GEOTECHNICAL CHARACTERIZATION FOR THE REGIONAL ASSESSMENT OF SEISMIC RISK IN CATALONIA

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ABSTRACT

Geotechnical characterization of soils is necessary to evaluate possible amplification of seismic effects in order to assess the seismic risk. The 944 municipalities of Catalonia, with an extension of 31.895 km² and a population of 6.080.732 inhabitants, present a broad geological variety. This study consists of a geotechnical classification of the municipalities based on the geology of the urban quarters, using four classes of soils: fresh rock; granular compact and coherent soils; altered or fractured rock, granular soils relatively compacts and coherent soils relatively consistents; granular and coherent soft soils. A first approach is carried out from the geological map of Catalonia at 1:250.000 scale available in Arc-Info format. A second approach uses more detailed geological cartography (from 1:200.000 to 1:10.000 scales). A third approach has been undertaken for the main towns of Catalonia (more than 100.000 inhabitants) plus the towns of Girona, Olot and Vielha; for all these towns the available geological cartography (1:100.000 to 1:22.500) has been digitised. Finally, the geotechnical characterization of Barcelona -where the 25% of the population of Catalonia is concentrated- is performed using the geological map at 1: 22.500 scale from Losan (1978), redrawn to 1: 5.000 scale, digitised and converted to Arc-Info format.

1. INTRODUCTION

This contribution is a part of the studies carried out in the frame of seismic risk assessment at a regional level with the objective of establishing preparedness plans for earthquake emergencies in Catalonia. In addition to earthquake hazard assessment (Goula et al., 1997) geotechnical characterization of soils is necessary to evaluate possible amplification of seismic effects in order to assess the seismic risk. Damages caused by seismic vibrations indicates that their intensity strongly depends on the local site conditions, which are related by factors like as the mechanical characteristics of the different surficial formations (density, rigidity, compressibility, etc.), the geometry of these formations (bedding, dip, sedimentary basins, etc.) and the surface topography (slope, cliffs, etc.) (Bard et al., 1995). So, in this paper we present a first step for the seismic microzonation analysis concerning a simple geotechnical characterization of the geological substratum of the municipalities in Catalonia.

2. CLASSIFICATION CRITERIA

Multiple empirical correlations between surface geology and seismic intensity increments have been extensively used for microzoning studies. The absence of the geotechnical parameters of the high number of the lithologies in Catalonia incapacitate the use of major precise geotechnical classifications (Dickenson & Seed, 1996; Borchardt, 1991). The present qualitative study is based in a simple surface geology of the urban quarters, using four classes of soils (Bard et al., 1995):

- (R) : Rocky, unweathered rock and hard; shear wave velocity higher than 800 m/s; very good mechanical characteristics. Fresh rock.

- (A) : Granular, compact material; and cohesive hard clay or marl; shear wave velocity between 800-400 m/s; good to very good mechanical characteristics. Compact sands and gravels, highly consolidated stiff clays.
- (B) : Weathered of fractured rock; granular, semi-compact material; cohesive, semi-compact material and soft chalk; shear wave velocity between 400-150 m/s; average mechanical characteristics. Relatively compact sands and gravels, mean stiff marls and clays.
- (C) : Granular, non-cohesive material; cohesive soft clay, mud and weathered chalk; shear wave velocity lesser than 150 m/s; poor mechanical characteristics. Softs sands or gravels and clays, altered gypsum and muds.

3. GEOLOGICAL MAP OF CATALONIA AT 1:250.000 SCALE

A first approach is proposed classifying the lithological tipologies of the geological map of Catalonia at 1:250.000 scale (SGC, 1989) in the precedent four classes. The list of the geological codes are the following:

Rock class : This group corresponds to paleozoic and mesozoic rocks, to paleogene consolidated rocks, and quaternary volcanic rocks.

C(AA,O,OC), D(CA,CO,P,SC,SNA), GR(A,B,C,DA,DB), P, TOA, O, OA... Hardrocks (Paleozoic times)

S, ST2, T(1,12,23,14,2)..... Dolomite and limestones, clays, evaporites, mudstone, gypsum and dolomites (Triassic)

J(1, 13,J3),C2B..... Breccias, dolomite and limestones (Jurasic)

C12, C5B, K(2D,4A,4D)..... Limestones and turbidites (Cretaceous-C-)

P(16B,2, 3B,4B, 4C, 67A, 67B, 6C, 6D, 7A, 7B)..... Limestones, marls, grainstones and conglomerates (Paleogene-P-,Eocene-E-)

P(7C,7D,7E,8B,8F,8J)..... Breccias, conglomerates and grainstones (P,E)

N(1A,1B,2E,2F)..... Recifal and bioclastical limestones, conglomerates and breccias (Neogene-N-

RV(Q,NA)..... Basalts, basanites, pyroclasts and trachists (N, and Quaternary-Q-)

A class : Paleogene, Neogene and Quaternary sediments with a high resistance and consistence grade.

