A HUMAN DEVELOPMENT APPROACH FOR THE CONSTRUCTION OF SAFE AND HEALTHY ADOBE HOUSES IN SEISMIC AREAS

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ABSTRACT:

The Pisco, Peru, earthquake of August 15th 2007 caused the death of 593 persons, the destruction of almost one hundred thousand houses and many historical monuments, built mainly with adobe. The Peruvian government promptly created a special agency to manage the reconstruction process (FORSUR). All the citizens who lost their home would receive a universal reconstruction bonus (about US $2000), and those who qualify would be offered a low-interest loan to buy new housing made with confined masonry. Unfortunately, many thousands of families do not qualify for the loan, and will have to rebuild their homes only with the small bonus offered by the government.

This paper presents a proposal developed by the Catholic University of Peru and CARE Peru for the dissemination, training and construction of new earthquake-resistant and healthy houses made of reinforced adobe, to be built by low-income families. The philosophy behind the proposal is that the communities involved in the reconstruction process should not be mere recipients of external aid, but should be agents of their own development. An important goal of the process is therefore the development of the capacities of the participants in such a way that in the future they will be capable of building safe and healthy adobe houses.

The proposal involves the development of educational materials, dissemination strategies for improving adobe construction, training of the community builders, logistics of materials purchase, and supervision of the construction by the home owners, and follow-up of the quality of future construction with adobe.

KEYWORDS: development, capabilities, adobe, reconstruction, safe and healthy housing.

1. THE PISCO EARTHQUAKE

On August 15, 2007, a strong earthquake occurred on the Peruvian coast. The epicenter was located in the Pacific Ocean, 74 km west of the town of Pisco. The earthquake therefore originated within the subduction region of the Nazca plate under the South American plate. The earthquake started at 18:50 (local time) and lasted approximately 210 seconds. Its Richter magnitude was 7.0 ML, with a maximum Mercalli intensity of VIII (Tavera et al. 2008). According to the National Institute of Statistics and Informatics 593 persons perished and 318 persons were missing.

In Peru, most traditional adobe houses are built informally, without technical supervision, and using materials of poor quality. As a result, they lack adequate seismic reinforcement and their walls are heavy, weak and brittle. Therefore, these houses are extremely vulnerable to earthquakes, as was confirmed by the widespread destruction of earthen buildings caused by the Pisco earthquake (Blondet et al. 2008a). Around 95 thousand dwellings, mainly built with adobe, were destroyed or became inhabitable (Fig. 1, INDECI 2008).

Fig. 1 Adobe dwellings destroyed during Pisco earthquake

2. INITIAL GOVERNMENT RESPONSE

The first emergency action undertaken by the Peruvian Government was the creation of a Fund for the Reconstruction of the South (FORSUR), which had the following objectives:

- Perform a general evaluation of the effects of the earthquake in the emergency areas,
- Supervise, approve and coordinate the development and execution of rehabilitation and reconstruction projects, and
- Collaborate with Civil Defense and local authorities with the emergency work

The Peruvian government also created a housing program based on the delivery of a reconstruction bonus of six thousand soles (about US$ 2000) to those families who lost their house during the earthquake that could demonstrate that they were owners of their dwelling. Some bonus recipients who qualify would have also access to complementary existing low-interest housing loans managed by the government. With the combined funds, these persons would be able to buy confined masonry houses. Low income persons who do not qualify for the housing loans would only have the bonus to rebuild their dwellings.

The reconstruction bonus will be delivered as construction materials. City dwellers will be able to buy materials through the Bank of Materials. Rural dwellers will be given a materials kit to be used for the supervised self-construction of safe and healthy adobe houses.

