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ANALYSIS OF THE POTENTIAL FOR INTRODUCTION OF STABILIZED ADOBE IN PERU

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ANALYSIS OF THE POTENTIAL FOR INTRODUCTION OF STABILIZED ADOBE IN PERU

I. INTRODUCTION: THE NEED

Adobe is one of the most widely used building materials in all of Peru. It is found throughout both the coastal zone and the sierra regions of the country, and in some cases in the high jungle along the eastern slopes of the Andes. Adobe structures are found in both urban and rural areas, and the architecture represented ranges from small one-room, owner-built houses in the pueblos jóvenes (squatter settlements) to sophisticated two- and three-story adobe houses found in Lima. Not only are adobe structures found in a wide variety of sizes, shapes and configurations; the adobes used to make these structures are also fabricated and used in a myriad of ways. The only factor that can be singled out as common to almost all adobe in Peru is the fact that it is generally of poor quality.

The weaknesses of adobe and adobe structures would not be a concern were it not for the fact that Peru is one of the most seismically active areas of the world. Within the last ten years, two major earthquakes and one minor earthquake have struck the country, and damage has been most severe to those houses built of adobe. Normally, the vulnerability of adobe structures in earthquakes is due not to an inherent weakness in the adobe material but rather to other factors such as the design, the configuration and the detailing (masonry work, joints, etc.) The adobe structures of Peru would not be inherently more dangerous than adobe structures in any other country if it were not for the poor quality of the adobes themselves. A detailed examination of the various design problems of the adobe structures found in Peru is contained in the booklet, "Improvement of Adobe Houses in Peru: A Guide for Agencies".

This booklet will examine the potential for improvement of the quality of adobe through the use of chemical or industrially-produced stabilizing agents.

II. THE QUALITY OF ADOBE IN PERU

The adobes in Peru are considered to be of poor quality for two primary reasons. First, the soils of Peru are not generally thought to be ideal for adobe-making. Second, the quality of adobe-making has been diluted, and the rapid population growth and the movement of many of the skilled masons from the sierra regions to the coastal cities have resulted in a loss of skills. Many of the best adobe masons no longer practice their skills or now build with materiales nobles (brick or block). For the masons who do continue to use adobe construction on the coast, often the soils are not well suited for adobe fabrication and, although the masonry work is still of good quality, the structure itself is inherently weak due to the poor quality of the adobe. In the sierra, the exodus of the best masons is shown by the deteriorating quality of adobe workmanship found in these regions.

A. Characteristic Weaknesses of Adobe in Peru

It is important to understand the characteristics and behavior of adobe in an earthquake, and to identify those points in a structure which become dangerous when poor quality adobe is used.

Adobe blocks are normally fabricated by taking a soil which has a mix of clay and sand with a small amount of humus material and adding water to make a mud base. Some natural fiber such as straw is added to serve as a binder The material is then allowed to cure for several days. When the material appears to have the proper consistency and moisture content, it is poured and packed into wooden moulds, then slipped from the moulds onto the ground for drying and curing. After one or two days, when the adobes have developed a crust on one side, they are turned over and allowed to continue drying on the other side for another day or so. When they are sufficiently solid enough to be moved, they are stacked on edge and continue to cure for an additional ten to twenty days.

Strength in adobe is determined by three factors: the composition of the soils, the relative value of the binder as a binding and stabilizing agent, and the attention given to the adobes while they dry and cure. In regard to the soil, if the adobe material has too much clay, expansion and contraction with temperature changes will crack the adobes; if there is too much sand, the adobes will not bind together properly. In regard to binders, if the binder chosen is not chemically compatible with the soils, stabilization will not be achieved. Finally, during the drying and curing process, if the adobes dry too quickly, they become brittle. If they are not properly moistened during the first few days, the outside crust will harden and trap the moisture on the inside, leaving the adobe soggy in the middle. If the adobes are rained on during the first ten days, the curing process may be altered and the adobes may begin to erode before they are properly set.

