Integrated monitoring and modelling approaches for better assessment of structural response to natural hazards

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Background

Many civil structures and infrastructures (e.g. bridges), that are currently kept in operation, are either close or beyond the end of their service life. In the field of heritage buildings, the situation is further complicated by the very large uncertainties (e.g. regarding material properties and components characteristics) affecting the reliability of the assessment. In both cases, sources of threats are due to anthropic factors, such as changes in the operational conditions (e.g. increasing traffic demand for the infrastructures or increasing tourist flow for historical monuments), and to intrinsic vulnerabilities (e.g. seismic loadings on structures designed for gravity loads only), ageing and degradation of materials, ect.
In addition to these endogenous factors, actions due to natural hazards (earthquakes, subsidence, floods, landslides, etc) or other environmental factors related to climate change, represents an exceptional source of damage, or even collapse of existing structures.
In this framework, the need to reduce the impact of natural hazards and to improve the reliability of the assessment procedures for existing structures located in potentially sensitive areas, has pushed research towards the development of advanced monitoring techniques at different scales, from the single building to the territorial scale.
In the structural field various classic "identification techniques" have been developed, which allow to obtain, through experimental measurements on the real system, the characteristic parameters useful to define and calibrate numerical models of the structure and of its interaction with the soil. In parallel, the development of the InSAR (Interferometric Synthetic Aperture Radar) technique for terrestrial monitoring, and its application for the control of surface displacements, allows integrating territorial information with the building response, and better calibrating the above mentioned models.

Aim

The research aim is to identify the relevant parameters to properly describe the response of existing structures (either civil infrastructures or heritage buildings) to the above-mentioned natural hazards and in particular to seismic-induced risks; to integrate geophysical prospecting methods, seismic micro-zoning and local amplification studies with structural identification techniques and numerical modeling for the estimation of site effects and soil structure-interaction phenomena; to develop enhanced monitoring and testing techniques; to develop early-warning tools. An innovative approach integrating data acquired directly on the structure by traditional SHM with those acquired via satellite will be explored. Improvements of seismic vulnerability assessment procedures for existing structures and better integration of the analysis process with the results of monitoring will be proposed, considering the relevant uncertainties to increase the reliability of the model predictions. The final goal is to develop methodologies that allow enhancing residual life estimations and the evaluation of the structural response to natural hazards, in order to correctly design maintenance and retrofitting programs.

Expected results

- Development of enhanced monitoring and integrated testing strategies and early warning tools;
- Combination of data of traditional SHM systems and satellite data (e.g. InSAR);
- Increase of model reliability by using new approaches for the uncertainties, better definition of system vulnerability in particular to earthquake-induced actions;
- Guidelines for maintenance programs and possible retrofitting interventions.

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