Seismic vulnerability and damage of Italian historical centres: a case study in the Campania region

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Abstract. The preservation of masonry buildings typical of Italian historical centres represents a very pressing dilemma founded on recovery need of the urban fabric original character. In the paper, based on a methodology developed by some of the Authors on building aggregates, the seismic vulnerability estimation of some masonry compounds in the heart of the town of San Potito Sannitico (Caserta, Italy) is presented and compared to the results achieved from applying the basic literature method for isolated constructions. Finally, the damage scenario of inspected buildings has been shown by highlighting clearly the influence of different positions of structural units on the damages masonry aggregates suffer under different grade earthquakes, leading to individuate the most vulnerable buildings.

THE HISTORICAL CENTRE OF SAN POTITO SANNITICO

San Potito Sannitico is an Italian town with 2,011 residents within the province of Caserta in the Campania region of Italy. It extends on about 22 km^2 and is placed in the Sannio-Matese territory, which is classified as a high seismicity zone. *San Potito* taken its name from the homonym saint of the 2nd Century. The territory was inhabited since antiquity, as evidenced by some archaeological finds. Therefore, the historic centre of *San Potito Sannitico* has ancient origin and taken its actual aspect from spontaneous aggregation of constructions developed over the Centuries. The urban structure is composed by a fairly homogeneous small building system developed along a succession of narrow streets lead to open spaces hosting the most important buildings, having facades richly decorated with stuccos, erected in the seventeenth and eighteenth Centuries.

In the historical centre of *San Potito Sannitico* ten building aggregates composed of 43 Structural Units (S.U.) have been herein examined (Fig. 1a). Each aggregate is referred to by a letter [A, B, C, D, E, F, G, H, I, L], while the structural units are referred to by a number [1÷8]. In order to assess the vulnerability of these aggregates, some surveys have been performed with the purpose to acquire photographs and maps for them. For the sake of example both the plan view and the main façade of the S.U. 8 of the aggregate H are shown in Figure 1b.

The masonry aggregates under study generally range from 2 to 3 stories. The inter-storey height is about 3.00-4.00 m for the first level and 3.00-3.50 m for other floors. Horizontal structures are made of either steel-hollow tile floors or timber ones. Instead, roofing structures are often composed of double pitch timber beams with clay tile covering. Vertical structures are made of tuff or brick masonry squared stones (51%), masonry roughly squared stones and bricks in bad conditions (35%) and masonry irregular stones (14%). Masonry walls usually have constant thickness along the building height, with values between 50 and 70 cm.

(a) (b)

FIGURE 1. Bird-eye-view of the historical centre of *San Potito Sannitico* (a) and structural unit 8 of the aggregate H (b).

The seismic vulnerability of inspected aggregates has been evaluated before considering the S.U. as isolated constructions, by applying the original vulnerability form with ten parameters (1), and after assessing the influence of the interactions with the adjacent S.U., by taking into account the fifteen parameters form also considering the more or less benefits deriving from the aggregate condition (2, 3) (Fig.2). The latter vulnerability form was developed by some of the Authors starting from damages detected into masonry building compounds after the 2009 L'Aquila earthquake (4, 5).

