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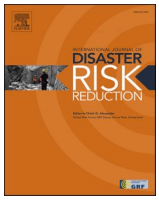

Calibration of vulnerability and fragility curves from moderate intensity Italian earthquake damage data

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ABSTRACT

The objective of this work consists in the calibration of vulnerability and fragility curves for the main masonry building classes detected in Lunigiana and Garfagnana (north-west of Tuscany, Italy). The large-scale procedure aims at providing damage and unusability scenarios starting from a seismic hazard map and a typological/structural characterisation of the building stocks lying in the different sub-municipal homogeneous areas.

The damage and vulnerability data collected in more than 3000 AeDES survey forms of rapid damage assessment, filled out in Lunigiana and Garfagnana after the June 21, 2013 Earthquake, along with the information derived from a fast visual screening of the facilities, have been processed to develop a specific database in a Geographical Information System (GIS) environment. The latter and the shakemaps downloaded from the National Institute of Geophysics and Volcanology have allowed to compare the actual fragility of the building sample with the expected one, which has been evaluated according to the Macroseismic Method.

The study concludes with a conservative proposal of modification for the vulnerability and fragility curves, for low values of EMS-98 macroseismic intensity (IV-VI) or PGA (0.04 g–0.30 g), and the identification of empirical correlations between the percentage of unusable buildings and the EMS-98 damage levels or the shaking parameters.

1. Introduction

In the last few decades, a severe increase in the losses induced by natural catastrophes has been registered worldwide. Between 1981 and 2012 more than 150 000 seismic events have occurred, 50 of which with a Richter magnitude greater than 5, victims have been numerous and economic losses have exceeded 181 billion euros [1]. Some of the most recent Italian seismic disasters (L'Aquila 2009, Emilia Romagna 2012, Central Italy 2016) definitely confirm this trend [2].

The increase in world population, the development of cities in areas that are characterised by a high seismic hazard, the fragility of the existing building stock, as well as the prevalence of vulnerable historical masonry buildings in many Italian municipalities, among other factors, have certainly contributed to this dangerous growth [3,4].

The possibility of a violent ground motion in a population centre poses multiple threats to the safety and continuity of a society and surely has a great impact on many fields. In too many cases the adopted policies have not been forward-looking, leaving space for uncoordinated actions, with ineffective or even detrimental effects. The heavy damage that has affected historic buildings emphasises the necessity of specific pre-disaster risk reduction strategies [5,6].

In this perspective, large-extent decisions are extremely important; the conception of long-term risk management strategies based on inexpensive data and evaluation algorithms that can be implemented rapidly is crucial and urgent [7,8].

In Italy, thanks to the work of the National Department of Civil Protection (DPC), risk scenarios at national scale (risk maps), were developed since 1996 [9]. Subsequently, with the evolution of scientific knowledge, the risk maps were progressively updated and improved (2001, 2008). Finally, in 2018 the DPC developed the National Risk Assessment (NRA) for the Italian territory [10]. The document deals with all the 8 natural risks considered by the Civil Protection Code, namely seismic, volcanic, tsunami, hydraulic, hydrogeological, adverse weather events, drought and forest fires. Concerning the seismic risk, the

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