All of the above factors, and sometimes combinations of factors, can be seen in the adobe fabrication in Peru. Whatever the cause, the most characteristic weaknesses of the adobe are that they are not resistant to moisture and that they are too brittle. In relation to earthquake hazard, failure to resist moisture causes the following problems:

1. In rainy areas, the adobes absorb the moisture of rains and the constant humidity during the rainy season and the walls are correspondingly weakened. The corners of buildings have been shown to be particularly susceptible to this type of damage. In an earthquake, the failure of the corners can be catastrophic.

2. Adobes at the base of a structure are often eroded by the dripping of water oft the roof or the splashing of water during rains. This type of damage to a structure along its base means that all the material above the line of erosion is essentially sitting on a potential shear line in an earthquake. The horizontal shear caused by an earthquake could induce total collapse of the wall.

3. Moisture often reaches and saturates the lower level of adobes at the point where the adobe wall comes into contact with the foundation, through what is known as "capillary effect". Ground moisture rises into this lower level of adobes, the adobes become moist and are weakened, and again a potential shear line is created.

The problems caused by improper curing are that the adobes may develop cracks or that the adobes may be moist in the center. In the first instance, cracks mean that the wall will have portions that are not properly bonded together. In the second case, adobes with moist centers will not have uniform strength and the entire strength of each adobe may rest on a thin crust surrounding a moist core. In both cases, the walls will not have sufficient strength to resist the forces of an earthquake.

B. The Behavior of Adobe in Earthquakes

The primary reason for the vulnerability of adobe structures in earthquakes is that they are heavy structures. By simple physics, the mass multiplied by acceleration (the motion caused by the earthquake) equals the force acting on the structure, its components, joints and materials. In short, the greater the mass of the structure, the the greater the forces that will act upon it. In the rainy areas of Peru, the problem is that, because of the characteristic erosion of the walls, people build thick walls so that the lifespan of the walls (and therefore the house) will be longer. Unfortunately, a thick wall also means a heavy wall. In order to build a lighter (thinner) wall, erosion-resistant adobes must be developed, or the wall must be protected by other means from erosion and the intrusion of moisture.

A second factor in the vulnerability of adobe is that, if an adobe is not cured or bonded properly, it is prone to partial disintegration in the movements and vibrations caused by an earthquake. Thus an effective and compatible stabilizing agent must be used, and quality control must be maintained throughout the curing and drying process.

C. Options for Correcting Deficiencies in Adobe

There are four methods that can be used to improve the quality of adobe and increase its resistance to seismic forces. They are:

1. To build better foundations and splash barriers which prevent moisture from entering the lower adobes in a structure;

2. To increase the distance from the end of an eave of the roof to the wall in order to reduce the drip damage and erosion at the base of a structure;

3. To cover the walls with some form of protective coating that will serve as a barrier to outside moisture;

4. To build a better adobe.

The first three options do not require any new technology and can be carried out through a program of training masons in new building techniques. The fourth option -- to build a better adobe -- requires a bit more. Some of the methods that can be used to improve adobes are:

a. the use of pressure (such as in a rammed-earth process, e.g., the CINVA-Ram) to build a more solid block;

b. the use of additional or substitute natural stabilizers and binders, by chemically analyzing the best type of stabilizer to use in each type of soil; or

c. the addition of chemical stabilizers to change the molecular structure of the soil material, to make it more water-resistant and bind the material together in a more durable manner.

Since the 1970 earthquake in Huaraz, a great deal of research has been undertaken in Peru to explore how to build better adobes. In 1971, the Government of Peru began a program of concentrated research on stabilized adobe. This project, known as the COBE Program, has been conducted as a joint effort by several of the nation's universities in conjunction with the Ministry of Housing & Construction. Of the various stabilizing agents examined, the one which appeared to be most promising was a common road asphalt diluted with diesel oil, known as RC-250.

