Abstract

The prediction of physical impacts on the built environment caused by natural disasters has always been a challenge for urban planners and decision makers. Damage assessment is a complex problem due to the strong correlation and interdependencies among buildings portfolio and different infrastructures of a community. Several parameters, such as buildings' spatially distribution, uncertainties in mechanical and geometrical parameters, different hazard intensities, etc. should be addressed by simulation models.

This dissertation aims at developing a quantitative model to assess damages occurred to the built environment after a seismic event. A virtual city was designed based on the city of Turin in Italy as a testbed to validate the developed methodology. The structural design parameters of each building were determined according to the seismic design codes associated to the buildings' year of construction, while the average mechanical, geometrical, and construction parameters were identified through a typological approach for each building. The dynamic structural response of each single building was evaluated by performing large scale simulations considering the buildings' spatial distribution across the city. Uncertainties related to geometric and mechanical parameters for each building were explicitly taken into account performing Monte Carlo Simulations. Fragility curves were developed for each building and the virtual city is accordingly mapped into different hazard zones. Results show that the level of the damage is directly proportional to the building's year of construction. The main share of damaged buildings belongs to masonry buildings which were mostly designed according to old design codes where either there was no seismic design procedure or less seismic design requirements.

Furthermore, the social direct losses in terms of causalities were estimated and the number of injured for each neighborhood was calculated. Results show that the expected number of casualties inside masonry buildings is about four

times more than the one referred to concrete buildings. This is due to the fact that in the virtual city masonry buildings are more vulnerable than concrete buildings.

The proposed simulation model was then extended to simulate the interdependency between buildings and the hospital network within the virtual city. The ability of the hospital network to provide care to all injured arriving at the Emergency Departments was investigated, and then two different solutions were proposed in order to make the city able to manage the post-earthquake scenario. The described method helps to estimate the capacity of cities' emergency network and provides an efficient and simple tool for evaluating the first order response of the healthcare facilities of a city under an emergency.

Finally, a new indicator-based approach for computing community resilience was presented. The methodology is a deterministic approach based on the structure of PEOPLES framework for assessing resilience. The interdependency among the resilience variables was taken into account by introducing an interdependence matrix approach. The methodology was applied to the virtual city and the resilience of the physical infrastructure under an earthquake scenario was computed. In order to enhance the community resilience, two different strategies including 'increasing system robustness' and 'reducing the recovery time' were studied. Results show that 'increasing system robustness' strategy is more efficient than the 'reducing recovery time' one in improving the resilience of the virtual city.

The work is considered a promising attempt to evaluate the earthquake-induced damage to the building stock for a variety of possible earthquake scenarios while reducing the computational effort. In addition, the resilience quantification model with its graphical representation can support decision-makers to explore how the community responds to a disaster and to identify where exactly resources should be spent to efficiently improve the resilience.