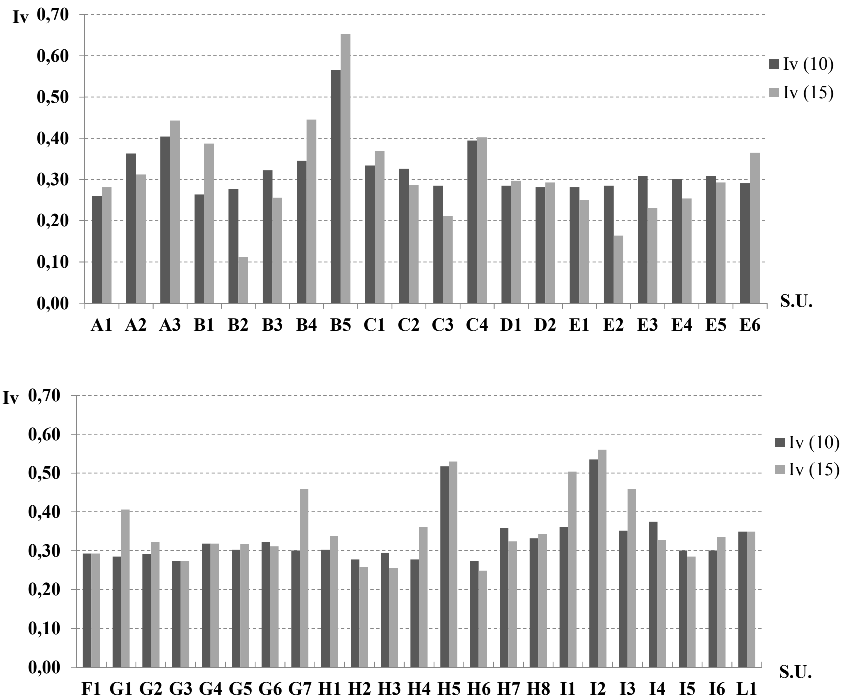
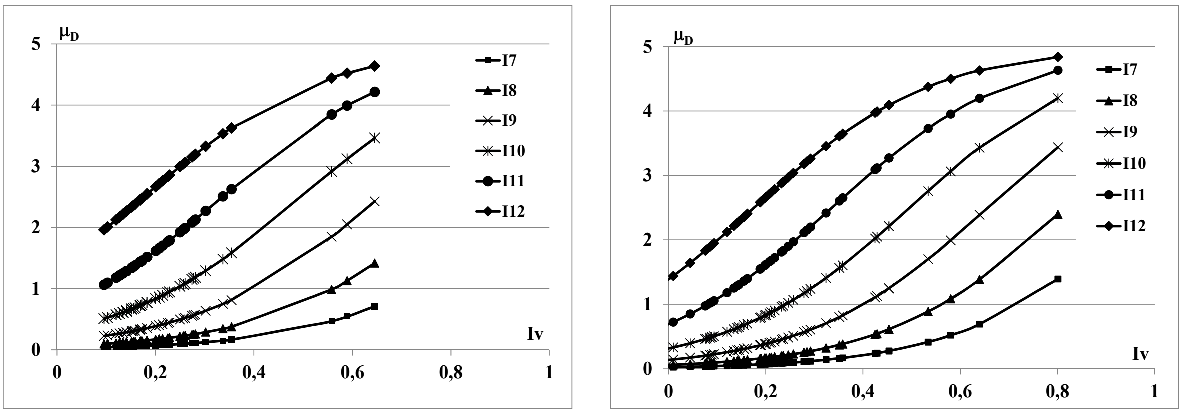


FIGURE 2. Vulnerability indices of examined masonry building aggregates.

THE DAMAGE SCENARIO

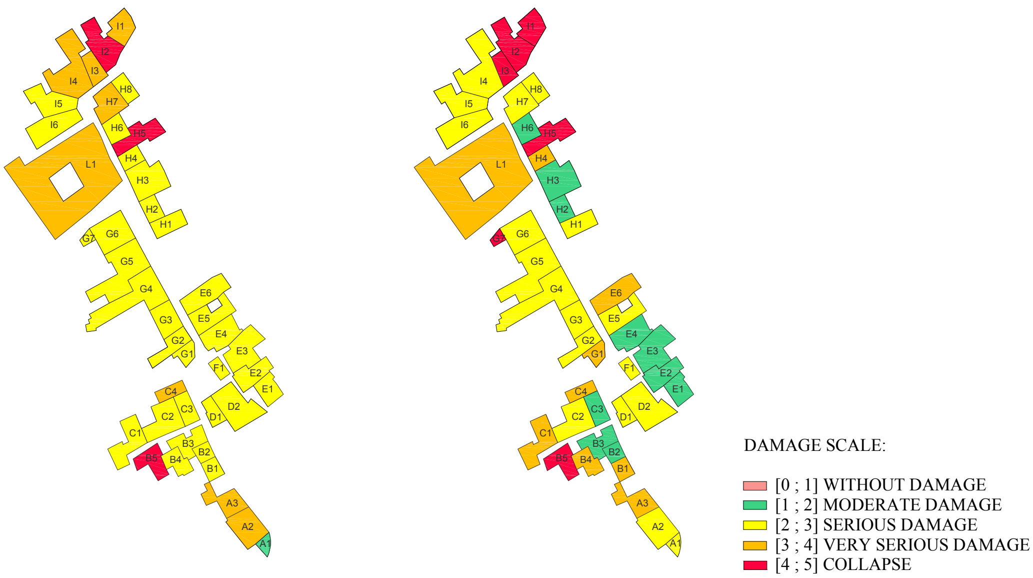
The results obtained by the above fast analysis provide a relative assessment of the vulnerability, indicating only what is the susceptibility at damage of a building with respect to another one. In order to assess the damages should be suffered by building aggregates under different earthquakes, the methodology proposed in (6) has been used.

