CHANGES IN HOUSING CHARACTERISTICS IN SEVENTEEN GUATEMALAN COMMUNITIES FOLLOWING THE EARTHQUAKE OF 1976

SUBSTANTIVE REPORT #2

GUATEMALAN EARTHQUAKE STUDY

Changes in Housing Characteristics in Seventeen Guatemalan Communities Following the Earthquake of 1976

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Preface

This is a preliminary report prepared on the basis of a partial analysis of the data available from the Guatemalan Earthquake Study. This study is being conducted using a longitudinal design which employs a control group. At this writing, control group data (from unaffected communities) are not yet available for comparison with the results obtained from damaged communities. Much of the information collected assumes comparisons with data yet to be gathered in Phase II and Phase III of this longitudinal study.

For these reasons the results reported here should be regarded as tentative until a full analysis has been completed. They are presented at this time as a progress report which may be of value to agency personnel and researchers interested in the reconstruction process following the February 1976 Guatemalan earthquake.

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Introduction

This paper discusses some of the preliminary findings which have emerged during the first year of a three-year longitudinal study of the 1976 Guatemalan earthquake. It focuses on the housing reconstruction process and on changes in house types as they are related to future earthquake vulnerability in Guatemala. In so doing, it examines some of the social and cultural factors which have influenced that process.

Housing in any society is a product of the social organization, technology and value system incorporated into the structure of that society. It is also a tool or facility utilized by members of society as they play certain vital domestic roles. Houses are not merely physical objects; they are social objects to which important cultural meanings are attached. Furthermore, the methods by which they are constructed, the materials used to build them, and the form that they take have important relationships to the social organization of society and to the life style of its members.

In societies with advanced technological systems that employ high levels of specialization in occupations, houses are produced by a different set of people than those who occupy them. They are often built using materials shipped over vast distances, some of which are not even produced in the society in which the finished house is located. They are acquired and traded, much like any other commodity in the market place. In such a society, a house is more an expression of the ideas and tastes of architects, designers, developers and contractors, coupled with the promoters, advertisers, and media experts who manipulate tastes than of ordinary citizens who occupy and utilize them. In contrast, in developing countries houses are more likely to be produced by the very people who occupy them, using simple technologies and employing indigenous materials. Under such circumstances they more closely approximate an expression of the values, tastes and domestic organization of their occupants.

The 1976 Guatemalan earthquake resulted in the deaths of over 25,000 people and in injuries to approximately 75,000 others. These deaths and injuries were partially a result of the fact that the disaster occurred at 3:00 A.M. while people were asleep in their homes, many of which had unreinforced adobe walls with heavy terracotta tile roofs. These roofs were supported by light frames which were not securely attached to the structure. Under the stress of the earthquake, the walls collapsed and the heavy roofs fell in on the sleeping victims. Many were crushed. Others sufficated in the heavy adobe dust which engulfed them.

These houses had been built largely by their owners, assisted by village albañiles (builders) using indigenous materials and following an established traditional pattern. Although this type of house predominated, there were other housing forms in use in Guatemala at the time of the earthquake which proved safer. For example, one traditional pattern used cane or corn stalks for a wall material and straw or palm for the roof, the whole structure being built around a wooden frame. Another pattern combined bajareque walls with either a tile, straw or palm roof. Bajareque uses a set of wooden posts sunk into the ground, across which cane is woven to form a lattice-like wall and then filled and plastered with adobe-like mud. Because of their flexibility, and because of their cross-braced wooden frame, these houses withstood the earthquake better than the adobe structures. A few houses were made of cement block and used lamina (zinc coated corrugated metal) roofs. These also fared better. The cane and palm houses and those of bajareque were generally considered less desirable than adobe before the earthquake and were found primarily in the more remote villages among the poorer people of the community.

Following the earthquake when it became obvious that a massive housing construction effort would be required, it was also apparent that the traditional adobe house with a tile roof was unsuitable in a seismic zone. The critical question was how to encourage the building of earthquake resistant houses while meeting two basic requirements. First, it would be necessary to rehouse the million homeless people in a very short time to prevent further suffering from exposure. Second, it would be necessary to build houses very cheaply and at the same time to avoid dangerous materials and construction patterns. This latter requirement can best be grasped if it is understood that the average house occupied by people in the towns and villages outside of Guatemala City cost under $500 to construct before the earthquake.

Although they incorporated aseismic design features and proved safe in the earthquake, houses made of cane with palm roof or of bajareque had other drawbacks which discouraged their use as replacement housing. Cane walls offer little protection from the elements and are not secure against intrusion. Bajareque and cane houses were associated with lower economic status than were adobe and concrete block. Few houses employed wood. The need was for a house form which would be cheap, easily produced and acceptable to the people and, at the same time, safer in an earthquake.

