A tool for the calculation of rockfall fragility curves for masonry buildings

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Masonries are common structures in mountainous and coastal areas and they exhibit substantial vulnerability to rockfalls. For big rockfall events or precarious structures the damage is very high and the repair is not cost-effective. Nonetheless, for small or moderate rockfalls, the damage may vary in function of the characteristics of the impacting rock blocks and of the buildings. The evaluation of the expected damage for masonry buildings, and for different small and moderate rockfall scenarios, is useful for assessing the expected direct loss at constructed areas, and its implications for life safety.

A tool for the calculation of fragility curves for masonry buildings which are impacted by rock blocks is presented. The fragility curves provide the probability of exceeding a given damage state (low, moderate and high) for increasing impact energies of the rock blocks on the walls. The damage states are defined according to a damage index equal to the percentage of the damaged area of a wall, as being proportional to the repair cost. Aleatoric and epistemic uncertainties are incorporated with respect to the (i) rock block velocity, (ii) rock block size, (iii) masonry width, and (iv) masonry resistance. The calculation of the fragility curves is applied using a Monte Carlo simulation. Given user-defined data for the average value of these four parameters and their variability, random scenarios are developed, the respective damage index is assessed for each scenario, and the probability of exceedance of each damage state is calculated. For the assessment of the damage index, a database developed by the results of 576 analytical simulations is used. The variables range is: wall width 0.4 - 1.0 m, wall tensile strength 0.1 – 0.6 MPa, rock velocity 1-20 m/s, rock size 1-20 m3. Nonetheless this tool permits the use of alternative databases, on the condition that they contain data that correlate the damage with the four aforementioned variables. The fragility curves can be calculated using this tool either for single or for groups of buildings, as long as their characteristics are properly reflected in the variability of the input parameters. Selected examples of fragility curves sets are presented demonstrating the effect of the input parameters on the calculated probability of exceeding a given damage state, for different masonry typologies (stone and brick).