BIBLIOGRAPHIC DATA SHEET	1. CONTROL NUMBER PN-AAJ-798	2. SUBJECT CLASSIFICATION (695) LD00-0000-G320

3. TITLE AND SUBTITLE (240)
Improvement of rural housing in the Dominican Republic to withstand hurricanes and earthquakes

4. PERSONAL AUTHORS (100)
Cuny, Frederick; Thompson, Paul

5. CORPORATE AUTHORS (101)
INTERTECT

6. DOCUMENT DATE (110)	7. NUMBER OF PAGES (120)	8. ARC NUMBER (170)
1981	105p.	DR363.5.C973

9. REFERENCE ORGANIZATION (130)
INTERTECT

10. SUPPLEMENTARY NOTES (500)

11. ABSTRACT (950)

12. DESCRIPTORS (920)

Dominican Rep.	Construction materials
Housing	Construction
Rural development	Disaster assistance
Improvements	Wind resistance
Hurricanes	Design
Earthquakes	Low-income housing
Earthquake resistance	

13. PROJECT NUMBER (150)

14. CONTRACT NO.(140) DS/H

15. CONTRACT TYPE (140)

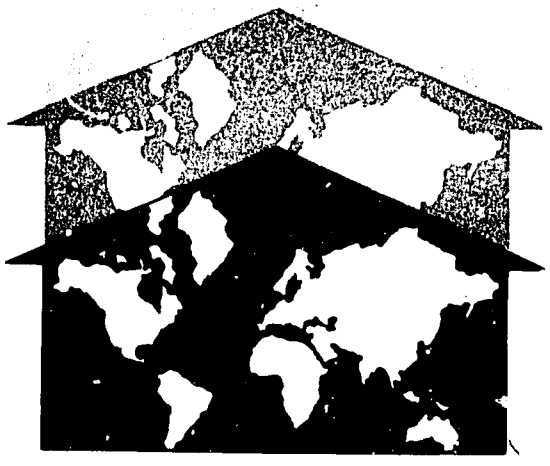
16. TYPE OF DOCUMENT (160)

AID 590-7 (10-79)

PN-AAJ-798

IMPROVEMENT OF RURAL HOUSING IN THE DOMINICAN REPUBLIC TO WITHSTAND HURRICANES AND EARTHQUAKES

Spring 1981



AGENCY
FOR
INTERNATIONAL
DEVELOPMENT

OFFICE OF HOUSING

IMPROVEMENT OF RURAL HOUSING IN THE DOMINICAN REPUBLIC TO WITHSTAND HURRICANES AND EARTHQUAKES

April 1981

Office of Housing,
Agency for International Development
Washington, D.C. 20523

UNITED STATES INTERNATIONAL DEVELOPMENT COOPERATION AGENCY
AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON D C 20523

FOREWORD

This study and recommendations were prepared for the Office of Housing of the Agency for International Development by INTERTECT, International Disaster Specialists, Dallas, Texas. The purpose of this study was to determine design changes for and improvements in the construction process of rural housing in the Dominican Republic that would make this shelter more wind and earthquake resistant, yet affordable and acceptable to the rural poor. The need for such improvements is clearly indicated by the history of hurricanes and earthquakes and the severe damage they have caused in the Dominican Republic.

