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ESTIMATION OF THE SEISMIC HAZARD FOR THE LIMA METROPOLITAN REGION: EARTHQUAKE SCENARIOS AND STRONG MOTION SIMULATION

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INTRODUCTION

A new international 5 years research project entitled "Enhancement of Earthquake and Tsunami Disaster Mitigation Technology in Peru", has officially started in 2010 involving a large number of Japanese and Peruvian universities and research institutions, under the sponsorship of the Japan Science and Technology Agency and JICA (SATREPS). We will give an overview of the planned research activities and methodologies regarding the evaluation of the seismic hazard for the Lima metropolitan region and its validation using real earthquake observations.

SEISMIC HAZARD ESTIMATION METHODOLOGY

Seismic hazard estimation in earthquake prone regions has been traditionally addressed using a probabilistic approach. However when a detailed study of the hazard posed from specific seismic sources for a particular site is required, the deterministic approach is more adequate. In this study we follow the deterministic approach as we want to investigate the possible effects of the most likely damaging earthquakes that could affect the Lima metropolitan region. Our models will be based on consideration of several earthquake scenarios from the Nazca plate in Central Peru, and will incorporate the actual geometry of the subduction zone at this region as well as a 3D velocity model of the shallow sediments beneath Lima, to calculate expected broadband frequency strong ground motions at Lima (Aoi et al. 1999, Pulido and Kubo, 2004).

EARTHQUAKE SCENARIOS

Central Peru and in particular Lima have recurrently experienced a large number of damaging earthquakes mainly originated at the subduction of the Nazca plate beneath South America. The 28 October 1746 is reportedly the worst earthquake Lima has experienced since its foundation. Compiled intensity reports suggest a source area of at least 350 km (Dorbath et al. 1990), which agrees with estimations of a moment magnitude of ~8.8 for this earthquake, based on reports of a tsunami runup height of 24m observed in Callao (Swenson and Beck 1996). This earthquake was followed by a long period of quiescence in the subduction margin of Central Peru, which concluded with the 1940 event, and was followed by a sequence of M8 class events near Lima that can be interpreted as a "buildup of smaller events, culminating in a gigantic shock" (Okal et. al. 2006). We choose this type of event as the worse case scenario to affect Lima. The recurrence of this type of event has been estimated in ~290 years which suggest it can very likely occur any time within the next 20 years (Figure 1).
As a second likely scenario we choose an intermediate M8 class event off-shore Lima. A representative example for such an event is the October 3/1974 Mw8.0 earthquake (Figure1), which occurred 80 km west of Lima at a depth of 10 km. This earthquake produced a moderate damage to Lima mainly in districts with soft sediments such as La Molina and Callao.

THE 2007/08/15 PISCO EARTHQUAKE

The 2007 Mw8.0 Pisco earthquake was located 160 km south-east of Lima with a source region filling the gap between the 1974 Lima earthquake and the 1996 Nazca ridge earthquake. The available source models of this earthquake show two distinct asperities separated by approximately 80 km (Yagi, 2007 [Figure 2], Sladen et al., 2010). Ground motions from this earthquake are also characterized by two clear events originating from the two asperities, as can be observed from IGP strong motion recordings of the mainshock at Lima (NNA), and Parcona (PCN) stations (Figure 2). Based on the aforementioned source models we are currently simulating the observed strong ground motions from this earthquake in order to obtain estimates of several very important source parameters such as adequate stress drop values for Peruvian subduction zone earthquakes, to be used for simulation of ground motion for our scenario earthquakes. Our preliminary analyses show that a variable radiation pattern across the fault plane can provide an appropriate explanation on the striking characteristics of observed ground motion at PCN, namely that the amplitude of the first event, which originates from asperity 1, is much larger than the amplitude of the second event, which originates from asperity 2, despite the fact that asperity 2 is located much closer to the station and has a larger moment release (Figure 3 and 4).

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Figure 1. Historical earthquakes affecting Lima considered as earthquake scenarios (overlapped on a USGS poster of the Pisco earthquake).

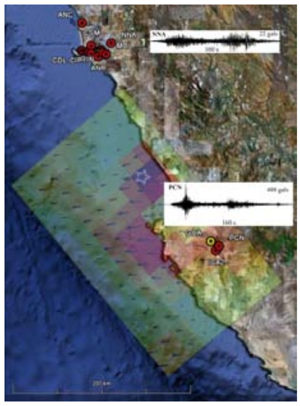

Figure 2. Source model and strong ground motion of 2007/08/15 Pisco earthquake.

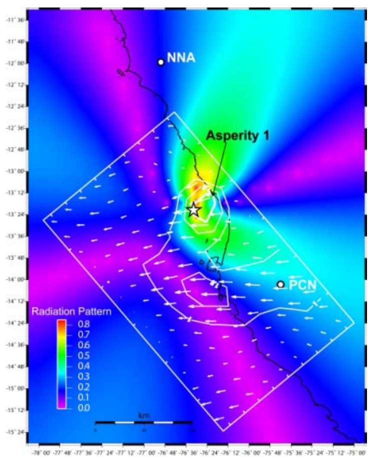

Figure 3. Radiation pattern of asperity 1 (thick white line near the hypocenter), 2007/08/15 Pisco earthquake.

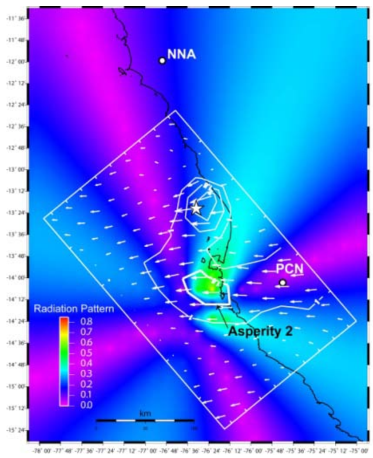

Figure 4. Radiation pattern of asperity 2 (thick white line), 2007/08/15 Pisco earthquake.