3. A RECONSTRUCTION PROJECT BASED ON HUMAN DEVELOPMENT CONCEPTS

In its transcendental book “Development as freedom” Amartya Sen (2000) states that the development of a society can be measured as the degree of freedom its constituents have. In a developed society the people have the freedom to choose the way they want to live. According to Sen, freedom has several dimensions: political freedom, economic facilities, social opportunities, guarantees of transparency and protective security. How to reach development? Many countries choose to emphasize improving the economic dimension (for instance by giving facilities for private and foreign investment) with the hope that improvement in the other dimensions will follow. Sadly, in most cases this has not happened, and an increase in PBI has not been reflected in the improvement of the quality of life of the majority of the population. It is possible, however, to increase the development level of a society by devoting some effort towards increasing the quality of those dimensions that do not require large economic investment. Although sustained investments in health and education are required to obtain long-term benefits in developing countries, modest efforts towards better health, education, and safety can yield significant results in the opportunities of the people to have a better life. An important key to development is therefore to expand the capabilities of the people to have the freedom to live a good life.

The Pisco earthquake was a tragedy that provided a unique opportunity to implement a reconstruction project based on the Capability Approach to Human Development. The central idea behind the project is that its beneficiaries will not be mere recipients of external aid, but they be agents of their own development.

To live in a comfortable, safe and healthy house is certainly one of the most cherished aspirations of most families. The earthquake destroyed the houses of many thousands of low income families, many of which lived in vulnerable, unsanitary adobe houses. The aim of the project describe here was to develop a "cascade" training program with the final objective to train the people who lost their houses and who have access to the government bonus in the construction of safe and healthy adobe houses, and to facilitate access to technical assistance for the reconstruction. In this fashion, the persons who participate in the project will develop the capability to improve their living conditions.

The project was conceived by faculty members of the Catholic University of Peru (PUCP) and personnel of CARE Peru. The Department of Engineering at PUCP has been working for more than 35 years towards the development of cheap and simple reinforcement systems to improve the seismic safety of adobe houses (Vargas et. al 2005, Blondet et al. 2008b). Their efforts to disseminate the technical solutions developed, however had not been successful. After several attempts to work with different communities in training the dwellers to build seismic resistant houses, not a single person has spontaneously built his house with the improved techniques. CARE Peru is part of CARE International, a non-profit relief and development organization that works in over 70 of the poorest countries worldwide. CARE Peru has a vast experience in developing and implementing successful water and sanitation projects in rural communities with an emphasis on training and capacity development. The symbiosis of PUCP and CARE Peru therefore constituted a powerful organization capable of developing and implementing a training and construction program in which the affected families will build their own safe and healthy adobe houses using the materials provided through the government bonus.

4. AN EARTHQUAKE-RESISTANT AND HYGIENIC ADOBE HOUSE

Most adobe houses in the world are built by low income families, who don't have access to technical assistance. Furthermore, dry soil is heavy, weak and fragile. In seismic zones, this is a perverse combination, and every time there is an earthquake, the adobe houses collapse or suffer significant damage, causing tragic deaths, injuries and loss of property. Additionally, many adobe dwellings do not have running water and sewage facilities, and their kitchens are primitive, and without proper ventilation. These deficiencies are usually the cause of unnecessary and preventable illnesses of the dwellers.

A vulnerable and unhealthy house that kills and sickens its dwellers is an abomination. A decent, comfortable, safe and sanitary house is an universal right. It is possible to design and build safe and healthy adobe houses. The PUCP-CARE Peru team designed a small seismically reinforced adobe house with an improved kitchen and an exterior latrine. The house can be built by the own dwellers using materials that can be bought with the government reconstruction bonus.

The seismic reinforcement is a geomesh which completely wraps all adobe walls. The geomesh provides confinement and additional stiffness and strength to the walls. During strong earthquakes, the walls may suffer significant cracking, but the mesh will hold the walls together, thus maintaining structural stability and preventing collapse (Blondet et al. 2006, 2008b). The geomesh selected for the project costs about US$ 1.50 per m^2. For an adobe house with 50 m^2 floor plan the cost associated with the geomesh is about US$ 375.

