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THE SELENA-RISE OPEN RISK PACKAGE

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EXTENDED ABSTRACT

Today, a considerable number of non-commercial seismic risk analysis tools are available. The happy circumstance that the tools are free is likely a result of the fact that the group of potential users or customers is small and with limited funds which are not sufficient for the distribution of commercial or proprietary seismic risk assessment software.

Nevertheless it is important to note that even though many risk assessment tools purport to be freely available, including downloadable free of charge from the web, their execution or complete utilization often requires a commercial software environment such as MATLAB or ArcGIS. As soon as proprietary software is introduced, accessibility to the code is restricted, preventing the user from examining the internal algorithms necessary for tasks as e.g. trouble-shooting.

Aware of the need for non-proprietary and open-source software for seismic risk and loss computation, the International Centre for Geohazards (ICG), through NORSAR (Norway) and the University of Alicante (Spain), began the development of the tool SELENA in 2004. The current version 4.1 of SELENA (*Seismic Loss Estimation using a Logic Tree Approach;* Molina *et al*., 2009), initially coded in MATLAB, has recently been translated into C. Thus, the code can be compiled as a stand-alone binary, which is then independent of MATLAB and its toolboxes. Furthermore, the code has been adapted in such a way that it can even be run in the free (open-source) MATLAB clone Octave.

Since a major feature of seismic risk and loss computations consists of generating suitable maps that illustrate geo-referenced information such as building inventory data, ground motion parameters or the distribution of expected building damage, economic losses or casualty numbers, the use of Geographical Information Systems (GIS) has become inevitable. In contrast to many other risk analysis tools, SELENA is not embedded or tied to any particular GIS so that it

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can be used across different operating systems and platforms. Therefore, all input and output files are provided in plain ASCII text format which allows the users to later use in their favorite GIS.

In order to make it even more attractive to use SELENA, the separate software tool *RISe* (*Risk Illustrator for SELENA*; Lang and Gutiérrez, 2009) has been developed to allow easy conversion of the geo-referenced SELENA input and output files into Google Earth kml-files. Since it is linked to the Google Earth visualization, the user automatically takes full advantage of the partly high-resolution satellite images provided by Google Earth. This is particularly important in situations where other commercial GIS packages do not provide a high resolution database, or for developing countries where many cities and municipalities cannot be displayed on high resolution base maps other than Google Earth satellite images. *RISe* is customized to SELENA's file structure, and it is further intended to assist the user during the different stages of the risk computation process. Like SELENA, *RISe* is openly distributed through NORSAR's webpage www.norsar.no.

Scientifically, SELENA follows the analytical (spectral displacement-based) approach using the principles of the capacity spectrum method (CSM) in order to compute estimates of physical building damage as well as associated economic losses and casualties.

The main innovation of SELENA, in contrast to many other risk estimation tools, is the implementation of a logic tree computation scheme that allows the user to define weighted input parameters and thus account for epistemic uncertainties. Thereby, final damage and loss results can be provided with corresponding confidence levels.

In SELENA v4.1 the user is given a number of different options regarding how seismic ground motion values are provided or which design response spectrum is to be used in order to represent seismic demand (IBC-2006, Eurocode 8, Indian code IS 1893:2002). Further, two different variants of the capacity spectrum method (CSM) are implemented (ATC-40, 1996 and FEMA 440, 2005), representing the main computation procedure.

Damage probabilities and absolute estimates of structural building damage are computed for the five damage states *no*, *slight*, *moderate*, *extensive* and *complete*. In addition, associated economic losses and casualties (injuries and deaths) are computed based on available building stock inventory, replacement values and demographic information.

The computation of economic losses caused by direct structural damage is done by adopting the methodology described by FEMA (2003) while two different approaches are implemented in order to derive casualty numbers (i.e. the HAZUS approach given in FEMA, 2003 or the basic approach following Coburn and Spence, 2002). Regardless of the methodology chosen, casualties are computed for three different day time periods (night time, day time, commuting time). Thus, those cases of occupancy that are strongly dependent on the time of

the day are covered. These scenarios are expected to generate the highest casualty numbers for the population at home (night time), the population at work or educational facilities (day time), and the population during rush hour (commuting time).

The open SELENA-*RISe* package is a powerful tool to conduct earthquake risk and loss computations at the level of geographical units (such as census tracts). Since SELENA offers a range of options to the user and is open to any user-defined input data, its application for scientific and analytical purposes is facilitated. In contrast, more practical applications of SELENA are enabled through its Google Earth interface *RISe*. This allows for easy identification of more vulnerable building typologies or building areas through a simple graphical visualization of inventory data and computation results. Further, SELENA-*RISe* can be used within cost benefit analyses since the impact of parameter changes (e.g. of building vulnerability) on final damage and loss estimates can be investigated and directly illustrated.

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