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Technical Note

Site response effects on an urban overpass

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ABSTRACT

Strong ground motion variability due to rapid changes in subsoil conditions may lead to different site responses, which in turn yields to beneficial or detrimental soil–foundation–structure interaction. This technical note presents the results of a seismic soil–structure interaction analysis conducted using a 2D finite difference model, developed with the program FLAC, of a critical section of a 60 km long strategic urban overpass, which is under construction in Mexico City, for a M_w 8.7 earthquake. Initially, the response of the free field was calibrated comparing the values obtained with FLAC, with those gathered using the computer code QUAD4M. Good agreement was observed between the results generated with these programs. Accelerations and displacements were determined at the upper deck and foundation of the urban overpass. Important seismic soil–structure interaction was observed along the overpass at the supports analyzed. This numerical study helps to gain insight regarding the site response ground motion incoherence effects that influence the dynamic behavior of this kind of structures during extreme events.

1. Introduction

A major transit system 60 km long, comprised of a series of interconnected urban vehicular overpasses, is currently under construction in Mexico City. The proper design of this kind of very long structures requires evaluating the ground motion variability effects along the structure (e.g. [1,2]), in order to quantify the potential relative displacements among consecutive supports, in both longitudinal and transverse directions to avoid collapse (e.g. [3,4]). Some of the most important sources of ground motion variability are site conditions (e.g. [5]), input motion (e.g. [6]), wave passage (e.g. [7]), geometry of the structure and its foundation (e.g. [8]), and local soil–structure interaction that occur in urban areas (e.g. [9]), specially when they are heavily populated, such as Mexico City. This evaluation is crucial when the seismogenic zone controlling the seismic risk of a populated urban area has the potential of producing major seismic events. Historical seismicity has proven that the subduction zone located along the Coast of Oaxaca state is able to produce events with moment magnitude, M_w=8.6, with potential fault rupture lengths of about 450 km [10]. Similar conditions have been found at the Columbia-Ecuador subduction zone, where a major seismic event (M_w=8.8) occurred in 1906 [11].

This paper presents the results of a numerical study conducted using a 2-D finite differences model, developed using the program FLAC [12], of one of the overpasses that comprised the aforementioned transit system for a hypothetic seismic scenario characterized by a M_w 8.7 event, with seismological zone located in the Pacific Mexican subduction zone. Only longitudinal effects were studied. The numerical model involves seven of the more critical supports of the overpass from the geotechnical stand point (Fig. 1).

2. Project description

The studied overpass section is located at the North-West region of Mexico City. The overpass consists of an upper deck resting on top of central and support beams, which are in turn, structurally tied to the columns, forming a frame. Beams are connected by mobile and articulated joints (Fig. 1). The columns are monolithically attached to a rectangular raft foundation $3.6 \times 4.6\ m^2$, connected to four 0.8 m diameter, cast-in situ, concrete piles. This massive pile cap is approximately 4.15 m thick, as shown in Fig. 2. The separation between piles is 2.30 m in the longitudinal direction, and 3.30 m in the transverse direction. All seven supports, belonging to the analyzed section of the urban overpass, have the same raft foundation geometry. However, the pile length for support S-1 is 16 m and for the rest of the pile supports is 33 m. The columns, beams and upper deck were pre-stressed and made of high strength concrete. The concrete strength at 28 days, f'_c, of the columns and beams was 58,841 kPa, and of the piles was 2417 kPa.

3. Subsoil conditions

The urban overpass is located in a nearly flat area. To characterize the geotechnical subsoil conditions where supports S-1–S-7 are

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