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REACONDITIONING OF EXISTING ADOBE HOUSES TO MITIGATE EARTHQUAKE EFFECTS

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TOPIC Number 9

SUMMARY

An advance of the present research project, that corresponds to the celebrated Agreement between the Regional Center of Seismology for South America (CERESIS) and the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), the same that is under execution at the Structures Laboratory of the Catholic University of the Peru (PUCP), is presented in this paper.

The main objective of the project is to evaluate and decide on simple and economic strengthening procedures that will enable existing adobe houses to resist strong earthquakes without collapse, letting their occupants enough time to get out and save their lives. This project was selected by UNDRO under the International Decade for Natural Disaster Reduction.

INTRODUCTION

In Peru, and throughout the Andean region, adobe has been and still remains as one of the traditional materials for building houses. The reason for constructions of this kind of material is undoubtedly its low cost for rural areas and even in cities. However, the response of adobe houses to earthquakes has been poor (Fig. 7 and Ref. 1) result of inherent mechanical limitations of the material, massive walls, fragile behavior and low resistance, poor construction techniques, and lack of engineering design.

Although many years of research (Ref. 2) have succeeded in developing improved constructions techniques (Ref. 3) and the Adobe Code for Building Constructions has been adopted in Peru (Ref. 4), these efforts are not directly applicable to existing adobe constructions, which represent a real seismic risk. This project deals with such existing adobe houses and how to reinforce them.

In this way, employing economic reinforcements typical of the housing location, and easy to implement in site, in this Project is intended to develop simple reinforcement techniques that would let the existing adobe housings retard their collapse, under severe earthquakes, thus the risk for the occupants will be reduced.

It is necessary to emphasize that our intention is not to employ costly systems of reinforcement, such as the used in the remodeling of the Historical Monuments, neither those which would have to be employed in the housings seriously deteriorated by lack of maintenance, or those which have their wall-base wet and eroded or with the roof in poor condition.

On the other hand, it is considered to investigate in - situ our constructive reality with this type of material; to study the types of defects that these systems have; to see if the inhabitants accept the proposed reinforcements, the same that will be verified through seismic simulation tests in shaking table; and, to prove, through pilot projects to be developed in five cities of the country, the efficiency of the selected reinforcements when a severe earthquake occurs.

ADVANCE OF THE PROJECT

The Project has several stages to be developed in 3 years; in this report only the concerning parts to the first and a half year already executed are presented.

1. Study of Existing Adobe Housings (Ref. 5, 6 and 7).

The development of this part has permitted to study our constructive reality, the types of defect that tend to occur in the unreinforced adobe housings, the deficiencies that have the existing housings and the reinforcements as well as the repair techniques that the people employ. Based on these results, the characteristics of the preliminary specimens were selected (Fig. 1). This part consisted on the following points:

a. - Bibliographical Summary. Comprised the elaboration of 380 bibliographical file cards, from 15 institutions, with emphasis in topics of adobe reparation, and the implementation of a computer file with the MICROISIS program.

b.- Elaboration of a survey format to study the possibility of reinforcing existing adobe houses in different cities of Peru.

c.- Technical visits and application of the surveys to several cities, in which a series of photograhs and videos were taken for the future dissemination of the project results.

2. Development of Simple Procedures of Reinforcement

Commonly, the first seismic defect that the unreinforced adobe houses exhibit, is through a vertical crack in the orthogonal walls connection and in the upper central region of the walls, after which the wall overturns. This defect is due to the seismic forces acting perpendicular to the wall, which produce flexure in the upper central part of the wall, due to the lack of a crossbeam girder, and tensions that are not adequately transmitted from the wall toward the transverse wall by the weak connection that exists between them, in spite that generally the connection is toothed.

A solution to the described problem consists of reinforcing the upper edge of the walls along the perimeter of the house, through a ring (for example, the rope shown in Fig. 3); however, this it is not possible to accomplish in the houses located between the property limits with other neighbour houses; therefore, in those cases the reinforcement of the front walls will be by connecting them against the transverse walls (Figs. 2 and 4), which generally have great length and have great resistance to the in-plane shear.

