THEME 1
Regional engineering geological mapping for planning purposes
Cartographie géotechnique régionale en vue de la planification

LARGE SCALE, 1:1,000 — 1:5,000, GEOTECHNICAL MAPPING BY THE INSTITUTO GEOLOGICO Y MINERO DE ESPAÑA, IGME (SPANISH GEOLOGICAL AND MINING INSTITUTE), FOR INDUSTRIAL AND URBAN PLANNING

CARTOGRAPHIE GÉOTECHNIQUE A GRANDE ÉCHELLE (1:1,000 — 1:5,000) DE L'INSTITUT GÉOLOGIQUE ET MINIER D'ESPAGNE POUR LA PLANIFICATION INDUSTRIELLE ET URBINE

ABAD FERNÁNDEZ J., AYALA CARCEDO F.J., PERNÍA LLERA J.M., Geotechnical Division, Spanish Geological and Mining Institute, Madrid, Spain

Summary

During the past twelve years the IGME has made, mostly for the Instituto Nacional de Urbanización (National Urbanization Institute), geotechnical maps of 60 industrial and residential areas at the 1:1,000 — 1:5,000 scale for a total of over 20,000 ha. The paper includes the aims of that mapping, its methodology and the lessons learnt from it, as well as its main problems and limitations.

Résumé

Pendant les dernières douze années, l'Institut Géologique et Minier d'Espagne a réalisé, surtout pour l'Institut National d'Urbanisation, la cartographie géotechnique de 60 zones industrielles et résidentielles à des échelles de 1:1,000 à 1:5,000. On a cartographié à ces échelles plus de 20 000 ha. On expose les objectifs visés, la méthodologie suivie et les résultats obtenus, ainsi que les principaux problèmes et les limitations.

Introduction

During the past twelve years the Geotechnical Division of the Spanish Geological and Mining Institute has been developing systematic geotechnical mapping. This task, the general lay-out and basis of which have been explained by Echevarría (1967), Abad et al. (1976) and Echevarría et al. (1978), has covered a total area of over 20,000 ha at 1:1,000 — 1:5,000 scales, consisting of 60 industrial and residential sites. For that purpose almost 20,000 m were drilled; 4658 SPT's were made and 3077 undisturbed samples were taken. 915 test pits were made also, and 1365 penetrations (soundings), mostly dynamic. Likewise, hundreds of electrical soundings were made and tens of plate loading tests. The number of samples tested in the laboratory was about 15,000. The study sites are shown in Fig. 1.

The IGME's Geotechnical Division has carried out other geotechnical mapping work, in short all of the Spanish territory, at the scale of 1:200,000; the Madrid subregion at 1:100,000; and several cities at 1:25,000 (Cordoba, Santa Cruz de Tenerife, and the Parla zone also while Almería, Malaga and Huelva are being done). Some of the above works have been described by J. Abad et al. (1975) and González (1977).

In those works the scales used by the IGME are indicated. Following the criteria recommended by the IAEG's Geotechnical Mapping Commission, (UNESCO 1976), the maps which are the subject of this study are large scale multipurpose maps, but sometimes include special purpose maps (see Figs. 9, 10, 11) such as embankment settlement and stability, subsidence hazards, etc.

Purpose of the maps

This large scale mapping was undertaken to meet the request of those technicians in charge of preparing new industrial and residential sites. After several years of planning without including this basic element, it was established that the absence of previous geotechnical mapping caused some unexpected problems while the works were being undertaken, sometimes with a considerable effect on costs and schedules.

The current systematic use of mapping served to establish that unexpected problems are not encountered nowadays. Problems can be foreseen, as well as the possible solutions for them, and that eliminates the logical uncertainty formerly present.

The basic purpose of these maps is to evaluate the constructive quality of the ground at the various points of the area under study. That evaluation is:

a) Qualitative: Identification of existing problems and description of possible solutions (for example, high groundwater level in a site where a building with two basements is to be erected. The problems are: 1) how to excavate, 2) how to maintain the excavation walls. The solutions would be: concrete diaphragm walls and floor grouting; depression by well-points.

b) Semiquantitative: Using the above example, it would answer such questions as: would it be necessary to drain a lot of water? or what would the magnitude of active thrust be against the concrete diaphragm wall?
Generally, the ground constructive situation is evaluated for several types of works in any industrial or residential area:

**Infrastructure**
- Roads
- Superficial and underground drainage
- Excavations
- Aggregate and fill materials

**Industrial and residential building**
- Foundations
- Floors
- Retaining walls and permanent drainage.

The geotechnical maps must provide enough data to help identify all possible problems that affect the aforesaid works, as well as the possible solutions that should be adopted and the parameters that would permit a semiquantitative approach (or quantitative in certain cases as, for example, the pile length necessary to reach the substratum), at preliminary design level, or even at design level for jobs that are not too important.

To attain the above mentioned purposes, representative maps should be used appropriate to the knowledge and understanding of these map users. In Spain, users of these maps are generally design engineers or site engineers, architects and contractors. Frequently users lack almost entirely a knowledge of geology, and often they even do not have a clear appreciation of soil and rock mechanics. Fortunately, this being alleviated to some extent, and hopefully the problem will gradually diminish, though usually this is not the case. This determines the terminology to be used, it should include local terms applied to certain formations and problems, and the representation method, in which the user's lack of geological knowledge should be considered.

**Methodology**

The methodology covers the following phases:

**Compilation of all information available**

Geological and geotechnical papers are sought as well as previous geotechnical studies covering the area involved or nearby areas and similar formations. The compilation of previous data provided by state or local bodies or persons living in or near the area is made in the following phase.

**Geological study**

Generally a geological base at the scale of 1:200,000 or 1:50,000 is used. The 1:1,000-1:5,000 study-scale requires a far more detailed geological study. In this respect we agree with Pasick and Rybál (cited by Echevarría, 1967), and think that a geotechnical map is a good geological map. Firstly, it is necessary to separate the various materials that usually are shown grouped in geological maps on the basis of time stratigraphic or biostratigraphic criteria. Secondly, the processes experienced by the substratum during the Quaternary should be considered of the utmost importance; usually these are not properly reflected in geological maps, although they are very important for most constructions, which are usually limited to less than 10 m depths. Thirdly, attention should be paid to rock joints, fracturing, fault filling, etc. Finally, active geodynamic processes (subsidence, etc.) should be considered. Generally, the inhabitants of the area can provide useful information on geological hazards.

**Site investigation**

This phase starts after the geological study is made in order to know the ground deeply and take samples to determine the soil mechanics performance.

**Techniques used**

The most suitable and powerful is drilling. The short depth of the holes (10-35 m) and the many changes from one hole to another make it advisable to use the cost saving and quicker truck mounted drills and helical rods whenever possible. During the drilling, SPT's are made and undisturbed samples are taken from all formations. Disturbed sampling is continuous. After the selection of samples in the field, they are sent to the IGME's Geotechnical Laboratory. PVC grooved tubing is used in most drillings to observe groundwater levels.

Penetration, generally dynamic (Borro type with 4 x 4 cm² points) is used in similar number to the drillings. This is made for two purposes: