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Community Resilience and Seismic Performance of Physical Infrastructures

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Abstract

Over the years, community resilience has attracted tremendous attention due to the increasing number of natural and man-made disasters. The lack of a concise and methodical approach makes it challenging to evaluate resilience, especially on large scale applications. This dissertation proposes new tools to evaluate seismic resilience at the regional and urban level. The proposed method to quantify regional resilience is inspired by existing indicator-based frameworks. In the analysis, only publicly available statistical census data has been used. For each Italian regions, three different indexes are calculated. The first is a measure of resilience in normal conditions, while the others are related to the emergency and the restoration phases following an earthquake. Results highlight those aspects and indicators that influence regional resilience the most and can be used to better distribute funds among the various regions.

The testbed for the performance and resilience assessment of infrastructure systems is a virtual city resembling a typical medium size European city. The analyzed infrastructures are the road transportation system, the power, and the telecommunication network. The transportation network has been modelled using graph theory. This allows to define different metrics that help to quantify the seismic performance. Moreover, the interdependence with the building portfolio has been considered. Once the level of the damage to the buildings is estimated, the footprint of the generated debris is determined. Thus, for a given seismic scenario, blocked roads can be identified. The information on roads blocked by debris is used to update evacuation paths and calculate the travel time of injured people to the closest hospital. The power grid is designed implicitly modeling the interdependency with the building portfolio. The fragility of the power network's substations is linked to the buildings' seismic fragility, as electrical substations are likely to fail because of the damages that occur to the buildings hosting them. As a result of the analysis, damaged substations and users not supplied can be determined. A new resilience index that considers redundancy and resourcefulness is introduced and compared to others available in the literature. The telecommunication network

has been modelled based on publicly available information and visual inspection. The connectivity is based on a three-layer hierarchical approach. The most significant damages suffered by this system are due to the interdependency with the built environment. Collapses of buildings where servers and towers are installed yield to the failure of those nodes. The performance metrics for resilience of this infrastructure are evaluated in terms of damage to telecommunication towers, throughput, and number of users per antenna.

The results of this research provide practical and replicable solutions to evaluate infrastructure performances and quantify resilience. The methodologies and tools proposed could help decision-makers not only in the emergency management phase but also in the allocation of resources for implementing preventive measures.