Activity of Research Unit 3 in Project S4

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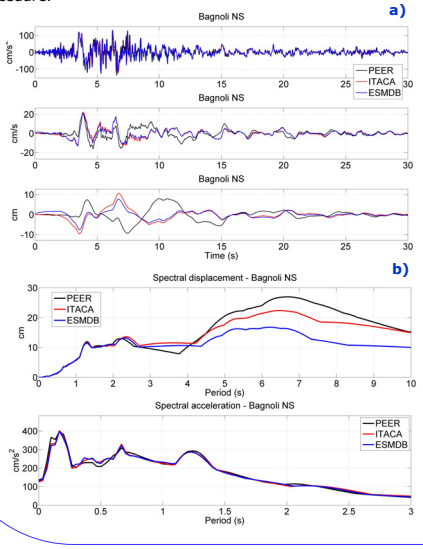
UPDATE PROCESSING OF ITACA RECORDS (TASK 1)

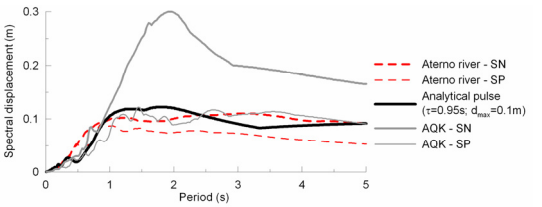
Corrected records in the alpha version of ITACA were carefully re-examined and compared with the corresponding records available within other international databases, such as the PEER and the European Strong motion Database. A new procedure for strong motion record processing has been devised, carefully checked, and implemented in cooperation with researchers of INGV Milano. This procedure ensures the compatibility of corrected accelerograms, so that the no further correction is required to obtain by single and double integration the velocity and displacement traces. Special care has been paid to a specific treatment of the late-triggered records, typically on the S-phase, to provide meaningful corrected records also for this case that is quite frequent in the Italian database. All ITACA records, including the most recent ones from the Parma and L'Aquila earthquakes have been re-processed according to the new procedure.



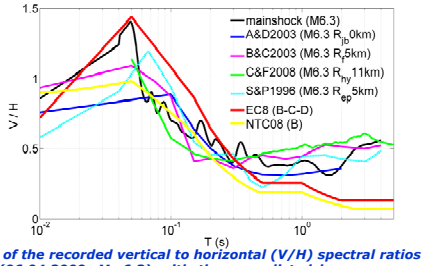
Comparison of corrected acceleration time histories (a) and response spectra (b) according to ITACA, European Strong Motion database and PEER. The case of Bagnoli record (NS component) from the Irpinia earthquake.

PROCESSING OF STRONG MOTION RECORDS IN THE NEAR-FAULT OF L'AQUILA EARTHQUAKE (TASK 1)

A notable effort has been made together with researchers of INGV Milano to make available in due time within ITACA the strong motion records of the Parma (December 2008) and L'Aquila (April 2009) seismic sequences. Particularly, the near-field L'Aquila records have been carefully processed in the long-period range and compared with the up-to-date ground motion prediction models.



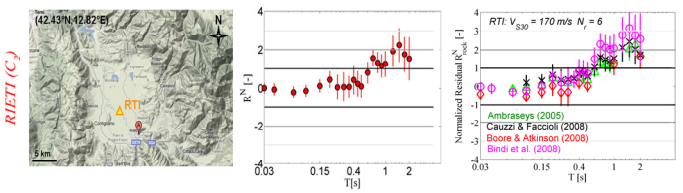
Comparison of 5% damped displacement response spectra along the SN and SP components. Gray continous lines: station AQK. Dashed lines: average spectra of the Aterno river array stations. Black continous line: analytical pulse according to Faccioli et al. (2004), for Mw=6.3 and r = 10km.



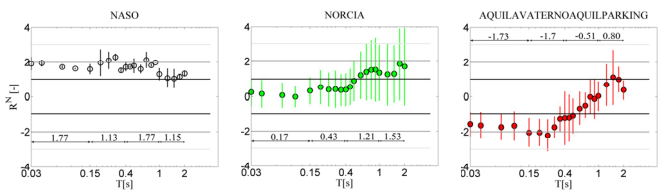
Comparison of the recorded vertical to horizontal (V/H) spectral ratios for L'Aquila mainshock (06.04.2009, Mw6.3) with those predicted by some recent empirical attenuation relationships (Ambraseys & Douglas, 2003; Bozorgnia & Campell, 2003; Cauzzi & Faccioli, 2008; Sabetta & Pugliese, 1996) and those prescribed by Eurocode 8 (EC8) and by the Italian Technical norms for buildings (NTC08).