In addition to these practical considerations, a number of less tangible factors entered into the decision-making processes affecting housing. First, a number of consultants to the government and to foreign agencies urged that the aid offered the Guatemalan people should be offered in such a manner as to avoid creating dependency on donor agencies. It was urged that housing programs should be such that after the relief effort was over, people could go on constructing similar houses on their own. This meant that both design features and construction method had to be within local economic means and the capacity of local skills and resources to construct. In short, whatever housing effort was to be carried on by outside agencies should be such as to fit into the technological and economic base and at the same time be aseismic. This, of course, was a tall order, given the severe economic constraints and the limitations of the prevalent house building technology practiced in the past.

In response to these requirements, a variety of housing programs was instituted under general policies laid down by the Guatemalan government's Emergency Committee and later its Committee on Reconstruction. There are two policies of importance to this paper. First, the government decided to divide the total task of relief and reconstruction among various domestic and foreign agencies offering assistance by assigning agencies to specific towns and villages where they would have primary responsibility for relief and reconstruciton. This meant that each town or village would have a different type of program, depending on the particular agency assigned to it. Second, the government requested that instead of giving away houses or housing materials and other relief supplies such as food, the people should be required to contribute either money or their own labor to help themselves. The argument given was that this would prevent the creation of dependency and at the same time increase the resources available for reconstruction and speed the recovery process.

Several types of agency housing programs were the result of these various considerations. The variety of programs in the area of housing can be summarized as follows:

1. One style of program distributed free lamina roofing to families who had first constructed for themselves a wooden frame which employed aseismic cross-bracing features. The idea behind this program was to insure aseismic construction by motivating people with the offer of free roofing. At the same time an educational

effort was conducted which was aimed towards long-run objectives with respect to future aseismic housing.

2. A second type of program distributed lamina at half price through local organizations, usually cooperatives, to anyone who could afford it. In most cases, the proceeds were then placed in a community fund which was later used to finance community reconstruction programs requiring a high labor input. The idea behind this program was to avoid imposing a housing pattern on the people and to avoid a dependency relationship. It also sought to provide a versatile building material and jobs that would keep money generated by subsidized sales in the community to help with reconstruction.
3. A third type of program concentrated on providing short-term housing that would serve the needs of people during a four or five year period while permanent solutions to the housing problems were being worked out. Whole houses,built using prefabrication techniques employing local labor, were given to people in return for work in helping to construct them. The idea behind this program was to furnish temporary shelter quickly and to offer it in such a way as to provide a period of time during which planning for permanent reconstruction could take place.
4. A fourth type of program concentrated on building permanent housing constructed according to an aseismic design, usually of steel reinforced concrete block, and arranging for housing loans which would permit people to pay for their houses over a ten to twenty year period at a price, hopefully within their means. These houses were usually subsidized by the agency offering them to keep the selling price within the limits thought appropriate for the local economy. Their construction often employed the labor

of the eventual occupants in a communal building program.

5. There were other patterns which mixed together features of these four types. However, most of the housing produced used one or the other of the dominant patterns.

In the following pages the results of the overall housing reconstruction process in seventeen communities will be discussed in terms of changes in housing style which have occurred and the implications of these changes for future earthquake vulnerability. Before presenting these results a brief description of the methodology employed is appropriate.

Background

The data upon which this article is based are the preliminary results of the first phase of a three-year longitudinal study of the long-term effects of the 1976 Guatemalan earthquake. The research design calls for household survey interviews in twenty-five Indian and Ladino communities in both heavily damaged and undamaged areas at two points in time. In addition, interviews with key people (formal and informal leaders) in each community are being conducted. These data are to be supplemented by ethnographic case histories of various communities and interviews and documentary research of selected relief, reconstruction and development agencies. The ultimate goals of the research are to understand the social and economic consequences of a major disaster through time, across cultural environments, and to test various hypotheses regarding the rates and directions of induced and secular social change. In addition, the research seeks to provide information for government and private agency planners and executive personnel that will be useful for future relief and reconstruction efforts.

Data Base

This paper is based on findings obtained in seventeen Guatemalan communities. Six of these communities are located in the Eastern part of the country in the relatively arid region around El Progreso. This area is almost exclusively Ladino in culture. Seven others are located in the Highlands west of Guatemala City where there is a high concentration of Indian population. Four others are city neighborhoods selected to represent new housing areas which have grown up following the earthquake.

Sampling

The sample of households interviewed was drawn in these communities using the following procedure. Each community was mapped so that every dwelling in the community was located. The map was then divided into sectors having approximately equal numbers of dwellings. Each sector was numbered in a serpentine fashion. Using a table of random numbers, a starting sector was drawn and then according to a predetermined sampling interval based on total population, houses were selected for interviews. This procedure produced a self-weighting random sample of households present in the communities between January and November of 1978. Table 1 presents data on the sample.

Pretest

All questions in the interview were extensively pretested in communities similar to those being studied. Over 300 pretest interviews were conducted by the same field team that conducted the final interviews. On the basis of the pretest, questions were revised, answer categories changed and new questions introduced or old ones dropped so that the final instrument utilizes language and concepts familiar to both interviewers and informants.

Interviews

All interviews were conducted in Spanish (or local Mayan dialect through translators) by Guatemalan interviewers who were trained over a four month period.

