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SIMULATION OF EARTHQUAKE GROUND MOTION IN GRANADA CITY (SPAIN).

Francisco VIDAL[1], Gerardo ALGUACIL[2], Manuel NAVARRO[3], Ignacio VALVERDE[4], Antonio GARCÍA-JEREZ[5], Francisco GARCÍA-VILLENA[6] and Takahisa ENOMOTO[7]

The characteristics of earthquake shaking are significantly influenced by local geologic and soil conditions. Soft soil deposits amplify ground shaking causing damage to man-made structures during earthquakes. One relevant contributor to the site amplification is the details of the shear wave velocity profile at the site. Shaking is stronger where the shear wave velocity is lower.

The city of Granada, located in the region of highest seismic hazard in Spain, was seriously affected in past by destructive earthquakes (e.g. april 24th, 1431 earthquake). We have evaluated the ground conditions in Granada to assess their influence on ground motion amplification and to estimate the intensity distribution of future earthquakes in the city. Geological sections, boreholes and geotechnical parameters have been revised to determine the characteristics of the surface geological structure. Then, we analyzed the shallow V_S structure (up to ~ 15 m) at 24 points from refraction seismic profiles (Figure 1). The Vs structure has been obtained in 10 points by joint inversion of dispersion curves (SPAC method) and H / V curves of microtremor (Figure 2). The sites have been classified based on seismic characteristics: V_{S30}, T_p and thickness of deposits Z_{800}.

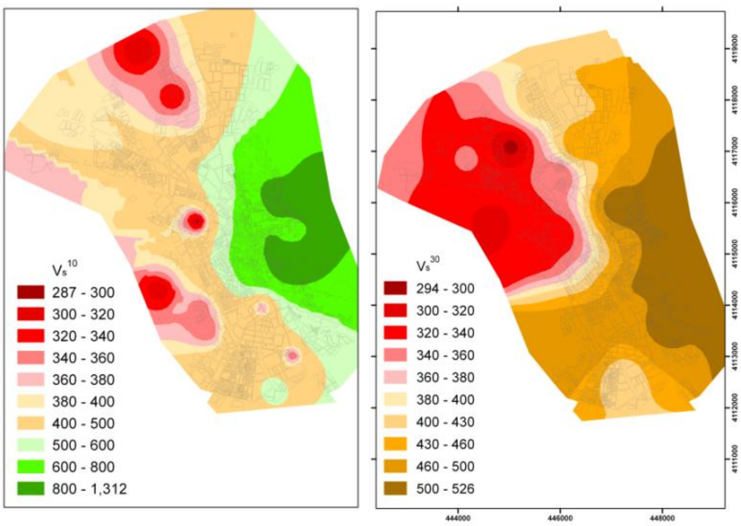

Figure 1. Maps of V_{S10} obtained from refraction seismic profiles (left) and V_{S30} from SPAC method (right).

[1] Professor, Instituto Andaluz de Geofísica, Universidad de Granada, Granada (Spain), fvidal@ugr.es
[2] Professor, Instituto Andaluz de Geofísica, Universidad de Granada, Granada (Spain), alguacil@ugr.es
[3] Professor, Universidad de Almería, Almería (Spain), mnavarro@ual.es
[4] Lecturer, Universidad de Granada. 18071. Granada (Spain), nachoval@ugr.es
[5] Lecturer, Instituto Andaluz de Geofísica, Universidad de Granada, Granada (Spain), agjerez@ugr.es
[6] Master Eng., Universidad de Granada. Granada (Spain), fagv@ugr.es
[7] Professor, University of Kanagawa, Yokohama (Japan). enomot01@kanagawa-u.ac.jp