By the mid-1970's, a number of pilot projects had been developed using stabilized adobe to determine the receptivity of builders to use of the material and to work out some of the technical problems associated with the use of stabilized adobe in construction. Tests of the material in the fabrication of adobe showed that it increased the moisture resistance of the typical soils used to a point where the adobe is, in essence, impermeable. Tests also indicated that the same mix could be used for mortar, thus creating almost uniform strength throughout the walls. Stabilized adobe can be made in all adobe-making regions of Peru with almost any combination of soils (with the exception of soils having a high concentration of salt). Stabilized adobe is not affected by rains during the curing process, and may be fabricated in a wider range of temperature bands.

When the stabilized adobe research began, the asphalt stabilizer was an economically sound choice. Peru anticipated finding large oil deposits and developing a strong production capacity. Production of the asphalt is a by-product of the oil-refining process, and it is widely used in the construction of hard-surfaced roads throughout the country; thus production and distribution of the stabilizer, at least in the urban centers, was not seen as a major problem. As the program progressed, however, the oil boom did not materialize, the cost of

all oil-based products skyrocketed, and the price of the material has now risen to a point where it is no longer as economically feasible as it once appeared. There are still, however, opportunities for the use of stabilized adobe, and potential exists for its introduction.

III. PROBLEMS TO INTRODUCTION OF STABILIZED ADOBE

There are a number of problems which must be identified and overcome before stabilized adobe can be introduced in Peru. The most serious of these are:

A. Tradition

Of all the obstacles that must be overcome, tradition is probably the most difficult. Especially in remote rural areas where adobe building has been a practice for hundreds of years, introduction of a new and "foreign" material will be difficult. Masons will be skeptical as to the added value and hesitant about using a material with which they are unfamiliar. Practical demonstrations promoting the use of a new stabilizer will be viewed with skepticism or, at best, with polite reservations. Excuses will be found for not using the material, and any difficulties encountered in early construction with the new stabilizer will be seen as a justification for discontinuation of its use. To overcome resistance to its introduction, a simple demonstration program wherein one or two models are built in each community will not be enough. For the idea to take hold and become a part of the normal building process, scores of houses will have to be built and occupied for a number of years before stabilized adobe is accepted.

B. Economics

As noted earlier, the cost of asphalt emulsion has risen rapidly in the last few years. This has increased the relative price of stabilized adobe to a point where the total cost of a wall made of stabilized adobe is almost equal to that of a wall made of brick or block. In rural areas, where the cost of transportation must be added to the cost of the stabilizing agent, the costs are even greater. Any housing program which attempts to introduce stabilizing agents as an alternative must sufficiently lower the cost to a point where it becomes economically feasible for widespread use. This means that the construction cost of a wall must be less than (not comparable to) the cost of using other masonry materials. If the cost is comparable, people will choose the brick or block, which in Peru are viewed as a "step up".

C. Distribution/Transportation

If a synthetic stabilizer is going to be accepted, there must be a sufficient distribution network and a readily available, ongoing supply of the material. One of the biggest obstacles to acceptance of an asphalt stabilizer is the fact that it is not available in

Peru at the present time. The people who make adobe do not have access to the refinery, and there are no commercial outlets where the stabilizing agent may be obtained. While it can be argued that, if sufficient demand for the material exists, commercial distributors will supply it, there first must be sufficient outlets in the beginning so that a demand can be created. It also must be made clear to the initial users that the supply will continue beyond the introductory period. Repair, modification and additions are all considerations of a homeowner and, unless he is assured that the stabilizer will be available for future use, he will be unlikely to choose the material for his initial construction.

Transport of the material itself is another major consideration in the distribution plan. A stabilizing agent which is heavy, bulky and cannot be carried by hand or by burro has little chance of being accepted in rural areas. In villages accessible by truck, distribution points can be set up for local community distribution. But outside the village the costs of delivering the material, even by small pickup trucks, would probably elevate the costs above that which the people will pay.

D. Material Compatibility

No matter how good a stabilizer may be, there will be one or two soils with which it will not be compatible. For example, asphalt emulsion cannot be used in soils with a high saline content. Those attempting to introduce a stabilizing agent must be aware of the limitations and must communicate these limitations to potential users. Other factors that should be considered include climate, season, and the PH factor (or acidity of soils and, in areas around mines, of the water used in making the adobes).