This included classroom instruction, field testing, role playing, critiques of tape-recorded interviews, and paired-comparison codings. The interviewers participated in the preparation of instruction booklets that contain nearly two hundred pages of detailed descriptions and interpretations of the meaning of question and answer categories.

Quality control of data was maintained by a series of checks and re-checks by the field supervisor and the interviewers both before and after preparation for machine analysis. The authors believe that the great care in collecting and processing these data has resulted in data that accurately reflect the situation in these communities as perceived by respondents.

Housing Characteristics Before and After the Earthquake

Prior to the earthquake, the "typical" rural Guatemalan house was a modest one or two-room structure that generally included a porch or "corredor." Cooking and other food preparation activities were usually conducted either in the corredor, or in a separate structure attached to the main building. The house site frequently held other structures that served various purposes such as storehouses and additional dormitory facilities. The social characteristics of households vary considerably, often including vertical or lateral kinship extensions and non-related members. For the purposes of this study, the household is the unit of analysis, and is defined as being composed of all individuals who share a common hearth. The "house" to which this research refers is defined as the principal dwelling on the house site where the household head (self-defined) sleeps and where household activities are centered.

Housing characteristics were determined by interview and observation. To obtain information on the pre-earthquake dwelling, interviewers defined terminology and then asked if the house prior to the earthquake had the particular characteristics in question. The respondent was asked to estimate the damage to each particular characteristic - "none," "little," "much," or "destroyed." The characteristics of the contemporary dwelling were then recorded, using both interview and observation techniques.

There are only three principal characteristics shared by all houses in this study: walls, roofs, and floors. Other features are expressions of individual variability according to economic resources and preference. Further, the structural significance (presence or absence) of some features such as corner posts, varies with the characteristics of the three principal components.

Changes in Primary Housing Features: Walls and Roofs

The type of wall and roof employed in housing construction has important implications for earthquake vulnerability. It also has a significant relationship to local tastes and values related to social status and to customary house-building economics and technology. These primary housing characteristics will be examined below, first separately, and then in combination with each other as house forms.

Wall Types

Table 2 shows the type of wall material used in house construction in the three regions studied. It also shows wall types for pre-earthquake houses and for the first and second structures built after the earthquake. This table (not unexpectedly) reveals that the great majority of houses in all regions were constructed using adobe walls before the earthquake. Of the 1072* pre-earthquake dwelling units occupied by residents, 840 (78.4%) had adobe walls. In the Highland region 88.3 percent had such walls, while in the East 76.8 percent were adobe structures. The communities studied in these two regions are reasonably representative of other communities in both the Highlands and

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*The number of households upon which data are available varies somewhat, depending on the characteristic being discussed. This is due to data being "missing" on some cases where answers were not given by respondents.

the East that were affected by the earthquake. In the city, the four sample units were not chosen to represent the various socio-economic districts or neighborhoods, but were chosen on the basis of the type of post-earthquake housing situation involved. They do not therefore approximate a random sample of city neighborhoods. Instead, they are heavily overweighted in the direction of the poorer people. With this in mind, it should be noted that 64 percent of all the houses occupied by the city dwellers studied had adobe walls before the earthquake. This undoubtedly over represents the number of adobe houses compared to others in Guatemala City.

The only other wall materials represented by more than fifty cases out of 1072, or around 5 percent, were made of bajareque 5.3 percent, wood 5.2 percent and cement block walls 4.9 percent. Most of the block and wood structures were found in the City, while most of the bajareque houses were located in the Eastern region. All other wall types make up only around ten percent of the total number of houses studied.

Due to agency housing programs typically featuring use of wood and/or cement block in wall construction, and due to individual preferences, a large change has taken place in the wall materials used in post-earthquake structures. The most striking change is in the use of adobe for wall material. Before this change is discussed in detail it is necessary to explain the meaning of "Structure I" and "Structure II," which appear repeatedly in the tables to follow.

It was discovered during interviewing in the pretest for this study that some families had built, or had received from agencies, more than a single house since the earthquake. One hundred and eighty-eight families in all had two separate structures which had been built during the reconstruction process. In all, 1078 families were interviewed. Therefore 17.4 percent of the sample families had built two structures. At the time of interview they were occupying both structures, either for purposes of housing themselves and their families or for business or other purposes. This means that in all, 1267 different post-earthquake structures were studied in terms of their characteristics. Of these, 105 had adobe walls compared to 840 pre-earthquake structures. In other words, the proportion of adobe houses dropped from 68 percent to about 8 percent following the earthquake.

The use of other wall materials greatly increased to supplant adobe as the primary building material. Considering Structures I and II together, there were 366 (28.9%) houses with wooden walls after the earthquake, compared to 56 (5.2%) before. Most of these were built by a single large agency which had a housing program in both the East and the Highlands. The use of cement block for building materials also increased dramatically for the same reason. Again, considering Structures I and II together, there were 358 houses with block walls constructed after the earthquake. This compares to 52 pre-earthquake houses, or about 5 percent as compared to 28.3 percent. There also was a substantial increase in both half-adobe and half-cement block structures. Prior to the earthquake only 10 structures had this feature. After the earthquake, 145 structures used this pattern. Half-adobe and half-block houses utilize these materials for the lower meter of the wall and a light weight material such as wood or lamina for the upper wall. Several agencies advocated this wall pattern as an aseismic construction feature.

