BUILDINGS MONITORING ACHIEVEMENTS IN HIGHLY RISK-EXPOSED CITIES

INFP

National Institute for Earth Physics

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Introduction

The seismic hazard of the Romanian territory is controlled by Vrancea seismogenic source, which generates strong intermediate-depth earthquakes that affect many highly developed cities. The capital, Bucharest, underwent a rapid and quite uncontrolled urban growth in the last decades, hence the high level of the seismic risk places the city as one of the most endangered metropolises in Europe.

Objectives

The aim was to evaluate and analyse the response of the certain structures located in highly risk-exposed cities areas within a monitoring program carried out at National Institute for Earth Physics (NIEP) which is in charge at national level in earthquake surveillance, seismic-related phenomena and data processing.

Study Area

Data recordings for providing results in seismic hazard evaluation and risk mitigation purposes. Seismic events of magnitudes M_W from 3.8 to 5.6 and a large variety of focal depths, 40 km to 148 km, for 2014-2017 time period. **Bucharest city**: ●~120-170 km from epicentre area; ●a wide distribution of buildings, various seismic design codes, large variety of construction materials; ● seismic source characteristics, geology and local effects, making seismic risk mitigation a difficult task. **Focsani city**: ●~40-50 km, nearer the epicentre zone, Vrancea.

Fig.1 Buildings and their location on Bucharest map.

Fig.2 Instrumented tower-type buildings.

Methodology

●accelerometers data recorded on certain buildings located in metropolitan areas; ●selection of the buildings according to their specificity (old buildings, retrofitted, etc.) (Balan et al., 2022a,b); ●the response of these structures, at the ground level, subjected to medium intensity earthquakes is discussed in terms of peak accelerations and spectral accelerations; ●the response of five structures in Bucharest metropolitan area, subjected to M_W=5.6, in terms of Fourier amplitudes; ●the performance of base-isolation and damping earthquake-protection systems during earthquake was assessed (Balan et al., 2022a,b).

Bibliography

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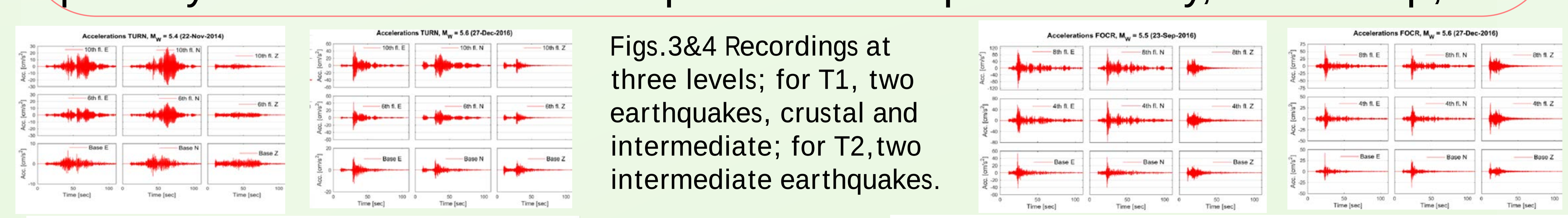
Balan, S.F. Apostol, B.F., Tiganescu, A., Dăneț, A. (2022b). Monitoring buildings at INFP for seismic vulnerability mitigation. *3rd European Conference on Earthquake Engineering & Seismology*, Bucharest, Romania (3ECEES), September 2022, pp.4381-4386.

Results

T1 building: ●increase of acceleration with focal depth, valid for higher magnitude, above 5.4, and also for 4.3-4.4 (M_w). For these rather lower magnitude earthquakes have almost the same epicentre localization; ●no clear relation of amplitude with magnitude; ●influencing factors are distance, focal depth, focal mechanism; ●clear difference of waveform for crustal (Mw=5.4;h=41km) and intermediate depth (M_w=5.6;h=97km) events. **T2 building**: ●higher accelerations for the M_w=5.5 compared to M_w=5.6 event, possibly due to different source parameters: rupture velocity, stress drop,etc.



Figs.3&4 Recordings at three levels; for T1, two earthquakes, crustal and intermediate; for T2,two intermediate earthquakes.

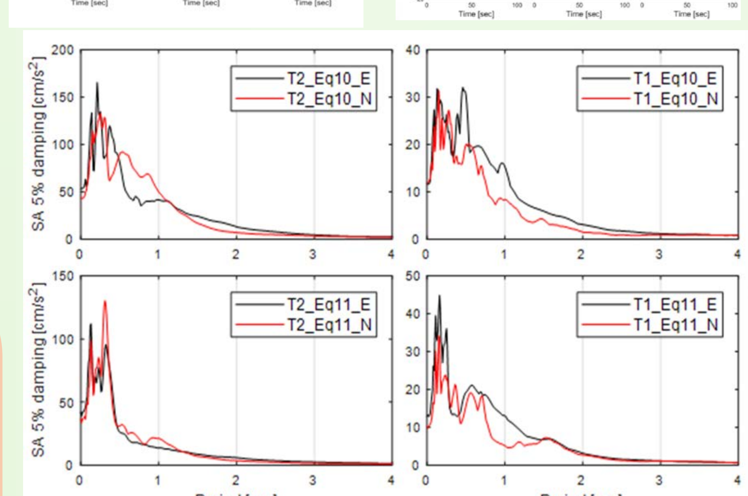


Fig.5 Acceleration response spectra for two horizontal components at the basement T1&T2 buildings, for two strongest earthquakes.

