MULTIDISCIPLINARY INVESTIGATIONS USING HISTORICAL DATA, SPECIFIC EXPERIMENTAL SURVEYS, NUMERICAL SIMULATIONS AND EARTHQUAKE DATA TO ASSESS SEISMIC HAZARD IN A DENSELY URBANIZED CITY: THE STUDY CASE OF PALERMO

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Introduction: The aim of this poster is to present the geological and seismological studies performed in downtown Palermo, a densely city of Southern Italy (Fig. 1) that was severely damaged in the past by moderate-magnitude earthquakes. This study case shows how the hazard of a complex urban environment can be approached with multidisciplinary investigations.

Geological setting: The main feature of the geology in downtown Palermo is the presence of Holocenic sea deposits and alluvial deposits of two rivers, Papiro and Kemoria, completely hidden by urbanization [7]. The analysis of aerial photos and of more than 2000 borehole data organized in the City-GIS of the University of Palermo [8] overcomes the difficulties of a surface geological survey and reveals the palaeodrainage system of the rivers (Fig. 2).

Weak motion analysis: On September 6, 2002 a Mw 5.9 earthquake occurred in the southern Tyrrhenian sea, 40 Km off the coast of Palermo. After the event, 9 sites within downtown were monitored with portable seismic stations. We selected about 30 out of 300 aftershocks to perform: i) S-wave spectral ratio between the horizontal components of the studied site and reference (rock) site (HVR on earthquakes); ii) S-wave spectral ratio between horizontal and vertical components at individual sites (HVS on earthquakes); iii) the spectral ratio between horizontal and vertical components using ambient noise (HVNSR).

Inferences on response spectra in Palermo: The aftershock recordings allow a comparison (Fig. 6) with statistical expectation of response spectra for the Italian territory [10] and Eurocode 8 [3]. Data have been scaled according to the results of the synthetic ground accelerations.

The fundamental resonance frequencies of 2D reproduces fairly well the HVNSR peaks. However, the spatial position of the peaks is not coincident. This is probably due to uncertainties of the geological reconstruction.

Microtremors surveys: to test the feasibility of using HVNSR spectral ratios on ambient noise (HVNSR) for evaluating the resonance frequency of a site and for recognizing the presence of alluvial deposits in an urban environment, we performed a large microtremor measurement campaign across several profiles (see Fig. 1 for details) [4].

The profile A-A' was selected for a tentative comparison with 2D simulation of SH-waves (Fig. 7).

Microtremors analysis evidences a peak around 1 Hz corresponding to the two rivers.

We used a simplified geological model as input for the 2D simulation.

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Correlating damage with HVNSR: Multivariate statistical (factor and canonical correlation) analyses [5] have been applied to microtremor and damage data. The HVNSR computed at each site has been digitized into 0.5 Hz-wide frequency intervals, from 0.5 to 5.0 Hz. We considered the damage of two events (1726, 1823) and the cumulative effect studied by Guidoboni et al. [9] (Fig. 3). The factor analysis shows that two independent factors likely reflect the most of the variance of the two sets of data (Fig. 8a and 8b).

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Response spectra reveal variations between class A and D that are significantly larger than those expected on the basis of the statistical predictions by Sabetta and Pugliese [10] and the EC8 prescriptions [3]. However, the EC8 spectra anchored to the PGA of Sabetta and Pugliese are well above the maximum envelope inferred from observations [6].

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CONCLUSIONS:
The September 6, 2002, Mw 5.9 earthquake offered the opportunity of applying different methods to estimate the parameters that control the seismic hazard of the city of Palermo. The study dealt with organization of geological and geotechnical data through a GIS, macroseismic investigations of both past and present time earthquakes, recording of weak earthquakes and modelling of strong motions in the city, and microtremor measurements. Multivariate statistical analyses established reliable correlations in downtown Palermo between the spectral properties of the HV/Rs of microtremor and damage variables as a function of local geology. The approach seems to be successful in predicting relative variation of damage, for intensity VII to IX MCS.

REFERENCES:
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