The increase in cement block houses is largely a result of several agency housing programs found in all three regions. The greatest increase in the use of block, however, was found in the city where two of the areas being studied contained block houses constructed by one large agency.

Two other interesting observations can be made concerning Table 2. First, little change took place in the use of bajareque in the post-earthquake period.

It is believed to be more aseismic than adobe alone or the wall type called tapia which consists of poured mud or adobe. The use of cane or palm and thatch increased following the earthquake from 2.8 percent to 6.8 percent in Structure I's and 3.7 percent in Structure II's. Such a wall type consists of a wooden frame upon which is woven cane, thatch, corn stalks or palm to fill in the walls. With a light weight roof of thatch or palm, such a house also has great earthquake resistance.

Of interest also is the fact that walls made of a patchwork of salvaged materials increased following the earthquake. There were 13 of these structures observed in the pre-earthquake period among the households studied. Ten of these were in the city. Following the earthquake, taking both structures together, there were 115 such structures. This fact indicates that many earthquake victims are still housed in more or less temporary shelters constructed of salvaged materials. Most of these are located in a squatter settlement in the City called The Fourth of February.

Roof Types

Table 3 gives roof types before and after the earthquake in the three regions studied. It shows dramatically two facts: first, that the most common roofing material used in the three study areas prior to the earthquake was lamina, and not tile as supposed by many persons who have reported on the earthquake. Tile was the second most commonly used roofing material. Since the earthquake a large decrease has taken place in the use of tile and a similar increase has occurred in the use of lamina. This change in roof materials must be understood in terms of the distribution of these materials by region prior to the disaster. Lamina, or corrugated galvanized iron, was most frequently found in the city where over 85 percent of all pre-earthquake houses had such roofs. Of the 320 city dwellers studied, only 25 reported having tile as a roof material before the earthquake. It should be recalled that the city sample is not representative of all areas of the city but over-represents the poorer people who were largely renters or tenants. Since lamina is relatively expensive compared to tile, these figures probably under represent the number of lamina roofs in the city.

Comparison of the Highland communities with those in the East reveals the following facts. Lamina was used far more frequently as a building material in the Highlands than in the East prior to the earthquake. There, 45 percent of all pre-earthquake structures had lamina roofs as compared to 12 percent in the East. Following the earthquake about 80 percent of all structures in the Highlands had lamina roofs and approximately 52 percent of those in the East had such roofs. This increase in the use of lamina is due largely to concentration on the distribution of this building material by reconstruction agencies.

For the most part, lamina replaced tile as a roofing material. It can be seen in Table 3 that the use of tile went down from 43 percent of all roofs to 9 percent for Structure I and 6 percent for Structure II. The reduction in the use of tile is greatest in the Highlands where around 3.5 percent of all houses now have tile roofs compared to about 49 percent before the earthquake. In the East 28 percent of Structure I's still have tile roofs and about 10 percent of Structure II's have such roofs.

A word needs to be said about another roofing material which has increased in usage since the earthquake. Duralita, a roofing material consisting of corrugated sheets of asbestos and cement, was used by several agencies as an alternative to lamina. This occurred especially in one community in the East where houses were constructed by an agency using cement block for walls and duralita for a roofing material. Duralita is light weight as compared to tile and in some of the following tables is grouped with lamina because it resembles it in both weight and aseismic qualities. Use of duralita increased from 17 (1.6%) cases before the earthquake to 112 (8.8%) cases.

The only other observation that should be made concerning Table 3 is that the use of thatch and palm for roof material has decreased somewhat since the earthquake. There were 63 pre-earthquake houses with thatch roofs as compared to 36 at present.

This table shows several interesting things. First it demonstrates that lamina was a common building material before the earthquake. At that time nearly half of the houses had lamina roofs in the Highlands and 86 percent of them had lamina roofs in the City. In the East the use of lamina was much less frequent. Agencies that featured lamina as a partial solution to the housing problem therefore were not bringing in an unknown material to be substituted as an innovation for more commonly used roofing. As a matter of fact, it appears that lamina was a status roof material prefered by a substantial number of Guatemalans. Tile, which had been a traditional material prior to the introduction of lamina, is manufactured in Guatemala in small "cottage" industries. This material is extremely heavy and was believed to be responsible for a large number of deaths during the earthquake. The substitution of lamina and duralita for tile therefore seems to improve the aseismic quality of housing as does the substitution of other materials for adobe as walls.

Combinations of Wall and Roof Types

Table 4 shows a cross tabulation of wall and roof types for all study areas combined. It is possible from this table to arrive at a house typology based on the combination of wall and roof features. Such a house typology is shown in Table 5. This latter table reveals that the most frequent house type prior to the earthquake was a structure using adobe for wall material and tile for roofing. Approximately 40 percent of all pre-earthquake houses utilized this combination. At present only 62 structures are of this type, or about 5 percent of all the post-earthquake buildings studied.

