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# LESSONS TAKEN FROM ITALIAN POST-SEISMIC MANAGEMENT AND THEIR INTEGRATION INTO ROMANIAN ASSESSMENT SISTEM OF BUILDINGS AFTER A STRONG EARTHQUAKE

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***Abstract***

*The paper presents aspects on post-seismic assessment of buildings according with Italian model. The authors of this work participated to international teams for building damage assessment in the framework of STEP (Strategies and Tools for Early Post-earthquake assessment) European project, after L'Aquila earthquake in June, 2009, and as invited experts in the framework of final workshop of Dr. House European Project in April, 2013. The projects were inserted within the framework of the Community Mechanism, whose main task is to facilitate co-operation in civil protection assistance interventions in the event of major emergencies which may require urgent response actions. The STEP project was a pilot project which constituted the technical and technological background for the Advanced Seismic Assessment module. ASA module was developed for strategic and/or complex structures, with dedicated instrumentation. According to the program activities, meetings were related to participation in international teams for post- earthquake assessment of buildings damages, organized by the Department of Civil Protection of the Council of Ministers of Italy as well as to applied of the visual assessment methods of state buildings in the field according to some special forms and exchange of experience at national and regional level with other European countries to develop common methodologies, taking into account national provisions in this regard, including the U.S. and Japan. In the EU context, the main purpose is to evaluate the possibility of participating in the investigation of international teams of experts damages in the event of major earthquakes that will hit some regions. Lessons taken by Romanian experts have been implemented in the post-seismic assessment system developed by NIRD URBAN- INCERC. Will be presented modern techniques used by the experts teams in the field as non-destructive methods, seismic instrumentation, temporary instrumentation, modal and dynamic analysis of buildings, and fast data transmission techniques from the field to clearinghouse. The data taken from the field will update the database created in INCERC Bucharest whose structure and operating will be presented.*

***Key words****: building assessment, post-seismic management, non-destructive methods, dynamic instrumentation, buildings database*

## INTRODUCTION

The accelerated expanding of urbanization at globally level makes that almost half the world's population to live in cities. Many of these are large cities and are expanded through uncontrolled development, although they are located in areas exposed to many natural hazards, including lines that border tectonic plates in areas prone to destructive earthquakes. The presence of numerous types of vulnerable structures aggravates this seismic risk (Dragomir, 2013).

In Europe, the post-seismic investigations are required of practice and tradition from Eurocode 8. Field investigations of national associations in collaboration with ministries from seismic engineering construction and planning domain, in countries affected by destructive earthquakes are known.

Romania is a signatory country from 2002 to "EUR-OPA Major Hazards Agreement", the Open Partial Agreement on prevention, protection and assistance in the event of major

natural and technological disasters. Countries are focused on prevention and early intervention, thus being created European/Euro-Mediterranean centers, including:
- Harmonization of procedures and protocols for data exchange and online information on the effects of disasters and the demands and proposals for emergency assistance;
- Procedures and techniques of risk assessment, of the stability of buildings and civil engineering works, safety of facilities in the chemical, radiological, vital systems, of evaluating losses.

## MATERIALS AND METHODS

## EUROPEAN EXPERIENCE OF SPECIALISTS FROM N.I.R.D. URBAN-INCERC

### Damages investigation after the L'Aquilla 2009 earthquake - STEP Project

In the STEP Project, at the action of damage assessment produced by 2009 earthquake to the constructions, in the L'Aquila region representatives of 11 countries, Greece, Turkey, Romania, Macedonia, Slovenia, Italy, Germany, Spain, Portugal, USA and Japan have participated (STEP Project, 2007).
That, in the context of the European Union, the main purpose of this investigation was to evaluate the possibility of participating in the damages investigation of international teams of experts in the event of major earthquakes that will hit some regions. On the other hand, a comparison between the results, obtained by the application of assessment methodologies specific to the two types of forms, Italian AeDES forms and those used in Bovec, Slovenia, in the STEP Project was desired.
Delegations of participating countries were housed in Celano town, about 50 km from the town of L'Aquila. The earthquake has caused no noticeable effects in this area.
The field inspection program referred to the following activities:
- in the first stage, teams were established to investigate, stating that the investigation will be done in parallel with the Italian expert teams.
- the field international inspectors teams have carried out the following activities:
- assessing visual field investigation of buildings;
- visiting Command and Control Directorate (Figure 1) established in L'Aquila, in the first hours after the earthquake, on 06.04.2009, and viewing a few places and important buildings of L'Aquila, which were badly damaged and subsequently evacuated, including local San Salvatore Hospital.

