4. NUMERICAL SIMULATION OF A DESTRUCTIVE EARTHQUAKE ON THE MALTA ESCARPMENT

4.1 Introduction

(E. Priolo)

The use of advanced methods capable of generating of synthetic seismograms can give a valuable insight into the evaluation of a seismic ground motion scenario. Three different approaches have been brought together into the Project with the aim of analysing complementary aspects of the problem. The reference event is the catastrophic earthquake (M7+) that struck Eastern Sicily on January 11, 1693, assumed as a level I scenario event in the Project.

The first two approaches (sub-section 4.2 and 4.3) solve the 2-D full-wave propagation through laterally heterogeneous media, and therefore are well suited to provide accurate seismograms, and analyse the effect of the medium heterogeneity and local conditions on the ground motion. In both cases, the main limitation lies in the model adopted to represent the source.

The first approach (sub-section 4.2) uses a 2-D Chebyshev spectral element method. The ground motion is simulated along few selected transects, where a realistic geological structure is defined, including the fine local details. A simplified extended source model is adopted. The results consist of detailed estimates of the main parameters that define the ground motion, and include some analyses of local response. The approach is validated through the simulation of the recent event of December 13, 1990, which struck the same area and was recorded by one strong-motion station (of the ENEL-ENEA network) in the Catania area.

The second approach (sub-section 4.3) uses an extension of the modal summation technique to laterally heterogeneous media for modelling the ground motion, and also for simulating the occurrence of a tsunami wave. In this study, the synthetic seismograms are computed for a large group of 2-D models, providing a more complete spatial coverage of the ground shaking estimates. The 2-D structural models are obtained by assembling together few 1-D models in welded contact. For one transect, the 2-D model is defined with higher detail. The earthquake is simulated by a scaled point source model, and therefore the results of the simulations of the scenario ground motion are better suited for spectral, rather than time-domain, analyses. As a matter of fact, beside some classical ground motion estimates, the study provides also a site response analysis, which is evaluated through spectral ratios computed with respect to a reference bedrock model.

The third approach (sub-section 4.4) aims at evaluating the effect of a complete rupture process occurring along the whole fault length. This is performed using a hybrid statistical-deterministic approach, in which several rupture occurrences are simulated. The high frequency seismic wavefield is propagated from the source to the Earth's surface through a homogeneous half-space model. Then, the site effect is included through the response of a 1-D layered surface model. This method provides a very efficient way to perform the large number of simulations needed to describe

the source by a stochastic approach. Synthetic seismograms are computed for several receivers spanning a wide area. In addition to some classical estimates, the results have also been summarised in maps which identify the area of strongest ground shaking and the variability of the estimates. The main methodological limitation lies in the high-frequency approximation used to perform the wave propagation.

As an example, we compare in Fig. 4.1 the acceleration response spectra computed by the three methods at a common site located on a lava flow. In general, the deviation is within 40% of the mean value. The two curves computed by the methods based on the solution of the full-wave equation (UNITS and OGS-TS) feature very similar values. Considering the completely different approach and model assumptions, the authors consider this result as very good. The reliability of the predictions has been further validated independently in both cases. In one case (UNITS), the energy response of the synthetics matches very closely that recorded for similar events on a medium-stiff soil (Fig. 4.14). In the other case (OGS-TS), the accelerograms recorded near the city during the December 13, 1990 M≅5.8 Eastern Sicily earthquake (Fig. 4.5), were reproduced rather closely. In the spectrum calculated by the UNINA Research Unit, the energy appears too concentrated in a narrow high frequency band. This is a typical "signature" of the asymptotic method used to propagate the wavefield away from the source through the medium. However, the effectiveness of this approach can be fully appreciated in Figure 4.15. In fact, UNINA was the only Research Unit in the Project that predicted a map of ground shaking values (PGA) for the whole area, taking into account a realistic extended source and estimating also the variability produced in the ground motion by several kinds of kinematic patterns of rupture (Fig 4.15).

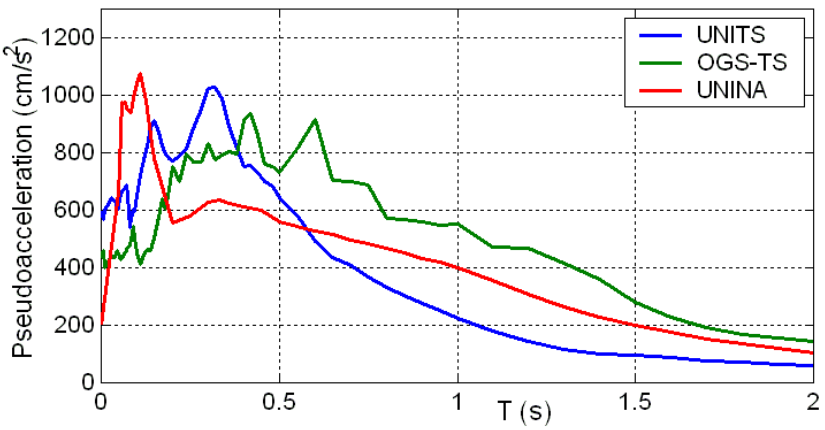

Figure 4.1 - Acceleration response spectra of the synthetic seismograms calculated by the three research units at a common site located on lava in the northern part of Catania within the University Campus (modified from Fig. 3.6 by Pessina, sect. 3).