The second most common house type prior to the earthquake utilized adobe for the walls and either lamina or duralita for the roof (most commonly lamina). There were 405 such pre-earthquake structures, or 37.5 percent. After the earthquake, only 38 such structures were reported, or about three percent of all post-earthquake buildings studied.

The third most common pre-earthquake house type featured wooden walls and a lamina or duralita roof. There were however only 51 such structures at that time, or 4.8 percent of the total sample. Now there are 363 such structures, or 28.6 percent of all houses studied. This house type is accounted for by the housing program conducted by one large agency in both the Highlands and the East. In the City, one of the study areas, Asentamiento Roosevelt, contains only wooden structures with lamina roofs built by a Guatemalan agency.

The fourth most common house type before the earthquake was constructed using cement block for walls and lamina or duralita for a roof. There were however only 41 such structures before the earthquake, or 3.8 percent of all houses. Following the earthquake 349 such structures were observed, constituting 27.5 percent of all structures built by or for the families. Most of these are houses built by several different agencies using these materials.

The remainder of the house types shown in Table 5 account for relatively few pre-earthquake houses. There was, however, a large increase in three types after the disaster. Half-adobe or block houses with lamina or duralita roofs increased from 8 to 127 (10%). Structures made of a patchwork of salvaged materials with any type of roof increased from 13 (1.2%) to 115 (9.1%), while cane houses with a lamina or duralita roof increased from 11 (1%) to 50(4%).

Changes in Other Housing Features

All houses have roofs and walls and therefore can be compared in terms of the materials used in construction of these features. There are only a few other characteristics that can be said to occur in every house, such as a floor, one or more rooms and some sort of door. Other features such as the presence or absence of windows, a porch, a kitchen or bathroom, or the use of columns, beams or cross-bracing vary from house to house. Furthermore, the significance of the presence or absence of such features as cross-bracing or corner posts depends on the type of wall and roof construction involved. For example, cross-bracing is tremendously important in an adobe house if it is to have aseismic qualities, but in one constructed of reinforced concrete, such cross-bracing is unnecessary. In the following paragraphs we will discuss a number of additional house features -- the type of floor, the type of foundation, and the use of columns, beams and cross-bracing in construction and the presence or absence of windows, a porch and a kitchen in the house.

Floor Type

Table 6 shows the types of floors used in houses in the three study regions for all pre- and post-earthquake houses. Most had dirt floors, both before and after the earthquake. Five hundred and fifty-eight pre-earthquake houses, or about 52 percent,had such floors and 678 post-earthquake houses had dirt floors, or about 54 percent. The next most common pre-earthquake floor was one made of concrete. Such floors consisted of poured and unpolished cement. This type accounted for nearly 20 percent of the floors in pre-earthquake houses. Since the earthquake the number of such floors has risen to 405, or about 33 percent of all structures. Tile, the third most commonly used pre-earthquake flooring material, accounted for approximately 19 percent of all houses at that time. There are now 124 structures with tile floors, or about 9.8 percent. A similar reduction in the use of brick for flooring has occurred since the earthquake.

There is considerable difference between the three regions in how much floor materials have changed. For example, in the Highlands about the same proportion of houses now have dirt floors as before the earthquake. In the East and City, however, the proportion of dirt floors has increased.

Close examination of Table 6 will reveal also that increases in the use of concrete for flooring have been greater in the Highlands and the City than in the East. These changes in floors are associated with types of agency housing programs found in various regions. The wood and lamina structures mentioned earlier all have dirt floors, while the concrete and lamina or duralita structures, for the most part, have concrete ones.

All in all, the change in type of floors used in houses has not been as great as have been changes in wall and roof material. It is also apparent that the changes that did occur have less significance for earthquake vulnerability.

Corner Posts or Columns

The use of corner posts or columns to reinforce the walls of a house is important to the earthquake resistant qualities of that structure, especially when adobe or tapia are employed as building materials. Each house studied therefore was examined to determine whether it used corner posts and other columns to reinforce the wall structure. The results for all houses before and after the earthquake are shown in Table 7 by region.

This table shows that 721 (67%) of all houses prior to the earthquake had no corner posts or columns employed in their construction. This compares to 97 (7.7%) cases in post-earthquake houses. Since most pre-earthquake houses had adobe walls, the absence of corner posts indicates an absence of reinforcement in these structures. Of the 823 pre-earthquake adobe houses which employed either tile or lamina or duralita as roofing material, 686 had no columns used in their construction. In other words, 83.4 percent of the most common forms of adobe houses had no columns or corner posts.

It is interesting to note, however, that adobe houses that had lamina roofs were more likely to employ corner posts than adobe structures with the more traditional tile roofs. There were 384 adobe and tile houses out of 426 that had no corner posts, or 90.1 percent. However, there were 302 adobe houses with lamina roofs out of 397 (76.1%) that had no corner posts. In other words, adobe houses that used more modern material for roofing were more likely to have corner posts and columns used in their construction. Further, the structures most in need of reinforcement, those with heavy tile roofs, were less likely to employ this feature.