C(3A,6D), K(51,5B,5D)..... Marls and clays, conglomerates and limestones (C)

P(16D,16E,P16F,23,3C,5A,5C),T34... Grainstones, mustones, conglomerates, clays, turbidites and gypsums (P,E)

P8A..... Arkoses (P, Oligocè)

N23A,N23B,N1G N2C,N2D,N3C,P8G, P8H, P8I..... Mudstones, grainstones, conglomerates, arkoses and limestones (N, P)

N1C, N3A..... Silts, marls and grainstones (N)

Q1A, Q1D, Q2D, Q2F, Q2C..... Conglomerates, travertines, clays, gravels, sands and mudstones (Q)

B class : Unhomogeneous evaporitic levels and ancient Quaternary.

P16A, P8L..... Gypsum (P)

Q2A, Q2E, Q3E, Q3G, Q3H..... Lacustrine mudstones, clays, gravels and pebbles, sands and silts (Q).

C class : Unconsolidated material with high organic content and shallower watertable.

Q3A, Q3B, Q3C, Q3D, Q3F..... Gravels, pebbles, sands and silts, sands, mudstones, silts and organic levels and charcoal (Q, mainly Holocene age).

In a second approach 100 lithological typologies are classified as follows: R class, 55 lithologies (35% of municipalities); A class, 30 lithologies (48% of municipalities); B class, 7 lithologies (4% of municipalities) and C class, 5 lithologies (12% of municipalities). An improvement of this second approach is obtained using more detailed available geological cartography (from 1:200.000 to 1:10.000 scales). So, 133 maps have been used: 53 maps 1:50.000; 55 maps 1:25.000 and 25 maps corresponding to various scales from 1:100.000 to

1:5.000. At the end, 326 lithological classes are differentiated corresponding to: R class (27%), A class (45%), B class (19%) and C class (7%) (Figure 1).
The majority of the population is concentrated in municipalities located on B and C classes (82.45%). Mainly, these municipalities are located on the modern alluvial terraces of major rivers (Ebre, Llobregat rivers, etc.) and on the Holocene sand barriers or deltaic plains.

4. MAJOR CITIES

A third approach has been carried out for the main towns (more than 100.000 inhabitants) of Catalonia plus Girona, Olot and Vielha cities which were damaged by earthquakes in their history: for all these towns the available geological cartography (1:100.000 to 1:22.500 scales) has been digitised following a boundering area of 100m equidistance from grouped urban nucleous code of Mapa Comarcal de Catalunya at scale 1:50.000 (for details to see Table I). We obtain the more favourable case for Olot (64% of R class) and the more unfavourable cases for Hospitalet de Llobregat and Vielha(close to 64% of C class, Figure 2).

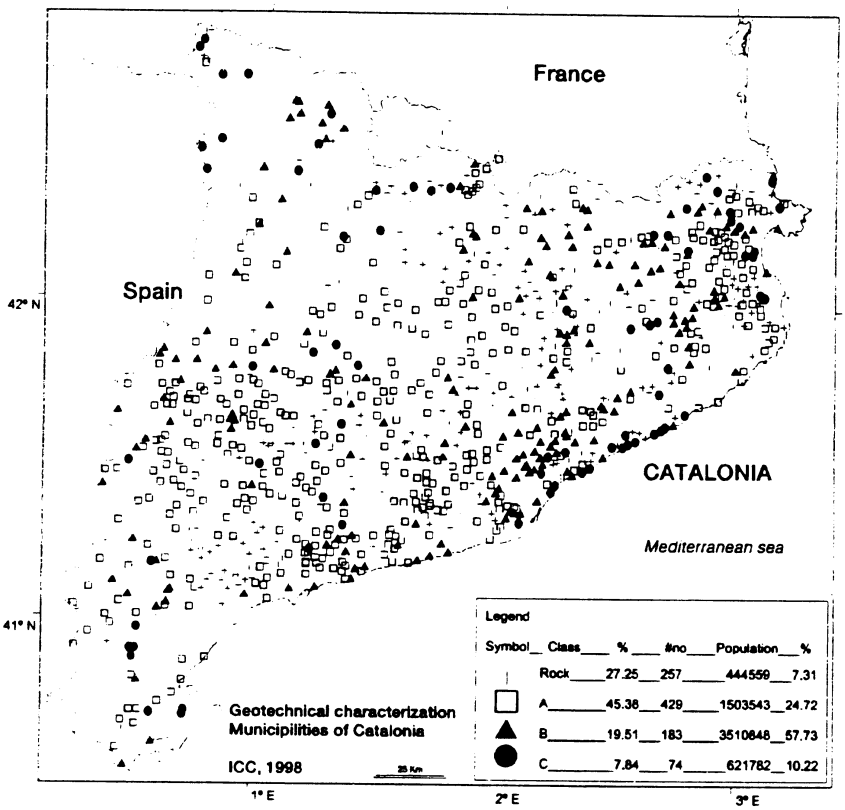

Figure 1 : Geotechnical characterization following the second approach.

