Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. IX, 2020
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

AN INTEGRATED NATIONAL SYSTEM FOR ASSURING THE QUICK EVALUATION OF THE VULNERABILITY OF ALL INSTRUMENTED BUILDINGS AFTER AN EARTHQUAKE. RECENT DEVELOPMENTS

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

[1]University of Agronomic Sciences and Veterinary Medicine of Bucharest, 59 Marasti Blvd., District 1, Bucharest, Romania
[2]Technical University of Civil Engineering Bucharest, 122-124 Lacul Tei Blvd., 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

Within the National Network for Seismic Monitoring and Protection of Constructed Heritage from INCD URBAN-INCERC, studies are being conducted in the field of structural health monitoring having as object real buildings, seismically instrumented with modern equipment. The identification of equipment and connection types existing within the Network for Seismic Monitoring and Protection of Constructed Heritage, as well as the implementation of solution for seismic data transfer to the Data Centre, these aspects are followed. A multi-criteria selection is applied, which takes into account also the compatibility with equipment existing within the National Seismic Network for Constructions at URBAN-INCERC, to ensure their efficient use.
Some case studies are presented in the general way, focused on achieving the connections in distinct locations, by applying the own solutions for data communication (INCD URBAN-INCERC local system; The Cathedral of Saint Alexandru and Saint Nicholas of SULINA local system; The Arnota Monastery local system; Balta Alba Block of flats etc.)

***Key words**: ambient/industrial vibrations, accelerations/velocities, damages.*

INTRODUCTION

Within the National Network for Seismic Monitoring and Protection of Constructed Heritage from INCD URBAN-INCERC, studies are being conducted in the field of structural health monitoring having as object real buildings, seismically instrumented with modern equipment (Figure 1).
The identification of equipment and connection types, as well as the implementation of new solutions for seismic data transfer to the Data Center, are issues to be solved in the development of the improved network.
There are several key parameters to consider when designing a physical data transmission system:

- the necessary information flow (the bandwidth of the channel for analogue links or the rate of data transfer with digital links);
- the desired reliability (the acceptable loading time of the connections, that is the maximum period of time per year when the signal-to-noise ratio is lower than necessary (analog connections) or the error rate of bits is higher than the allowed one (digital connections);
- the physical network and the protocol that will be used to establish a virtual seismic network (internet, WAN property networks (large space networks), public analog telephone network).

A multi-criteria selection is applied, which takes into account also the compatibility with equipment existing within the National Seismic Network for Constructions at URBAN-INCERC, to ensure their efficient use (Dragomir et al., 2012; 2017; 2019).

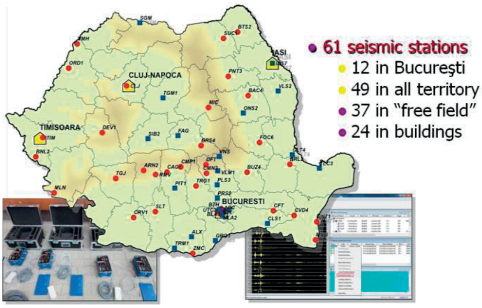

Figure 1. Seismically instrumented buildings by URBAN-INCERC

MATERIALS AND METHODS

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); an Ethernet connection and optional Wi-Fi for fast data transfer; a mobile network available in the area from which the data is transmitted; a software; automatically applying different types of filters to recorded data etc.) After the acquisition of the signal, before calculation of any response spectrum, the baseline correction (to have a zero-mean signal and to remove any linear trend) and high-pass/low-pass filtering (to remove the high-frequency and low-frequency noise) are necessary.

Some case studies are presented in the general way, focused on achieving the connections in distinct locations, by applying the own solutions for data communication.

RESULTS AND DISCUSSIONS

INCD URBAN-INCERC. The local system for connection to the existing monitoring network: Connection via Lantronix Server/MoxaNPort Express DE-311 RS-232/422/485 Device Server, Switch, Accelerometer ETNA (Figure 2).