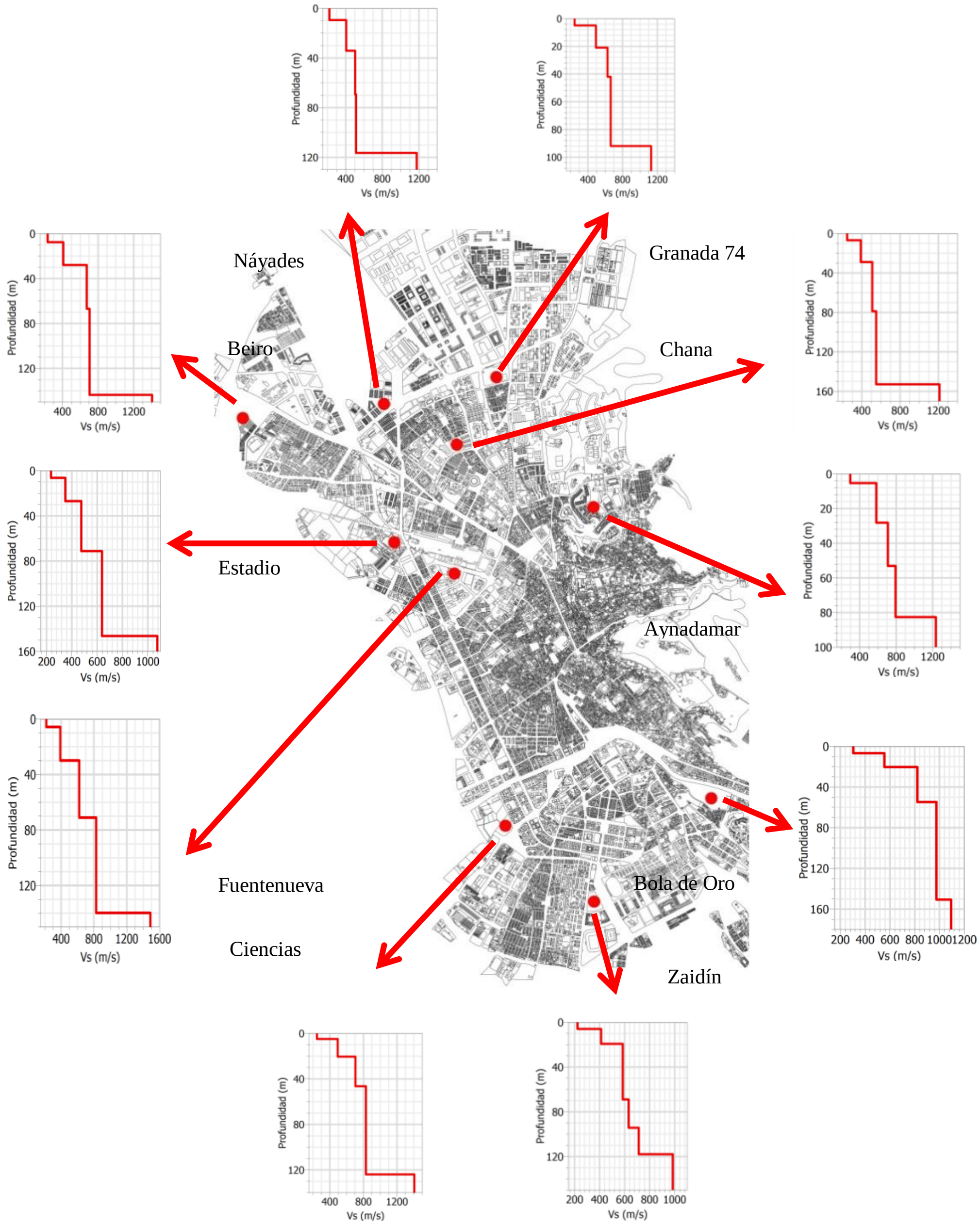

Figure 2. Map of the 10 array sites of the Granada city and their Vs velocity models.

To evaluate the effect of local geology in modifying ground motion in Granada, accelerograms were simulated at 10 soil sites from earthquake records on hard soil. We used *Vs* ground models (up to a depth of h ≈ 100 m) obtained through a joint inversion of dispersion curves (SPAC method) and H/V estimates from microtremor (Figure 2). 1D simulations have been made with the Thomson- Haskell method using three local (Mw ~ 4.0) and two Italian (Mw 5.3 and 6.3) recent earthquakes. From the simulated ground motion, we have evaluated key engineering parameters. PGA, PGV, CAV and AI values show significantly higher amplitude (about 2-3 times) than the input ones. The acceleration response spectra for soil sites have at least a double value that input one for the full period band (0.1-3 s), with higher peaks for site-dependent periods. The input power spectra show an amplification of more than twice the reference value between 0.1 to 1.2 s with site-dependent peaks as well.

