EARTHQUAKE GROUND MOTION SIMULATION FOR ISTANBUL

Eser Durukal, Mustafa Erdik
Boğaziçi University, Istanbul

After the 1999 Kocaeli and Düzce earthquakes a significant amount of research and application oriented activities focusing on the characteristics of expected ground motion in the Marmara Sea region in general and in Istanbul in particular have taken place. In this talk we will try to present a summary of these efforts.

Essentially the results of any strong motion simulation technique are very sensitive to the input parameters used. A realistic simulation should not only provide peak values in accordance with empirical ground motion prediction relationships, but also produce good waveforms with satisfactory resolution in time and frequency domain, so that they can be employed in time-domain structural analysis. In that sense, from the engineering point of view, the simulation has a very clear target and it is not done for the sake of simulating ground motions. The simulation of strong ground motion in Istanbul is emerging as a new focal point of interest. Two studies have been carried out to this date within the EU-FP5 project RELIEF (Atakan et al, 2004) and EU FP6 project Less-Loss (Cultrera et al, 2006). Both of them involved hybrid simulation techniques using a 1-D velocity model and tried to come up with distribution of peak ground accelerations and velocities in and around Istanbul. Benchmark studies carried out to compare the and to investigate the effectiveness of several methodologies employed in simulation (Durukal et al, 2006) and well as studies on the efficiency of the methodology employed (Sanli et al, 2005) before setting out for a large-scale region-specific simulation are important. The development and verification of a regional 3-D velocity model is important. There exist a preliminary velocity model of the Marmara basin (Durukal et al 2003), currently used in on-going simulation studies by several groups (Durukal et al, 2006, Richwalski et al, 2006, Wenzel et al. 2006))

The urban strong motion network in Istanbul consists of 100 stations and serves to near-real time generation of post-earthquake damage distribution maps in Istanbul to assist local administrative bodies in emergency planning. In addition there are 10 stations dedicated to earthquake early warning. Using several small magnitude events recorded by the larger number of stations by the so-called IEEWRR interesting results have been obtained regarding the effect of local site conditions on the distribution of ground motion in Istanbul (Birgoren et al, 2004, 2006) and about spatial variation of strong ground motion within the city (Harmandar et al, 2006) . Grid-based high-frequency simulation of strong ground motion due to the rupture of fault segments in the Marmara Sea have been carried out using FINSIM, for employing in the development of an early warning algorithm (Böse, 2005). The data obtained from small magnitude earthquakes will be archived to serve as empirical Green's functions for site-specific simulations.

Today there are several large-scale engineering projects in Istanbul either in design or construction stage. Performance-based design criteria of these projects necessitate simulation of site-specific strong ground motion. The most important among such projects and efforts can be cited as Marmaray submerged tube tunnel, seismic retrofit of two suspension bridges over Bosphorus, base isolated Tarabya Hotel, Halic metro bridge and AnadoluRay lightrail transportation system. A state-of-the art hybrid simulation approach has been employed in characterisation and simulation of expected, site-specific strong ground motion at these project sites due to a series rupture scenarios along several segments of the North Anatolian Fault in the Marmara Sea (Erdik et al, 2003, 2004, 2005, 2006)

Several EU-FP6 projects, which are concerned with several aspects of strong ground motion, are either in execution or about to start. In project NERIES simulation methodologies for higher level shake-map generation will be developed and tested for the case of Istanbul. In SAFER ground motion will be simulated for on-line post earthquake shake-map generation for Istanbul and also for Naples and Thessaloniki. In TRANSFER generation and propagation of tectonic-origin tsunamis, as well as tsunamis due to submarine landslides will be investigated for the Marmara Sea region selected as one of the test-beds. Project 'MegaCity Istanbul' is a collaborative effort between CEDIM in Germany and KOERI and IMM in Turkey. One of the subprojects of this large-scale effort is concerned with the characterization of site conditions in Istanbul (Parolai et al, 2006), particularly at the IEWRR stations with the ultimate aim of simulating strong ground motion at these sites due to a large rupture along the Main Marmara fault.

The current level of existing knowledge regarding the characterization of source parameters associated with the segments of the North Anatolian Fault in the Marmara Sea is satisfactory except for simulation using the Empirical Green's function technique. The IEEWRR has the potential of providing a very good data set for simulation of ground motion in Istanbul using EGF. However the occurrence and thus the number of records of small earthquakes has been very limited so far. This obviously imposes a certain limitation on characterization of source parameters associated with Northern Boundary and Central Marmara segments if and when other simulation methodologies are employed. However existing historical and instrumental data are sufficient to pursue simulation studies using methods other than EGF. The main difficulty lies with the lack of a verified and tested 3-D crustal velocity model of the larger Marmara Region. Such a model will be extremely helpful not only for regional simulation of strong ground motion, but also for locating earthquakes. As stated above the ultimate aim of simulation from the earthquake engineering point of view is to provide design engineers with realistic broad-band time histories. As such the provision of 3-D ground motion is important. So far the efforts in general have been focusing on getting the horizontal components; however recent developments in our understanding of structural design, as well as capabilities of modern structural analysis tools require successfully simulated vertical components as well.