JST-JICA Project on Earthquake and Tsunami Disaster Mitigation in Peru

Fumio Yamazaki
Professor
Chiba University
Chiba, Japan
yamazaki@tu.chiba-u.ac.jp

Shoichi Nakai
Professor
Chiba University
Chiba, Japan
nakai@faculty.chiba-u.jp

Shun'ichi Koshimura
Associate Professor
Tohoku University, Sendai, Japan *koshimura@tsunami2.civil.tohoku.ac.jp*

Taiki Saito
Chief Research Engineer
Building Research Institute
Tsukuba, Japan
tsaito@kenken.go.jp

Saburoh Midorikawa
Professor
Tokyo Institute of Technology
Yokohama, Japan
smidorik@enveng.titech.ac.jp

Carlos Zavala
Professor
National University of Engineering, Lima, Peru
czavala@uni.edu.pe

Zenon Aguilar
Associate Professor
National University of Engineering, Lima, Peru
zaguilar@zergeosystemperu.com

Miguel Estrada
Associate Professor
National University of Engineering, Lima, Peru
estrada@uni.edu.pe

Summary

This project aims to conduct a comprehensive research towards earthquake and tsunami disaster mitigation in Peru under the framework of "Science and Technology Research Partnership for Sustainable Development (SATREPS)", sponsored by Japan Science and Technology Agency (JST) and Japan International Cooperation Agency (JICA). Five main research fields are seismic motion and geotechnical issues, tsunami, buildings, spatial information database and damage assessment, and disaster mitigation plan. After signing on the Record of Discussion (R/D) in January 2010, the project has started and will continue for the five-year period (until March 2015). This paper introduces the objectives and research plan of the Peru project.

Keywords: Peru; earthquake; tsunami; disaster mitigation; international cooperation; seismic motion; building; damage assessment.

1. Introduction

A new international research program named "Science and Technology Research Partnership for Sustainable Development (SATREPS)" has started since 2008 under the joint sponsorship of Japan Science and Technology Agency (JST) and Japan International Cooperation Agency (JICA). The scheme of SATREPS is shown in Fig. 1. Research proposals in the following four fields were invited to apply for the grant: Environment and Energy, Bioresources, Natural Disaster Prevention, Infectious Diseases Control. A proposal submitted by the present authors, "Enhancement of Earthquake and Tsunami Disaster Mitigation Technology in Peru," was selected as one of the projects in the field of natural disaster prevention in April 2009.

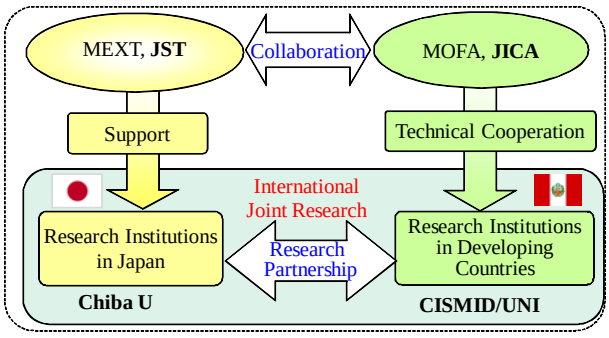


Fig.1: Scheme of JST-JICA SATREPS program (http://www.jst.go.jp/global/english/about.html)

The project aims to conduct a comprehensive research towards earthquake and tsunami disaster mitigation in Peru considering regional characteristics, under the strong collaboration among researchers of Peru and Japan. The first author (F. Yamazaki) is the principal investigator (PI) of the Japanese team and the sixth author (C. Zavala) is the PI of the Peruvian team. After the nomination of our

project, the preparatory phase started to plan the detail of the joint research, considering the needs of the developing country (Peru) and the promotion of science and technology on the global issue (disaster mitigation).

The Record of Discussion (R/D) was signed on January 15, 2010 by the responsible authorities of the two nations: JICA, Peruvian International Cooperation Agency (APCI) and National University of Engineering (UNI) in Lima, Peru. Then the project has formally started and will continue for the five-year period (until March 2015). This paper describes the overall objectives and joint research plan of the project.

