A comparison between empirical procedures for the definition of vulnerability classes of masonry buildings: application to five historical centres struck by 2016 Central Italy earthquake

Y. Saretta*[1], L. Sbrogiò[1] and M. R. Valluzzi[1]

[1] Department of Cultural Heritage (dBC)
Università degli Studi di Padova
Piazza Capitaniato 7, 35139 Padova, Italy
e-mail: ylenia.saretta@unipd.it, luca.sbrogio@phd.unipd.it, mariarosa.valluzzi@unipd.it

ABSTRACT

The definition of seismic risk scenarios necessarily depends on the attribution of a vulnerability class to each building of a stock. In the macroseismic scale (EMS-98) the vulnerability class – from A to F – results from the combination between horizontal and vertical structures. On the basis of post-event surveys carried out in Italy after the earthquakes occurred in the last 50 years, many rules for converting the masonry quality and the stiffness of horizontal diaphragms into a vulnerability class have been proposed [1]. However, despite the now high number of retrofitted or strengthened buildings in Italy [2], structural interventions are not mentioned in these procedures, except for metal tie rods and r.c. tie beams.

The paper proposes a critical approach to the definition of vulnerability classes, by the means of applying the conversion rules to the same sample of 525 masonry buildings located in five historical centres struck by 2016 Central Italy earthquake: Acquasanta Terme, Campi Alto di Norcia, Castelsantangelo sul Nera, Muccia and Vezzano. They have been chosen due to the extensive strengthening campaigns that had been carried out after earlier seismic events [3]. The preliminary recognition of the structural features of each building happens at the terms of the *MUSE-DV Masonry* (*MUltilevel assessment of SEismic Damage and Vulnerability of masonry buildings),* a rapid visual screening procedure recently proposed by the authors. Differently from others, this procedure explicitly considers the contribution of structural interventions to the seismic behaviour.

The *damage probability matrices* (*DPM*), obtained from each conversion are compared to the ones derived from the theoretic model of the EMS-98 [4]. Given the same poor masonry quality, the existing rules classify buildings in class A or B depending only on floors' stiffness and horizontal connections. As a result, both low and high damage may appear in the same vulnerability class causing a bimodal trend in the damage distributions. Conversely, the *MUSE-DV* procedure allows to reduce these two frequency peaks by considering interventions. In fact, overall interventions, even on very poor masonry structures, may led to a very low damage and, consequently, to low vulnerability classes (even C or D), while uncontrolled interventions could obtain a high damage and a high vulnerability. The twofold consequence is that a) structural interventions have a 'relative', i.e. positive or negative, contribution; b) the usual limitation to A and B vulnerability classes for irregular masonry buildings needs to be widened to better explain the damage observed in the 2016 Central Italy earthquake.

REFERENCES

[1] M. Dolce, E. Speranza, F. Giordano, B. Borzi, F. Bocchi, C. Conte, A. Di Meo, M. Faravelli, V. Pascale, "Observed damage database of past Italian earthquakes: the Da.D.O. WebGIS", *Bollettino di Geofisica Teorica ed Applicata*, Vol. **60**(2), pp. 141-164, (2019).

[2] C. Gavarini (ed.), *Costruzioni e terremoto*, Roma, Nisa (1983).

[3] G. Valensise, G. Tarabusi, E. Guidoboni, G. Ferrari, "The forgotten vulnerability: A geology- and history-based approach for ranking the seismic risk of earthquake-prone communities of the Italian Apennines", *International Journal of Disaster Risk Reduction*, Vol. **25**, pp. 289-300, (2017).

[4] A. Bernardini, S. Giovinazzi, S. Lagomarsino, S. Parodi, "The vulnerability assessment of current buildings by a macroseismic approach derived from the EMS-98 scale", Asociaciòn Espanola de Ingenierìa Sismica. Girona, 8-11 May (2007).