In this part of the project the following points were developed:

a. - Element tests: anchorage of the rod tie on the wood board, flexure of the wood board, compression and flexure of the adobe units, axial compression of 5 adobe prisms and calculation of the elasticity modulus, diagonal compression of 3 small square adobe walls and rope overlapping.

b. - Construction and seismic simulation tests in shaking table (Figs. 11 and 12) of four preliminary specimens, whose geometric characteristics are shown in Fig. 1. These specimens were: Wall 1, traditional unreinforced; Wall 2, reinforced with wood board and steel rod ties (Figs. 2 and 8); Wall 3, reinforced with rope (Figs. 3 and 9); and, Wall 4, reinforced with wire mesh covered with mortar (Figs. 4 and 10). The seismic record used was the corresponding to the Peru earthquake of May 31, 1970, with 30 seconds long.

PRELIMINARY CONCLUSIONS

The seismic tests accomplished in the four preliminary specimens showed that the unreinforced wall collapsed 20 seconds before that the walls reinforced with wood boards and rope, while the wall reinforced with wire mesh did not collapse. In this way, it was demonstrated that the wood board and the rope retarded the collapse, leaving enough time for the occupants of the adobe house could escape. However, given that the wire mesh reinforcement showed the best results, it was selected for future reinforcement tests.

The advance accomplished during this period, demonstrates that it is possible to reach the main objective of the Project. The next step is to investigate the seismic behavior of the described reinforcement, using it in specimens that actually represent the type of existing adobe houses in Peru (figs. 5, 6, 13 and 14).

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Fig. 1

Preliminary Adobe Walls Tested on Shaking Table

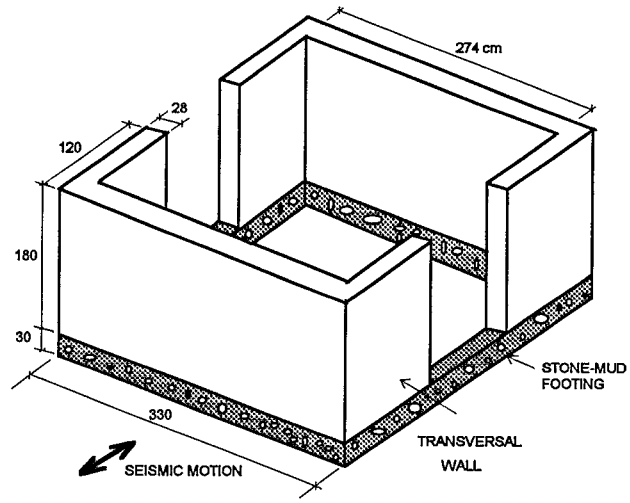
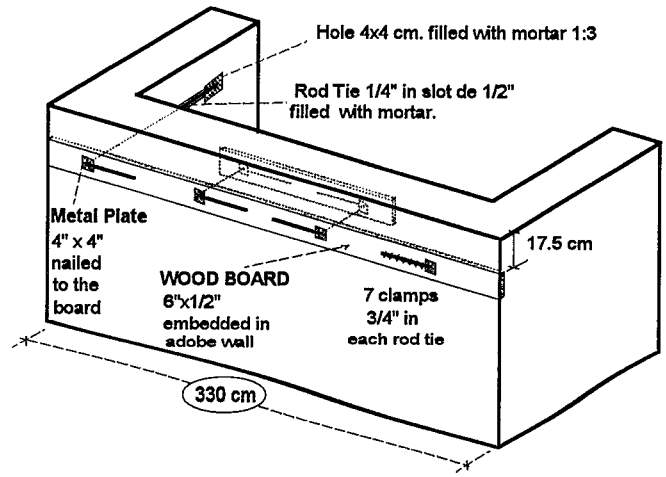