2. Background and Objectives of the Peru Project

Natural disasters are one of the major concerns for people in the world. Especially for the countries in the Asia-Pacific region, earthquakes and tsunamis are the major obstacles towards sustainable developments. In order to reduce disaster risks, understanding of natural hazards and upgrading of societal resilience are necessary. Since earthquakes and tsunamis are rare but devastating events, the data collection in a global scale is necessary and international collaboration is essential to reduce the losses due to these events, as highlighted in Hyogo Framework of Action [1]. In this sense, Japan is expected to serve as a leading role in the promotion of international disaster mitigation because of its long history to cope with natural disasters.

Peru locates in the circum-Pacific seismic belt with high seismic and tsunami risks. Figure 2 shows the tectonic settings and the epicenters of earthquakes in Peru and the surrounding region. It is seen that both Peru and Japan are located in a similar seismic environment, frequently hit by damaging earthquakes and tsunamis. In this region, large plate-boundary earthquakes occurred recently in the offshore of Atico (*Mw*=8.4, 23 June 2001) and in the offshore of Pisco (*Mw*=8.0, 15 August 2007). A large number of buildings and infrastructures were destructed, hundreds of people were killed, and tsunamis were also generated by these events. Thus, earthquake and tsunami disaster mitigation draws considerable attentions in Peru.

Not just physical similarities of the two countries, Peru and Japan have a long-term relationship since 1873, when the official relation has started. A large number of immigrants from Japan settled down in Peru in the early 20th century.

The relationship in the field of disaster mitigation technology also has some history. Japan-Peru Center for Earthquake Engineering and Disaster Mitigation (CISMID) was established within National University of Engineering (UNI) in 1987 by the support of Government of Japan. CISMID became the leading center of earthquake engineering research in South America. CISMID has been in collaboration with many Japanese research institutions, notably, Building Research Institute in Tsukuba, Japan.

Importance of this joint research between Peru and Japan can be summarized as the four points: 1) contribution of Japanese science and technology to disaster mitigation in Peru, 2) providing research fields to Japanese geoscience and earthquake engineering, 3) contribution to international tele-tsunami research for subduction-zone earthquakes, e.g. the 1960 and 2010 Chile earthquakes, and 4) promotion of disaster mitigation and capacity building through sharing the knowledge from the international joint research.

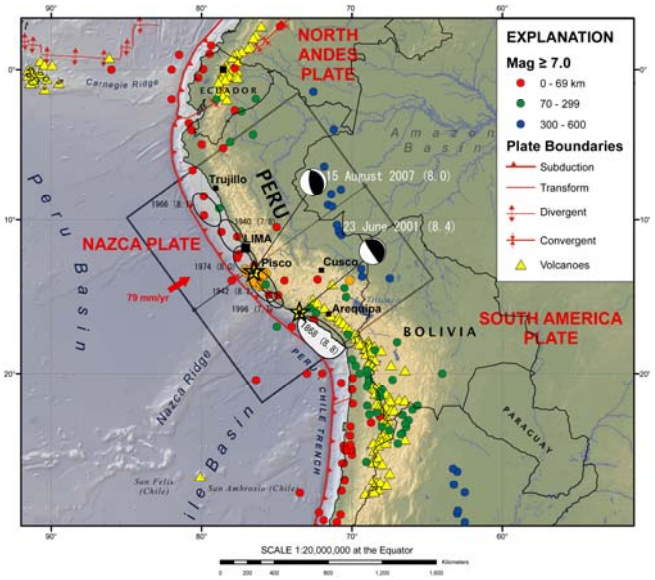


Fig. 2: Tectonic setting and the epicenters of earthquakes in Peru and the surrounding region (modified from [2] and [3]))

3. Overall Research Plan and Organizational Structure

In this research project, a comprehensive research towards earthquake and tsunami disaster mitigation in Peru is carried out under the strong collaboration among researchers of Peru and Japan. Figure 3 shows the organizational structure of this five-year project. The joint research will be carried out in five main research topics: Strong motion prediction and development of seismic microzonation (G1); Development of tsunami countermeasures based on numerical simulations (G2); Enhancement of seismic resistance of buildings based on structural experiments and field investigation (G3); Development of spatial information database using remote sensing technology and earthquake damage assessment for scenario earthquakes (G4); Development of earthquake and tsunami disaster mitigation plan and its implementation to the society (G5). Japanese research team consists of the five groups and their leaders are the authors of this paper.

