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To cite this article: Claudiu Sorin Dragomir and Daniela Dobre 2019 *IOP Conf. Ser.: Mater. Sci. Eng.* **471** 052089

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Processing Data from Vibration Recordings

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Abstract. The article aims to present a way of processing the data within a real-time transmission system of recorded vibration. At present, Romanian National Strong Motion Network for Constructions of URBAN-INCERC has 56 seismic / digital accelerometer stations, of which 46 are in territory and 10 in Bucharest. The seismic stations of this system are placed in some ground floor-buildings type, assimilated with the free-field, or in buildings with 1-3 levels. First application of the real-time transmission system is related to the accelerometric records from moderate earthquakes, which have shown a spatial distribution of PGA with NE-SW directivity, similar to that observed under certain conditions of seismic severity in previous strong earthquakes. Some charts illustrating the acceleration amplitudes recorded from the 2016 and 2017 earthquakes in the URBAN-INCERC network will be shown. The second application is referred to the structural response (structural behaviour under ambient vibrations or moderate and severe seismic motions). Generally, the spectral analysis of these records leads to getting: the natural frequencies, the influence of the general directivity of waves propagation specific to the Vrancea source (on the spectral content and on structural response), the influence of the local soil conditions etc. In this case, for a study building, the vibration modes, the drift/the relative floor displacement etc. can result from this processing, with a validation based on a structural modelling with finite elements. The seismic wave propagation direction is the first option for determining the direction of propagation of severe effects on buildings. The correlation between them can be validated by the existence of pre-event dynamic characteristics of those buildings (before a major seismic event) and at post-event time.

1. Introduction

The seismic network of the National Institute for Research and Development in Construction, Urban Planning and Sustainable Spatial Development “URBAN-INCERC” in Romania plays an important role in earthquake data acquisition, being in continuous operation for 50 years (providing the record of the M=7.2, 1977 Vrancea earthquake, and a complete record database for the 1986 and 1990 Vrancea earthquakes).

Currently, the National Network for Monitoring and Protection of Built Environment of NIRD URBAN-INCERC has 56 seismic stations. Within the real-time transmission system of recorded



vibration, the seismic stations are placed in some ground floor-buildings type, assimilated with the free-field, or in buildings with 1-3 levels, as well as mobile stations, figure 1.

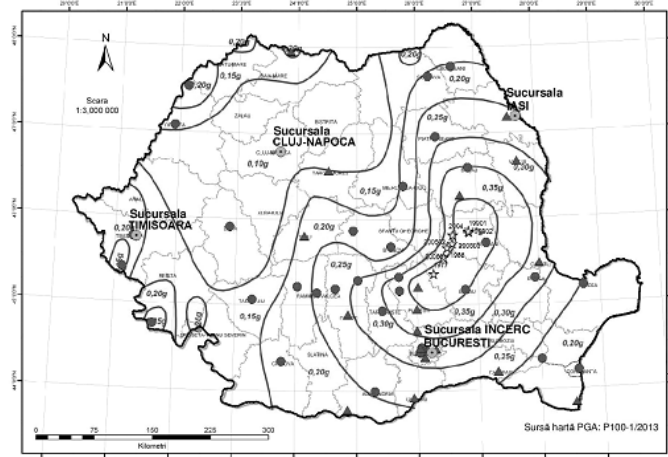


Figure 1. The location of the seismic stations of the NIRD URBAN-INCERC National Network for Monitoring and Protection of Built Environment, in correlation with the zoning map of Seismic Design Code P100-1 / 2013 (PGA, IMR = 225 years)

In figure 2 are presented some types of instrumented buildings.

