Peru and the Mapping of Seismic Hazard

Mapping History

A mapping project of historical seismic activity will help the Peruvian national and local governments assess the earthquake hazard of the country and provide information for the reduction of disaster risk (e.g., loss of life, infrastructure, buildings, and basic services). A hazard assessment begins with the compilation of historical records into a database that could be visualized as a seismicity map. Maps provide a visual and spatial understanding of natural events. A spatially represented database of seismic events reveals patterns of occurrence, location, and frequency, and can, thereby, enable the scientific community, government authorities, and the general public to plan for probable future occurrences. In addition, maps provide the input to enable authorities to improve building standards by incorporating seismic design concepts in the construction of schools, hospitals, office buildings, and large public works, such as dams, hydroelectric plants, mines, and roads. Finally, a comprehensive analysis of seismicity (frequency and magnitude of earthquakes) improves a country’s ability to protect progress already made and plan for the future.

Technical Assistance Project (TAP)

The Peru seismic hazard assessment exercise is the product of a Technical Assistance Project (TAP) using the CAPRA Probabilistic Risk Assessment software platform. The TAP is sponsored by the World Bank, funded by the Spanish Fund for Latin American and the Caribbean (SFLAC), and implemented by the Geophysical Institute of Peru (Instituto Geofísico del Perú, IGP). The engineering consulting firm Evaluación de Riesgos Naturales—América Latina (ERN-AL) is providing training services and technical advice for the seismic analysis.

The CAPRA software platform was originally developed to assist Central American governments in the assessment of hazards from natural events and the adoption of standards that reduce the risk of natural disaster. CAPRA is a free and open source platform for risk analysis and decision making, which applies probabilistic techniques to hazard and risk assessment. CAPRA TAPs are under implementation in South America and in other regions, such as South Asia, where natural events can turn into disasters. In addition to CAPRA’s goal of strengthening risk
assessment, the training activities enable participants to continue the work after the TAP is completed.

The TAP will provide seismic information of the entire country and more detailed information of the Metropolitan Area of Lima. This will enable the national and local governments to identify safe investments for the short, medium, and long-term, strengthen institutional and technical capacities to assess seismic risk, and allow relevant institutions to systematically update the data. Thus, the TAP’s main objectives are to:

■ Prepare national level seismic information and maps for regulatory purposes and proposal of earthquake-response spectra for Peru’s capital.

■ Reduce risk resulting from inadequate design or construction. The results will be incorporated into the seismic design standard update led by the Committee on the Seismic Design Standards. They may also be included in the hazards database of the public investment system.

In addition to producing seismic hazard maps, the CAPRA platform evaluates risk in terms of physical and direct damage and losses (buildings, infrastructure and human life). This provides a complete evaluation of the potential losses from an earthquake.

The History and Geography of Earthquakes in Peru

The Lima Metropolitan Area includes the cities of Lima and Callao and their surrounding municipalities. With a combined population of over 9 million, the Lima Area is the most populous urban area in Peru, and the country’s economic and political center.

Peru has a long history of seismic activity. One of the earliest descriptions comes from 1582, when an earthquake destroyed much of Arequipa. The earthquake and tsunami of 1746 resulted in around 5,000 deaths and the complete destruction of Callao. The earthquake of 1940 was felt as far away as Arica, Chile to the South and Guayaquil, Ecuador to the North. In 1946, a magnitude 7.3 earthquake generated landslides that destroyed the town of Quiches and severely damaged the towns of Conchucos and Mayas. This event also caused a two-mile wide break in the Quiches Fault and the land in the break to sink by ten feet.

Finally, on August 15, 2007, two earthquakes took place—at 6:40 pm and 6:42 pm. The overlap of the two seismic events shook the ground for two minutes, which resulted in the immediate evacuation of buildings. Also, transit was disrupted, and electric power lines and communications networks failed. Fortunately, damage in the area of Lima was moderate. The cities of Paracas, Ica and Chincha and nearby villages were the hardest hit. Churches and public buildings collapsed. Transportation networks, including the Pan American Sur highway and several bridges, experienced significant damage or collapsed. A tsunami flooded Paracas.

CAPRA Maps

In 2010, the IGP published a seismicity map for the period between 1964 and 2008. This represented a major step in making available a visual tool summarizing the occurrence, location, and magnitude of earthquakes. That same year, the TAP supported the consolidation and update of seismic information and building institutional and technical capacities to assess seismic hazard using the CAPRA platform.
The CAPRA TAP’s general activities are:

- review and study of existing attenuation laws for similar tectonic environments;
- development of earthquake-response spectra for Lima;
- probabilistic seismic hazard assessment at the national level; and
- inclusion of site-effects in maps at the city level.

The TAP researchers are addressing a variety of challenges. In the Lima Area, the institutions and agencies working on seismic engineering and disaster risk management need basic seismic information.

The first TAP workshop, in November 2010, introduced the participants to the seismic hazard modeling software of the CAPRA platform. The workshop also introduced concepts such as attenuation rate of seismic waves (loss of energy as the wave passes through the ground), site effects (impact of local conditions), data needs and logic trees, and the CRISIS2007 V7.2 component of the CAPRA suite, which estimates seismic hazard scenarios for risk analysis. Participants discussed the existing studies and reviewed general and available information on previous earthquakes. They further evaluated seismicity parameters from the pre-existing sources and the most appropriate methods of evaluation of seismic hazard.

During the second workshop, in March 2011, participants reviewed the seismic catalogue prepared by the IGP. They also commented on preliminary maps of seismic hazard and agreed on plans for upcoming analyses. Map 2 shows a preliminary map presented at the workshop of seismic risk for a 475-year return period by zone of influence. During the workshop, participants demonstrated interest in further studying the northwestern region of Peru (Latitude 4, Longitude 81), which presents high seismic intensity.

The participants reviewed the tectonic cartography (map of tectonic plates), assessed seismogenic areas

This is a specific project with advice from experts, not only local experts, but also renowned international experts, to address the problem of quantitatively assessing earthquake hazard of different magnitudes in Peruvian territory.

—Ronald Woodman, Geophysical Institute of Peru.

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(capable of producing earthquakes) associated with plate convergence and the formation of thrust earthquakes, and analyzed the attenuation rates for the subduction zones. A thrust earthquake occurs in a subduction zone, where one tectonic plate passes under another plate. In South America, the plate consisting of the ocean floor passes under the continental plate. For the purposes of seismic engineering, the participants also reviewed the preliminary response spectra results for different cities, comparing the attenuation rates. A response spectrum is a measure (a plot) used to analyze how structures respond to an earthquake in terms of displacement, velocity, and acceleration.

**Moving Beyond the Maps**

As Ronald Woodman, President of the IGP, has pointed out, earthquakes will occur and we have no control over when, where, or at what magnitude. However, we can prepare for the event, seek to mitigate its effects, and reduce vulnerability. This is best done through education, preparation, and earthquake-resistant design of buildings and infrastructure.

The seismic information produced in the TAP will enable policy makers to improve their understanding of seismic hazard at the national and city levels for Lima and be able to design policies that will lead to sustainable development.

The TAP’s achievements include adjustments and improvements in the measures used in the ongoing analysis, such as the attenuation ratios, acceleration rates (a calculation of ground motion), and response rates (of a structure), among others. With this level of detail and the ability to update existing data and include additional information, institutions responsible for building design standards will have the necessary data to improve standards; and emergency response agencies will be able to build effective contingency plans based on potential hazard and damage scenarios. In this way, the next earthquake will not result in a disaster. Rather, cities will have safe buildings and constructions, and safeguard infrastructure investments.

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