Another alternative used in this work has been to generate synthetic accelerograms at the sites of interest by using two semi-empirical simulation methods. The stochastic method of Ordaz, Singh and Arboleda (1995) and the kinematic method based on Irikura (1986), Irikura &Kamae (1994) and Kamae et al (1998) (Irikura method) have been programmed in MATLAB®. The first one is easier and faster because the simulation only needs to set the values of seismic moment and the corner frequency of the target event. The use of the second method is more complex since it requires knowing the focal mechanism (particularly the azimuth and dip of the fault plane) and possibly the start point of rupture. With these two models, a number of accelerograms have been simulated, which have been used in the estimation of characteristic parameters of the ground motion at the recording sites (Figure 3). The records used as EGF correspond to the February 24, 1997 Agron earthquake (Mw = 4.3) and the January 5, 2007 in Sierra Elvira (Mw = 3.7). Synthetic accelerograms were obtained using the records of these earthquakes at acceleration stations in and around Granada city. The magnitudes chosen for the target events are Mw 5.5, 6.0, and 6.5, similar to those of some historical earthquakes. An example is shown in Figure 4.

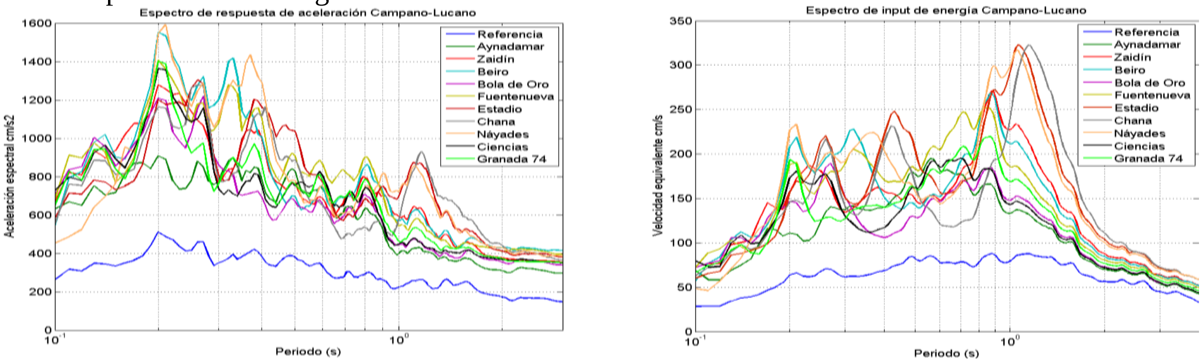

Figure 3. Example of acceleration response (left) and input energy (right) spectra of the Campano-Lucano earthquake in the 10 sites of study and in the reference site.

The ground motion parameter values achieved from these simulations show amplification in soils and in some cases atypical higher values, which might be associated with directivity phenomena in the EGF event used. It is remarkable that results with the Irikura method show clear differences between the two horizontal components, while they do not appear in the OSA method simulations.

The results obtained in this work are complementary and congruent among them, and they are a first step in the development of shake-map scenarios for Granada and surrounding areas.

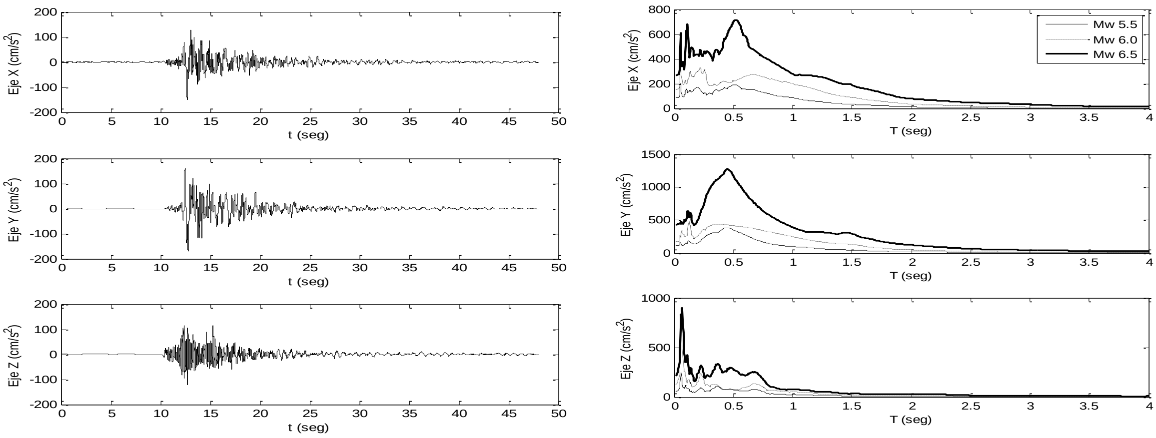

Figure 4. Simulated accelerograms and absolute acceleration response spectra in CAC station for an objective event of Mw = 6.0 using the Agrón earthquake as EGF event and the Irikura method.

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