Several large agencies conducted educational programs to encourage the use of corner posts and columns in the construction of post-earthquake housing. At least two agencies required earthquake victims to build a structure with this feature incorporated into an aseismic frame before receiving free lamina for roofing. The increased use of corner posts and columns in the post-earthquake period noted above can be partially attributed to these efforts.

The use of such a housing feature is most important when employing adobe as a wall material. As already noted, very few adobe structures were discovered to exist in the post-earthquake period. There were, however, 83 structure I's after the earthquake that utilized adobe in the walls and either tile or lamina in roofs. Fifty-two of these still employed no columns or corner posts in their construction. This amounts to 62.7 percent of all post-earthquake adobe structures employing these two roof materials that had no posts or columns, compared to 82.4 percent before the earthquake. Some of these post-earthquake adobe structures represent survivers of the disaster. Later we will examine damage to such structures to determine the extent to which the presence or absence of corner posts and columns affected their resistance to the earthquake and therefore their survival rate.

Cross-bracing

Cross-bracing is another feature important to building aseismic qualities into housing structures made of unstable material such as adobe. For purposes of this study, cross-bracing is defined as "diagonal or x-shaped reinforcement used to brace the walls." It can be made of either wire, wood, iron or steel.

Table 8 shows the use of various kinds of material for cross-bracing in both the pre- and post-earthquake houses studied. It can be seen that nearly 94 percent of all pre-earthquake houses lacked cross-bracing as compared to 95.1 percent of current structures. In other words, a slight decrease in the use of cross-bracing has been observed since the earthquake. This, however, is probably a result of the increase in houses with wooden walls which require no such cross-bracing feature and also in walls built of concrete block which do not employ this feature.

Again, it will be instructive to look at the adobe houses which employed either tile or lamina for roof material, both before and after the earthquake. Before the earthquake there were 823 such houses upon which information on cross-bracing was available. Of these, 769 (93.4%) had no cross-bracing employed in their construction. After the earthquake there were 83 Structure I's employing similar roof types with adobe walls. Of these, 78 (94%) had no cross-bracing. In other words, there was a slight decrease in the use of cross-bracing in adobe houses. There is a difference, however, between adobe houses with the more traditional tile roofs and those with the more modern lamina or duralita roofs. About 95 percent of the pre-earthquake adobe houses with tile roofs lacked cross-bracing. Of the present structures of this sort, 98 percent lack such a feature. Ninety-two percent of adobe houses with lamina roofs lacked cross-bracing before the earthquake, as compared to 86 percent now. Thus, in the more modernized adobe house with a lamina roof, there was an increase in the use of cross-bracing but in the more traditional adobe house which employed a tile roof there was a decrease in the use of cross-bracing. Again, it appears that those structures most in need of an aseismic feature are those which lack that feature. It will be recalled that this was true in the case of columns and corner posts as well. Again, this difference may be associated with the survival of homes which included the aseismic feature.

Foundations

Table 9 shows the types of foundations found in both pre- and post-earthquake houses. It can be seen that a substantial increase has taken place in the number of houses with no foundation. This means the house is resting directly on the ground without having any prepared foundation upon which to place it. Before the earthquake 197 such houses existed. Now, counting all structures, there are 588 foundationless houses. These are partially accounted for by the large agency program which distributed wood and lamina houses in both the East and the Highlands. These houses were set directly upon the ground and were intended to serve only as short-term housing for earthquake victims, later to be replaced by more permanent structures.

A cross-tabulation between house type and foundation indicates that 280 out of the total of 588 are wood and lamina structures produced by agency programs. Ninety-five of the post-earthquake houses lacking any foundation are of the type called patchwork. These houses are shacks thrown up out of salvaged material by earthquake victims, almost always without use of a foundation. Seventy-nine cases of foundationless houses fall into the category "Other wall types and roof types" which constitutes a catch-all category for various individualistic forms of houses. If houses with adobe and bajareque walls are grouped together, 80 more foundationless houses in the pre-earthquake period are accounted for. The remainder of the foundationless houses are scattered among the various other house types.

Table 9 shows that the greatest increase in a given foundation material for houses occurred in the category "reinforced concrete." Prior to the earthquake only 33 houses (3.1%) employed a reinforced concrete foundation. Taking all structures, 366 (29%) now have such foundations. Two hundred and eighteen of the houses with such foundations have cement block walls and a lamina or duralita roof. One hundred and fourteen more are accounted for by houses with either half cement block or half adobe wall construction and a lamina or duralita roof. In other words, 332 of the houses with reinforced concrete foundations either have block or half block and half adobe walls with lamina or duralita roofs. Most of these "half and half" houses were built in agency housing programs or in accordance with recommendations made by agency housing specialists. It can also be said that the houses employing the more modern or industrialized types of materials are those most likely to employ a reinforced concrete foundation.