E. Perception by Potential Users

In order for stabilized adobe to become popular, it must be perceived by potential users as a beneficial alternative to other types of construction. In the hierarchy of building preferences, adobe ranks in the middle -- higher in value than quincha, tapial or other cheaper building methods, but lower in value than brick or block. The potential users of stabilized adobe will be those who already use adobe houses and those who reside in the less preferred types.

As long as the problems of cost and tradition can be overcome, those living in the less preferred types will be more receptive to building with stabilized adobe. However, people who already live in adobe houses will take more convincing, as the next step upward in perceived value is a house of brick or block construction. The problem to be overcome will be to convince these people that the added cost of stabilized adobe and the benefits provided by the material justify the investment. As noted earlier, the only way whereby this group of people will choose stabilized adobe over other forms of construction is if the costs of stabilized adobe are still less than the other alternatives, or if the alternative materials are unavailable.

IV. OPPORTUNITIES FOR INTRODUCTION OF STABILIZED ADOBE

Once the problems and obstacles that must be overcome have been identified and discussed, the question remains: can these problems be overcome, and are there opportunities for the introduction of stabilized adobe? The answer is that, while there are major difficulties to introduction and only a limited number of areas where the material can be introduced, still opportunities do exist where, with proper planning and program execution, stabilized adobe can be successfully integrated into the normal building practices. These opportunities exist in the following areas and situations:

A. In Urban Areas

The most obvious place to introduce stabilized adobe is in the urban growth centers along the coast, especially those near the country's oil-refining facilities. In the larger sierra towns (such as Cuzco, Huaraz, Arequipa and Huánuco) which are served by heavy and continuous truck traffic, there are also good possibilities. Government-sponsored programs in the pueblos jóvenes of these towns appear to be an ideal starting point for successful promotion of the new material. In the urban areas, the problem of tradition is more easily overcome, as many come to the city looking for opportunity and change and are therefore more receptive to new ideas. The biggest problems are still economics and the perceived value of stabilized adobe vis-a-vis other types of construction. However, with proper promotion, programs in the pueblos jóvenes could yield a high success ratio.

B. In Post-Disaster Housing Programs

The introduction of stabilized adobe following a disaster presents both the greatest opportunity and the greatest challenge to program planners. Both earthquakes and floods can create a widespread need for new replacement housing in a short period of time. In the case of earthquakes, an entire region may require new housing. In both types of disaster, the failure of traditional adobe construction may be one of the major causes of casualties; thus people will be more receptive to suggestions on ways in which adobe construction can be improved. Although many people (and programs as well) will attempt to reconstruct with other materials that are considered to be safer, the economic reality will be that many people will reconstruct with adobe. It is within this group that the opportunity exists.

If properly planned, a program that introduces stabilized adobe on a widespread basis and continues to promote the material long after the disaster can effect a long-term change. In order for such a program to be successful, the benefits of the material as a means of reducing future vulnerability must be explained in detail to not only the builders but also the homeowners and occupants. Of course, the emphasis should not be solely on the adobe material itself, but should include other information such as proper configuration, balance, and detailing for seismic-resistant construction.

It is often projected that, in areas where a high risk exists for earthquakes, there is a pre-disaster opportunity to introduce new building methods. As one part of an overall disaster mitigation strategy, such an undertaking is desirable. First, the areas with a high potential for earthquakes are identified. Then, within these areas, communities with a high concentration of vulnerable structures are identified. Within each of the communities where new construction activities are taking place, a program is set up to introduce and promote the use of better building methods -- stabilized adobe being one of them. The potentials and problems associated with such an approach are discussed in the report, "Analysis of the Potential for Housing Improvement in High Risk, Vulnerable Areas of Peru".

C. In Economically Stable, Rural Areas

In some of the more fertile valleys of Peru where the economic situation is relatively stable and where agricultural production is high and/or expanding, new or replacement housing is built on a slow but continuous basis. In those areas where there has been an increase in the net farm income, an opportunity exists for introduction of stabilized adobe. In this case, the biggest obstacles will be perceived value and distribution.

