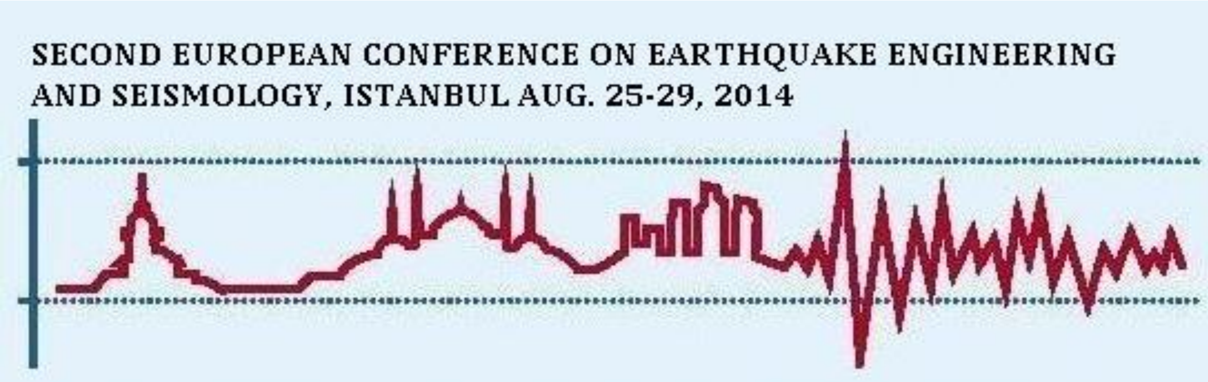

ADAPTING SEISMIC LOSS ESTIMATION SOFTWARE TO LOCAL CONDITIONS – VRANCEA INTERMEDIATE-DEPTH EARTHQUAKES CASE STUDY

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The recent development of new seismic loss estimation software, derived from the HAZUS initiative, has created in the last 5 years the possibility of using analytical methods for assessing the possible seismic damage, in areas with other particularities than the US territory (to whom HAZUS is so intimately related). These particularities are in fact very important, whether they are related to the seismic hazard or the building and socio-economic vulnerabilities. The local site conditions, the predicted attenuation of the seismic waves from earthquakes with specific foci and depth, the building stock characteristics reflecting the building practices and the seismic design codes etc., these all can have a great impact on the loss estimates. Therefore, the softwares have to be flexible and allow the user to integrate its own requirements.

In this paper we analyze the possibilities of adding custom data to various european state-of-the art seismic loss estimation software, testing how much can the limitations of these software affect the results. We also review the up-to-date literature, trying to find downsides or bottle-necks in the methods used by these software and possibilities of improvement. Our interest is based on the desire to use hazard data from Vrancea intermediate-depth earthquakes, which, as we will show, have a very distinct signature compared to crustal earthquakes (90% of worlds earthquakes are crustal), and need to be taken into account accordingly.

We use two software solutions, which are also compared in the end:

- ELER vers. 3 (Earthquake Loss Estimation Routine), developed by the KOERI Institute (Turkey) within the NERIES Project
- SELENA vers. 2010 (SEismic Loss EstimatioN using a logic tree Approach), developed by the NORSAR Institute (Norway)

As showed in figure 1, the Vrancea Source is located in the Carpathian Arch Curvature, at the intersection between the East-European Plate and the Moesian and the Intra-Alpine Subplates. Statistically, 2 or 3 earthquakes with moment magnitudes greater than 7 occur per century. The depth of the earthquakes is quite variable, being in a 60 to 180 km range. This variability, as well as the nature of intermediate-depth earthquakes (below the Moho discontinuity), leads to several problems when trying to express the ground parameters, especially for loss estimations:

- Because the extent of the area that can be damaged is much wider than in the case of crustal earthquakes (it can reach a 400 km radius), many strong motion stations are needed for recording the earthquake. Romania’s National Seismic Network has ~150 stations, still the variability of the local soil conditions makes interpolation not useful for now.
- For gaps and simulation purposes, a specific ground motion prediction equation (GMPE) has to be formulated. For Vrancea, Sokolov et al. (2008) and Marmureanu et al. (2006) GMPE’s are available, and the first one has different coefficients for different regions,

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which is a problem when trying to perform compute ground motion estimates for a large grid.

- The periods of the earthquakes, as seen in figure 2, can have peaks in the 1-2 seconds interval, therefore the form of the design spectrum (derived generally from peak ground acceleration and spectral acceleration values at 0.2/0.3 and 1 second) is presumed to be adjusted.