Number of Rooms

Another feature upon which all houses can be compared in addition to wall, roof and floor is the number of rooms present in the structure. Table 10 presents a tabulation of the number of rooms for pre- and post-earthquake houses. Before the earthquake 48 percent of all houses had only a single room. Of the 1073 Structure I's built after the earthquake, upon which information on the number of rooms is available, 53 percent have a single room. This should be evaluated against the fact that 188 families have built more than a single structure since the earthquake. Table 10 shows the number of rooms in Structures I and II combined, in addition to the number of rooms in Structure I only. It can be seen that 445 families (41%) live in single-room dwelling units now. When Structures I and II are taken together, the number of rooms available to a given family is substantially increased on an average. These combined figures, however, cannot be compared to the pre-earthquake situation as shown in the same table. The interview asked only the number of rooms for the principal dwelling occupied by the family before the earthquake and did not count any additional structures used to house family members. The proper comparison in Table 10 therefore is between the pre-earthquake house and Structure I which comes close to being the principal dwelling unit now occupied by the family. When this is done it can be seen that there has been a slight increase in the number of single room dwelling units and decreases in units with larger numbers of rooms.

Windows

Many traditional houses in Guatemala entirely lacked windows before the earthquake. Table 11 shows that of all pre-earthquake structures, 38 percent were windowless. It also shows that of those having windows, only 11 percent had glass panes in them. Most windows were covered with wooden shutters. Since the earthquake the number of houses without windows has slightly increased. However, the difference is well within sampling error. Taking Structures I and II together, 40.9 percent of current houses are windowless as compared to 38.3 percent before the earthquake. All in all, Table 11 shows very little change in the patterns associated with having windows in the house. Most are still covered with wooden shutters as they were before the earthquake and few utilize glass window panes. This is despite the fact that large agency housing programs considerably changed the wall and roof patterns of houses they supplied earthquake victims.

Kitchens

Most houses in rural areas did not have kitchens included within the house* before the earthquake. Instead, a separate structure detached from the house was often utilized for this purpose. As can be seen in Table 12, 62 percent of the houses followed this pattern. Post-earthquake houses display a slight increase in the number of houses which have kitchens included inside the structure itself. Again, it is necessary to take into account the existence of 188 cases in which families occupied two houses. In such cases it is likely that only a single kitchen was employed to serve both structures. It is not reasonable to add together the number of Structures I and II which had or did not have kitchens, to arrive at an estimate of the proportion of families with houses including

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*A kitchen is defined here as a place to cook. Formal kitchens (a room set apart) in the house are not common in rural areas, but cooking often is done on the floor on a hearth of three rocks.

kitchens inside the structure, and then to compare them to the pre-earthquake situation. Nevertheless it is instructive to note that 62.7 percent of all structures lacked a kitchen inside the house, meaning that 36.3 percent contained internal kitchens. This is approximately the same proportion of structures with internal kitchens that existed prior to the earthquake. There has not been a significant change in the cultural practice of carrying on cooking activities outside of the principal dwelling unit.

Porches

Another common feature of pre-earthquake houses which was widely established in the culture of rural Guatemala was that of having a porch or corredor attached to the dwelling unit. This area was used as supplementary storage and sleeping space and frequently employed as a kitchen area. Almost 66 percent of all pre-earthquake houses had porches. Table 13 shows considerable reduction in the number of houses having this feature has taken place. Taking Structures I and II together, 35 percent now have porches as a housing feature. This reduction in the number of porches on houses considerably lessens the usable living area available to families and marks a change in house form. The housing programs of various agencies operating in the communities being studied which furnished whole houses to earthquake victims, generally did not include a porch as a housing feature.

Summary of Change in Housing Features

The largest changes to have occurred in housing form and patterns since the earthquake have been those involving a shift in the materials used in house construction. Adobe as a wall material has been replaced by wood and concrete block, while tile as a roofing material has been replaced by lamina and duralita. The number of rooms in houses has slightly increased by virtue of families having multiple structures available to them. However, the number of houses with five or more rooms has decreased.

There have been slight improvements in the use of earthquake resistant features in post-earthquake houses requiring these features. For example, the number of houses using columns or corner posts has increased. It has been noted, however, that this increase in both the use of corner posts and cross-bracing has not affected the adobe houses with tile roofs as much as it has more modern structures. The practice of having a kitchen outside the house and of having few windows has remained relatively stable, while that of attaching porches to the structure to expand the living space has decreased.

Many of the changes in housing practices can be summarized by saying that house construction has changed in the direction of dependency on industrial materials and industrial construction methods,as opposed to indigenous materials and indigenous methods. Table 14 shows the number of pre- and post-earthquake houses that employed indigenous materials in both the roof and walls as compared to those which utilized strictly industrial materials for these two features. Included also are those who mixed indigenous and industrial materials. Indigenous materials are defined as such things as straw, cane, palm, adobe, bajareque, tapia and tile. Industrial materials include milled lumber, lamina and duralita, reinforcing steel, concrete block and prefabricated concrete posts, etc.

