Influence of local subsoil conditions on the earthquake effects in the town of Aiquile - Bolivia

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Abstract
The objective of the present work relates to the analysis of the response of the soil deposits in the town of Aiquile (Bolivia) during the last earthquake (Ms=6.8) occurred on may 1998. In situ tests were performed over the area such as electrical resistivity, SPT and SASW. A provisional microzonation map could be proposed.

Introduction.
The present synopsis describes briefly the work carried out for the development of a microzonation map for the town of Aiquile. Several tests were performed such as the standard penetration test (SPT), electrical resistivity test, spectral analysis of surface waves (SASW) and the classification of all soil samples collected.

Seismic microzonation is actually a multi – disciplinary work; however, the present study is referring only to a geotechnical analysis, principally due to the lack of appropriated seismological and geological information for the area.

Earthquake and structural damage distribution.
An earthquake, M=6.8, stroke the town of Aiquile on may 1998. An intensity level of VII on the MMI scale, a distance to the epicentre of 60 km and a focal depth of 13 km were reported by the S. Calixto observatory.

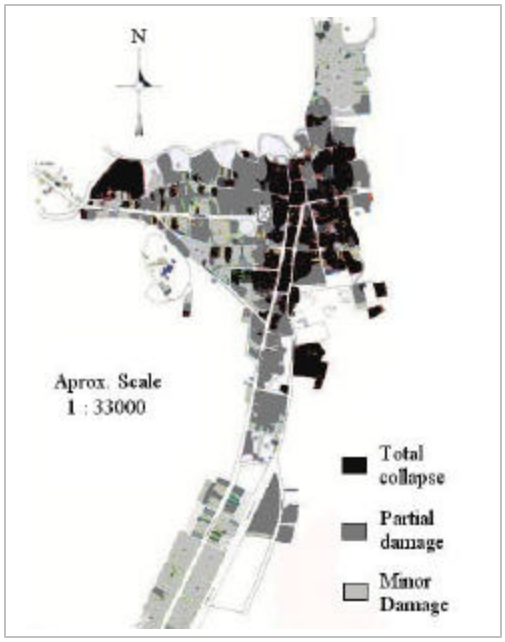

Figure 1 Actual structural damage pattern (UMSS)

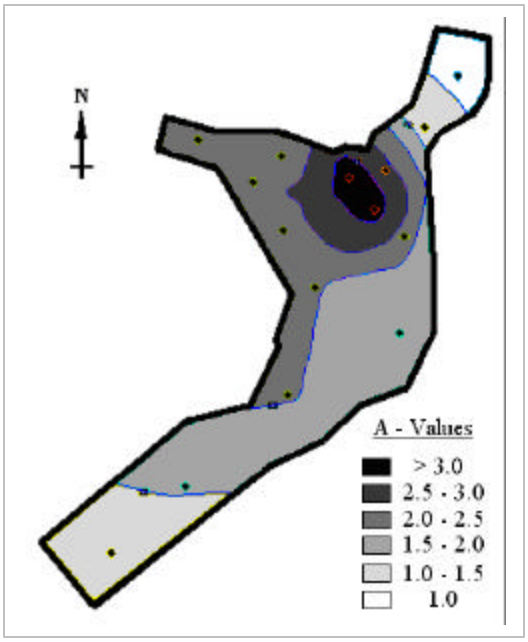

Figure 2 Relative amplification factors in Aiquile

Just after the event a field inspection was carried out, by a team of the San Simon University (Bolivia). The objective was to examine the level of damage. The results are summarised in figure 1. It clearly shows a regular pattern of damage distribution. The darkest zone reflects the most affected area (houses totally destroyed) surrounded by a less damaged belt and even farther the damage was minor.

Geotechnical characterisation and relative amplification factors.

The area was subdivided into 3 zones according to the subsoil conditions. To the north, a rock outcrop was found, the measured shear wave velocities (V_S) reach values over 1000 m/s. In the centre of the town the subsoil corresponds to a clayey and silty clayey deposit of soil, with variable and non determined maximum depth, the V_S varies from 160 to 400m/s. To the south, a stiff and deep deposit of a mixture of clay and boulders was identified, with Vs from 400m/s increasing up to 1000 m/s.

With the data and a correlation (equation 1) proposed by Midorikawa (1987) the relative amplification factors (A) were estimated. The results of the damage level zones connected A values are summarised in figure 2, the darker areas corresponding to higher amplification factors.

$$A = 68 \cdot V_S^{-0,6} \qquad \text{(Eq.1)} \qquad ; \qquad V_S = k_1 \cdot N_{SPT}^{\,k2} \qquad \text{(Eq.2)}$$

The susceptibility distribution from SASW measurements in figure 2 shows good agreement with the actual structural damage distribution (figure 1). One should be aware that figure 2 clearly relates to information directly linked to the soil conditions, while figure 1 implements both vulnerability of structures and soil conditions.

Correlation S-wave velocity with N_{SPT}.

Simultaneously, a comparative analyses was carried out, aiming at selecting an appropriate correlation between the shear wave velocity and the N_{SPT} of the standard penetration test. The general form is given by equation 2.

There are several of such correlations in literature (ISSMGE - TC4) (Imai & Tonouchi, 1982; Ohba & Trauma, 1970; Ohsaki & Iwasaki, 1973). Some results of the analysis are presented in figures 3 and 4.

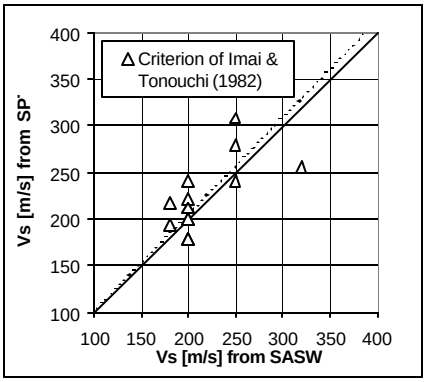

Figure 3 Data processed from SASW/ SPT

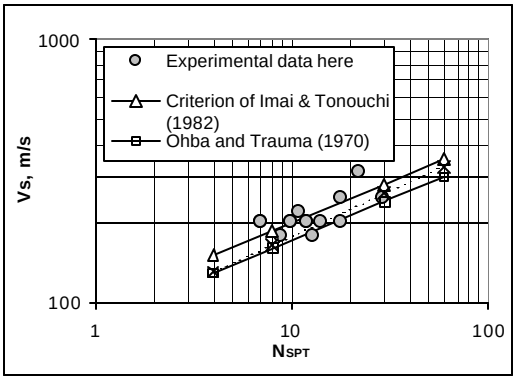

Figure 4 Shear wave velocity vs. N_{SPT}

According to our data, it was possible to state that the correlations following the Imai et al. (1982) criterion provides the closest values to the V_S measured by the SASW technique. That fact allows its employment and it becomes a useful tool since the standard penetration test is commonly practiced for site investigation in Bolivia.

Summary.

The influence of local soil conditions played a predominant role in the response of the soil deposits in the town of Aiquile. Although limitations on the testing equipment available reduced the extent of the research work, the results obtained are useful for preliminary planning purposes in the reconstruction phase of the town.

The data correlation making use of the Imai & Tonouchi (1982) criterion was shown to be appropriated in estimating the shear wave velocity of Bolivian soils from N_{SPT}.

References.

Verástegui, R.D. Salinas L.M. and Van Impe W.F. (2000). Soil dynamics and microzonation in Bolivia. Report on soil dynamics, Ghent University. Not yet published.

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