PROCEEDINGS OF IAMG'97
V. Pawlowsky-Glahn (Ed.)

MEASUREMENTS OF MICROTREMORS IN BARCELONA: A TOOL FOR SEISMIC MICROZONATION

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SUMMARY

To study the predominant periods of seismic amplification due to the sediments it is possible to use the measurement of the environmental noise (microtremors) performed by triaxial accelerometers on different points. A preliminary map of predominant periods characteristics of the different soils of Barcelona, computed by the Nakamura's method is presented.

1. INTRODUCTION

Barcelona is classified by the new national seismic code ("Norma de Construcción Sismorresistente NCSE94") with a PGA of 0.04 g. The values given in this code correspond to a "medium rock" site. Important soil amplifications, however, have been observed in past distant earthquakes in the form of observed macroseismic intensities larger than what could be expected considering the epicentral distance.

Thus, soil amplification is expected to be a significant factor to be considered when assessing the earthquake risk for the city of Barcelona. Different studies have been recently undertaken in order to evaluate the importance of seismic amplification in relation with the geotechnical characteristics of different soils.

One of the more useful experimental methods in urban areas is analysed in this study and the preliminary results of a microtremor survey (70 measurements) are presented in form of the predominant resonant frequencies obtained.

2. GEOLOGICAL CHARACTERIZATION

The city of Barcelona (2.000.000 inhabitants) is located at the Mediterranean coast, on the pediment (6 km length) of the Catalan Coastal Ranges. The main part of the town is constructed on a quaternary layer that lies above a basement composed of paleozoic slates, granitoids or miocene marine marls, depending on the district (see a geological sketch in Figure 1). Paleozoic mountains with slates, quartzites, sandstones and metamorphic rocks are represented; the granitoid rocks appear in a small belt of the Coastal Range. They bound with the Quaternary Pediment and constitute the major basement extension of Barcelona City [2], [3], [4].

Tertiary sediments, composed by Miocene block of Montjuïc and Pliocene sequence, are discordant over the granitoids. Tertiary sediments form the underground of the eastern part of the city, where the pliocene sequence is locally outcropping as in the Cathedral area (Fig. 1).

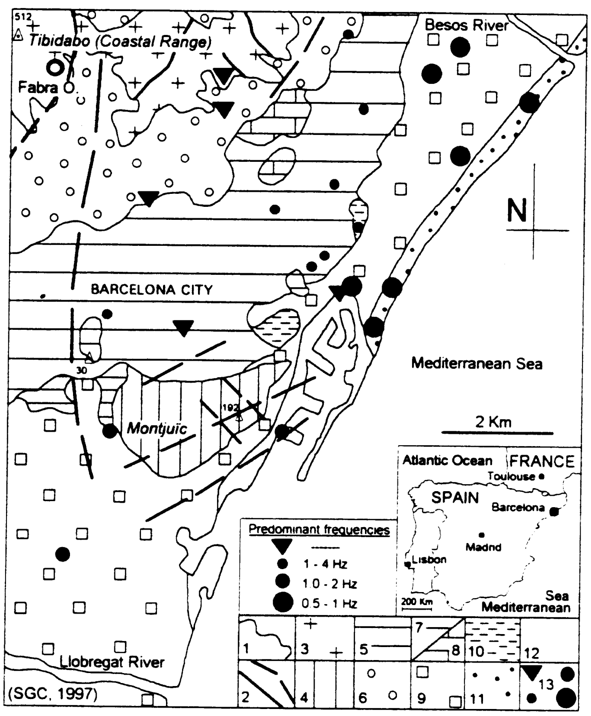

Fig. 1 : Geological map. Legend: **1**. Lithological contact ; **2**. Faults and supposed faults; **3**. Metamorphic and granitoid rocks (Paleozoic basement); **4**. Siliceous and bioclastics sands, marls and conglomerates of Montjuïc (Mid-Upper Miocene); **5**. Clays, marls, sands and conglomerates (Pliocene); **6**. Gravels and clays (Mid-Upper Pleistocene); **7**. Clays, sands, silts and gravels ("Triciclo", Mid-Upper Pleistocene); **8**. Calcareous crust and calcareous muds("Triciclo", Lower Pleistocene); **9**. Sands, muds and gravels (Holocene); **10**. Muds and sands (Holocene); **11**. Sands (Holocene); **12**. Anthropic soils **13**. Studied sites (Modified from LOSAN, 1978; IGME, 1977; SGC, 1989).

