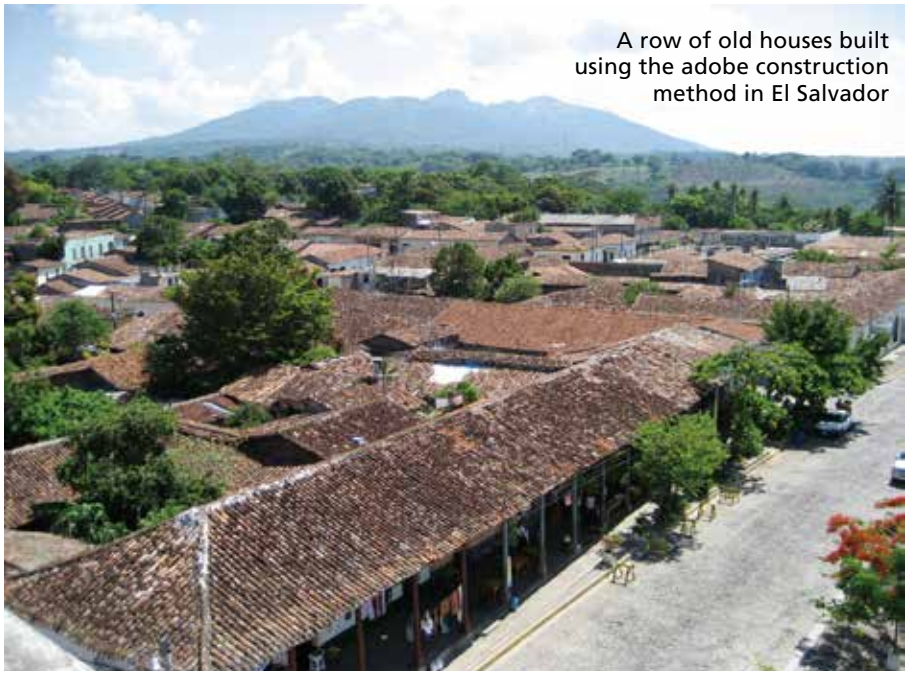
Building Safer Houses in El Salvador and Beyond

Over the last ten years the Japan International Cooperation Agency (JICA) has been working alongside partners in El Salvador on projects to enhance the earthquake resistance of housing in that country and elsewhere in Central America. We asked Fukuyama Hiroshi, director of the Department of Structural Engineering at the Building Research Institute and a leader in the work, about the projects' achievements.



A row of old houses built using the adobe construction method in El Salvador

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On 13 January 2001, the Central American nation of El Salvador was struck by an earthquake with a magnitude of 7.9. This was followed just a month later on 13 February by another quake with a magnitude of 6.6. The two quakes together claimed more than 1,000 lives and inflicted severe damage on the entire country, including the capital of San Salvador. In particular, homes across a wide area suffered damage, with about 20 percent of the 1.36 million homes nationwide being partly or totally destroyed. About 60 percent of these were the homes of low income people.

"In many developing countries like El Salvador, residents try to hold down building costs by building their homes on their own or with the help of others in the local community," says Fukuyama Hiroshi, director of the Department of Structural Engineering of the Building Research Institute. "Most of these homes are non-engineering housing which doesn't make appropriate use of engineering-based construction methods. That's why they often have poor earthquake resistance qualities."

Based on a request from the government of El Salvador in the wake of the 2001 quake, the Japan International Cooperation Agency (JICA) between 2003 and 2008 implemented an "Enhancement of Technology for the Construction of Earthquake-Resistant Popular Housing" project (the TAISHIN Project) as Phase I, and between 2009 and 2012 implemented the "Enhancement of the Construction Technology and Dissemination System of the Earthquake-Resistant Vivienda Social" project as Phase II. Fukuyama participated in these projects, working to introduce technology for the construction of earthquake-resistant housing.

Low-income housing in El Salvador is mainly built according to four construction methods. The first is block panel construction in which reinforced concrete pillars are erected, between which concrete panels are stacked up to serve as the walls of the house. The second method is adobe construction using stacked bricks made of clay dried in the sun. The third is concrete block construction, while the fourth construction method is confined masonry using soil-cement brick.

Masonry walls constructed by stacking materials such as adobe, concrete blocks or soil-cement brick hold up well against vibration waves coming at an angle parallel to the wall surface but hold up poorly against vibration waves coming at right angles to the wall surface. TAISHIN Project personnel

Fukuyama Hiroshi (back row, left) with project counterparts in El Salvador

An improved adobe structure was successfully tested on the incline platform built at the University of El Salvador.

A framework masonry test structure using the soil-cement method under construction at Central American University

carried out experiments which explored ways which might enhance the earthquake resistance of these four construction methods. In the adobe construction method, for example, one technique was to strengthen the walls by running bamboo vertically and horizontally between the adobe blocks to reinforce the structure. In order to prevent walls from falling over, buttresses were erected at right angles to the walls. Reinforced concrete beams were then placed atop the four walls between them and the roof so as to ring the adobe structure.