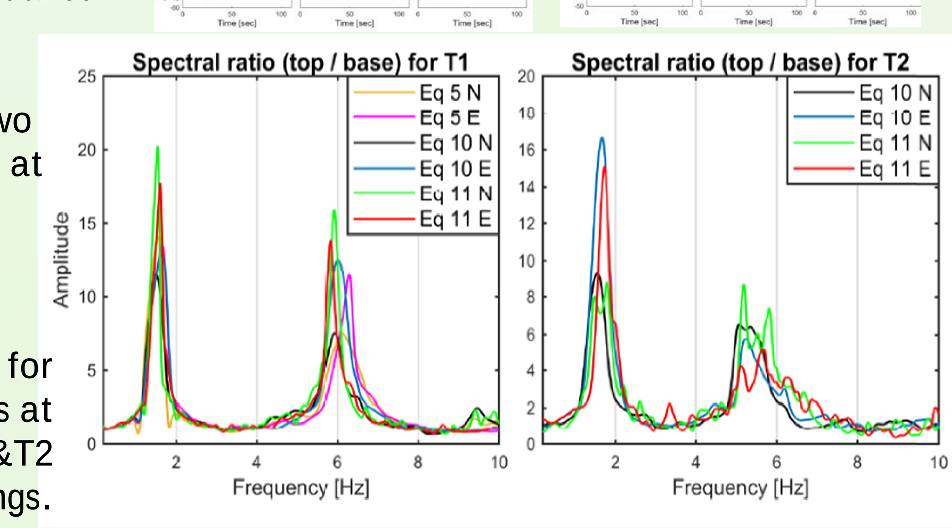


Fig.6 Spectral ratios for several earthquakes at two tower-type T1&T2 buildings.

Building T1: the spectral ratio for three earthquakes M_W>5; a good consistency for the peaks, despite different focal depths; fundamental frequency mean value 1.59 Hz (period 0.63 seconds, Fig.6, left). **Building T2**: a larger dispersion of the results regarding the second peaks (Fig.6, right); fundamental frequency mean value 1.64 Hz (period 0.61 seconds), and compared to T1 building, which is 2 stories higher, the two values are close (0.61 and 0.63 seconds). Possible explanation: the two structural systems are different, shear walls and frames, and T1 was retrofitted after the 1977 (M_W 7.4) earthquake.

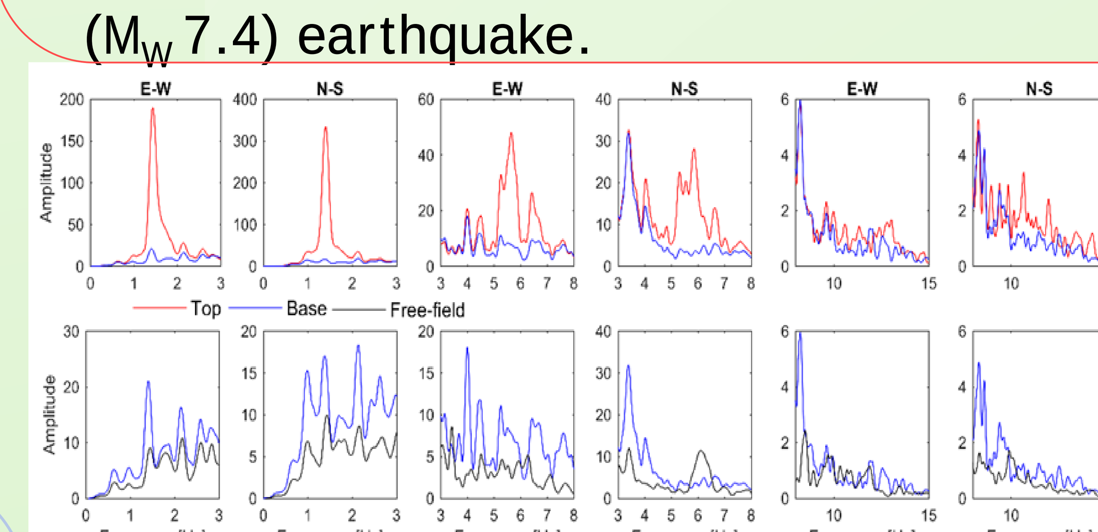


Fig.7 Fourier Spectra on three frequency intervals at TURN-BUC1, for 28th of October 2018 Vrancea earthquake (M_W=5.5)

