European Seismological Commission

Genova (Italy), September 2002

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SITE EFFECTS IN URBAN AREAS

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The XXth century, and especially its second half, has been characterized by an unprecedented urbanization process, not always well controlled. Unfortunately, good sites for settlements and dense urbanization (with easy communication and transportation facilities) are often not as good as to their seismic response: they are often located along river valleys, along the coast, or within flat sedimentary basins. As a consequence, the risk is increasing in urban areas, and the damage is partially (sometimes totally) controlled by site conditions, as repeatedly illustrated in almost all recent destructive earthquakes. The presentation will therefore focus on two issues : a) how to estimate site effects in urban areas ? b) are there specific "urban" site effects ?

Estimating site effects in urban areas faces two specific difficulties: while there often exist a significant amount of shallow geotechnical information, it is still rarely well archived and available, and direct S-wave velocity measurements are very rare, and often impossible for thick sediment sites (use of explosives is generally forbidden, oil-industry type exploration methods using trucks exceed the available budgets): site response computations are therefore based on very fuzzy information and their results are highly uncertain. On the other side, obtaining direct site-specific earthquake recordings is hampered by the high-noise level, especially in moderate seismicity areas. The recent results that will be presented try to overcome these difficulties and provide a better control on numerical computations:

- on one hand, ambient seismic noise itself can be used to derive some information on the site conditions and/or directly on response. It may also be misused or overused ! The latest results obtained within the framework of the EC SESAME project, addressing both the H/V "Nogoshi – Nakamura's" technique, and the noise array measurements, will be discussed.
- on the other hand, despite the heavy trend to rely more and more on computations, some recent examples from Grenoble and Tehran, will be given to illustrate how interesting, meaningful, and sometimes unexpecetd results may be obtained even in moderate/low seismicity areas with long seismological experiments.

Then, the issue about the existence of specific urban effects will then be (partially) answered with results from a series of field and centrifuge experiments, and numerical modelling as well, showing that the seismic wavefield may be very significantly modified by dense urbanization in some specific conditions. The basic phenomenon leading to such modifications is a combination of wave radiation from buildings due to soil-structure interaction, and wave trapping due to shallow impedance contrast. The ground motion amplitude resulting from this "secondary" diffracted wave field may be comparable to the direct "free-field" one, when the building and soils have comparable resonant frequencies. Such situations are found in Mexico City, but also in more common cities such as Nice, or possibly Grenoble, and might be one explanation for the frequent observations of apparently erratic damage in groups of similar buildings.