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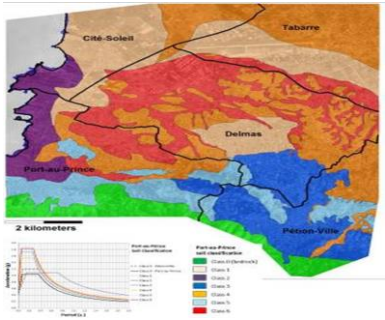
Seismic microzonation in Haiti: an important tool for seismic risk mitigation

The problem

The catastrophic, magnitude 7.1 Mw earthquake on January 12, 2010 caused major damage in the Haitian capital city of Port-au-Prince, but also in Jacmel and other settlements in Haiti. A large number of buildings were totally destroyed or significantly damaged, resulting in the death of more than two hundred thousand people according to the Haitian Government estimation. These abnormally high damages and death toll are mainly due to the high vulnerability of building structures in the country[1,2]. Additionally buildings were also at greater risk of damage due to local features of the soils and the bedrock: including soft soils and lithological site effects[3], topographic site effects[4] and liquefaction[5].



Mapping of lithological site effects classification for Port-au-Prince microzonation

The science

Reducing the vulnerability of urban areas to seismic hazard requires research to clearly identify the characteristics of ground responses to seismic waves and to map them at a scale small enough for use in urban areas (between 1:25,000 to 1:10,000). The other objective of this action, a process called seismic microzonation, is to provide recommendations dedicated to land-use planning and construction. These seismic microzonation engineering techniques were used to study lithological and topographic site effects in Haiti, as well as active faults rupture at the surface, liquefaction and ground instabilities.

The French Geological Survey (BRGM) used the French Association for Earthquake Engineering[6] guidelines to undertake numerous microzonation studies in the French West Indies, and cross-checked results obtained in Pointe-à-Pitre city (Guadeloupe) using ground-motion recordings from local seismological stations[8]. The surveys were then successfully carried out on nearly 20 municipalities in the Guadeloupe and Martinique islands, and used for the implementation of Risk Prevention Plans[9].

The application to policy and practice

Upon the request of the Haitian Government, the same methodology used in Martinique and Guadeloupe was applied in 2011-2013 for the microzonation study of the Port-au-Prince metropolitan area. Additionally, four major cities located in the Northern part of the country were mapped in 2012-2015 within the framework of the UNDP, HAI/11/146 Project "Earthquake Prevention Plan for the North of Haiti": Cap Haitien, Fort-Liberté, Ouanaminthe, Port-de-Paix.

An important component of this action has been dedicated to knowledge transfer and on-the-job training with two Haitian public institutions: the Laboratory in charge of Civil Engineering (LNBTP) and the Bureau of Mines and Energy (BME). Following a 15 days theoretical course with BRGM staff in France, practical training was carried out in Haiti, covering the whole range of data acquisition and processing: from investigations in the field including geological studies and geophysical measurements to desktop studies. As a validation, a multidisciplinary team of LNBTP-BME engineers is now finalizing on its own the microzonation mapping of Port-de-Paix city. In addition to site effects and liquefaction maps, desk studies and field surveys have resulted in:

- an updated map of the surficial geological formations and the identification of unknown active faults;
- numerous geophysical measurements using Multichannel Analysis of Surface Waves[10] (MASW) and Horizontal-to-Vertical Spectral Ratio Seismic[11] (H/V) methods;
- sample analyses of geotechnical drillings +/- 30 m. deep and;
- a new ground instabilities survey and mapping.
- Derived building recommendations have been made in agreement with the National seismic building code in Haiti.

Did it make a difference?

Large scale mapping of site effects provide more detailed soil characteristics than the homogeneous classification usually prescribed in construction codes. The LNBTP foresees to arrange awareness actions towards people working in the construction sector in order to ensure assimilation and effective use of these new and accurate data.

MASW profile measurement by LNBTP in Ouanaminthe city (credits: D. Bertil)

This work has also revealed the existence of unknown active faults in the Port-au-Prince area[12], for which additional analysis is needed. It also points out highly populated urban areas where the hazard levels for ground instabilities and liquefaction are very important. Hence this mapping is used to target the most vulnerable zones and raise public authorities' awareness on places where the protection of populations takes priority.

The major difficulty in earthquake risk reduction is the operational and effective application of seismic risk prevention measures, especially regarding the wide and systematic use of earthquake-resistant design rules. In that way, seismic microzonation mapping appears to be a very useful and accessible information tool. It will progressively be available to the general public on internet[13] for the main cities in Haiti. It is also a critical input for the set-up of earthquake-resistant regulations. Today, the LNBTP is using this knowledge on a daily routine for the analysis of foundations of public buildings.

Authors: Dr. D. Bertil (BRGM, Service géologique national, France), Ing. C. Prépetit (BME, Bureau des Mines et de l'Energie, Haiti), Dr. A. Roullé, Dr. J.-P. Rançon, Ing. A. Vagner (BRGM)

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