The mesh is firmly embedded in a concrete foundation and attached to a wooden crown beam at the top of all walls. It is attached to the adobe walls with plastic strings placed across the walls during construction and covered with a mud plaster. The mud plaster is crucial to protect the geomesh from ultraviolet sun rays and provides additional strength and stiffness to the walls. Figure 2 shows some details of the geomesh reinforcement


a) Geomesh placement


b) Geomesh and plastic tie


c) Reinforced adobe wall

Fig. 2 Geomesh reinforcement of adobe walls

The seismically safe house includes a dry hole latrine and an improved firewood stove to provide basic sanitation facilities to its dwellers. The latrine (Fig.3) is a hygienic facility to contain human excreta. Its correct construction, location and usage will contribute to avoid environmental contamination and to preserve the health of the dwellers. The building and installation cost of a single latrine is about US$ 130. The improved stove (Fig.4) uses less firewood than traditional stoves. It has good ventilation and low smoke emissions, thus preventing respiratory illnesses caused by excessive firewood smoke. It can easily be built by any family, as its design is very simple, and its cost is minimal, as it is made with local materials.


Fig 3 Dry hole latrine


Fig. 4 Improved firewood stove

5. TRAINING PROGRAM DESIGN

The PUCP-CARE Peru team decided to join efforts with FORSUR, the government agency newly created to reconstruct the areas affected by the Pisco earthquake, and with SENCICO, the government agency in charge of construction codes and training. This larger group has the complementary resources, experiences, and technical knowledge required to implement a massive scale training and reconstruction program with adobe. The main purpose of the program was to develop the capabilities of the affected families to build safe and healthy adobe houses based on the PUCP-CARE Peru design. It was considered of extreme importance that this development of capabilities also had the potential for replication and dissemination during the reconstruction process.

The training program comprised the following steps:

- Design and development of training and educational materials
- Design of the Bono6000 adobe house. This is the earthquake-resistant and hygienic house to be built by the affected families using the 6000 soles (US$ 2000) bonus offered by the government.
- Implementation of the training program
- Technology transfer and supervised self-construction by the dwellers

6. DISSEMINATION MATERIALS AND PROPOSED MODELS OF ADOBE HOUSES

6.1 Construction Manuals

Two booklets were designed by the PUCP and CARE Peru team, with contributions from SENCICO and FORSUR, one for arid regions, such at the Peruvian coast where Pisco is located, and another for rainy regions, such as the Peruvian highlands, where many adobe houses were also destroyed by the earthquake. The booklets were published by the PUCP Editorial Fund (Vargas et. al 2007 a, b).

Each booklet explains with simple language and many illustrations how to build a hygienic and earthquake resistant adobe house. The house presented in the booklet for arid regions is shown in Fig. 5. It has 50 m^2 of floor plan and has four rooms. It includes instructions for building a firewood improved stove and a latrine located outside. The materials required cost about US$ 2000. Therefore, the house could be built by supervised self-construction by the own dwellers using the reconstruction bonus.

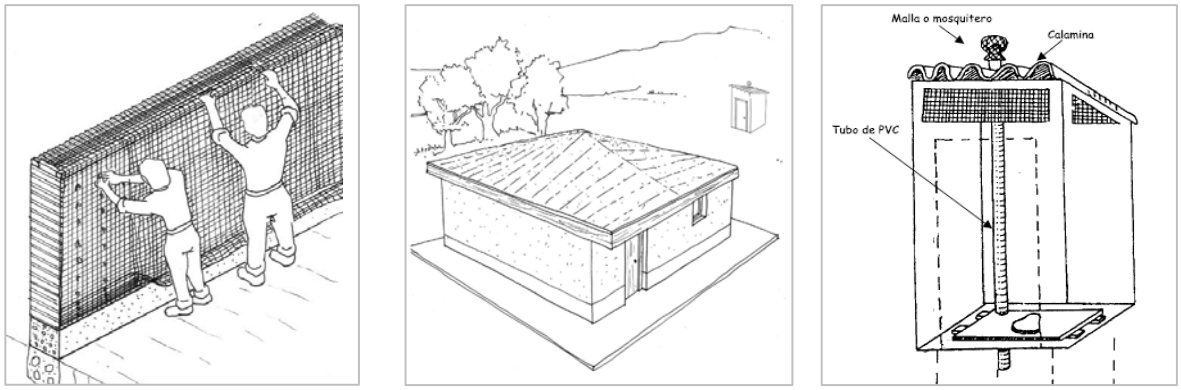

Fig. 5 Illustrations from construction manual

6.2 Instructional Module and Video

In preparation for the practical lessons, a portion an adobe house reinforced with geomesh, similar to that presented in the booklet was built near the Structures Lab. Each step of the construction of this instructional module process was performed according to the instructions in the booklet and was carefully videotaped. This demonstration model was built in such a way that it clearly shows the most relevant details at each stage of the construction process. The video material was edited and the resulting video program was widely distributed.

