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SUSTAINABLE SOLUTIONS IN BUILT ENVIRONMENT SAFETY

Claudiu-Sorin DRAGOMIR[1, 3], Daniela DOBRE[2, 3], Iolanda-Gabriela CRAIFALEANU[2, 3], Emil-Sever GEORGESCU[3]

[1]University of Agronomic Sciences and Veterinary Medicine of Bucharest, 59 Marasti Blvd, District 1, Bucharest, Romania; National Institute of Research and Development URBAN-INCERC, 266 Pantelimon Street, District 2, Bucharest, Romania
[2]Technical University of Civil Engineering Bucharest, 122-124 Lacul Tei Avenue, District 2, Bucharest, Romania
[3]National Institute of Research and Development URBAN-INCERC, 266 Pantelimon Street, District 2, Bucharest, Romania

Corresponding author email: dragomirclaudiusorin@yahoo.com

Abstract

The paper presents the current level in the development of an integrated system to ensure the security of the built space, with semi-automatic generation of PGA maps from seismic actions or other vibrating sources and rapid assessment of the vulnerability of instrumented/monitored buildings. The integrated and automated system is an essential step for the early detection of damage to future earthquakes. As performance benchmarks are listed: identification and acquisition of specialized software, an instrumentation campaign of public utility buildings belonging to NIRDs at national level, some case studies. The obtained results are transferable and of special technical and legal importance, the elaborated documents representing the basis for the Technical Book, and the archived data constituting initial records for the future data obtained after a major earthquake. Finding a reliable solution for a quick analysis after an earthquake, by generating a report with the dynamic parameters of the monitored buildings behaviour, is a challenge of a strategic and logistical nature, of acquisition, storage and continuous processing of data, elaboration of analytical models for validation, in context of digital approach for structural engineering.

***Key words**: built environment, digitalization, integrated system, security, structural dynamic parameters.*

INTRODUCTION

Laborious research at present is being undertaken to determine sustainable and ecologically integrated solutions in the spatial development and safety of the built environment, with the advanced potential of open innovation (Figure 1).

Thus, a national project seeks a reliable solution for performing a semi-automatic rapid analysis after a moderate/severe earthquake (M > 5) (PN 19-33.01.01).

In this context, the digitization process is based on a network of sensors for monitoring the structural health of buildings, and seismic instrumentation/ monitoring offers the opportunity to generate digital maps, which centralize all technical data of a building, in addition to information on the evolution dynamic defining characteristics, for the elements of resistance, or non-structural, the directions of propagation of the effects of an earthquake, or referring to the nature of the registered damages (visible or not). These sensor assemblies include electrical, optical, mechanical, photometric, photogrammetric or geodetic technologies - in conjunction with the cost-benefit function, being necessary to be controlled remotely and the evolutions in their operation to be stored automatically.

The allowed digitization optimization allows the authorities and the owners to monitor not only the equipment for utilities, but also the overall behaviour of the building (Dragomir et al., 2017; 2018; 2020; Dobre et al., 2019).

Some activities involved in structural health monitoring-SHM are:

- permanent seismic monitoring of some special public buildings, belonging to importance classes I and II, in accordance with the current Romanian seismic design code, indicative P100-1/ 2013;
- seismic instrumentation (temporary) of special public buildings, of class II importance

(according to the current seismic design code, P100-1: 2013);

- identification and acquisition of software dedicated to monitoring, as well as the acquisition of new seismic stations etc.