IDENTIFICATION OF ITACA STATIONS WITH DISTINCTIVE FEATURES IN THEIR SEISMIC RESPONSE (TASK 4)

An empirical procedure was developed in the framework of Task 4 to identify which stations or earthquake events exhibit a distinctive trend so that the recorded peak values of ground motion deviate significantly from the estimations provided by the attenuation relationships. In particular the method consists of computing the residuals of the recorded 5% damped response spectral acceleration with respect to the predictions from two selected attenuation relationships calibrated on the Italian data.



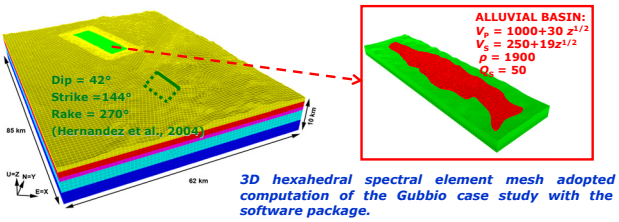
Left: residuals corrected for the inter-event variability for the station of Rieti (RTI), located on deep alluvium (soil classification = 2 according to Sabetta & Pugliese, 1996). Filled dots indicate the median value, while the vertical bars denote the 16th-84th percentiles. Right: sensitivity analysis with respect to the adopted GMPE.



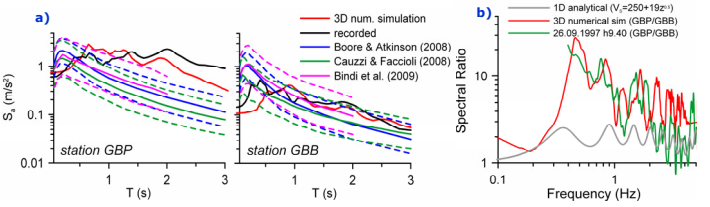
Residuals as a function of period for 3 representative stations for soil class 0 (rock, NASO), 1 (shallow alluvium, NORCIA) and 2 (deep alluvium, AQUILA V.ATERNO PARKING). The average residuals in 4 representative period bands (0.03≤T≤0.15s; 0.20≤T≤0.40s; 0.45≤T≤1s; 1.25≤T≤2.0s) are also superimposed.

3D NUMERICAL SIMULATIONS OF THE SEISMIC RESPONSE OF GUBBIO BASIN (TASK 4)

A considerable effort was also devoted to perform high performance 3D numerical simulations of the seismic response of the Gubbio sedimentary plain (Central Italy) during the main shock of 1997 Umbria-Marche earthquake sequence (MW6.0 26.09.1997, time 09.40). The spectral element code GeoELSE (http://geoelse.stru.polimi.it) for seismic wave propagation analyses in 3D heterogeneous media was used for this purpose. The numerical ground motion time histories turn out to be in good agreement with the recordings at two representative accelerometric stations at Gubbio downtown (GBP) and inside the Gubbio plain (GBP), at least between 0 and 2 Hz. Furthermore, the comparison between the results obtained by both 1D and 3D numerical modelling points to the need of realistic 3D numerical simulations to predict specific features of earthquake ground motion, related to the presence of an irregular geological structure, that can not be predicted by standard approaches based on vertical plane wave propagation in horizontally layered media.



3D hexahedral spectral element mesh adopted for the computation of the Gubbio case study with the GeoELSE software package.



a) 5%-damped response spectral acceleration at GBP (Gubbio plain) and GBB (Gubbio downtown): comparison of the numerical simulations (red) with the recordings (black) and some recent attenuation relationships. b) comparison of the observed spectral ratios GBP/GBB with those simulated by both 1D (grey) and 3D (red) numerical simulations.

KEY PUBLICATIONS

Ameri A., M. Massa, D. Bindi, E. D'Alema , A. Gorini, L. Luzi, S. Marzorati, F. Pacor, R. Paolucci, R. Puglia and C. Smerzini (2009). The 6 April 2009, Mw 6.3, L'Aquila (Central Italy) earthquake: strong-motion observations, accepted for publication in *Seismol. Res. Letters.*

Ameri G., Bindi D., Cauzzi C., Chioccarelli E., D'Alema E., Iervolino I., Luzi L., Marzorati S., Massa M., Pacor F., Paolucci R., Puglia R. (2009). Strong ground motion recorded during the L'Aquila seismic sequence. Special issue of *Progettazione Sismica*, Accepted for publication.

Paolucci R. Long-period earthquake ground motion: recent advances and observations from the April 6 2009, Mw6.3 L'Aquila earthquake, Italy. Invited lecture at the ACES Workshop on Performance-Based Earthquake Engineering, Corfù, Greece, 5-6 July 2009.

Stupazzini M., Paolucci R. and H. Igel (2009) "Near-fault earthquake ground motion simulation in the Grenoble Valley by a high-performance spectral element code". *Bull. Seism. Soc. Am.*, Vol. 99(1): 286-301.