Fig. 2

Type 1 Reinforcement: Wood Boards with Rod Ties



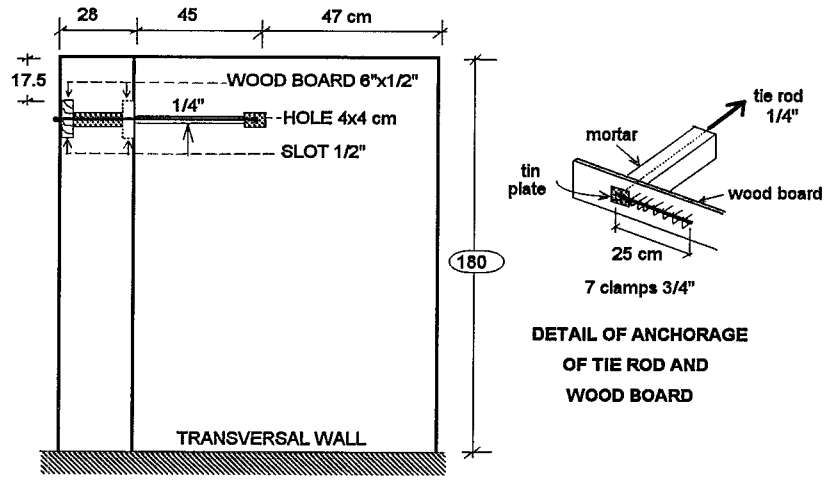


Fig. 3

Type 2 Reinforcement:
Rope Embedded
in Adobe Wall

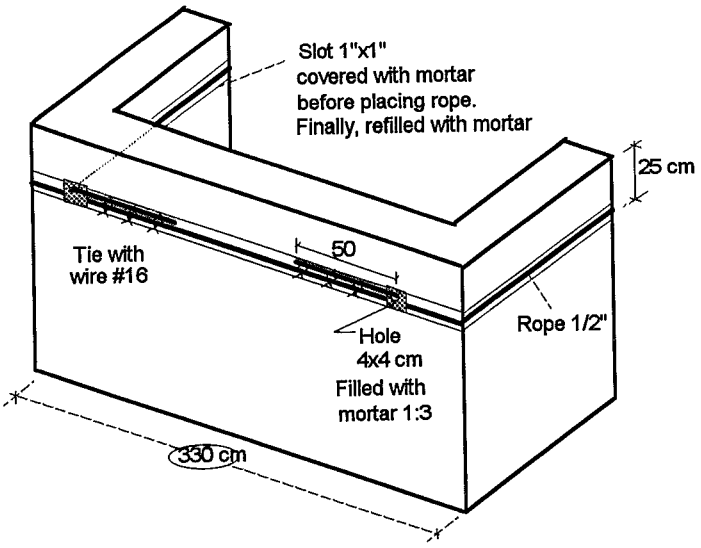
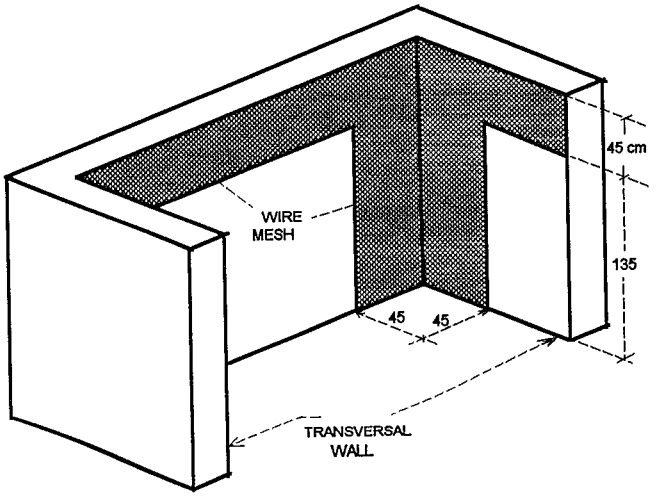
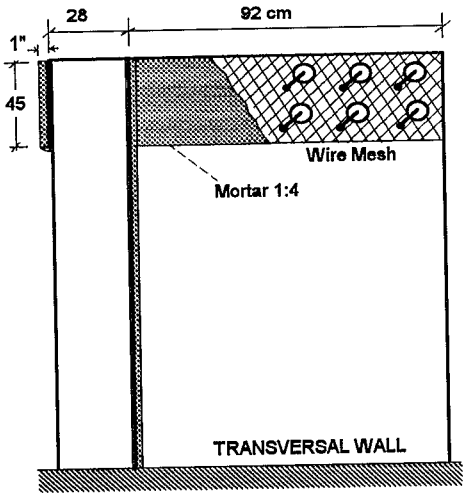
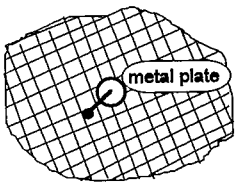


Fig. 4

Type 3 Reinforcement:
Wire Mesh Covered
With Mortar







DETAIL OF CONNECTION OF THE WIRE MESH TO ADOBE WALLS WITH NAILS 2" @ 25 cm

Fig. 5

Unreinforced Adobe House Specimen (Typical of Coastal Zone)