6.3 Bono6000 Reinforced Adobe House

A smaller adobe house with better finishings than that presented in the booklets was designed by a team from PUCP, CARE Peru, and the Swiss and German cooperation agencies (Fig. 6, CARE Peru et al. 2008). This house was approved by FORSUR to be built in rural areas with the 6000 soles bonus. It has two rooms and a total floor plan area of 19 m^2, based on minimum standards for humanitarian disaster response. The higher cost per square area is due to the cement floor, wooden doors and windows, and steel grids.

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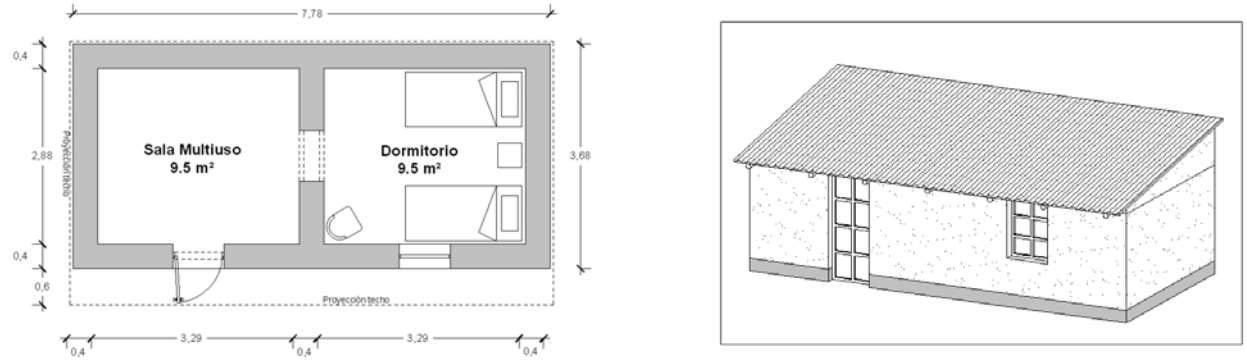

Fig. 6 Bono6000 reinforced adobe house.

This adobe house proposal comes together with a materials kit, which includes all the materials required to build the house, except the adobe blocks, which must be built by the house owner. One thousand soles (about US$ 300) should be used to pay a qualified adobe builder and the remaining five thousand soles should be used to acquire the materials kit. Currently (August 2008), it is being discussed how the kit will be delivered to the head of the family who qualifies for the reconstruction bonus. It is expected that the beneficiary (and possibly some family members) will participate in the construction of his or her house, and that technical cooperation agencies will provide free technical assistance and supervision. Currently, PUCP and CARE Peru are working with the government to develop the implementation mechanisms for the 6000 soles bonus through a model by which groups of organized families will manage the reconstruction resources.

7. IMPLEMENTATION OF TRAINING PROGRAM

The training program was designed as a "cascade" process, in which first a few people are trained, then they participate in the training of more persons, who in turn help training more persons, until the actual dwellers of adobe house are trained in the safe and hygienic construction of their own houses. In this way, their capability to choose to live in better housing conditions will have been expanded.

7.1 Phase 1: Training at PUCP Campus

The first phase of the training program on the construction of seismic-resistant and hygienic adobe houses was developed at the PUCP campus with funding provided by CARE Peru. About 100 persons participated in the course. The participants were builders, masons, construction technicians, civil engineers, architects, and personnel from NGOs and governmental institutions. The requisites to take the course were to have some experience with adobe construction, a reasonable communication capacity and a commitment to say in the training program. They came from Lima and from the areas affected by the Pisco earthquake. Many participants were selected by the local governments of the affected areas.