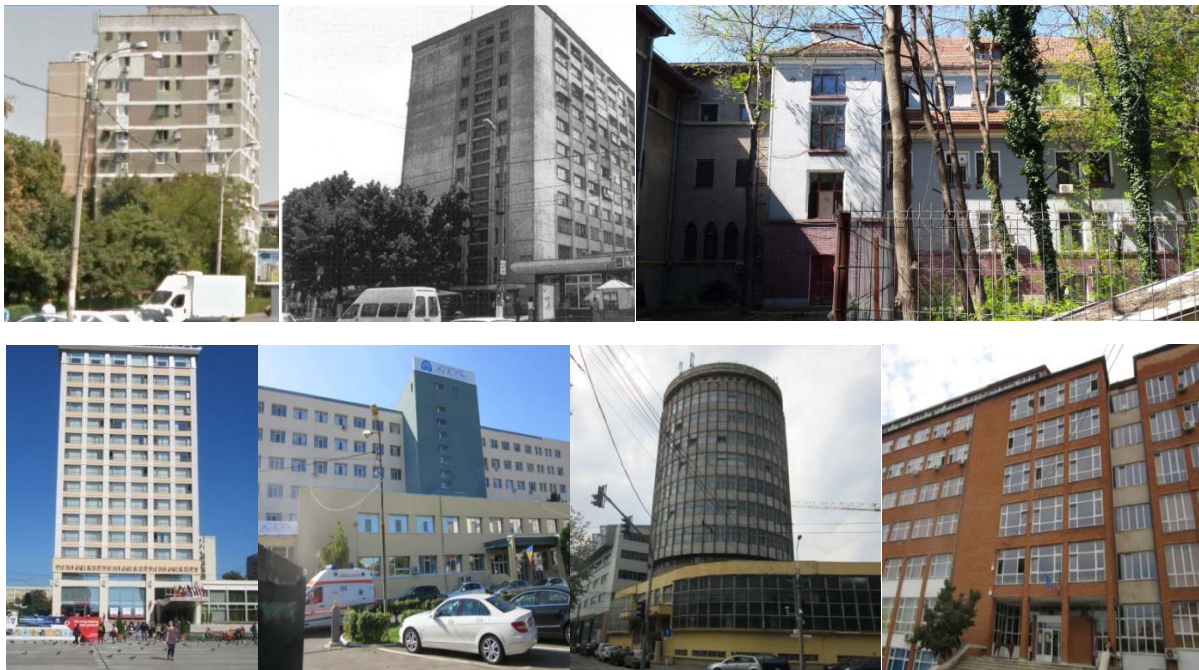


Figure 2. Buildings instrumented by URBAN-INCERC: multi-apartment building, Bucharest and Galati; Section A of Endocrinology Institute, Bucharest; hotel (Iasi), Clinical Hospital (Iasi); National R&D Institute for Welding and Material Testing (Timisoara); Civil Engineering Faculty- Politechnica University of Timisoara

2. Some conceptual and applicative aspects developed within the real-time transmission system of recorded vibration

In figure 3 is presented the current state of seismic instrumentation and methods for determining the dynamic characteristics of buildings, some conceptual and applicative aspects etc. developed with the setting of the system [1-5].