This method is based on the definition of the average damage degree μ_D, a parameter variable between zero and five, they representing respectively absence of damage and building collapse. In the case under study, by varying the macro-seismic intensity I_s from 7 to 12, the average damage degrees of S.U. belonging to the inspected masonry building compounds have been assessed starting from the vulnerability indices before calculated through the forms with 10 (a) and 15 (b) parameters (Fig. 3). The damage maps referred to $I_s = 12$ for isolated S.U. and aggregated ones are shown in Figure 4.



(a) (b)

FIGURE 3. Average damage degree vs. vulnerability index for isolated (a) and aggregated (b) S.U.



(a) (b)

FIGURE 4. Damage maps of isolated (a) and aggregated (b) S.U. ($I_s = 12$)

In the last figure it is apparent that, when placed into aggregates, some S.U. having intermediate and corner positions show a damage reduction, whereas others in the corners have increased damage levels.

In Figure 5 the percentage difference in terms of damage among S.U. considered as isolated buildings and the same units grouped into aggregates for $I_s = 12$ is shown. If average values of these percentage differences are considered, it is achieved that, when inserted within compounds, the damage level is higher for headed buildings (increase of 22.15%), whereas it is reduced for intermediate buildings (decrease of 5.85%) and corner ones (decrease of -18.30%). This confirm the beneficial effect of the aggregate condition for intermediate and corner S.U.. Contrary, the aggregate detrimental effect is evident for headed S.U., which show higher damage levels due to the torsion effects typical of compounds with elongated plan layout.

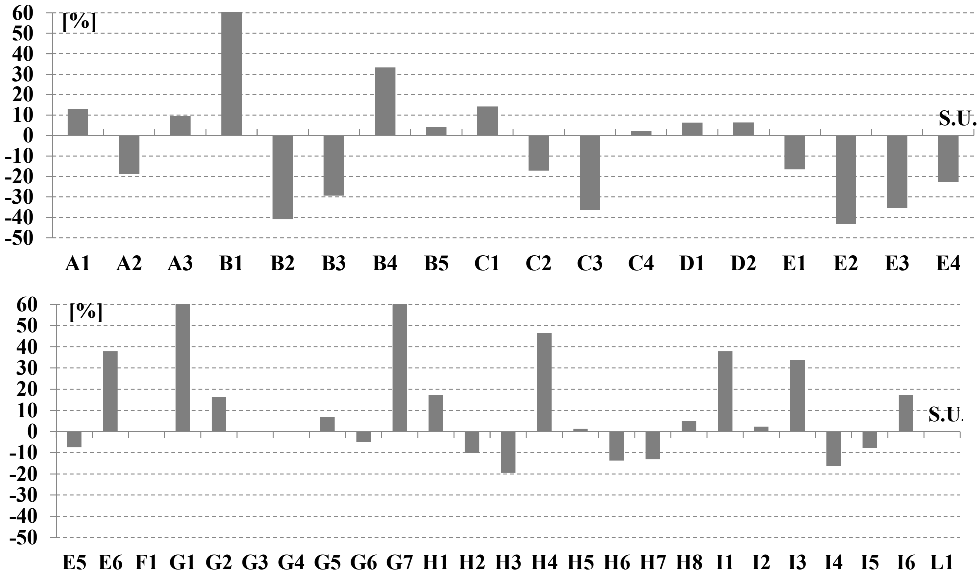


FIGURE 5. Percentage of damage for macro-seismic intensity I=12.

CONCLUSIONS

In the paper the seismic vulnerability and damage of an urban sector with ten building aggregates within the historical centre of *San Potito Sannitico* (district of Caserta) has been presented. First, about seismic vulnerability analyses, the basic survey form for isolated constructions and an innovative one for buildings within aggregates have applied to the case study. The analysis results have shown that the aggregate condition reduces the vulnerability of intermediate and corner S.U. and increases the vulnerability of those placed in heading position. Later on, the damage scenario of inspected aggregates, having seismic vulnerability calculated according the two applied methods, has been plotted under different grade earthquakes. The percentage difference detected in terms of average damage level between aggregated buildings and isolated ones has shown that, when inserted within compounds, the damage level is higher for headed buildings (increase of 22.15%), whereas it is reduced for intermediate buildings (decrease of 5.85%) and corner ones (decrease of -18.30%). This confirm the beneficial effect of the aggregate condition for intermediate and corner S.U., as well as the detrimental effect evidenced for headed S.U.

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