Supporting Actions to Increase Seismic Response in Areas with Potential for Disaster

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Abstract. Seismic resilience of urban community is ensured also through organization and preparation of technical activities in order to build a post-seismic investigation capacity. Thus, some elements are necessary: responsible structures, competencies and specific legislative references for the management of post-earthquake response measures, at central and local level; information resources; collection and storage of information related on the existing built fund; computerized databases - creation, maintenance and management of information; organizing the keeping of the primary documents of the investigations; training of inspectors and technical staff; material resources; stocks of materials strictly necessary in the event of an earthquake for the implementation of emergency response measures; buffer spaces for sheltering persons evacuated from unsafe damaged area etc. The paper presents in this context the role of the building instrumentation before and after the incidence of severe earthquakes. An interdisciplinary investigation system in-situ and with advanced techniques of the effects on buildings with different functions, in emergencies produced by powerful earthquakes is also defined. The level reached by the research studies within NIRD URBAN-INCERC and the future premises for development in this direction will be reviewed, as a safety necessity and as a European requirement.

1. Introduction

Within the Sendai Framework for Disaster Risk Reduction (2015-2030) some targets and priorities in order to reduce disaster risks through understanding, strengthening to manage, investing in reduction and enhancing preparedness for effective response are considered important.

Building a seismic resilience is one of the major goals of a developed society which in the same time has developed an intrinsic vulnerability (e.g. by the existence of a housing stock that no longer meets the latest structural performance requirements and a significant number of exposed inhabitants). It can be ensured through measures and actions of prevention and preparation, but also through organization and preparation of technical activities in order to build a pre-seismic consolidation and post-seismic investigation capacity.
Thus, in this context, some more issues are considered necessary in Romania [1]...[5]:
- the preparedness before the incidence of the seismic event with a proactive involvement of the whole society;
- competencies and specific legislative references for the management of post-earthquake response measures, at central and local level;
- existing information resources;
- collection and storage of information related on the existing building stock;
- computerized databases - creation, maintenance and management of information;
- organizing the keeping of the primary documents of the investigations;
- training of inspectors and technical staff;
- design education/training material resources;
- stocks of materials strictly necessary in the event of an earthquake for the implementation of emergency response measures;
- buffer spaces for sheltering persons evacuated from unsafe damaged area etc.

Beyond traditional methods, the instrumentation and monitoring process (with real-time data transmission) plays an important role in assessing structural vulnerability after a significant seismic event, relying in a first stage on the evaluation of pre- and post-earthquake dynamic characteristics and subsequently the evaluation of the degree to which the defining characteristics of the structural systems of the respective buildings have changed. Intelligent solutions must be found for the safety, resilience and monitoring of the built heritage in earthquakes: concepts and solutions for seismic risk reduction, design, investigation, consolidation, rehabilitation and maintenance of constructions [6], [7].

2. Aspects related to the building stock and the exposed population
From the point of view of the building stock, an integrated system can be built to ensure the security, of strategic interest through the role it plays in the field of seismic risk assessment and reduction. The success of this approach involves carrying out the following activities:
- identification and implementation of the seismic data transfer system: identification and acquisition of equipment suitable for monitoring, online connection for network equipment;
- permanent seismic monitoring of some public buildings; with the assessment of the vulnerability of the instrumented / monitored buildings;
- automation of the permanent seismic monitoring system and development of a specific data center concept;
- acquisition, storage and processing of data from seismic actions or other vibratory sources;
- generation of results in GIS graphic formats and semi-automatic reports following the occurrence of strong earthquakes etc.

In terms of population exposure, some actions for social resilience are considered:
- earthquake training and preparedness of citizens for earthquake response;
- provide practical knowledge and create positive risk reduction perception;
- development of specific knowledge transfer / training materials;
- knowledge transfer by training seminars using courses, printed materials and didactic seismic simulators;
- direct transfer of earthquake preparedness knowledge to the community using verbal explanations, didactic mini-simulators and leaflets etc.

