Probabilistic seismic-hazard assessment in Belgium

Kris Vanneste, Royal Observatory of Belgium
Jozef van Dyck, K.U.Leuven, D'Appolonia

Probabilistic seismic-hazard assessments (PSHA) are based on three elements:

- Seismic source-zone model: definition of seismic source zones where future earthquakes are thought to occur. These are either known active faults, or seismotectonic zones if earthquakes cannot be clearly linked to individual faults;
- Characterization of the seismic activity inside each source zone: this implies determining the frequency-magnitude relation, source depth and maximum magnitude, based on instrumental, historical and paleoseismic data. Usually the recurrence model is assumed to be Poissonian, but if enough data are available, time-dependent models are also possible;
- Determination of appropriate ground-motion model ("attenuation law") for the region, describing ground acceleration in function of earthquake magnitude and distance.

With these elements we can calculate the maximum ground motion, usually peak ground acceleration (PGA), which can be expected at a given site for a certain return period. Eurocode 8, a European standard for the design of earthquake-resistant constructions which will be adopted in all the member states of the EU in 2011, recommends a reference return period of 475 years. This is equivalent to a probability of exceedance of 10% in 50 years, the expected life span of an ordinary construction. The corresponding reference PGA is calculated at a national level based on the variation of seismic hazard with geographical location within the territory. Based on this calculation, the national territories are subdivided in seismic zones, in which the reference PGA is assumed to be constant.

The zonation map in the Belgian national annex to Eurocode 8 is based on a PSHA study by Leynaud et al. (2000), which made use of their own source-zone model, the earthquake catalog of the Royal Observatory of Belgium (ROB) at that time, and the depth-dependent attenuation law of Ambraseys (1995). In a first step, we reimplemented the PSHA calculations by Leynaud et al. (2000) in two different computer programs, CRISIS and SeisHaz. We also investigated the effect of some unclarified assumptions concerning the truncation of the attenuation-law uncertainty, the cutoff magnitude, and the inclusion of a "background" seismic zone. The reimplementation allowed constructing a new zonation map with finer gradation suitable for the updated version of the Belgian annex. In addition, we conducted new PSHA calculations using the updated ROB earthquake catalog, and two new source-zone models: the seismotectonic model (Verbeeck et al., this volume), and a more simple model consisting of only two zones, the Roer Valley graben and the region outside. We also evaluate the effect of using a more recent attenuation law by Berge-Thierry et al. (2003). The differences in the predicted seismic hazard are small but significant, and increase with longer return periods. The uncertainty associated with the attenuation law has the largest influence. But also the uncertainty on the frequency-magnitude relation for the different zones is found to be an important factor, particularly for regions with relatively low seismic activity. Future PSHA studies should therefore incorporate as much of these epistemic uncertainties as possible in a logic tree.

Ambraseys, N.N., 1995. The prediction of earthquake peak ground acceleration in Europe, Earthquake Engineering and Structural Dynamics, 24, 467-490.

Berge-Thierry, C., Cotton, F. & Scotti, O., 2003. New empirical response spectral attenuation laws for moderate European earthquakes, Journal of Earthquake Engineering, 7, 193-222.

Leynaud, D., Jongmans, D., Teerlynck, H. & Camelbeeck, T., 2000. Seismic hazard assessment in Belgium, Geologica Belgica, 3, 67-86.