Seismic assessment of masonry towers: the case of Castellum Aquae system in Pompeii

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ABSTRACT

The archaeological site of Pompeii is an extraordinary evidence of Roman architectural heritage which comprehends a large number of masonry constructions, buried after the Vesuvius eruption in 79 AD. They were discovered in the XVIII century when renewed cultural interest induced numerous archaeological excavations. In this scenario, the remains of the Roman aqueduct system, i.e. Castellum Aquae system [1], includes a series of approximately 6 m height masonry water towers (WTs). Among the fourteen surveyed, four free-standing towers (i.e. no. 1, 2, 3 and 4) have been investigated in 2015 by means of non-destructive techniques (sonic pulse velocity tests, ground penetrating radar (GPR), ambient vibration tests), aimed at gathering information on the constructive systems and the current conservation state, as well as data on the overall dynamic behaviour. According to the on-site inspections outcomes, 3D finite element models of the towers were constructed and calibrated on the results of operational modal analysis (OMA) [3]. The model updating procedure was able to describe and simulate the soil-structure interaction, introducing a Winkler elastic soil model [2], and to define the elastic parameters of masonry.

This paper describes the seismic vulnerability assessment of the four WTs, considering both equilibrium capacity and material strength, performing analytical kinematic analyses and numerical finite element modelling.

Aiming at improving the previous studies [4], equivalent modal parameters (i.e. natural frequencies and mode shapes) are used to calibrate analytical models and furtherly refine FE model updating. The numerical models were generated using DIANA software [5], implementing a nonlinear constitutive law for masonry material, i.e. total strain crack model. Afterwards, sensitivity analyses are performed to calibrate both the elastic properties of materials and the Winkler springs' stiffness. Eventually, analytical kinematic approach and FE pushover analyses (with uniform and modal force distribution) are executed to assess the seismic vulnerability of the WTs, according to Italian code [6].

Results of the analyses are presented and discussed. The study was the occasion to compare the results of kinematic and numerical procedures applied to archaeological structures.

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