Cities	R (%)	A (%)	B (%)	C (%)	AREA Km2
Badalona	2.7	3.1	53.8	40.3	10.41
Barcelona	18.6	4.2	47.4	29.7	100.5
Girona	4.6	0.0	92.9	2.5	4.49
Hospitalet	0.0	2.8	33.9	63.3	11.94
Lleida	0.0	75.0	7.2	17.7	10.06
Mataró	33.3	44.7	0.0	22.0	6.54
Olot	64.3	17.3	10.3	8.1	4.75
Sabadell	2.9	82.1	2.1	12.9	15.87
Sta.Coloma	41.9	1.7	40.3	16.1	4.25
Tarragona	5.3	0.0	48.9	45.8	4.81
Terrassa	32.9	46.8	0.0	20.4	17.68
Vielha	35.4	0.0	0.0	64.6	1.87

Table I : Geotechnical characterization of major cities.

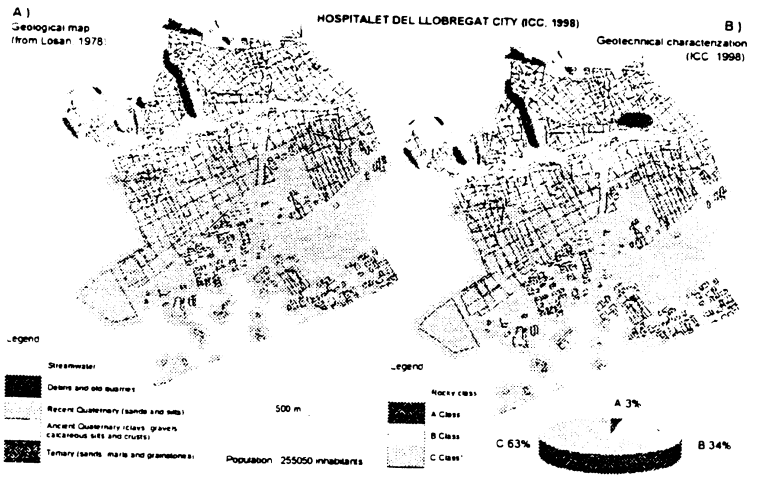

Figure 2 : Geotechnical characterization of Hospitalet de Llobregat.

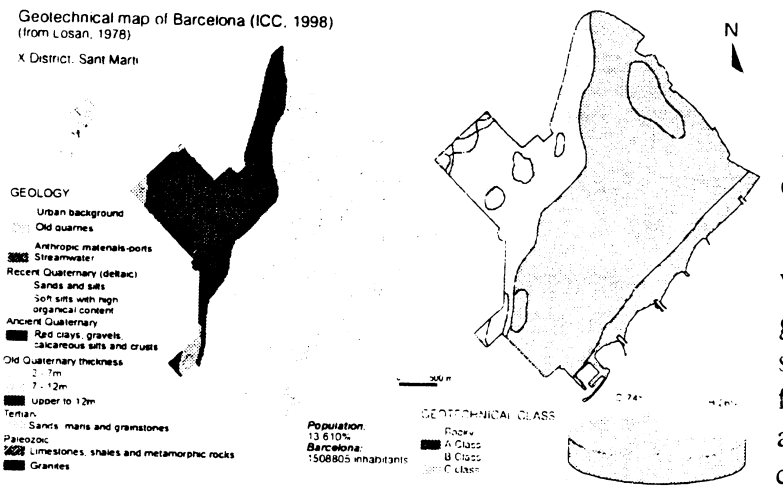

Figure 3 : Geotechnical map of the Sant Martí district.

5. BARCELONA CITY

The last approach corresponding to the geotechnical characterization of Barcelona - where 25% of the population of Catalonia is concentrated- is performed using the geological map at 1: 22.500 scale from Losan (1978), redrawn to 1: 5.000 scale, digitised and converted to Arc-Info format. In Barcelona the districts with better geotechnical qualities correspond to Horta-Guinardó (54% of R class) and to Nou Barris (42.7% of R class); while the most unfavourable, are Sant Martí (74% of C class, Figure 3), Ciutat Vella and Sants-Montjuïc (both with a 67% of C class).

6. CONCLUSIONS

We have proposed a preliminary geotechnical characterization to study seismic amplification useful for the regional seismic risk assessment of Catalonia. The comparison between first and second approaches enable us to confirm a decreasing about 5% of Rock, A and C classes of the number of the municipalities and an increasing close to 15% of B class. This 15% variation of B class is reflected in an increasing of the 49% of population in the same class. With the third approach we obtained a detailed geotechnical characterization of the urban surfaces of the major cities.

ACKNOWLEDGEMENTS

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7. REFERENCES

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