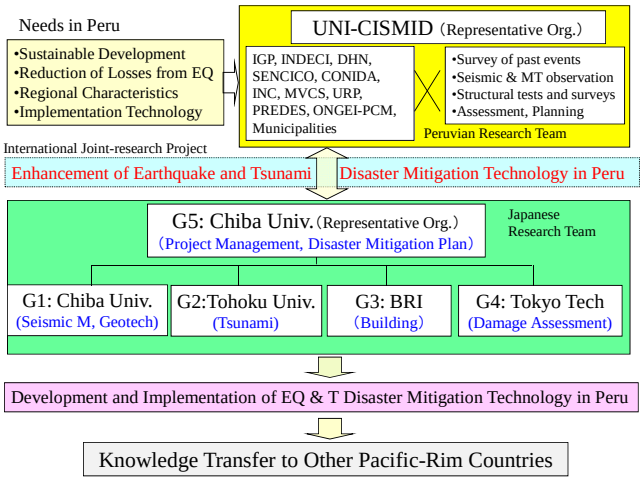


Fig. 3: Organizational structure of the project

Peruvian research team consists of CISMID/UNI, National Institute of Civil Defense (INDECI), Geophysical Institute of Peru (IGP), Direction of Hydrology and Navigation (DHN), National Committee for Aerospace Research and Development (CONIDA), Disasters Prevention and Study Center (PREDES), National Institute of Culture (INC), Ministry of Housing, Construction, and Sanitation (MVCS), National Service of Training for the Construction Industry (SENCICO), Ricardo Palma University (URP), National Office of Electronic Government and Information (ONGEI-PCM), and Municipalities of the project study areas.

Figure 4 shows the research topics and items of the project and the groups in charge the items. Based on the research outputs from the four groups (G1-G4), the disaster mitigation plan group (G5) will propose and implement earthquake and tsunami disaster mitigation plans to case study areas in Peru. Three case study areas will be decided soon after preliminary surveys. A part of Metropolitan Lima including Callao has already been selected as one of the study areas. The other two areas are still in discussion; currently, Chimbote in the north and Moquegua or Tacna in the south are possible candidates. Other than these areas, the affected areas due to the recent earthquakes, Pisco (the 2007 event) and Camana, Arequipa etc. (the 2001 event), will also be considered in developing hazard and damage assessment models.

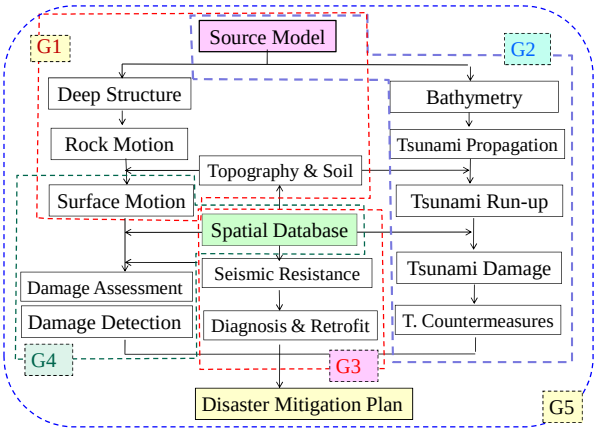


Fig. 4: Research topics and items of the project and the groups in charge the items

4. Implementation and Prospected Outputs of the Project

The Japanese Detailed Planning Survey Team organized by JICA visited Peru from August 5th to 13th, 2009, for working out the details of the technical cooperation program concerning the project. During its stay in Peru, the team exchanged views and had a series of discussions with the Peruvian organizations concerned, led by CISMID/UNI. As a result, the team and the Peruvian concerned organizations agreed on the matters referred to in the document [4].

The objective of this project has been agreed as "To develop technologies and measures for assessment and mitigation of earthquake/tsunami disasters caused by large-magnitude inter-plate earthquakes occurring off the coast of Peru." It is further envisaged that such technologies should be widely used in Peru, and also disseminated and applied to pacific-rim countries, especially to neighboring countries, facing the risks of large-magnitude inter-plate earthquakes and tsunamis. In addition, the project is expected to contribute to the enhancement of capacity as well as the advance of research for both Peruvian and Japanese research institutes involved in this project.