3. Results and discussions
The directions in which notable progress has been made, at the level of NIRD URBAN-INCERC, are:

Digitalization of structural health and seismic monitoring of buildings
By using sensor technologies and incorporating these into seismology and building infrastructure is an important step forward in understanding and responding to the status of built environment before,
during, and after an extreme seismic event. New information on what is happening within a building, by incorporating high-density seismic instrumentation, both at the ground level and on upper floors, at any moment, can be used to make manual and automated real-time decisions, figure 1 ... figure 4.

Within the National Network for the Seismic Monitoring and Protection of Building Stock, the recent research studies are being conducted in the field of digitalization of structural health and seismic monitoring of buildings having as object real buildings, seismically instrumented with modern equipment.

Modern equipment of last generation exists, many buildings can be monitored from distance and data can be transmitted to users or to research institutes in the field through a system of transmitting in real time (wireless smart sensor networks, within a frequency range (0 ... 100 Hz).

Research conducted converges towards the development of a large monitoring system capable, in the future, to allow remote identification, in a very short time after a seismic event, of possible dangerous changes in the condition of the instrumented/monitored building, figure 3 and figure 4.

**Figure 1.** Digitalization of structural health and seismic monitoring of in progress in the case of Building of Ministry of Internal Affairs-General Inspectorate for Emergency Situations and Building of Ministry of Research, Innovation and Digitalization

**Figure 2.** Digitalization of structural health and seismic monitoring of in progress in the case of Riverside Tower building and Biotechnology Faculty Building (with seismic sensors in locations assimilated as free-field)
Figure 3. Global method of detecting damage through environmental vibration recordings, or from earthquakes

Figure 4. Example of modal analysis in order to identify natural periods

Preparative to support the forthcoming Strategy of seismic risk reduction in Romania, using knowledge to ensure earthquake resilience of important community buildings. Through assessing specific risks and adapting measures and actions accordingly the resilience strategies for important public facilities, as schools, hospitals and other public institutions/facilities, with developing cooperation among all decision-makers in disaster risk reduction. Also disseminated in online training lectures, figure 5.
Figure 5. Online presentations - training lectures on seismic risk reduction for school / educational facilities, addressed to professors, directors and administrative staff, as well as to local authorities staff / employees, 2020 (in Romanian and English)

A holistic and integrative concept for strong motion records on constructions of the URBAN-INCERC National Seismic Network

The infrastructure includes at present, among other research facilities, a strong-motion network of 66 permanent seismic stations, to which other temporary stations are added for various short-term vibration monitoring projects, distributed all over the country, according to its characteristic seismicity patterns. The management of the network implies conducting a complex set of activities, centered on the recording, processing, analysis and interpretation of natural- and human-induced vibrations. All of these are seconded, in parallel, by various maintenance, reporting, logging, communication and dissemination tasks. The logistic and financial management also plays an important role. A rational and efficient administration of the seismic network cannot be acquired without a rigorous organization of data flows pertaining to the various activities performed. The paper provides insights from the organization of the network, highlighting the intercorrelation between the hierarchical levels of its functionality and the logical course of operation.
Clearinghouse-type system and database for post-seismic buildings assessment
A system for interdisciplinary assessment that envisages a coordination Centre and a clearinghouse at Bucharest, in NIRD “URBAN-INCERC” that coordinates branches of the territory (Iaşi, Timișoara and Cluj-Napoca).

4. Conclusions
In the context of national seismicity, it is important to obtain more data on the performance of a structural system, its real resistance, as well as on how a structure behaves after exceeding the elastic limits of behaviour. Digitalization of structural health and seismic monitoring of buildings are active research approaches from which the dynamic characteristics are obtained in structural identification and a damage detection could be possible using a specialized software. all financial investments in this field will lead to a dense network from which useful information related to the behaviour of structural systems will make possible the adoption of measures to increase urban resilience. In the future stages, INCD URBAN-INCERC will continue with digitalization of structural health and seismic monitoring of buildings for the entire network of national research institutes in Romania.

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