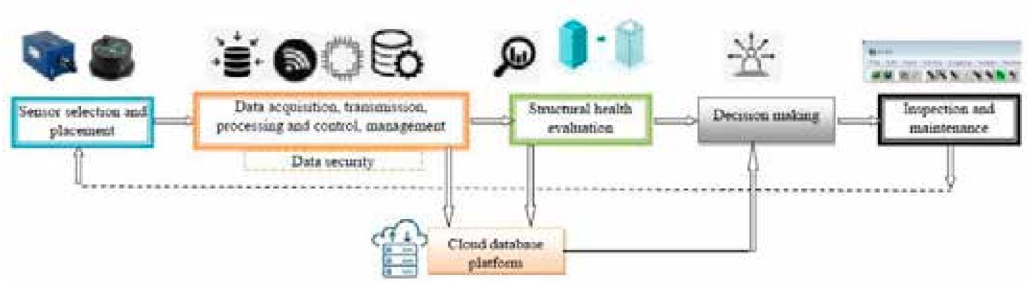

Figure 1. Logical scheme in the context of structural health monitoring and digitization

METHODOLOGY FOR DATA ACQUISITION AND PROCESSING

It is strongly related to the steps taken in order to obtain "zero" data records for the structural dynamic characteristics are the following:

- establishing the locations of the seismic stations according to the objectives, the structural configuration and the access mode; the layout schemes (on the vertical / horizontal direction of the building) of the sensors will be established;
- the effective location of the seismic stations according to the pre-established schemes; their connection with the equipment and with the laptop;
- starting the multichannel recording stations and the laptop and, respectively, launching the communication application with the equipment; setting how the recording is triggered (manually or automatically by defining a trigger threshold);
- determining how to recover / transfer the recorded data, stating that some types of transfer;
- making recordings/verification/calibration tests according to the procedures required by the equipment supplier;
- triggering recordings and recording structural vibrations due to vibration sources (ambient, seismic vibrations); at least five sets of recordings (2 minutes per recording) will be made in the same location;
- verification of each record after its completion with the available monitoring possibilities;
- completing the record form with the parameters of each location and the operating conditions of the vibration source;
- transfer of recordings on the HDD of the laptop/PC on which the recorded data processing software is installed;
- data processing in order to obtain graphic images regarding the time histories of accelerations, velocities and displacements; for each time history, the maximum amplitude obtained in that record will be specified etc.

The specific items of the methodology for data acquisition and processing are presented below (Figure 2).

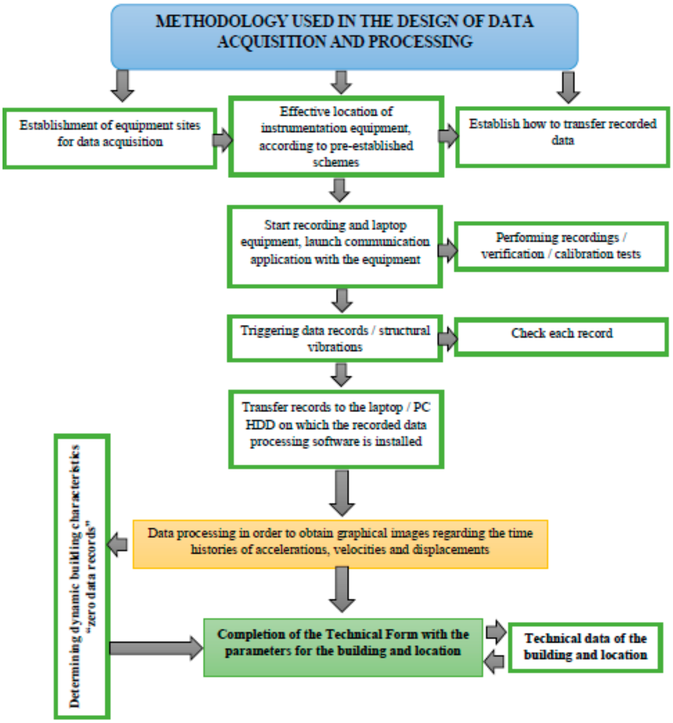

Figure 2. Steps of the Methodology for data acquisition and processing

SEISMIC INSTRUMENTATION/ MONITORING

Regardless of the studies on the identification and acquisition of monitoring software, are necessary activities referred to:

- documentation, identification and description of advanced software used in seismic monitoring of buildings (SeisComP - GFZ and Gempa, OASIS Plus and AUTOPRO (Kinemetrics), GEOSMART (GEOSIG), ARTEMIS Modal Pro, ANTELOPE (Kinemetrics) (Figures 3 and 4);
- identifying the software applications that will be purchased and installed in the data center; For example, Seiscomp, GeoSIG, ARTeMIS software are installed for the seismic monitoring of buildings to the data centre of NIRD URBAN-INECRC.
- temporary seismic instrumentation of some public buildings - elaboration of the technical files of the instrumented buildings, basic data obtained, analysis of the registered data;
- documentation and identification of software dedicated to the study of the structure-field interaction;
- activities carried out within the national seismic network in order to maintain the general functionality throughout the territory etc.