The Cathedral of Saint Alexandru and Saint Nicholas of SULINA. The local system for connection to the existing monitoring network: ODU - outdoor unit, IDU - indoor unit, BDID - WIMAX antenna, ETNA2 accelerometer (Figure 3).

The Arnota Monastery. The local system for connection to the existing monitoring network: ETNA accelerometer, tp-link Switch light wave ls105g, Huawei Router model B311s-220 (with IP purchased from Internet Service Provider; Network Connection Solution: Orange Card Subscription) (Figure 4).

Balta Alba Block of flats. The local system for connection to the existing monitoring network: ODU - outdoor unit, IDU - indoor unit, BDID - WIMAX antenna, ETNA2 accelerometer (Figure 5).

Figure 2. The connection system, Bucharest

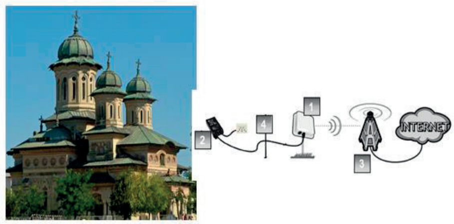

Figure 3. Position and the connection system, Sulina

Figure 4. Position and the connection system - Valcea

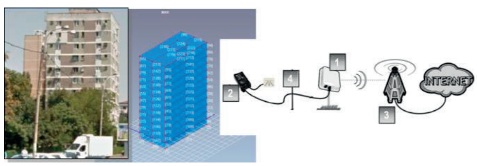

Figure 5. Position and the connection system - Bucharest

In the case of each case study, the purpose was to obtain data, received through the made connections that would allow later processing and interpretation.
Thus, in the following figures, the acceleration in the basement of the building, the velocity monitoring from the ambient vibration, the acceleration during the detonation from the limestone quarry, the operational modal analysis (OMA) in real time – with the identification of the dynamic characteristics of the structure and the damage assessments are shown (Figures 6, 7, 8 and 9).

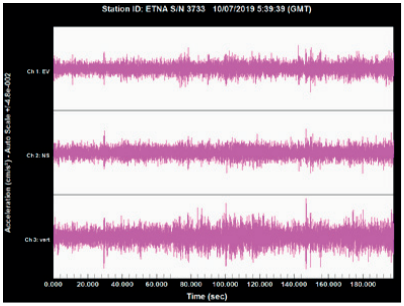

Figure 6. Acceleration monitoring in the basement of the building. INCD URBAN-INCERC

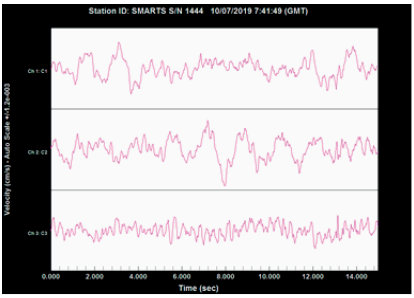

Figure 7. Velocity monitoring from the ambient vibration. The Cathedral of SULINA

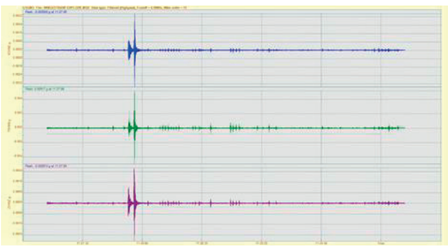

Figure 8. Acceleration during the detonation from the limestone quarry. The Arnota Monastery

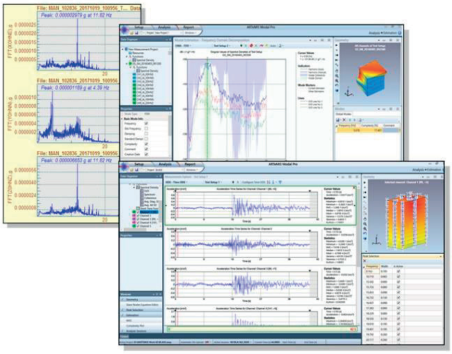

Figure 9. Operational modal analysis (OMA) in real time - identification of the dynamic characteristics of the structure. Damage assessments. Balta Alba Block of flats