The specific of the impact of the earthquake on public institutions (Prefecture Hall) from L'Aquila earthquake was given where Prefecture Palace was crashed and therefore the management has moved it in the ItalTelecom Center.
The Department of Command and Control was established in the town of L'Aquila in only three to four hours after the earthquake on his 06.04.2009, carrying on all the activities of coordination and control in a sports hall belongs to the Financial Guard.

Figure 1. Organize command centre DI.COMA.C

Figure 2. Inspection teams with owners of damaged buildings

In the area around L'Aquila, a quasi-military regime was introduced, the access to town without inhabitants, and especially in the "red zone" (the historical centre, with buildings badly damaged), being controlled by the Police, Fire, Military and Financial Guard and being allowed the access only to those authorized to make inspections, accompanied by owners, planned in that day (Figure 2).
After the earthquake, the L'Aquila village was evacuated and about half of the residents were accommodated in tents placed in available spaces by Civil Protection teams (Figure 3).

Figure 3. Camp tent near L'Aquilla town

From the first hours after the earthquake, the fire crews went to secure the buildings seriously damaged (Figure 4). This measure applies, however, and about two months after the seismic event.

Figure 4. Emergency measures to secure a building after earthquake

**Advanced Seismic Assessment module – Dr. House Project**

The ASA Module is coordinated by Eucentre and it is aimed at performing fast post-earthquake structural evaluation of strategic or complex structures using combined numerical and experimental techniques. ASA technology is based on the technology developed within the European STEP project (Strategies and Tools for Early Post-Earthquake Assessment) (DRHOUSE Project, 2010).
Particularly, a special mobile unit (MU) equipped with instrumentation, workstations and servers, is used to perform and coordinate experimental testing activities as well as advanced assessment of buildings (Figure 5). The mobile unit has also functions of data repository and wireless hub. Field data will be transferred from ASA teams to MU via satellite connections and wireless technology. The safety assessment is based upon a detailed geometrical survey of the building and non-destructive in-situ tests and can be performed on multi-storey reinforced concrete or pre-cast buildings, masonry buildings, towers, churches and landslides.
The main objective is to estimate both the damage level and the residual capacity of the structures.
As general lessons, useful to the preparation for the earthquake in Romania, we mention:
- At European level, the investigation of state buildings is required by law. In the days after the earthquake, some investigation teams dealing with the present state of the buildings on the field. This is particularly important in the restoration of normality shortly before the earthquake.
- It is appreciated that at the investigation of building and data collection assist Civil Protection, Council engineers of Architects, some universities. In the investigation teams were six members of the profession.
- A very important issue for Romania will be to cover the entire affected area. For this reason, the European cooperation is beneficial to the establishment of emergency tent camps in the available spaces, ensuring all the facilities to people would live in these facilities after a strong earthquake.

Figure 5. Devices used for advanced buildings assessment

## RESULTS AND DISCUSSIONS

### THE CONCEPT OF ROMANIAN SYSTEM OF DAMAGE INVESTIGATION

Regarding the specific seismic hazard and vulnerability, Romania is currently in preparation for the impact of a possible earthquake, unpredictable situation in time, but possibly in the general statistical sense at the beginning of this century. At present, there is a shortage of hard data on the situation of hazard and risk factors of locality, as the effects of previous earthquakes.

In order to design the system for investigating and defining thematic structure, research institutes, universities and institutes in the area of decentralized powers and resources in the investigation were analysed. For infrastructure networks, national agencies and institutions / technical departments, namely research institutes in the field, were analysed. The thematic structure was established from the regulations approved by ministries as well as by European and international requirements in the field.

The created system (Figure 6) will collect the needed data to be taken lessons in engineering and management regulations disasters and to have the knowledge base and calibration for future research. To this system was took into account the fact that, in Romania, Vrancea large earthquakes have features practically unique in the world, occurring every few decades, and the affected area is very large, so the investigation requires a special effort and the loss of the effects would be unrecoverable (Dragomir, 2011).

This fact has imposed the study of problem at system level, finding solutions and developing a regulatory director material, with adequate resolution of the involved resources, to ensure the application through both central and the decentralized authorities.