Regardless of the analysed building, the frequency ranges in which the spectral amplifications and the PGA level from ambient vibrations take place are highlighted in extensive technical reports.

From the point of view of the natural vibration periods of the instrumented building (ambient vibrations), based on the results obtained from the analysis of the response spectra it is found that, for the two orthogonal directions in the plane, the spectral amplifications are included in some domains of frequencies and the maximum accelerations do not exceed a limit value (Figure 5).

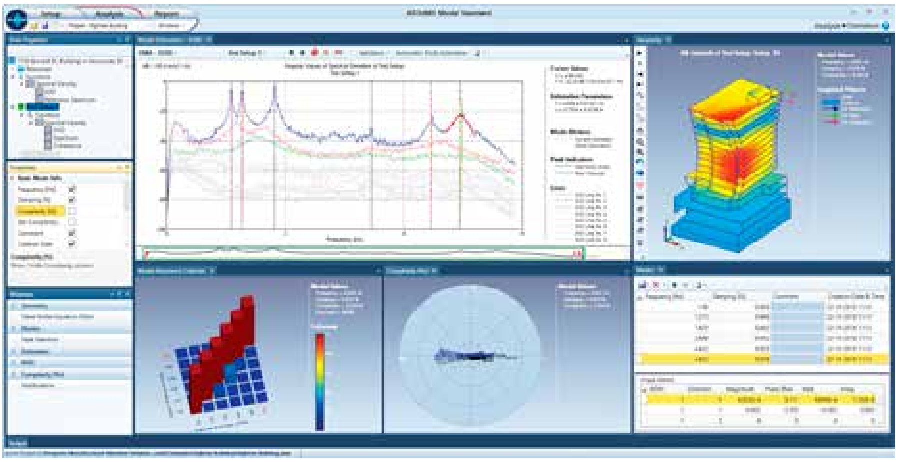

Figure 3. Results of seismic instrumentation/monitoring of buildings (Artemis)

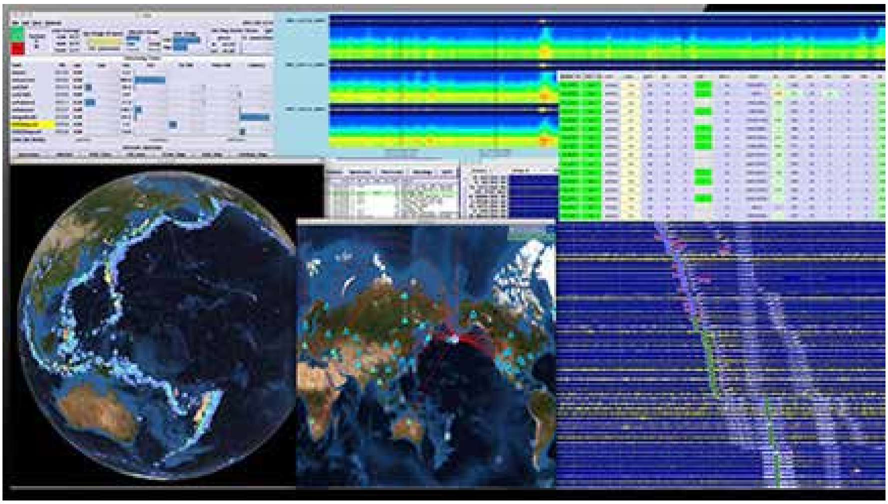

Figure 4. Data organizer, records and processing (Antelope)

