Seismic assessment and strengthening interventions of atop single-block rocking elements in monumental buildings: the case study of the San Felice sul Panaro Fortress

S. Degli Abbati*, S. Cattari†, S. Lagomarsino† and D. Ottonelli†

* Department of Civil, Chemical and Environmental Engineering
University of Genova
Via Montallegro 1, 16145 Genova, Italy
e-mail: stefania.degliabbati@unige.it

† Department of Civil, Chemical and Environmental Engineering
University of Genova
Via Montallegro 1, 16145 Genova, Italy
e-mail: serena.cattari@unige.it; sergio.lagomarsino@unige.it; daria.ottonelli@unige.it

ABSTRACT

The seismic assessment of local mechanisms and single-block rocking elements in masonry monumental buildings (such as battlements, spires, plane-belfries…) implies the evaluation of the possible amplification effects due to the filtering effect of the main structure. Traditionally, the approach proposed by technical codes is based on the evaluation of the seismic input in terms of floor spectra. Recently, the Authors proposed an expression for the floor spectra definition [1]. This latter allows evaluating the floor spectra in different points of the building and at different levels by considering the contribution of the more relevant modes, properly combined. To apply the expression is sufficient to know (through detailed approaches or in a simplified way): the input spectrum at the base of the main building and some modal dynamic parameters of the own main structure; the damping of the main structure and of the local mechanisms/secondary elements to be verified. The paper presents the application of the expression for the seismic assessment of some battlements placed in the San Felice sul Panaro fortress (Italy), significantly damaged by the 2012 Emilia earthquake [2]. In the paper, firstly the application of the expression for the floor spectra definition is explained, by critically examining the selection of the relevant modes and the procedure for the estimation of the other necessary parameters, taking advantage of the results of detailed analyses performed on a Finite Element Model (FEM) of the whole fortress [3]. Then, the performance-based assessment of the fortress's battlements is described according to the procedure proposed in [4]. Finally, different proposals of strengthening interventions (more or less traditional) are illustrated.

REFERENCES

[1] S. Degli Abbati, S. Cattari, S. Lagomarsino, "Theoretically-based and practice oriented formulations for the floor spectra evaluation", *Earthquakes and Structures* 15(5), pp. 565-581, (2018).

[2] S. Cattari, S. Degli Abbati, D. Ferretti, S. Lagomarsino, D. Ottonelli, A. Tralli, "Damage assessment of fortresses after the 2012 Emilia earthquake (Italy)" *Bulletin of Earthquake Engineering*, 12(5), pp. 2333-2365, (2014).

[3] S. Degli Abbati, A. D'Altri, D. Ottonelli, G. Castellazzi, S. Cattari, S. de Miranda, S. Lagomarsino, "Seismic assessment of interacting structural units in complex historic masonry constructions by nonlinear static analyses", *Computers and Structures*, 213, pp. 51-71, (2019).

[4] S. Lagomarsino, "Seismic assessment of rocking masonry structures", *Bulletin of Earthquake Engineering*, 13(1), pp. 97-128, (2015).