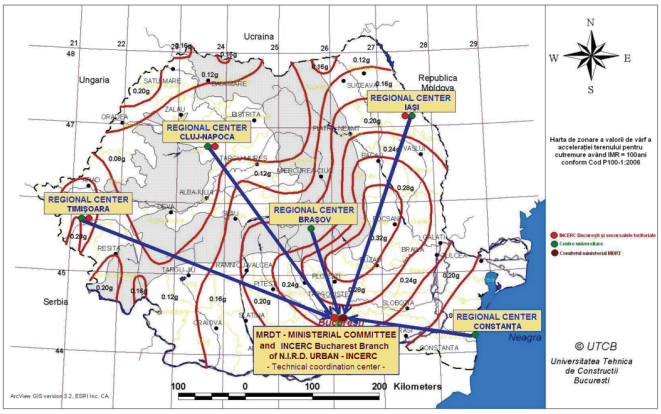


Figure 6. The structure of assessment system

**THE STRUCTURE AND OPERATING MODE OF THE DATABASE FROM INCERC BUCHAREST**

By exploiting the software created in INCERC Bucharest Branch, one can obtain numerical values and graphs for the six buildings investigated by INCERC Bucharest Branch specialists who travelled to the L'Aquila earthquake dated 06.04.2009.

For SIS INV TEREN.mdb some tables (imported from databases - data collection teams investigare.xls) and the relationships between these tables are presented. Also the output data in the form of reports created in Access are presented.

The input data used to create the database are:

- Input data for achieving domain "Inspectors': badge number, name and electronic signature
- Input data for achieving domain "building": the Land Code, Geographical coordinates, Description, Type, and Destination.
- Input data for achieving domain "Assessment of buildings and proposals"(Figure 7).

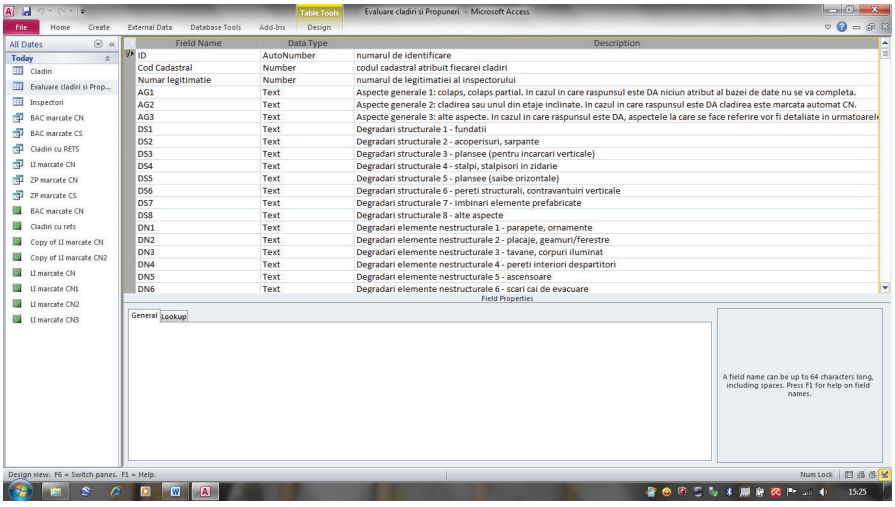


Figure 7. Description of the “Assessment Buildings and Proposals” domain attributes

The output data in the form of lists containing data on investigated buildings using the following query is presented: buildings with reinforced concrete frame structure (BAC) declared SAFE BUILDINGS (CS); buildings with reinforced concrete frame structure (BAC) declared UNSAFE BUILDINGS (CN); masonry bearing wall buildings (ZP) declared

SAFE BUILDINGS (CS); masonry bearing wall buildings (ZP) declared UNSAFE BUILDINGS (CN); individual houses (LI) declared UNSAFE BUILDINGS (CN); public buildings (CP) for which some recommendations on their technical expertise are made (RETS).

## CONCLUSIONS

In Romania it was considered that Vrancea large earthquakes have different characteristics from other European countries through the fact that they produce every few decades and the affected area is very large, so the investigation requires a special effort.

On the other hand, Romania cannot afford to lose field observation data and we must correlate them with the instrumental records.

In this respect, the created and presented system proves its usefulness and more of this the database ensures that vital information about structure will be maintained throughout the period of their existence. This is beneficial for any structural interventions, when required knowledge of certain structural features and their evolution over time due to seismic events.

In addition the integrated system ensures the applicability of ME-003-2007 Romanian methodology on emergency assessment of buildings post-seism safety and establishing framework solutions for interventions.

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