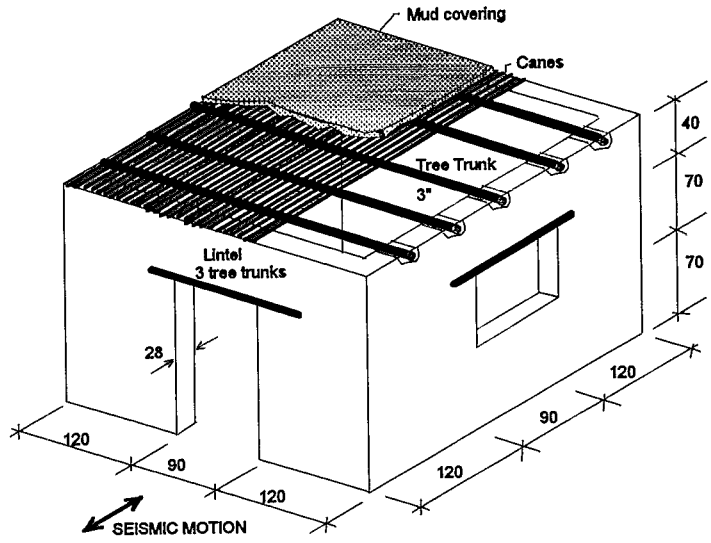
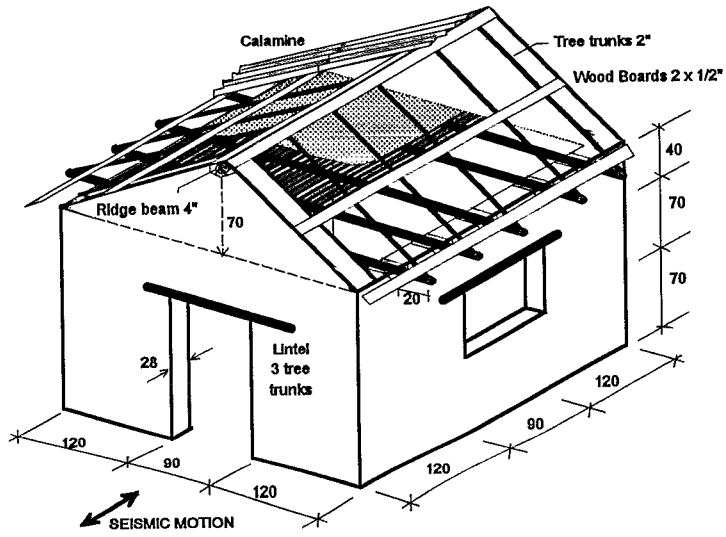


Fig. 6

Unreinforced Adobe House Specimen (Typical of the Andes)



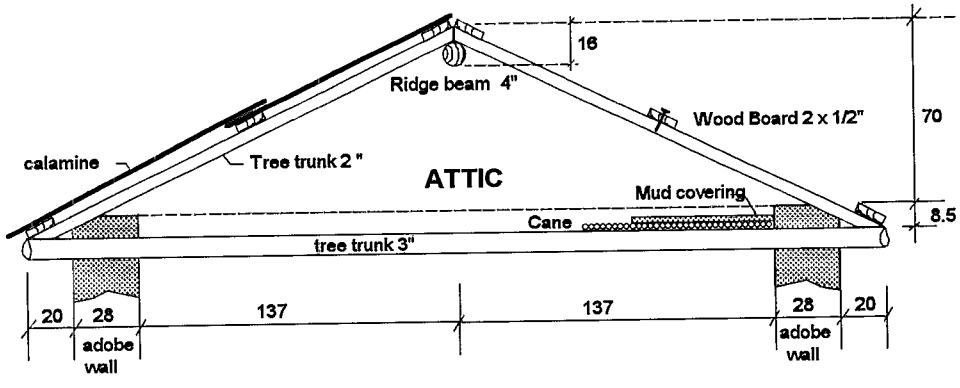


Fig. 7 Collapse of Adobe Houses in Ancash, Peru, after the May 31, 1970 earthquake.