The following seven outputs are listed in the agreed master plan.

1. Scenarios of large-magnitude inter-plate earthquakes are identified which will cause the most significant losses in Peru (G1, G2).
2. Geographical information of the study areas is prepared (G4).
3. Tsunami disaster losses in study areas by scenario earthquakes are estimated, and mitigation technologies are developed (G2).
4. Strong motion and ground failure in study areas by scenario earthquakes are simulated (G1).
5. Earthquake disaster losses in study areas by scenario earthquakes are estimated, and mitigation technologies are developed (G4).
6. Technologies for evaluation of seismic-resistance and structural retrofit are developed, adapting to building characteristics of Peru (G3).
7. Earthquake/tsunami disaster mitigation is promoted in the study areas (G5).

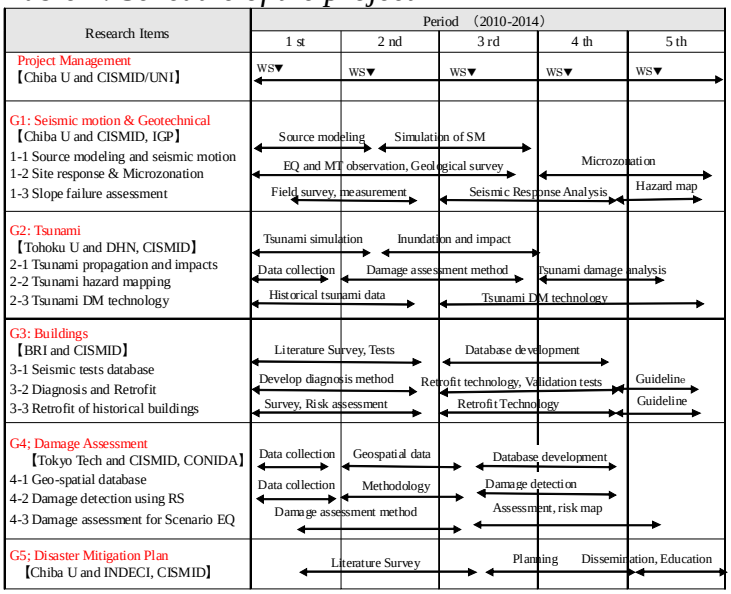
The schedule of the five-year project is shown in Table 1. To implement the project, JICA will provide the services of the JICA experts (Japanese research members), machinery, equipment and other materials necessary for the implementation of the project, and will invite the Peruvian personnel connected with the project for technical training in Japan. The actual joint research will be carried out by the five joint research groups in Table 1.

Other than group-based technical collaborations, the leading members of the project will meet annually either in Peru or Japan in the occasion of project workshops.

The Joint Coordinating Committee (JCC) will be organized soon to oversight the project and meet at least once a year and whenever necessity arises, in order to serve the following functions [4]:

(1) To approve the annual work plan of the project
(2) To review the progress of the annual work plan
(3) To review and exchange opinions on major issues that may arise during the implementation of the project
(4) To discuss any other issue(s) pertinent to the smooth implementation of the project

Table 1: Schedule of the project



5. Detailed Research Plans and Activities

To obtain the expected outputs, the following research activities are planned for the five research groups. The schematic image of the research for each group is shown in Figs. 5-9.

5.1 Source, Seismic Motion and Geotechnical Issues

1-1 Surveying historical records of earthquakes, and grasping the characteristics of inter-plate earthquakes occurring off the coast of Peru

1-2 Developing earthquake source models that are suitable to the characteristics of inter-plate earthquakes occurring off the coast of Peru
1-3 Having preliminary estimation of earthquake/tsunami disaster losses using the source scenarios, and identifying the most devastating scenarios of inter-plate earthquakes
1-4 Observing microtremor in the study areas
1-5 Developing seismic observation networks in the study areas, and observing strong seismic motions
1-6 Collecting existing geological data of the study areas, and undertaking supplementary borehole surveys
1-7 Modeling deep and subsurface ground structures of the study areas
1-8 Simulating strong motions and ground failures in accordance with the inter-plate earthquake scenarios

