Integrated approaches for advanced seismic risk assessment including site effects

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Background.

Seismic risk assessment at the territorial level is now widely recognised as essential for countries with intense seismic activity, such as Italy. Academia is called to give its contribution in order to synergically deepen the knowledge about the various components of this risk, starting from the definition of the actual hazard expected to the complex evaluation of the exposure/vulnerability of the built heritage.

At present, hazard and exposure/vulnerability are often treated independently due to the different scientific skills they require, relating to geophysics and structural engineering. However, there are many areas, even with low-moderate seismicity, where site effects and other induced seismic phenomena (such as the liquefaction of saturated soils) can be very significant, such as to substantially affect both the seismic hazard and the vulnerability of the structures. Some examples are floodplains (e.g., Po Valley), paleo-riverbeds and historical centres with significant underground urban stratifications. It is therefore necessary to work in synergy, developing integrated approaches that combine the relevant geophysical and engineering knowledge, in order to increase the reliability of current risk forecasts.

Among the main limitations for an in-depth risk analysis are: i) high costs for an accurate and distributed measurement of telluric phenomena, also able to identify specific local effects amplifying the risk; ii) difficulty in characterizing the exposure of building stocks in an accurate but sustainable way; iii) need to evaluate the soil-structure interaction in a rational but also efficient way for the purposes of large-scale risk assessments. However, recent technological and IT developments – such as innovative low-cost sensors for measuring local seismicity, extended satellite information and advanced approaches of artificial intelligence for big data processing – would allow the previous limits to be overcome, leading to an advanced, integrated and certainly more reliable risk assessment.

Aim.

The research aims to develop integrated seismic risk assessment approaches, based on an accurate knowledge of the soil response and on innovative methods for the rapid characterization of the vulnerability of building stocks. To this end, the use of innovative networks for the measurement of ground motion will be explored which, being based on low-cost sensors, allow sufficiently accurate seismic monitoring over a fairly large area. Machine Learning can then provide efficient models, such as Convolutional Neural Networks (CNN), to process input data deriving from these sensors together with the information of soil and structures retrieved from satellite images, with the aim of developing geo-referenced maps of soils and exposed structures. Furthermore, the core of the research will be the development of appropriate methods and models to evaluate the soil-structure interaction, in order to appropriately include site effects and other induced seismic phenomena in the risk investigations.

Expected results.

- Development of algorithms and procedures for the use of new low-cost sensor networks.
- Development of innovative methods, based on artificial intelligence, to retrieve soil and structure information from satellite images and process them together with sensor network data.
- Definition of appropriate experimental methods and numerical models to evaluate the soil-structure interaction, with calibration on case studies, also through structural monitoring.
- Integration of previous results to define more reliable large-scale risk assessment procedures.
- Development of geo-referenced maps (GIS) of soils and exposed structures, with risk information.

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