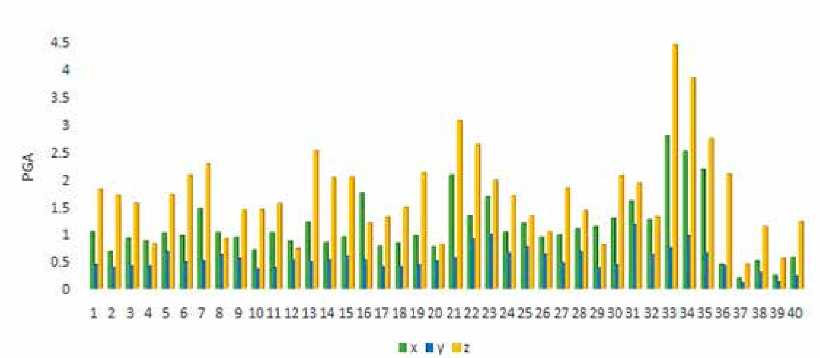

Figure 5. Example of PGA level from ambient vibrations

CONCEPTUAL FLOW OF APPROACHES TO SEISMIC VULNERABILITY ASSESSMENT. DIGITIZATION AND AUTOMATION

The usefulness of digitization is also reflected in the ability to collect and compare data obtained in real time from sensors located in a building (on different floors), or in collecting and comparing data received from an area for which certain value judgments are required. on the level of the dynamic parameters of the recorded movement/vibration, resulting in a large volume of data, which requires archiving and management to support immediate or subsequent analysis.
The following figure shows the conceptual flow of approaches for assessing seismic vulnerability, based on digitization and automation (Figure 6).

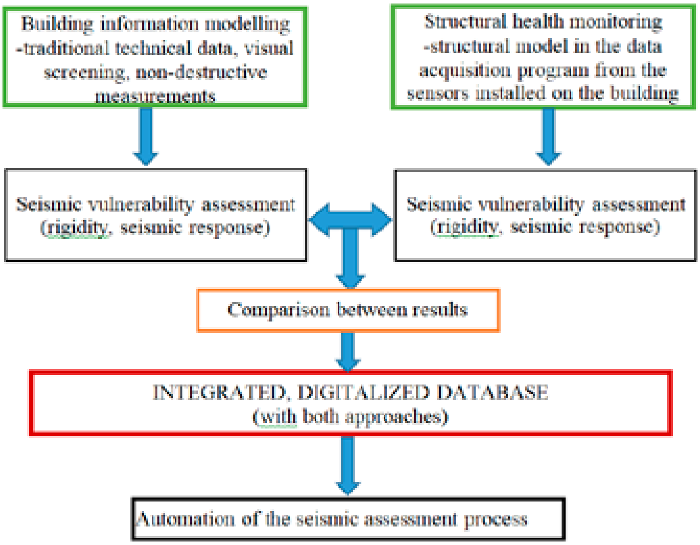

Figure 6. Building information modelling and Structural health monitoring

RESULTS OF THE INSTRUMENTATION/ MONITORING

The obtained results are transferable and of special technical and legal importance, the elaborated documents representing the basis for the Technical Book, and the archived data constituting initial records for the future data obtained after a major earthquake.
Finding a reliable solution for a quick analysis after an earthquake by generating a report with the dynamic parameters of the monitored buildings behaviour, is a challenge of a strategic and logistical nature, of acquisition, storage and continuous processing of data, elaboration of analytical models for validation, in context of digital approach for structural engineering.
The prepared technical data sheets include (variably, depending on the possibility of collecting data from existing plans/reports/ works) some details represented in (Figure 7).