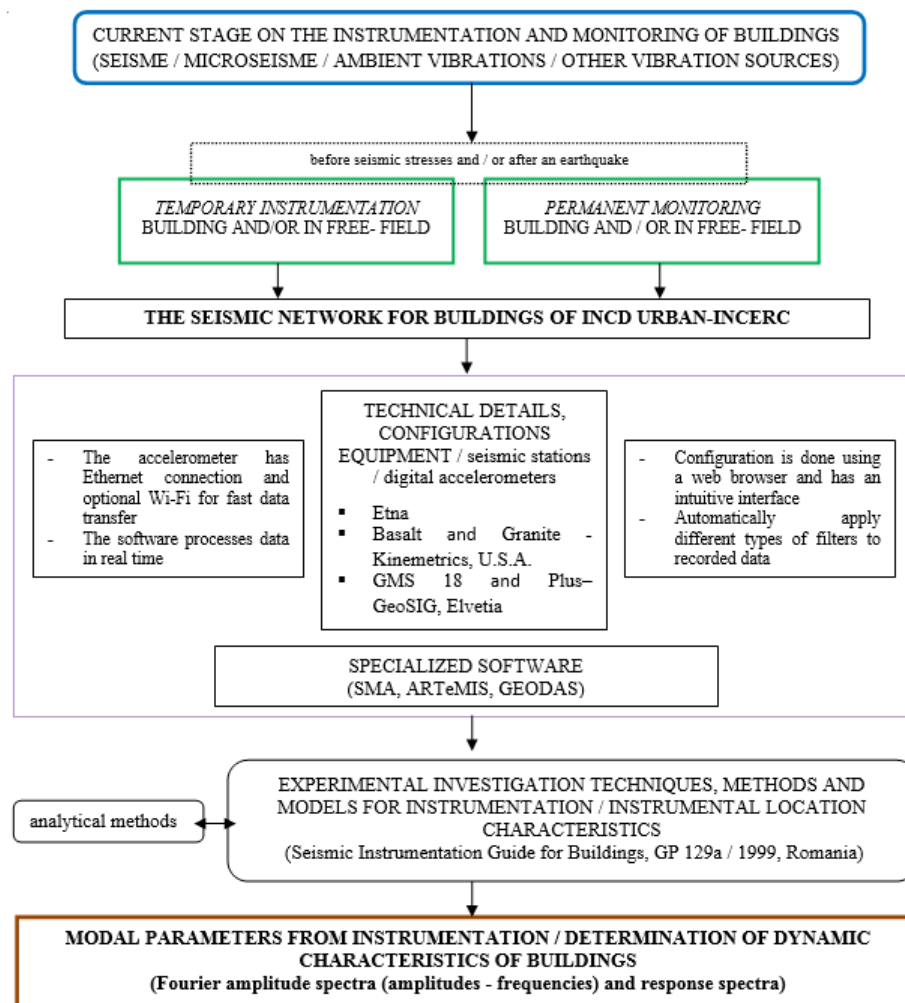


Figure 3. Conceptual and applicative aspects within the real-time transmission system

3. Accelerometric data from recent earthquakes

First application of the real-time transmission system is related to the accelerometric records from moderate earthquakes, which have shown a spatial distribution of PGA with NE-SW directivity, similar to that observed under certain conditions of seismic severity in previous strong earthquakes.

Some charts illustrating the acceleration amplitudes recorded from the 2016 and 2017 earthquakes in the URBAN-INCERC network are shown in figure 4.

