Implementation of seismic microzonation in municipality ordinances in Caracas, Venezuela

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1. Abstract

Strong site effects, which caused the collapse of 4 buildings with 10 and more storeys during the Caracas 1967 earthquake, and the damage of a big number of them in the same deep sediment area, motivated the development of the Caracas Seismic microzoning project in the years 2003-2009. The final results of this project were the development of design response spectra for the different microzones within the sedimentary basins, as well as antiseismic ordinances of local authorities. A detailed mapping of the seismic microzones was done in association with local authorities. They are aimed to address mitigation for new constructions by the application of the specific design spectra, for existing buildings via evaluation and retrofitting strategies, and for slope areas (informal, as well as formal development) due to the identification of areas that may not be developed or require detailed studies of slope stability.

2. Seismic hazard

In 1967, 4 modern high-rise buildings collapsed and more than 200 were damaged in a distinct area of the city, characterized by deep sediments.

The main seismic hazard is attributed to the San Sebastián fault system, which marks the plate boundary between the Caribbean and South America plates, is located just 5 km north of the city. Simulations of seismic hazard show decrease from north to south, with amplifications in the sedimentary basins, as for example for a severe scenario like the 1902 earthquake (Yamazaki et al., 2005).

3. Caracas today

Caracas is a city of more than 3.5 million inhabitants. High-rise buildings prevail within the metropolitan valley, and informal buildings with up to 4 storeys cover most of the surrounding slopes. 5 municipalities comprise the Caracas Metropolitan Region.

4. Subsurface investigations

A series of geophysical measurements, including seismic refraction, noise measurements and gravimetric modelling, together with pedological (siltations, aquifer data) and pedological investigations lead to a subsurface model. A detailed assessment of the seismic behaviour within the valley in 3D and 2D investigations is required for construction permits within this corridor.

5. Seismic microzones and adjustment to cadastral limits

An as a result from geological, geotechnical and seismic engineering studies, a seismic microzoning map was derived, which allows to define zones of similar seismic behavior within the city (Schmitz et al., 2011).

Seismic microzones were adjusted to the cadastral limits in each of the municipalities in order to avoid ambiguities for the application of the elastic response spectra (Hernandez et al., 2011).

6. Landslide hazard

A fast growing part of the city with more than half of its population comprises informal housing at steep hillsides surrounding the valley, with earthquake or rainfall triggered landslides as the principal hazard in these areas. Therefore, a methodology for the evaluation of the susceptibility to slope movements, including local calibrations, was applied (Hernandez et al., 2008).

Recommendations are given how to treat areas of high landslide hazard, and how to calculate the affected slope areas, as well as indications for response spectra that take into account topographic effects of hillsides.

7. Active faults

Corridors are defined around the outcrops of the active Tacasaj – El Avila fault, on the northern and eastern Caracas valley. Geophysical investigations are required for construction permits within this corridor.

8. Use of microzonings in municipality ordinances

Since 2011, after finishing the Caracas seismic microzoning study, considerations are necessary within the different Caracas municipalities, and since 2012 also with the other municipalities Chacao, Sucre, and Baruta and El Hatillo. Local authorities are currently discussing for new buildings in occuppation of the building codes, as well as for existing buildings and hillides, within existing laws and technical regulations.

9. Libertador municipality

Priorities for detailed building evaluation and possible retrofitting are defined based on the parametric studies of building behavior (Hernandez, 2009), as well as for the school buildings, based on a detailed study, including retrofitting plans for typical buildings (Schmitz et al., 2007).

10. El Hatillo municipality

El Hatillo municipality is located in the highly south western part of Caracas Metropolitan Region, with the contribution of sedimentary areas, but predominant karstic and weathered bedrock with moderate landslide hazard.

11. Chacao municipality

Chacao is the business district of Caracas with high-rise buildings in the area affected by the 1967 earthquake. The Local Urban Development Plan PDVU is actually in discussion and restrictions to building heights were introduced in areas of high sediment thickness in order to mitigate seismic risk to high-rise buildings.

12. References


Amarís, E., Schmitz, M., Murphy, V., 2011. Sediment thickness as primary input for the Caracas Seismic Microzoning Project.
