



Seismic risk assessment of Navarre (Northern Spain)

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The RISNA project, financed by the Emergency Agency of Navarre (Northern Spain), aims at assessing the seismic risk of the entire region. The final goal of the project is the definition of emergency plans for future earthquakes. With this purpose, four main topics are covered: seismic hazard characterization, geotechnical classification, vulnerability assessment and damage estimation to structures and exposed population. A geographic information system is used to integrate, analyze and represent all information collected in the different phases of the study. Expected ground motions on rock conditions with a 90% probability of non-exceedance in an exposure time of 50 years are determined following a Probabilistic Seismic Hazard Assessment (PSHA) methodology that includes a logic tree with different ground motion and source zoning models. As the region under study is located in the boundary between Spain and France, an effort is required to collect and homogenise seismological data from different national and regional agencies. A new homogenised seismic catalogue, merging data from Spanish, French, Catalanian and international agencies and establishing correlations between different magnitude scales, is developed. In addition, a new seismic zoning model focused on the study area is proposed. Results show that the highest ground motions on rock conditions are expected in the northeastern part of the region, decreasing southwards. Seismic hazard can be expressed as low-to-moderate.

A geotechnical classification of the entire region is developed based on surface geology, available borehole data and morphotectonic constraints. Frequency-dependent amplification factors, consistent with code values, are proposed. The northern and southern parts of the region are characterized by stiff and soft soils respectively, being the softest soils located along river valleys. Seismic hazard maps including soil effects are obtained by applying these factors to the seismic hazard maps on rock conditions (for the same probability level). Again, the highest hazard is found in the northeastern part of the region. The lowest hazard is obtained along major river valleys.

The vulnerability assessment of the Navarra building stock is accomplished using as proxy a combination of building age, location, number of floors and the implantation of building codes. Field surveys help constraining the extent of traditional and technological construction types. The vulnerability characterization is carried out following three methods: European Macroseismic Scale (EMS 98), RISK UE vulnerability index and the capacity spectrum method implemented in Hazus. Vulnerability distribution maps for each Navarrean municipality are provided, adapted to the EMS98 vulnerability classes. The vulnerability of Navarre is medium to high, except for recent urban, highly populated developments.

For each vulnerability class and expected ground motion, damage distribution is estimated by means of damage probability matrixes. Several damage indexes, embracing relative and absolute damage estimates, are used. Expected average damage is low. Whereas the largest amounts of damaged structures are found in big cities, the highest percentages are obtained in some municipalities of northeastern Navarre.

Additionally, expected percentages and amounts of affected persons by earthquake damage are calculated for each municipality. Expected amounts of affected people are low, reflecting the low expected damage degree.