The Barcelona plain, where most of the city was built, is set up by two geomorphological units separated by a 20-30 m high scarp corresponding to the contact between pediment plain and deltaic terrains of the Besos and the Llobregat rivers. The pediment plain (ancient quaternary age so called "Triciclo" deposits) is composed by red clays, eolian muds, calcareous crust and gravels; the deltaic terrains (recent quaternary age) are made up by sands, muds and rounded gravels.
It is also important to remark the antropic modifications introduced by urbanism, in particular the "relleno" of ancient "ramblas", "rieras", "torrentes", crossing the plain and industrial areas created on the sea board.

3. EXPERIMENTAL TECHNIQUE: MICROTREMORS MEASUREMENTS.

In order to investigate the predominant soil frequencies, the Nakamura microtremors technique was used, carrying out measurements at several sites in Barcelona. They were performed using a 19 bit resolution triaxial Strong Motion Accelerograph (Kinemetrics - K2). Given the high ambient vibration level due to traffic during day time in a big city as Barcelona, measurements had to be carried out overnight (11 p.m. to 4 a.m.) in order to obtain records with few perturbations. The assistance of the Fire Brigade of Barcelona Council during the field surveys was very helpful.
Measurement points have been selected for: i) having a good coverage of the various districts in the city and ii) being significant of the different soil structures, according to the known geological and geotechnical data [2] (figure 1). The City Council provided

us with detailed digital cartography of the town. Spatial distribution of the wastewater and subway systems were considered in the selection of the measurement sites in order to avoid possible perturbations; building influences were reduced choosing, when possible, gardens and parks.

A first campaign took place on July 1996 with a total of 20 sites measured [4], a second one in February 1997 with 30 other sites and a third one in April 1997 with 20 other sites [5]

For every site several records of three minutes of duration each were obtained. Sampling rate used was 100 samples per second.

An average Fourier spectrum of 30 second overlapped windows is obtained for each component. Spectral ratios H/V are computed from the smoothed average spectra. The computer program that has been developed [6] allows us the use of different window durations and the application of various smoothing techniques. Plots of time histories, smoothed Fourier spectra and spectral ratios are produced.

Mean peak values of microtremors recorded are about 200µm/s/s.

4. RESULTS

A first analysis of the results allows us to classify spectral ratios in four main groups, according to a first classification of the geological conditions (Figure 1):

For sites located on Basement and Tertiary outcrops spectral ratios do not show predominant frequencies, with the exception of some (spurious?) peaks at frequencies near 15 Hz for some of these sites (Figure 2).

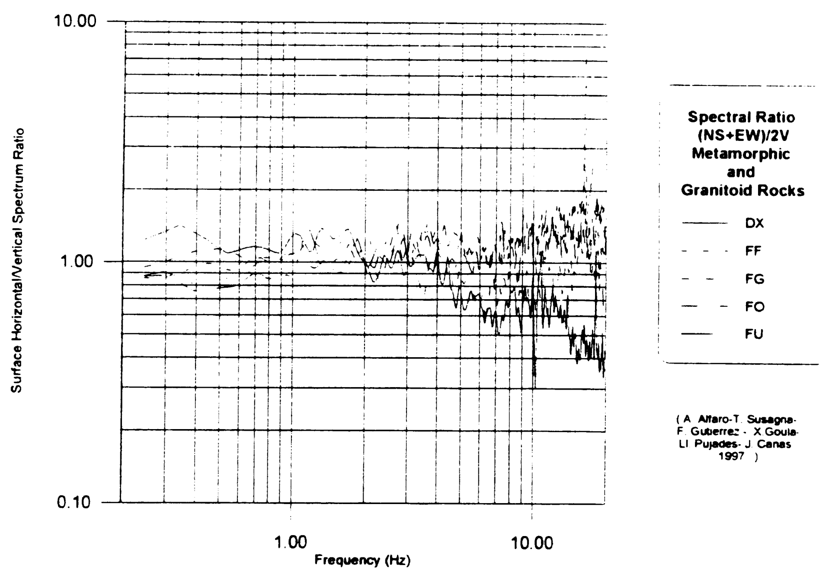

Fig. 2. Spectral ratio H/V for Basement and Tertiary outcrop sites.

For sites on Pleistocene deposits (clays, sands, silts and gravels) of the plain ("Tricicle") predominant frequencies appear on the spectral ratio plots near 1 Hz (Figure 3).

For sites on Holocene alluvial materials (sands, muds and gravels) two zones appear to have different predominant frequencies: the sediments of Besós River show frequencies between 0,5 Hz and 1 Hz (Figure 4) and the sediments of the Llobregat River show frequencies between 1 Hz and 4 Hz (Figure 5).