CONCLUSIONS

Research conducted in INCD URBAN-INCERC 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 buildings (Dragomir et al., 2012; 2017; 2019; Alexe et al., 2006).
The temporary instrumentation and/or (permanent) monitoring of a building, under the conditions specified by the codes P130/1999 and P100-2013, is a necessity fulfilled through the studies elaborated within this research.
The completion of the registered and processed data, from the sites where seismic sensors (free-field type, or in buildings) were installed, provides a clearer picture of the level of local accelerations, specific to different soil conditions (Dobrescu, 2013; Dobrescu et al., 2017), and soil-structure interaction (Dobre et al., 2013) and of compared to the values of the accelerations from the seismic zoning map. As a future stage, after determining the vibration level through temporary instrumentationand/or (permanent) monitoring, different vibration active and-semi active control systems can be adopted in order to minimize the vibrations in real time (Luca et al., 2015; Pastia et al., 2016).

ACKNOWLEDGEMENTS

Results are part of the project “Research on the implementation of an integrated system for ensuring the security of the constructed space, with semi-automatic generation of PGA maps provided by seismic actions or other vibratory sources and quick evaluation of vulnerability of instrumented buildings" (PN19 33 01 01).

REFERENCES

Alexe R., Calin A., Calin C., Dragomir C. S., Nicolae M., Pop O., Slave C. (2006). Earthquake risk reduction of university buildings, *First European Conference on Earthquake Engineering and Seismology* (a joint event of the 13th ECEE & 30th General Assembly of the ESC) Geneva, Switzerland.

Dobre D., Dragomir C. S., Borcia I. S., Georgescu E. S. (2013). Modelling seismic response of adjacent buildings under Vrancea earthquake input, *SE-50 EEE, International Conference on Earthquake Engineering*, Skopje, Macedonia.

Dobrescu C. F., Călăraşu E. A., Stoica M., Moldoveanu Tr., Tamas Fl. L. (2013). Experimental testing for the analysis of a landslide phenomenon produced in a hillside area from Romania, *Advanced Materials Research*, Vol. 969.

Dobrescu C. F (2017). Study concerning bearing assessment of natural and stabilized soils using binders with ecological benefits based on parametric correlations*, Romanian Journal of Materials*, 47-1.

Dragomir C. S., Dobre D., Craifaleanu I. G., Georgescu E. S. (2017). Ex-ante and ex-post instrumental diagnosis of buildings structural health, an approach at the level of the National Seismic network, URBAN-INCERC. *Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering*, Vol. V.

Dragomir, C. S., Craifaleanu, I. G., Dobre, D., Georgescu, E. S. (2019). Prospective Studies for the Implementation of a Remote Access Earthquake Damage Detection System for High-Rise Buildings in Romania. *IOP Conference Series: Earth and Environmental Science*, Vol. 221.

Dragomir, C. S., Dobre, D., Craifaleanu, I. G., Georgescu, E. S. (2017). On-line Data Transmission, as Part of the Seismic Evaluation Process in the Buildings Field. *IOP Conference Series: Earth and Environmental Science*, Volume 95, Session I. Tectonics & Structural Geology, Engineering Geology, Geotechnics, Hydro & Hydrogeological Sciences, Vol. 95.

Dragomir C. S., Matei C. L., Dobre D., Georgescu E. S. (2012). New concept and solutions for post-seismic assessment and strengthening of buildings, *Scientific Papers. Series E. Land Reclamation, Earth Observation&Surveying, Environmental Engineering*. Vol. I.

Luca S. G., Pastia C., Budescu M., Teodoru I., Bejan F. (2015). Evaluation of Seismic Energy in Structures using Passive Fluid Dampers, *15-th SGEM GeoConference on Science and Technologies in Geology, Exploration and Mining*, *SGEM 2015* Conference Proceedings, Bulgaria, Vol.III.

Pastia C., Luca S. G., Păuleţ-Crăiniceanu F., Florea V. (2016). Passive, Active and Semi-Active Vibration Control of a Classical Mass-Spring-Dashpot System, *16-th International Multidisciplinary Scientific GeoConference SGEM 2016*, Bulgaria.