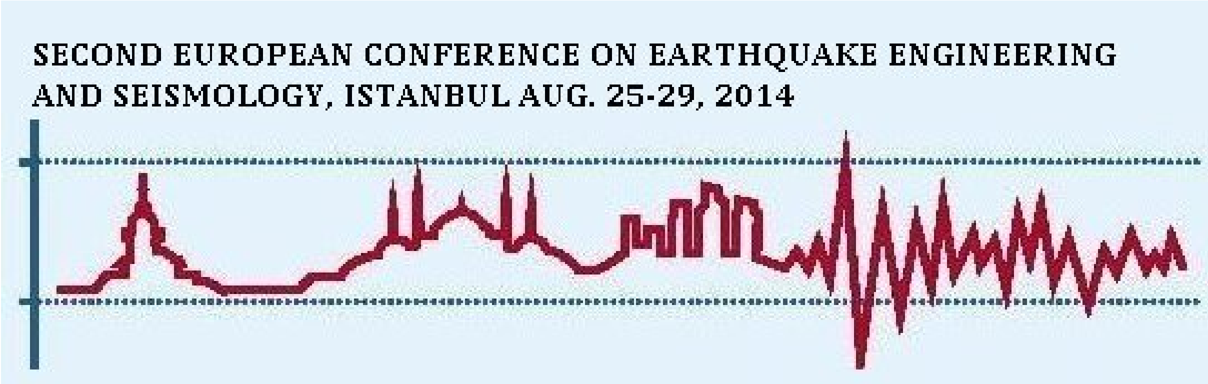

SEISMIC HAZARD, VULNERABILITY AND RISK ANALYSIS IN THE URBAN MT. ETNA AREA

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This contribution deals with activities within the framework of the European project "UPStrat-MAFA" emphasising the hazard evaluation, vulnerability assessment and seismic risk on buildings stock in Mt Etna area. The study area covers part of south-eastern flank of the volcano for an area approximately 510 square kilometres and consists of 28 municipalities.

The tectonic system, in the eastern flank of volcano, is the source area responsible for most of the strongest earthquakes known to have occurred in the last 205 years: from a total of twelve events occurred at Etna with epicentre intensities I_0 larger than degree VIII EMS (European Macroseismic Scale), ten of them are located in this area, thus indicating a mean recurrence time of about 20 years. This area is highly urbanized and many villages are located around the volcano at different altitudes up to 700 m a.s.l. In particular, the southern and eastern flanks are the most populated areas, where villages are very close to each other. The probabilistic seismic hazard due to local faults of Mt. Etna was calculated adopting the SASHA approach. The contribution, in terms of shaking, due to regional earthquakes was not considered, as only site histories of local earthquakes were taken into account. Moreover, hazard map was calculated only in the areas of the southern and eastern flank of the volcano where are located residential buildings.

The damage data used in this application refers to residential buildings. The data about the buildings were extracted from the 1991 and 2001 Italian National Institute of Statistics (ISTAT) census. The data are grouped according to the census sections, and the vulnerability indices were evaluated using the approach proposed by Lagomarsino and Giovinazzi (2006). The ISTAT data on residential buildings allows the definition of the frequencies of groups of homogenous structures, with respect to a number of typological parameters: vertical structures, age of construction, number of storeys, state of maintenance, and state of aggregation with adjacent buildings. Seismic vulnerability of the elements at risk, belonging to a given building typology, was described by the vulnerability index, varying between 0 and 1, and independent from the hazard severity level. The average vulnerability of a region, was obtained by weighting the typology vulnerability index by the existences of the several typologies present in the region.

For estimating economic losses due to physical damages in buildings, an integrated impact indicator, the equivalent lost building volume, was evaluated. To compute this indicator, each damage state was associated to the non-dimensional variable Damage Factor, DF_d, defined as the ratio between the building repair cost, when it is in a certain damage state d, and the economic value of that typology building at the time of the earthquake.

The transformation of damage states into damage factors leads to a loss index that is, in fact, an expected loss value, $E(L|h)$, conditioned by a seismic hazard level, h. The conditional expected loss is obtained by averaging the number of buildings that belongs to a given damage state and typological class with vulnerability $V=v$, weighted by damage factors, for a given hazard level. Of note is the fact

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that, in this work, the economic losses are exclusively based on building damage estimates and on related lost area repair costs. Once the conditionally expected loss is obtained, a simplification was made to evaluate the expected value of losses, for a given time interval, averaging the conditional loss with the pdf of the seismic hazard, $f_H(h)$, according to the following expression:

$$\mathrm{E}(L) = \int_H \mathrm{E}(L \mid h)\, f_H(h)\, dh \qquad (1)$$

When seismic hazard is described by an annual exceedance probability, the latter expression describes the expected Annualized Economic earthquake Losses, referred to as AEL.

In practice, a beta theoretical distribution was fitted to the hazard curve in each site and, after being differentiated, was used as the seismic hazard pdf in expression (1).

A map with the expected Annualized Economic earthquake Losses has been evaluated. The area with higher values of AEL shows a good agreement with areas of the severest seismic hazard and with the regions where more vulnerable buildings are located.

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