In order to test the earthquake resistance of this improved adobe structure, Project members used an incline platform built at the University of El Salvador, one of the counterparts. After mounting a test structure built pursuant to the improved construction method on the platform and conducting tests, they confirmed that its earthquake resistance was high enough to clear Japanese construction standards.

A structural test building was constructed at Central American University, another counterpart, and experiments were carried out to test the earthquake resistance of soil-cement construction. Based on the results of experiments carried out on the soil-cement construction and concrete block construction methods, experimenters worked out standards governing the dimensions of the columns and beams and the reinforcing bar arrangement methods required in the construction of quake-resistant houses.

Based on these findings, TAISHIN Project members helped build model homes and prepared construction manuals. The construction manuals made plentiful use of illustrations to ensure that lay people could understand them easily. They also prepared a DVD using videos to demonstrate construction methods.

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A model home built using the improved adobe construction method

"It's easy for one to say that building houses using the adobe construction method is dangerous," says Fukuyama. "But houses built this way are suited to the regional climate and lifestyle. They're part of El Salvador's culture. If appropriate adjustments are made, though, that culture can be preserved and adequately earthquake-resistant homes can be built at the same time."

Promoting TAISHIN in Central America

One important pillar in the El Salvador project is human resource development. The Building Research Institute and JICA joined hands to launch an International Training in Seismology and Earthquake Engineering training program. The program involves one year of training aimed at enabling participants to obtain a master's degree from the National Graduate Institute for Policy Studies. About twenty people from El Salvador have participated in the course since the TAISHIN project started. Most are college instructors. The training provides lectures in a wide range of areas, including the history and lessons of earthquake damage in Japan, construction mechanics, and earthquake-resistant construction methods. It also conducts structural experiments and offers field trips to various locations in Japan.

As the successor to the TAISHIN Project, Phase II from 2009 is intended to strengthen the capacity of construction administration by establishing anti-quake standards and enacting regulations to ensure compliance with those standards, the aim being to promote the benefits of the TAISHIN Project among home builders. The key people involved in furthering the Project are former participants in the International Training in Seismology and Earthquake Engineering courses.

"I sensed that participants were zealous in their determination to learn from Japan and make the most of that knowledge in their own countries. I think that, through the Project, they've acquired a much stronger sense of responsibility," says Fukuyama. "One of the participants I taught in the international seismology and earthquake engineering training was quite reserved on first coming to Japan and didn't speak up very much. But he gained self confidence after he finished a year of study and wrote up his master's thesis. Now he expresses his thoughts without hesitation on any topic and seeks for solutions with confidence. As a result, he's been named sub-leader for the Project."

Thanks to varied efforts by those

The implementation manual for the improved adobe construction method prepared in the course of the TAISHIN Project makes plentiful use of illustrations.


Fourteen engineers and officials from El Salvador, the Dominican Republic, Nicaragua and Peru attended a training program on earthquake-resistant technology in June and July 2014 at the Building Research Institute in Japan.

involved in the Project, legislation was enacted in El Salvador in March of 2014 to provide aseismatic standards for concrete block construction and soil-cement construction and in June of 2014 for improved adobe construction. The government of El Salvador is now moving ahead to promote quake-resistant housing by providing training to the local regulatory officials who will carry out the actual screening of homes along the lines of the new aseismatic criteria.

Phase II came to an end in 2012, but JICA continues to provide assistance for the promotion of quake-resistant technology in El Salvador. From June through July of 2014, the Building Research Institute conducted training courses for the Enhancement and Dissemination of Earthquake-Resistant Technology for Buildings in Latin American Countries attended by fourteen engineers and officials from El Salvador, the Dominican Republic, Nicaragua and Peru. The training included lectures on geotechnical engineering, structural engineering, earthquake-resistant structures, base-isolation engineering and action plan preparation, with the latter half of the training covering the structural experiments conducted in El Salvador.

Mexican experts who had studied quake-resistant technology in Japan participated in both the TAISHIN Project and Phase II. Mexico and El Salvador share not only a common Spanish language but also have similar cultural backgrounds and customs. Moreover, they also use a similar construction method for buildings and have similar living conditions in many ways too. Such being the case, South-South cooperation contributed significantly in helping to facilitate the transfer of technology to El Salvador. Moreover, El Salvador is itself now providing assistance to other countries in Central America. In the Improvement of the Earthquake-Resistant Housing Construction Technology project which JICA implemented in Nicaragua from 2010 through 2013, experts from El Salvador provided technological assistance to their counterparts in Nicaragua. In 2011, moreover, the JICA alumni associations in the Dominican Republic and El Salvador played leading roles in providing seminars in the Dominican Republic to demonstrate El Salvador's quake-resistant projects for officials and university staff of the Dominican Republic and Republic of Haiti. A practical seminar on quake-resistant construction was also held during the same year in Honduras in which experts from El Salvador conducted technical training relating to the engineering underlying quake-resistant adobe construction.

"The Salvadorans are now in a position to promote earthquake-resistant technology on their own," says Fukuyama. "In fact, promoting earthquake-resistant technology is by no means easy. It may take time before the benefits of the projects become apparent, but I'm confident that earthquake damage in El Salvador will be lessened."


Residents receive instruction in the improved adobe home building method.

SAWAJI Osamu, *The Japan Journal*