a part of Croatian cultural heritage will soon disappear. Moreover, poor seismic performance of earthen structures poses one of the biggest obstacles in finding proper ways of preserving existing and building new earthen architecture.

It is fair to assume that from the middle of the 19th century to today, earthen buildings encountered strong ground motions, but their seismic performance and possible fracture mechanisms are still unknown. Therefore, this paper deals with seismic risk assessment determined on a numerical model of a rammed earth structure. Only few papers worldwide have delt with seismic behavior of rammed earth structures [3-10]. Authors worldwide have mostly focused on seismic performance of rammed earth walls with means of experimental testing and numerical analyses. Merely two papers [8, 10] have described rammed earth house model tested on a shaking table. However, to our knowledge, no previous research has been conducted that produced fragility curves of rammed earth structures.

2. Methodology, numerical model and analysis

The method used to determine fragility curves of an observed rammed earth structure in this paper is Incremental Dynamic Analysis (IDA). Vamvatsikos and Cornell [11] proposed the algorithm for analysis in 2002 and according to them, the basis of IDA is scaling. Essentially, structures are subjected to a suite of several ground motions, each scaled to multiple levels of intensity, all resulting in the IDA curve. However, IDA on a micromodel would take enormous amount of time and computational effort making it unreasonable to conduct. For that purpose, Dolšek [12] proposed a simplified method for seismic risk assessment of buildings based on aleatory and epistemic uncertainty. The method combines micromodel pushover analysis with IDA of an SDOF model. Moreover, it is important to note that simplification regarding IDA conducted on the SDOF model rather than the model of the house was necessary for rammed earth structure. Namely, IDA can be performed on frame structures. Nevertheless, to our knowledge, rammed earth structures should not be modelled as frame structures but as solid structures. For that reason, in this paper the method proposed by Dolšek [12] was used. First, pushover analysis on micromodel of rammed earth house was conducted using ANSYS software. Then, particular parts of N2 method [13, 14] were used. Namely, capacity curve obtained from the pushover analysis was used to determine parameters needed to define the SDOF model, as described according to the N2 method. Lastly, IDA was conducted on the SDOF model, using SeismoStruct software, to determine fragility curves. It is important to note that in this paper, analysis was conducted on deterministic model to test only seismic performance of a rammed earth structure. Material properties were assumed with their average values, based on literature review [15] since material properties of rammed earth architecture from Eastern Croatia are yet to be determined. Furthermore, ground motion records for ground type C [16] with peak acceleration lower than 0,1 g were used.

3. Concluding remarks

Fragility curves determined within this analysis indicate that single story rammed earth structures built on ground type C, using material with average material properties, would be severely damaged by earthquakes with peak acceleration lower than 0,1 g. However, this is the first seismic risk assessment of rammed earth structures from Croatia, thus more research with different ground motion records and different ground types is mandatory. However, with this paper, determining fragility curves of rammed earth structure using method conventionally used for steel or concrete structures was proven possible.

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