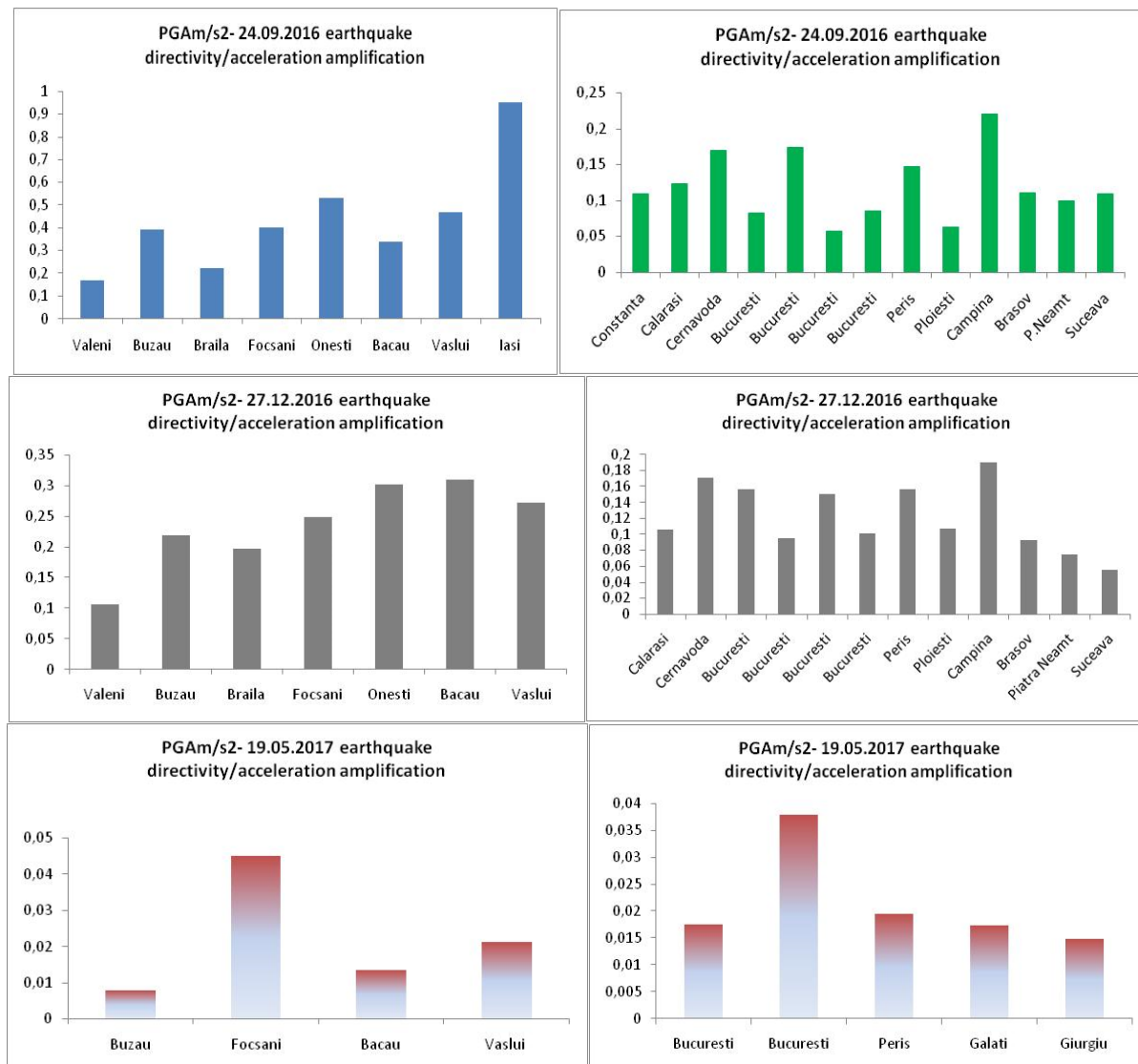


Figure 4. Peak ground acceleration values, compared for earthquakes from 2016 and 2017

4. Structural behaviour under ambient vibrations or moderate/severe seismic motions

The second application is referred to the structural response (structural behaviour under ambient vibrations or moderate and severe seismic motions). Generally, the spectral analysis of these records leads to getting: the natural frequencies, the influence of the general directivity of waves propagation specific to the Vrancea source (on the spectral content of the seismic recording and on structural response), the influence of the local soil conditions etc.

A building with an interesting history related on the instrumentation over time, for which it is desired to fill in the information regarding the evolution of the dynamic characteristics before and after the incidence of a major seismic event, was chosen.