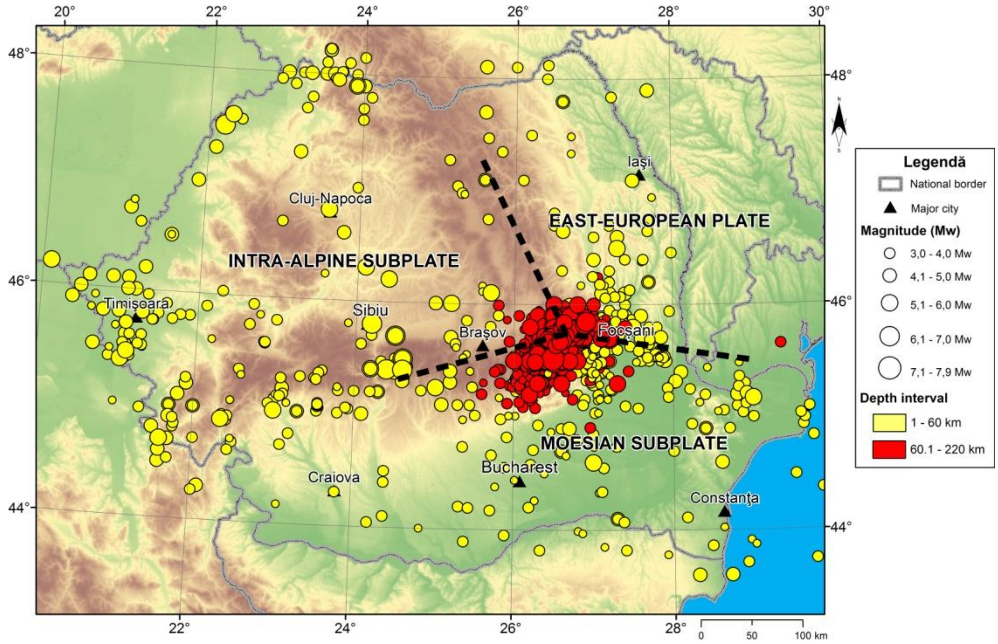

Figure 1. Epicenters of the earthquakes in Romplus catalogue (December 2011 edition), according to magnitude (greater than 3 Mw) and depth intervals. Vrancea area can be seen very distinctively. The total number of earthquakes in the catalogue is 14847, more than a half being in Vrancea.

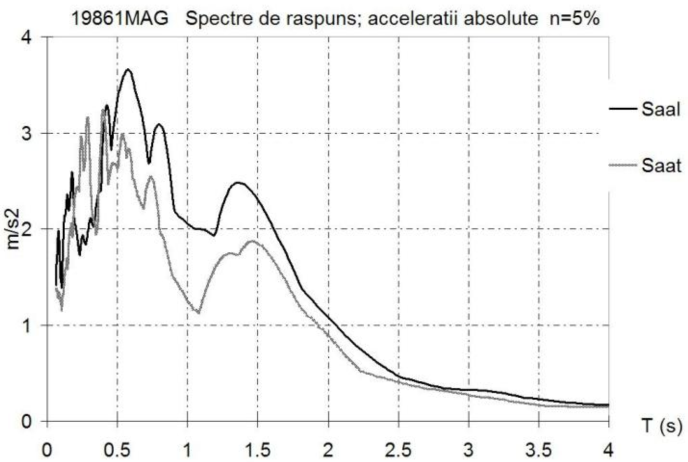

Figure 2. Response spectrum of the 1986 Vrancea Earthquake (Mw 7.1, depth 131.4 km), at station MAG near Bucharest (170 km away from the epicenter)

We aim to test the hazard modules of each software and try to find solutions for expressing the particular problems stated above. We also focus on the possibility to implement this modules in near real-time. Various scenarios for major earthquakes, based on real recordings and GMPE's are tested.

Beside the hazard input to be taken into consideration, we also analyze the required formats for the vulnerability data, compared to the typical available data collectable from censuses and state authorities' databases. When using capacity-spectrum based methods, the most important aspect is quantifying the buildings stock into a relevant set of vulnerability curves, as specific as it can for the area of interest. We propose to implement the newly compiled building database of the DACEA (DAnube Cross-border Earthquake Alarm system) Project for Bucharest.

Another aspect taken into consideration is the visual impact of the representations of the damage; a GIS module is proposed, in order to generate maps depicting more relevant aspects of the analysis, both for scientists and for end-users, allowing a much better dissemination of the final product of seismic loss estimation software.

The results of this study already contributed to the newly developed Near Real-Time System for Estimating the Seismic Damage of the National Institute for Earth Physics (NIEP), Romania, and we hope that our experience proves to be useful to other institutions interested in applying local knowledge in loss estimation software, and also for software developers and scientific advisors in charge of these type of programs.