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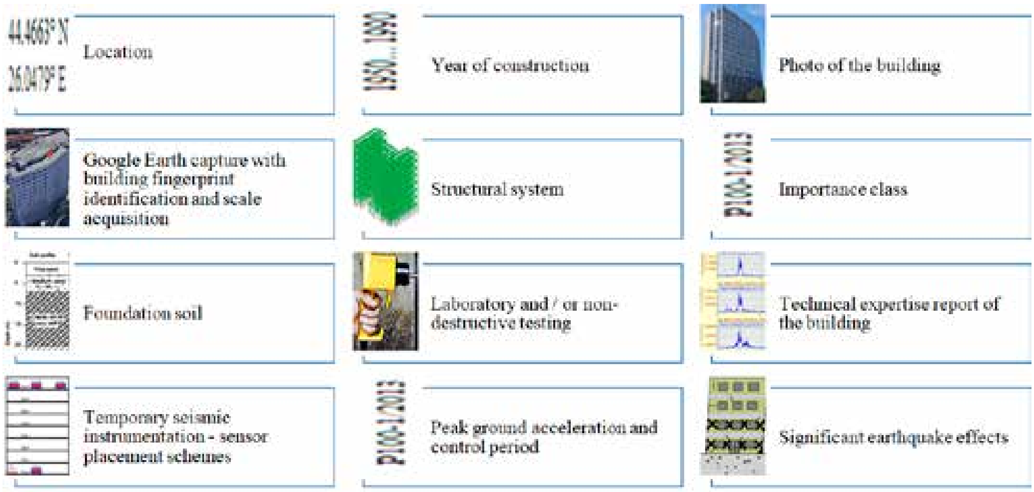

Figure 7. Block scheme with technical data

CONCLUSIONS

Monitoring seismic vibrations or from other sources, both on the ground and on buildings, has many applications in maintaining the safety and normal functionality of the built fund. Internationally, many integrated hardware and software solutions have been developed recently, which ensure the acquisition, processing and analysis of recorded data, quickly or in real time. They are an essential element in preventing the effects of earthquakes or dangerous vibrations on buildings and infrastructure, in early warning and in substantiating rapid post-earthquake response strategies.
Based on the synthesized information, we proceeded to identify software solutions for real-time data transmission, acquisition and processing, which will be installed in the Data Center of the seismic network of INCD URBAN INCERC, infrastructure operating within the Department "National Monitoring Network and Seismic Protection of Built Heritage (IOSIN)". The most appropriate solutions have been identified, both in terms of functionality and the necessary investment, respectively available. An important criterion in the selection was the modular structure of the platform used, so that the gradual expansion and completion of the system can be considered, through successive endowments, but acquiring, from the very beginning, one or more basic functionalities, so that the system can be installed in a pilot, preliminary form.

ACKNOWLEDGEMENTS

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REFERENCES

Dragomir C.S. & Dobre D., (2017). "Selection criteria for investigation of microseismic and ambient vibrations. Case studies", 17th International Multidisciplinary Scientific Geoconference & Expo SGEM, Albena, Bulgaria, doi: 10.5593/sgem2017/14/S05.049.

Dragomir C.S., Craifaleanu I.G., Dobre D. & Georgescu E.S., (2018). "Prospective studies for the implemen tation of a remote access earthquake damage detection system for high-rise buildings in Romania", Proceedings of the The World Multidisciplinary Earth Sciences Symposium/WMESS, Prague, Czech Republic, doi:10.1088/1755-1315/221/1/012036.

Dobre D., Dragomir C.S. & Georgescu E.S., (2019). "Experiential learning for seismic protection using living lab approach in Romania", Proceedings of the World Multidisciplinary Civil Engineering-Architecture- Urban Planning Symposium World Multidisciplinary Civil Engineering - Architecture-Urban Planning Symposium/WMCAUS, Prague, Czech Republic, DOI:10.1088/1757-899X/603/2/022020.

Dragomir C.S. & Dobre D., (2020). "Improvements in a smart monitoring system for buildings", XXth International Multidisciplinary Scientific GeoConference Surveying, Geology and Mining, Ecology and Management - SGEM 2020, doi: 10.5593/sgem2020/1.2/s05.075, 2020.

Dragomir C.S., Dobre D. & Iliescu V., (2020). "A comprehensive approach for the seismic vulnerability of a building of public utility", The 5th World Multidisciplinary Civil Engineering-Architecture-Urban Planning Symposium WMCAUS, doi:10.1088/1757-899X/960/4/042073.