D. As Components

One opportunity for the introduction of stabilized adobe that has been generally overlooked in much of the research to date is the use of a limited number of stabilized adobes in key locations (or as components) of a house rather than as an entire wall. For example, one or two layers of stabilized adobe at the base of a wall where the adobes come into contact with the foundation of the building would provide a suitable moisture barrier and reduce damage from both capillary effect and from splash and drip erosion. Stabilized adobes could also be used in the corners of buildings and around doors and windows -- components of traditional adobe structures in Peru that are particularly susceptible to failure in earthquakes.

An advantage to using stabilized adobe for component construction is that the cost would be very minimal in relation to the overall benefits provided, especially in the zones with high rainfall. The small number of adobes which would have to be produced would also mean that the stabilizing agent could be produced in small containers and thereby would be easy to transport and distribute. As the first stage in a step-by-step program to encourage widespread use of the material, this method also has the advantage that it is easier to promote use in a component rather than for the entire structure. Thus, it should be easier to overcome the barrier of tradition.

V. STRATEGIES FOR INTRODUCTION

Where opportunities for introduction can be identified, program strategies and approaches must be developed in order to facilitate acceptance and to promote use. This section will discuss the various strategies used or proposed in other areas of the world to promote the introduction of new building materials.

A. Subsidies

The most successful approach to the introduction of new materials is often the subsidizing of the material being offered. Subsidies are not a new idea; they have been used for many years in housing programs on virtually every continent. Some subsidy programs provide money for an entire house, with the qualification that specific materials must be used. In other cases, they simply provide the material at a reduced cost, usually about 30%-50% off the normal price. Advantages to subsidy programs include the following:

1. A subsidy lowers the purchase price of the material being offered and thereby makes it competitive as well as attractive.

2. A subsidy program increases the purchasing power of the initial investment of the program. A 50% subsidy with constant reinvestment of the sales proceeds, for example, can double the purchasing power of the original money invested in the program.

3. If the material being distributed under a subsidy program is sold through the assistance of a local institution such as a cooperative, that institution not only receives a great deal of experience in materials handling, but also its position in the community can often be strengthened. (If too much is expected of the institution, however, negative consequences can result.)

4. If the volume of sales is higher than originally predicted or if adequate plans are made in advance, a portion of the funds from sales (the reflow funds) can be used for developing community incentives or can be returned to a community for use in other projects. Following the 1976 Guatemalan earthquake, for example, reflow funds were used by some institutions to build up a community fund that was then used for community construction activities such as road construction, schools, etc. It has been proposed that an ideal variation of this as an incentive program would be for an agency to offer to match the amount of money in the community fund (created by the reflow funds), should a target number of structures meeting a basic building standard using the new material(s) be met by a certain percentage of the community.

5. Subsidy programs have been shown to work well in rural areas, as people in these areas are not usually eligible for other types of programs such as low-cost loans.

6. Finally, subsidy programs can be set up quickly and are relatively easy to administer.

B. Loans and Grants

Numerous approaches have been developed whereby low-interest or long-term loans (or both) have been offered to people willing to use new materials in the construction of houses. In some countries, these may be accompanied by the development of basic building standards or codes which must be met in construction of a house in order to be eligible for the loan. Loan programs are especially popular with governmental financial institutions, although the success ratio of loan programs in the field of low-cost housing is not considered to be more than marginal. Among the problems with this type of program are:

1. Loan programs take longer to set up and often, especially in the case of post-disaster programs, may miss opportunities due to excessive delays.

2. Many program recipients have trouble obtaining credit for the loans or meeting basic eligibility requirements. (In many cases, it is not so much a matter of meeting the requirements as being able to prove that they meet the requirements.)

3. In many cases, low-income families do not wish to encumber themselves with long-term debts. Often the working mechanisms of loans and the obligations are not fully understood by the potential borrower and therefore low-income families tend to shy away from such programs. Even if they do participate, without an adequate loan education program accompanying the loan itself, pay-back rates are often much lower than projected.