Each course had a total duration of 24 hours and was given in three days of a single week. It comprised classroom and practical classes. During the classroom lessons PUCP faculty members presented concepts of seismic behavior of unreinforced and reinforced adobe buildings as well as the PUCP-CARE Peru proposal for earthquake-resistant and hygienic adobe houses.

During the practical lessons, each step of the construction was carefully explained with the aid of the demonstration module and a practice adobe wall, which included the attachment strings in such a way that each group had the opportunity to practice attaching the geomesh to the adobe wall and plastering the wall with mud (Fig. 7). At the end of this training phase, each participant received a certificate.

Fig. 7 Practical training classes

7.2 Phase 2: Training in the Affected Areas

The three cities that suffered most damage during the Pisco earthquake, Cañete, Chincha and Pisco were initially selected for the second phase of the training program. The program was financed by FORSUR and was

directed to the general population, especially to those persons who live in adobe houses. Instruction was performed by personnel from PUCP and from CARE Peru. Around 360 persons completed this program.

Classroom lessons had 6 hours duration, given in two days. They included a presentation of the instructional video developed in Phase 1. Practical lessons followed the "learning by doing" approach. The participants actually helped building a complete house, following each step of the instructions given in the construction manual, as shown in Fig. 8. Three houses were built in each city, each in a different neighborhood, to facilitate the participation of a wider number of people. The model houses were given to families selected by the community, which had lost their house during the earthquake and did not have the resources to rebuild a new house. The training program will be extended to 4,000 families affected by the earthquake, in Chincha with funding from OFDA (Office of U.S. Foreign Disaster Assistance) and in the provinces of Huaytará and Castrovirreyna in Huancavelica with funding from CIDA (Canadian International Development Agency).

Fig.8 Building reinforced adobe houses

7.3 Phase 3: Training of Dwellers and Reconstruction

This phase is currently being developed. It is planned that, after receiving training from a member of the community previously trained, those families who qualify will be able to use the reconstruction bonus to obtain the materials kit and build their new adobe house, preferably under supervision from a qualified builder. Most probably, the seismic-resistant and sanitary features will imply a significant improvement in the quality of the house, and therefore it will be a source of pride and enjoyment. In order to disseminate this seismic resistant technology, CARE and PUCP have shared all of the materials developed with other NGOs and cooperation agencies involved in the reconstruction effort. Several other organizations involved in the reconstruction process are already following a similar training procedure.

After many destructive earthquakes that have afflicted the Peruvian population, especially those with few resources, this is the first time that the government has joined efforts with university and development organizations to generate and implement a systematic and orderly reconstruction process. The Peruvian adobe construction code had to be changed to include adobe construction with geomesh. Therefore the hygienic and earthquake-resistant adobe construction technologies developed by PUCP and CARE Peru have became officially recognized as valid.

Although the Pisco earthquake was a tragic event which caused suffering and loss to thousands of families, it also provided an unprecedented opportunity to learn to deal with disasters in a productive and efficient way. The human development approach which guided this project was crucial to reach the complementary objectives of reconstruction after the disaster and development of the capability of the affected communities to build safer and healthier homes.

8. FINAL THOUGHTS

It is clear that construction of traditional unreinforced, unsanitary adobe houses should be avoided, especially in seismic areas. This project has demonstrated that it is possible to build earthquake-resistant houses with adequate sanitary conditions. If the technology to build safer, healthier adobe houses exists, why is it so difficult to convince people to use it to build their adobe homes? This is really a monumental task, because traditions are not easily abandoned, and requires a multidisciplinary effort, involving institutions at all levels, from the academia to local and central government, to international and local organizations.

The human development approach to development, based on expanding the capabilities of the people to opt for better living conditions provides a framework for successful post-disaster reconstruction work. PUCP and CARE Peru have cooperated in the development and implementation of a training and construction program based on this approach, which is being implemented in cooperation with the government and many concerned institutions.

The work has not been easy and is not finished. Even one year after the Pisco earthquake there are still many families living in precarious conditions. The people and organizations involved in this project, however, are optimistic in that their efforts will result in improved living conditions of many thousands of families, and that, furthermore, the project will serve as a successful example of a reconstruction program centered in the development of the persons affected by the disaster.

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