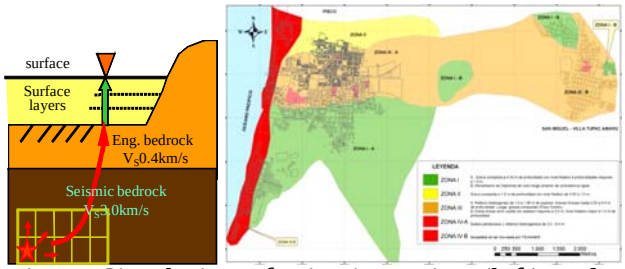


Fig. 5: Simulation of seismic motion (left) and an example of seismic microzonation (right)

5.2 Tsunami Simulation and Damage Mitigation

2-1 Surveying historical records of tsunamis, and grasping the characteristics of tsunami propagation along the Pacific coast of Peru
2-2 Preparing merged bathymetry and topography data of the coastal zones of the study areas
2-3 Evaluating vulnerability of buildings and infrastructures in the study areas
2-4 Simulating tsunami propagation and run-up in accordance with the earthquake scenarios, and estimating tsunami disaster losses

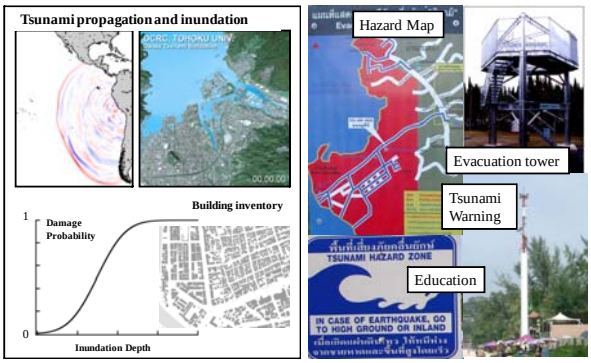


Fig. 6: Tsunami simulation, damage assessment (left) and countermeasures (right)

2-5 Making tsunami hazard maps for the study areas
2-6 Making guidelines of designing emergency evacuation facilities

5.3 Enhancement of Seismic Resistance of Buildings

3-1 Developing a database of structural test results and material test results for buildings
3-2 Developing technologies of seismic-diagnosis and retrofit for different types of buildings prevalent in Peru
3-3 Identifying historical buildings in the study areas that face significant earthquake disaster risks
3-4 Verifying the effects of structural retrofit technologies through structural tests and numerical analyses

Fig. 7: Structural testing (left) and construction site of reinforced masonry house (right)

5.4 Geo-spatial Database and Damage Assessment

4-1 Making digital surface models (DSMs) of the study areas using satellite images
4-2 Making land-use maps and building maps of the study areas using satellite images
4-3 Estimating earthquake disaster losses of the study areas in accordance with the

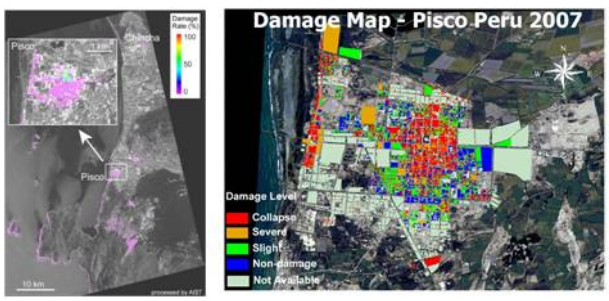


Fig. 8: Damage assessment of the Pisco EQ

inter-plate earthquake scenarios

4-4 Developing technology for rapid detection of earthquake/tsunami disaster losses using satellite images

5.5 Development of Disaster Mitigation Plan

5-1 Developing land-use proposals for mitigation of earthquake/tsunami disasters

5-2 Developing local disaster mitigation plans for the study areas

5-3 Raising the awareness through the dissemination activities of earthquake/tsunami disaster mitigation for disaster management organizations and local communities