Table 14 shows that before the earthquake 47.5 percent of all structures employed strictly indigenous materials in their walls and roofs. In contrast, 8.8 percent of the current structures employ such materials. On the other hand, the use of industrial materials has increased from 10 percent to 62 percent. This demonstrates better than anything else the movement of housing technology away from the indigenous pattern of employing locally available materials easily obtained by family members or local builders without dependence on external sources of supply.

The use of concrete and lamina, of reinforcing steel and of sawed lumber in house construction means that families in the villages and towns of Guatemala must depend more heavily now on a cash economy and on a source of supply outside the village for house building materials. Industrially manufactured materials are more expensive than indigenous materials produced in the local community.

It should be realized, however, that the increase in earthquake resistant qualities of housing noted above is due in large part to the substitution of these industrially manufactured building materials for more fragile or heavier traditional materials.

Damage to Housing Features

The damage reported by respondents to the walls and roofs of the houses will be examined below, first separately and then together by house type. Later these damage estimates will be employed as a basis for evaluating whether improvements have occurred in the earthquake resistant features of current houses.

Table 15 shows the damage reported by respondents to the walls of their houses classified by the type of wall material used. Respondents were asked to rate the damage to their walls on a 4 point scale from "none" to "destroyed." When possible, from existing physical evidence, the interviewer checked the damage estimate by visual inspection. For the most part, however, the damage estimates which follow are based on respondent's perception of damage.
Table 15 which shows the average damage to walls, ranks adobe highest on the damage scale. Sixty-one percent of the walls of pre-earthquake adobe houses were destroyed in the earthquake. The average damage estimate is 2.4 which is about half-way between "much or heavy damage" and "destroyed." This should be compared with walls made of concrete block where almost 53 percent reported "no damage." In the case of block, the average damage reported was 0.8; between "none" and "slight." Bajareque and half-adobe structures, although

few in number, experienced relatively high damage in the earthquake, averaging 1.8 on the damage scale.

Since adobe was the primary wall material used in most pre-earthquake structures, it far overweighs any other type of wall in the total damage estimate. Taking all houses together, the total average damage estimate is 2.2; in other words, slightly more than the "heavy" or "much" damage category. It should also be noted from Table 15 that light weight materials, such as wood and cane or palm, suffered relatively light damage in the earthquake.

Table 16 shows similar damage estimates and scores for various roof types. Here the most striking fact is that tile roofs have the highest average damage estimate of 2.2. Not surprisingly, of the common type with sufficient numbers to evaluate damage, thatch and palm have a relatively low damage estimate. Lamina, however, ranks surprisingly high, with a damage estimate of 1.8. Before the meaning of these damage estimates for both wall and roof taken separately can be thoroughly evaluated, it is necessary to cross-classify walls and roofs and to examine the damage which occurred to various house types.

Table 17 shows the average damage suffered by each house type and the standard deviation for damage to that category. The averages in this table give the mean damage to roof and walls of the house type. The score of 2.30 for a house with adobe walls and a tile roof therefore means that the damage to such houses was between "heavy" and "destroyed."

It is apparent that the greatest damage occurred to houses with adobe walls regardless of the type of roof. The lowest damage was found, not surprisingly, in the case of cane and thatch houses, but those of cement block and lamina or of wood and lamina also show relatively low damage. In all of these cases the average damage was between "none" and "slight." This is an important fact since agency housing programs concentrated on building two types of houses, wood and lamina or cement block and lamina or duralita.

Since most houses had adobe walls before the earthquake, the damage to these houses heavily weights the total damage estimate shown in Table 17. All houses together averaged 2.08 on the damage scale, or slightly higher than "heavy damage." In general, the houses employing indigenous materials for walls, with the exception of those using cane or palm, suffered heavier damage than those using industrial materials. Adobe, bajareque and cane, when combined with lamina, suffered damage between 1.37 and 2.31 on the damage scale, while houses of wood or block were in the range of 0.60 to 0.91.

Table 18 shows the damage to tile and to lamina when combined with adobe or with other wall materials. These data demonstrate that when either tile or lamina were combined with adobe they suffered greater damage. For example, when lamina is used with an adobe wall, 31.8 percent report that a lamina roof was destroyed. This compares to 18 percent which report a lamina roof was destroyed when combined with any other wall type.

Table 19 presents the average amount of damage to each combination of wall and roof. It shows that the average damage to the lamina roof, when combined with non-adobe walls, is .79, but when combined with adobe is 1.07. In short, the high damage figure for lamina, shown in Table 16, is accounted for by the fact that most lamina roofs were on adobe structures. When combined with such structures they have little chance of surviving since the walls are apt to collapse and bring the roof down. Both Table 18 and Table 19 show that tile is much more likely to be destroyed or to suffer heavy damage than lamina. However, it, too, suffers heavier damage when combined with an adobe wall. The average damage for tile is 2.13 as opposed to 1.03 for lamina. Tile rates slightly higher than "heavy" on the damage scale, while lamina roofs on an average suffered "slight" damage. Figures are not presently available on fatalities suffered