Fig. 8 Type 1 Reinforcement

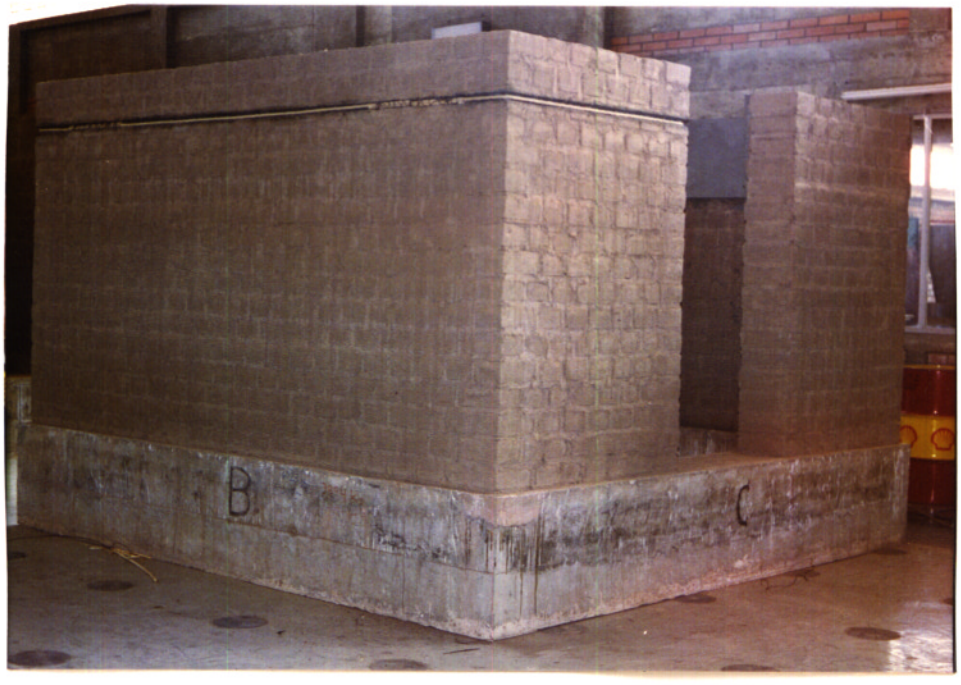


Fig. 9 Type 2 Reinforcement

Fig. 10 Type 3 Reinforcement

Fig. 11 Shaking table test on unreinforced wall (left) and wall with type 1 reinforcement (right)

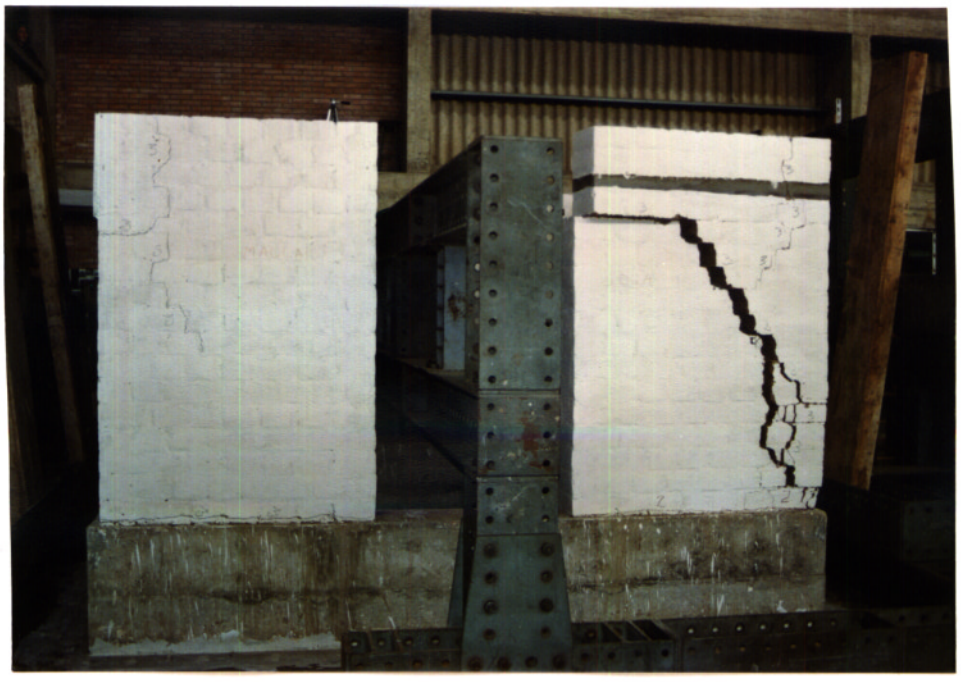


Fig. 12 Shaking table test on wall with type 2 reinforcement (right) and wall with type 3 reinforcement (left)

Fig. 13 Collapse of unreinforced adobe house specimen (typical of the Coastal Zone), tested on shaking table

Fig. 14 Unreinforced adobe house specimen (typical of the Andes) under construction