4. Loan programs require a great deal of administration and are usually only attractive to financial institutions such as housing banks and savings & loan associations or cooperatives. If a program is to be administered locally by a non-financial institution (such as a cooperative), its administration is much more sophisticated than a subsidy program and often requires a great deal of administrative assistance on the part of the sponsoring agency.

Outright grants to people who agree to build with a new material are proposed as a means of reaching the very poorest who would not qualify for loans. Grant programs are usually short-term in nature and generally do not have a very high degree of success. Grants are usually popular only with the recipients; those who do not receive a grant, but who would qualify were more funds available, generally resent the fact that they did not receive a portion of the funds being distributed. In terms of developmental consequences, grant programs are generally viewed as having a negative impact on the development potential of a community and are therefore not highly regarded by development agencies.

C. Codes

The formulation of building codes and standards, and the active enforcement of these regulations, has often been proposed as a means of improving the quality of housing and encouraging the use of new materials. The actual record of code enforcement in the developing countries, however, is very poor. Few governments have the staff to enforce the codes and the few codes that have been developed, especially in relation to low-cost traditional houses, fail to consider the economic realities that force people into this type of housing. Even when used in conjunction with loan and grant programs, codes have not been an effective stimulant to change in housing.

D. Post-Disaster Housing Policies

One method that has been discussed as a means of effecting change in housing following disasters is the adoption of uniform reconstruction policies by a government, enforcing these through control by the relief or reconstruction agencies. As a theoretical example following an earthquake, agencies would be required to produce housing that met certain basic, minimal standards and make certain contributions to a community's building process (through training programs, etc.) in order to obtain a permit to operate in the disaster-affected area. To demonstrate compliance, agencies would have to present evidence that the housing programs undertaken met these basic requirements and that the structures being built met certain performance standards set by the uniform reconstruction policy.

While it is not advocated that each agency be required to build exactly the same style house, nor even to use the same materials, basic standards can be set and the agencies' programs monitored. Through such a policy, new and innovative materials can be introduced as long as adequate plans are developed in advance to ensure that sufficient supplies and technical resources are available.

VI. TOOLS FOR PROMOTION

Once a strategy has been selected and a program worked out for introducing stabilized adobe, a variety of promotional tools are necessary to the success of the program, such as:

A. Training Aids

A complete package of training aids should be developed in order to provide information about stabilized adobe not only to potential users and builders, but also to provide detailed information to those who will be instructing others on how to build with the material. Booklets, pamphlets, promotional posters, etc., must all be developed as part of this package. Some materials have already been produced by the Office of Research and Standards (Oficina de Investigación y Normalización, Ministerio de Vivienda y Construcción) in Lima.

B. Simple Designs

A number of simple designs for one-, two- and three-room houses should be developed and provided to families as a guide. After several houses have been constructed, photos of the occupied structures can be taken and distributed along with the designs.

C. Demonstration Models

In any target community, model houses will have to be built to show how the new methods work. It is not enough simply to demonstrate new techniques of making stabilized adobe; entire structures must be built. In order for the idea to catch on, many demonstration structures must be erected. Agencies should be aware that, before a construction method becomes a permanent part of the normal building process, more than 20% of the total structures in the community must utilize that method. Some programs have chosen to build one community building or house as a training mechanism to show builders how to use the method and to provide a demonstration structure for the community. This process will only be successful if used in conjunction with other strategies such as material subsidies or loan programs.

(See also the report, "Improvement of Adobe Houses in Peru: A Guide for Agencies", for additional information on where program emphasis should be placed when introducing change in housing.)

VII. CONCLUSIONS

This report has examined the problems which must be overcome before there can be widespread acceptance of stabilized adobe in Peru. Despite the problems, however, there are opportunities for introduction and, in certain instances, the potential is fairly high. With the development of adequate tools for promotion, and the selection of workable strategies and approaches for overcoming the problems encountered, stabilized adobe can become a valuable means for reducing in part the vulnerability of traditional adobe structures in earthquakes.

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