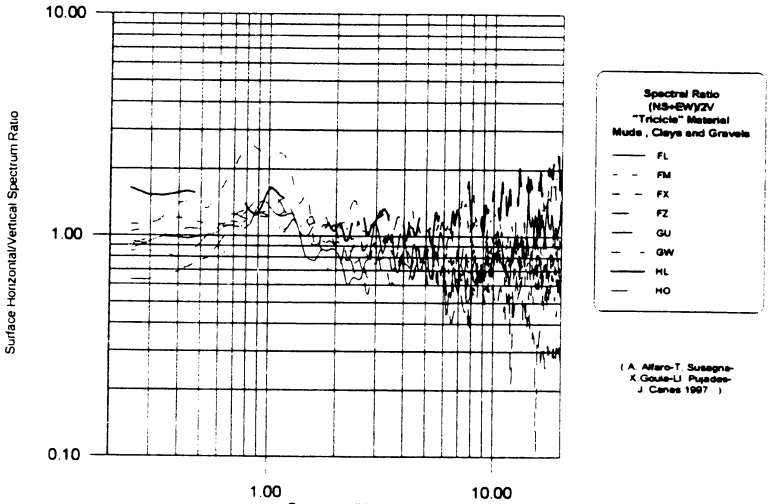

Fig. 3. Spectral ratio H/V for Pleistocene deposits (clays, sands, silts and gravels) sites.

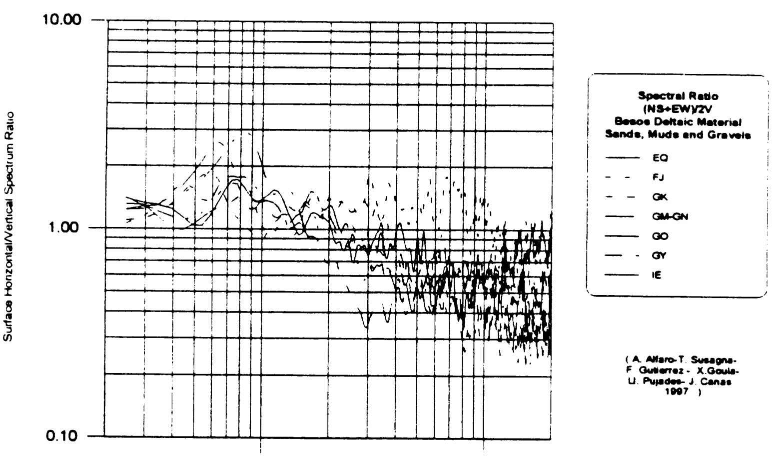

Fig. 4. Spectral ratio H/V for Holocene alluvial materials (sands, muds and gravels) for Besos River sites.

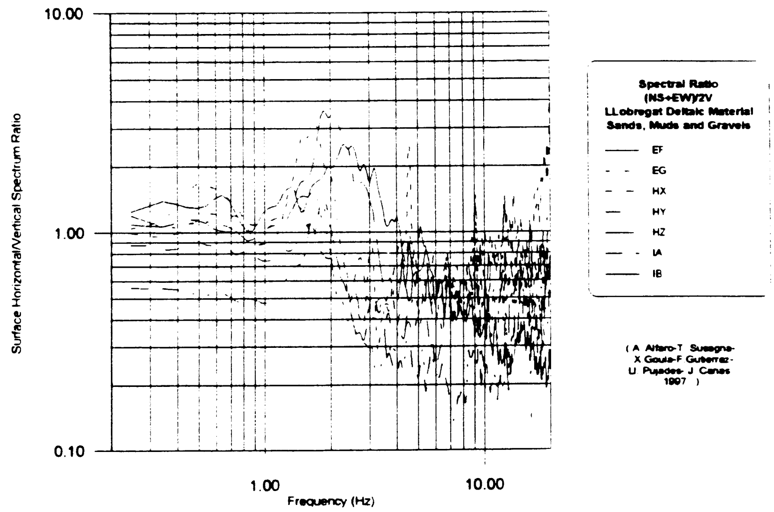

Fig. 5. Spectral ratio H/V for Holocene alluvial materials (sands, muds and gravels) for Llobregat River sites.

ACKNOWLEDGMENTS

This study was supported by a CEE project (ENV4-CT96-0255). The Instituto Iberoamericano de Cooperación supplied grants for the Master Thesis of F. Gutierrez, L. López and A. Alfaro. The services of Protección Civil of the Barcelona Council made possible microtremors survey due to the assistance of Fire Brigade. Instrumentation support was done by J.C. Olmedillas and geological aspects by J. Fleta.

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