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Site Effects estimation in the Po Plain area (Northern Italy): correlation between passive geophysical surveys and stratigraphic evidence

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The recent case of the 2012, Mw 6.1, Emilia seismic sequence (Northern Italy) highlighted the importance of the site effects estimation in the Po Plain, the larger and deeper Italian sedimentary basin. This study, applied on extensive collection of geophysical and geological data in the entire area, allows a macrozonation of the site effects estimation, useful for scientific and applied purpose. In particular, site-response analysis can be performed in defined macrozones, where the geological-geotecnical and geophysical characteristics are homogeneous at macroscale.

The collection of the available stratigraphic discontinuities and passive geophysical surveys (single station and array measurements) allowed defining a general macrozonation in terms of amplified frequencies and shear waves velocity (Vs) gradients. The correlation between the obtained geophysical evidence and the known geological information can then be crucial in order to define the most important stratigraphic discontinuities responsible for the local seismic amplification.

In particular, ambient vibration data, recorded by all permanent and temporary seismic stations installed in the target region, were collected and then analyzed with the Nakamura technique, to determine the H/V spectral ratio. Moreover, all the available ambient vibration arrays where collected and analyzes to assess the local Vs profile, considering the Rayleigh waves fundamental mode. The Po Plain stratigraphy is defined by regional unconformities (aquifer limits) that have been extensively mapped throughout the basin and by regional geological and structural maps.

In general, the H/V results show two ranges of amplified frequencies, both lower than 1 Hz: the former at frequencies lower than about 0.25 Hz and the latter between 0.4 and 1 Hz. The higher frequency range moves from about 0.4 Hz, in the eastern-Adriatic part of the plain, to about 0.8-1.0 Hz in the central and western part. Based on the available seismic array results, this amplification peak seems related to a velocity discontinuity, located in general between 100 m and 300 m of depth, where the Vs exceed 800 m/s. This interface can be ascribed to the seismic bedrock according to the actual seismic code (NTC 2008, Vs> 800 m/s, class A) and may be related to different stratigraphic discontinuities moving from East to West. In order to verify the supposed correspondence between geophysical and geological data, also the H/V ratio where inverted, considering the Sanchez-Sesma method and the nearest array velocity profile as indicative for the target inversion.

Finally, an empirical relation between amplified frequencies and depths was calculated, allowing to preliminary map, at regional scale, the most important geological discontinuities for the site effects evaluation.

An example of site-specific hazard analysis was performed in correspondence of the INGV seismic station CTL8 in terms of displacement response spectra for periods up to 10 s. The results show that neglecting the effects of the deep discontinuities implies underestimation in hazard evaluation of up to about 49% for MRP of 475 years and about 57% for MRP of 2,475 years, with possible consequences on the design of very tall buildings and large bridges.