3D VELOCITY MODEL OF GRENOBLE BASIN (FRANCE) INCLUDING NEAR-SURFACE LAYERS SPATIALLY VARIABLE PROPERTIES

C. Cornou(1), G. Ménard(2), E. Koufoudi(3), E. El Haber(4), M. Collombet(5), E. Maufroy(6), E. Chaljub(7), F. De Martin(8), I. Zentner(9)

(1) *Researcher, Univ. Grenoble Alpes, Univ. Savoie Mont-Blanc, CNRS, IRD, IFSTTAR, ISTerre, cecile.cornou@univ-grenoble-alpes.fr*
(2) *Researcher, Univ. Savoie Mont-Blanc, CNRS, EDYTEM, gilles.menard@univ-smb.fr*
(3) *PhD, Univ. Grenoble Alpes, Univ. Savoie Mont-Blanc, CNRS, IRD, IFSTTAR, ISTerre, eleni.koufoudi@univ-grenoble-alpes.fr*
(4) *PhD, Univ. Grenoble Alpes, Univ. Savoie Mont-Blanc, CNRS, IRD, IFSTTAR, ISTerre, elias.el-haber@univ-grenoble-alpes.fr*
(5) *Associate professor, Univ. Grenoble Alpes, Univ. Savoie Mont-Blanc, CNRS, IRD, IFSTTAR, ISTerre, marielle.collombet@univ-smb.fr*
(6) *Associate professor, Univ. Grenoble Alpes, Univ. Savoie Mont-Blanc, CNRS, IRD, IFSTTAR, ISTerre emeline.maufroy@univ-grenoble-alpes.fr*
(7) *researcher, Univ. Grenoble Alpes, Univ. Savoie Mont-Blanc, CNRS, IRD, IFSTTAR, ISTerre, Emmanuel.chaljub@univ-grenoble-alpes.fr*
(8) *researcher, BRGM, F.Demartin@brgm.fr*
(9) *researcher, EDF, irmela.zentner@edf.fr*

Abstract

Sedimentary basins are generally exposed to significant ground motion amplifications during earthquakes. These site effects can be investigated experimentally using seismological recordings and/or by performing numerical simulations of the seismic wave propagation in vertically and laterally inhomogeneous media. However, a common shortcoming of site effects numerical prediction at high frequency (from 1 Hz to 10 Hz) is the poor knowledge of the subsurface geology, especially ground structure heterogeneities within small spatial scale (tens to hundreds of meters). Located in a Y-shaped embanked alpine valley sited on hundreds of meters of post-glacial lacustrine deposits, Grenoble city (France) is facing large site effects within frequency range from 0.2 to 5 Hz. Extensive geophysical investigations (seismics, deep borehole and gravity measurements) have been carried out to determine the structure of the valley in terms of sediment thickness, P- and S- wave velocities and bedrock topography. These measurements have allowed to build a 3D numerical model of the Grenoble basin which was adopted during a ground motion simulation international benchmark [1]. Results of this benchmark have stressed the relevance of the current velocity model to correctly reproduce seismic motion amplification between 0.1 and 1 Hz but its failure to explain site amplification and ground motion duration lengthening beyond 1 Hz that we attribute to wave propagation within the heterogeneous most surficial sediment layers.

In order to build a 3D velocity model that includes both deep sediments mechanical properties and geometry and variable properties of near surface layers, we analyse all available geophysical data (140 active and 15 passive surface wave measurements) and geotechnical and geological drillings (> 1300 shallow boreholes). We show very consistent relationships between the nature of surface geological deposits (gravel, sand, clay) and the related S-wave velocities (Vs): high values of Vs (300-400 m/s) correspond to coarse sediment deposits (gravels, sands) from the Drac river in the western part of the basin, while lower values (100-200 m/s) correspond to the fine grained deposits (clay) from the Isere River in the eastern part. Making use of these relationships and the dense spatial sampling of boreholes, we then quantify the spatial variability of Vs heterogeneities from the surface to 20 m depth: vertical and horizontal correlation lengths are about 2 m and 20 m, respectively, whatever the geological surface deposit, while coefficient of variation on Vs is 20% for geological units dominated by coarse deposits and 50% for geological units dominated by fine grained deposits. Such large spatial variability of near-surface elastic soil properties is explained by the history of fluvial sedimentation process including past large flash floods and human effort to control the rivers flow. Finally we derive a high resolution 3D Vs model of Grenoble basin that will further serve for numerical simulation of ground motion.

Keywords: site effects, 3D velocity model, spatial variability, soil properties

References: [1] Chaljub et al (2010). Quantitative Comparison of Four Numerical Predictions of 3D Ground Motion in the Grenoble Valley, France, Bulletin of the Seismological Society of America 100(4), 1427-1455.