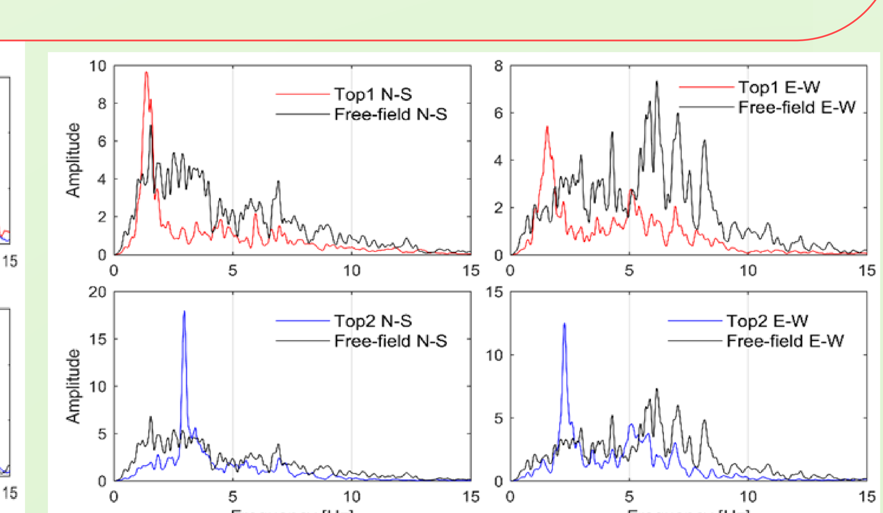


Fig.8 Fourier spectra comparison for NTR-BSTR pair

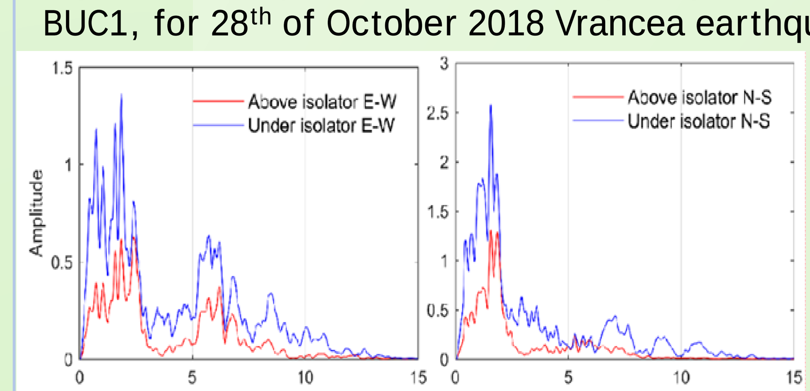


Fig.9 Fourier spectra comparison for ASE building

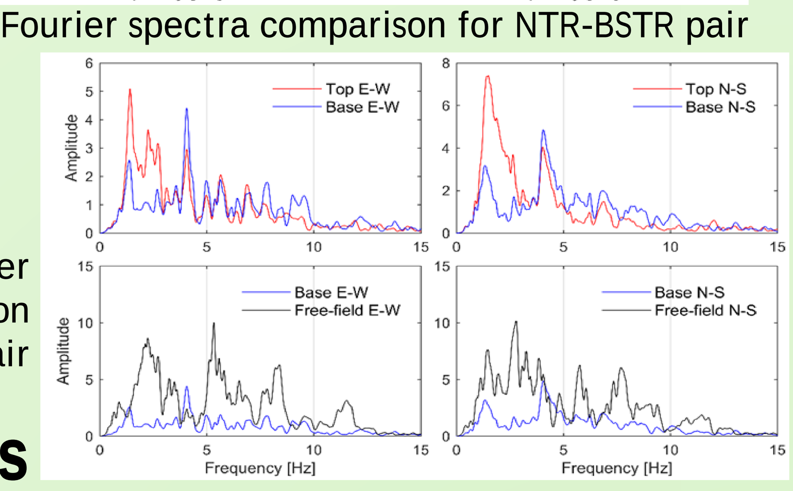


Fig.10 Fourier spectra comparison for ARC-ARCB pair

Conclusions

- TURN(T1) – high amplification of the motion base to the top, mainly controlled by the dynamic characteristics of the building. Larger values of acceleration at the base, compared to free-field station at 340 m away (BUC1) (Fig. 7);
- NTR – low values of acceleration on top, compared to the free field data (240 m away)(Fig.8);
- ASE – higher values of accelerations under the isolated structure, compared to the free-field station (BSTR) 600 m away. Efficient earthquake protection system, signal reduction with a factor of 2.1 (E-W) and 3.7 (N-S) (Fig. 9);
- ARC - earthquake protection system (base-isolators and dampers) that has reduced the free-filed acceleration by a factor of 3 (N-S) and 4.4 (E-W). Almost no amplification from base to top;
- PMB - seismic isolators, small amplification from base to top. Similar or slightly smaller acceleration of the base compared to free-field sensor (BTMR, 1.1 km away).