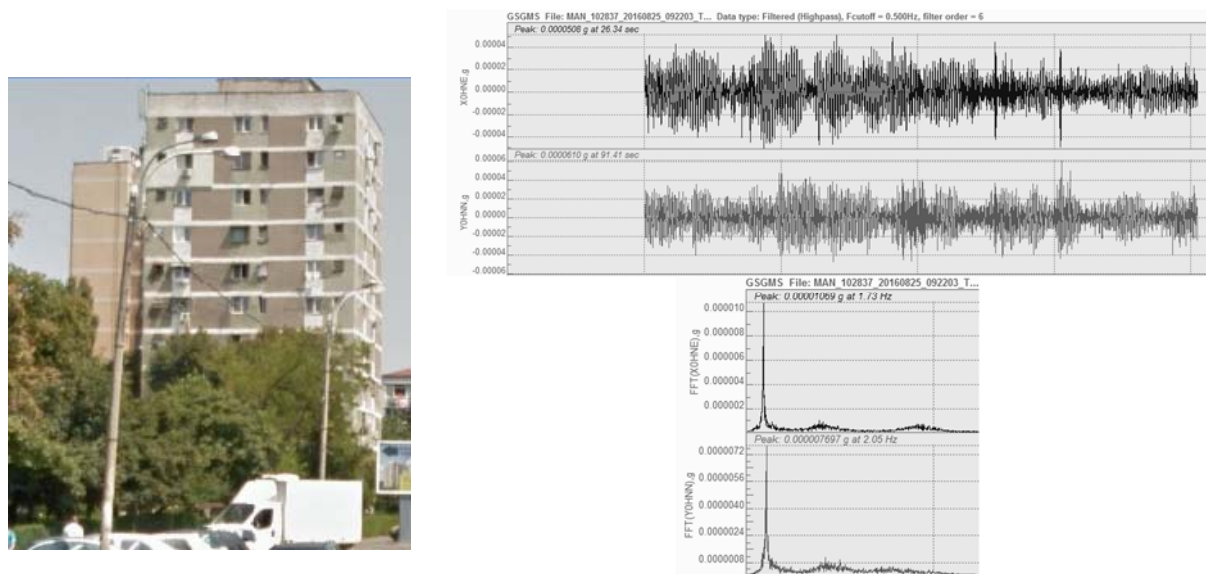


Figure 5. An instrumented building from Bucharest, a block of flats (ongoing permanent monitoring)

In Tables 1, 2 and 3 are shown: the maximum acceleration values recorded at some severe earthquakes, the maximum acceleration values from ambient vibrations, as well as the evolution of vibration frequencies.

Table 1. Maximum acceleration values recorded at some severe earthquakes (m/s^2)

4.03.1977 earthquake	30/31.08.1986 earthquake	30.05.1990 earthquake	31.05.1990 earthquake
Basement -	Basement $a=0.87$ (tr) $a=0.92$ (long)	Basement $a=0.53$ (tr) $a=0.66$ (long)	Basement $a=0.18$ (tr) $a=0.11$ (long)
Level 10 $a=2.25$ (tr) $a=4.65$ (long)	Level 10 -	Level 10 $a=0.95$ (tr) $a=2.07$ (long)	Level 10 $a=0.38$ (tr) $a=0.27$ (long)

Table 2. Maximum acceleration values from ambient vibrations, 2016 (m/s^2)

Level	Direction x	Direction y
Basement	0.000924	0.002043
Level 5	0.001588	0.001517
Level 10	0.00133	0.002329
Terrace	0.003356	0.003573

Table 3. Evolution of vibration frequencies (Hz)
(from calculations and seismic/microseismic and ambient records)

Before 1977(computed)	After 1977(computed)	1986(computed)	2017(instrumentation)
$f_{tr}=1.88$	$f_{tr}=1.70$	$f_{tr}=1.69$	$f_{tr}=1.73$
$f_{long}=2.32$	$f_{long}=2.22$	$f_{long}=2.04$	$f_{long}=2.05$

5. Results and discussions

Applications within the on-line data transmission system have been implemented, which involved the processing of the obtained data, with the available specialized software. The order of magnitude for accelerations, obtained in the case of earthquakes from 2016 and 2017, shows the directivity NE-SW

and the predilection of the spatial distribution, similar to those observed under certain conditions of seismic severity in previous strong earthquakes (and presented in other Romanian studies).

From Table 3, a correlation of the values of the structural dynamic characteristics determined in situ and theoretically is observed for the case study.

6. Conclusions

The seismic wave propagation direction is the first option for determining the direction of propagation of severe effects on buildings. The correlation between them can be validated by the existence of pre-event dynamic characteristics of those buildings (before a major seismic event) and at post-event time.

Acknowledgements

This research work is based on results obtained in National Research Programs: Integrated researches for resilience, efficiency and comfort of built environment – CRESC, PN 16-10.01.01 and Research for smart specialization, sustainable territorial development, environment preservation and resilience of building heritage – CONCRET, PN 18 - 10.01.01.

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