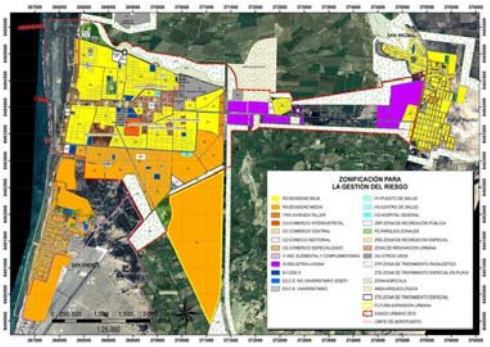


Fig. 9: Post-EQ land-use plan of Pisco city proposed by CISMID

6. Kickoff International Workshop in Lima

The first project workshop was held at CISMID's conference hall in Lima on March 15 and 16, 2010 as shown in Fig. 10. From Japanese side, Japanese Ambassador to Peru, Head of JICA Peru Office, JST Representative from Washington DC Office, and Representatives from Ministry of Education, Culture, Sports, Science and Technology (MEXT) participated in the event as well as twenty five research members. From Peruvian side, President of UNI, Representatives from Peruvian Agency of International Cooperation (APCI) and other government agencies attended as well as researcher members and ordinary engineers/practitioners. The total number of participants was about five hundreds. The rapid increase of awareness to earthquakes and tsunamis due to the 27th, February 2010 Chile earthquake might be the reason to attract so many audiences to the workshop, together with the efforts by the organizers. Ten earthquake engineering researchers from neighboring Latin American countries were also invited to the workshop.

In the first day of the workshop, the opening addresses from the authorities of the both countries were made, and then F. Yamazaki and C. Zavala delivered the objectives and plan of the JST-JICA project, followed by the presentation by the group leaders. Group discussion on the research plan was made by each group in the morning of the second day. In the afternoon, country reports were delivered from the Latin American representatives and theme lectures were given by Japanese researchers. The workshop was concluded successfully after the summary presentations of the group discussion.

Fig. 10: Photos from the international workshop on 15 and 16 March, 2010 in Lima, Peru. The reserachers from Japan, Peru and Latin American countries (left), Opening ceremoney (middle), and group discussion (right).

7. The 2010 Chile Earthquake Field Survey by JST-JICA Project Team

A magnitude Mw 8.8 earthquake occurred off the Pacific coast of Maule, Chile at 3:34 am (local daylight saving time), on 27 February 2010. The epicenter was located at 35.909^{o}S 72.733^{o}W with a depth of about 35 km. The event took place at the boundary of the Nazca and South American plates where they converge as the Nazca plate moves below the South American plate. Tsunamis

were generated by the earthquake and they propagated to Pacific islands and even to Japan, not just hitting the coast of Chile.

Although the primary target of the JST-JICA project is large-magnitude inter-plate earthquakes occurring in the offshore of Peru, the same type of events occurring off the coast of Chile are considered to be good references since such events are infrequent. Soon after the occurrence of the earthquake, we started to plan joint field survey by Japanese and Peruvian researchers with close collaboration of Chilean researchers. With the financial support by JST, the project dispatched the following three survey teams to Chile (Fig. 11):

T1: Gathering ground truth data using satellite images and GPS (April 1-10, by G4 & G5)
T2: Tsunami run-up water-depth measurement and damage survey (April 17-27, by G2 & Central Research Institute of Electric Power Industry, Japan)
T3: Seismic motion and geotechnical issues and detailed building damage investigation (April 27 to May 3, G1, G3 and Architectural Institute of Japan)

The results of the survey will be presented elsewhere.

Fig. 11: The Chile earthquake survey team of JST-JICA Peru project. Team 1 (left), Team 2 (middle), and Team 3 (right).

8. Conclusions

Under the joint sponsorship of JST and JICA, a new international research program named "Science and Technology Research Partnership for Sustainable Development (SATREPS)" has started. The proposal submitted by the present authors to SATREPS, "Enhancement of Earthquake and Tsunami Disaster Mitigation Technology in Peru," was accepted in the category of natural disaster prevention in 2009. In this paper, the background, objectives and research plan of the project were introduced. The project aims to conduct a comprehensive research towards earthquake and tsunami disaster mitigation in Peru considering regional characteristics, under strong collaboration among researchers of Peru and Japan. After the preparatory phase of one year, the project formally started from March 2010. The kickoff international workshop was held in Lima on 15 and 16 March, 2010, gathering the researchers and stakeholders of Peru and Japan with the participation of researchers from Latin American countries. The field survey of the 27 February 2010 Chile earthquake was also conducted by the project members. The progress of the project will be presented in the near future.

9. References

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