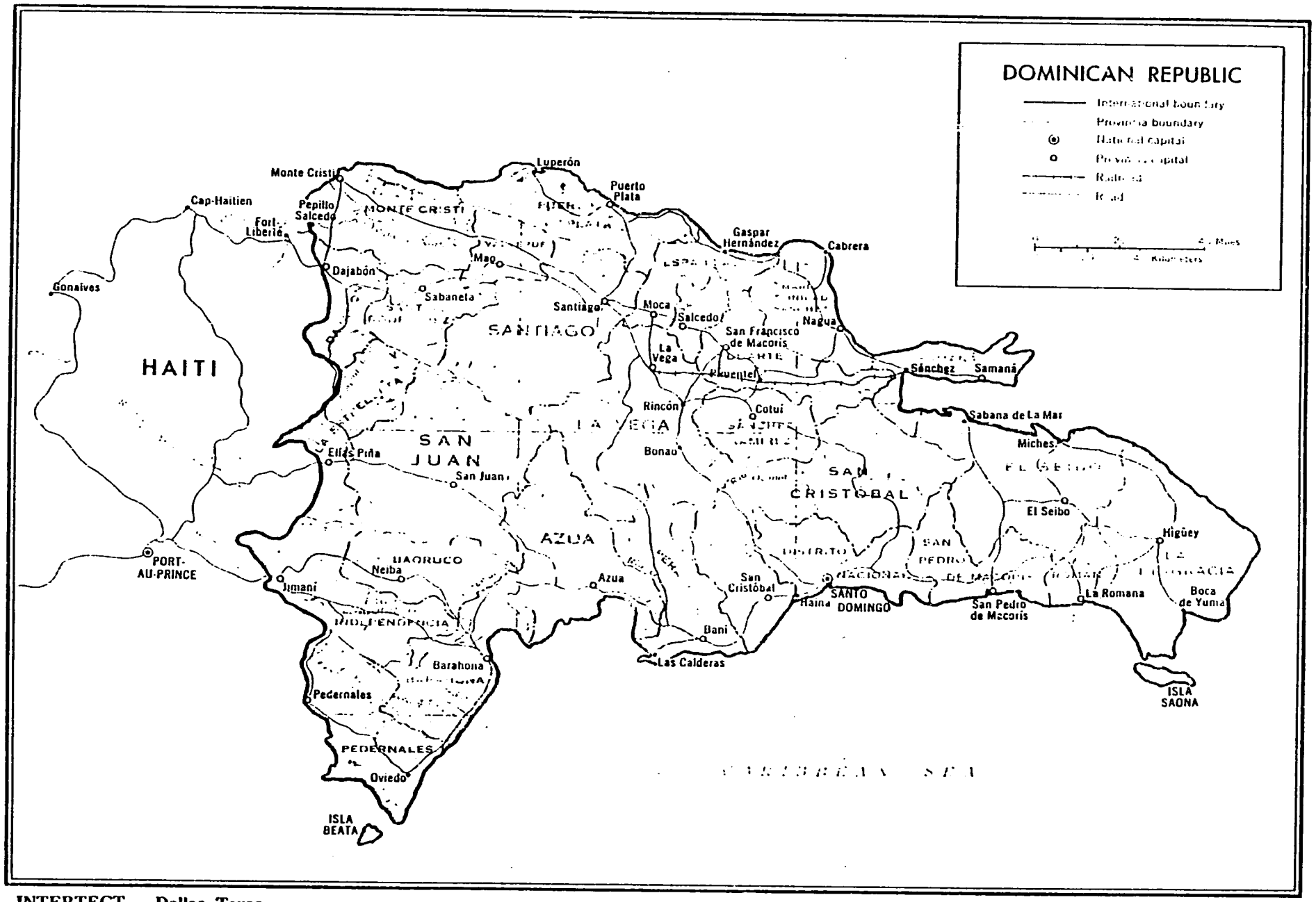
The study also contains recommendations for a comprehensive program for housing improvement, including a public awareness project.

Frederick Cuny of INTERTECT led the study team. Field work was completed by Paul Thompson in April, 1981 in the Dominican Republic.

While the study has been discussed with representatives of the Government of the Dominican Republic, it is not to be considered as the official position of either the Government or of the Agency for International Development. It is hoped, however, that the report will be useful in the development of future shelter programs in the Dominican Republic.

Peter Kimm

Director
Office of Housing



INTERTECT Dallas, Texas

TABLE OF CONTENTS

		Page
I.	INTRODUCTION	1
	Objectives	1
	Background	1
	Definition of Terms	2
II.	RISK AND VULNERABILITY IN THE DOMINICAN REPUBLIC	3
	Basic Building Types	3
	Determinants of Vulnerability	5
	Hurricane Risk and Vulnerability	6
	Earthquake Risk and Vulnerability	11
III.	TRENDS IN HOUSING	16
	Areas of New Housing Construction	16
	Material Considerations	16
	Impact of the 1979 Hurricane Reconstruction Programs	17
IV.	THE TRADITIONAL BUILDING PROCESS IN THE RURAL AREAS	19
	The Role of the Albañil and Carpintero	19
	Financing	20
	Perceived Value of Various Building Materials	20
	Material Costs	21
V.	COMMON HOUSING TYPES AND THEIR VULNERABILITY	23
	Problems Common to All Building Types	23
	Siting	32
	Vulnerability Analysis of the Basic Housing Types	36
	A. Yagua House	37
	B. Tejamaní House	39
	C. Wood Frame House with Palm Board Siding	41
	D. Concreto Armado House	44
	E. Wood Frame Housing with Sawn-Board Siding	47
	F. Concrete Block Housing	50
	Vulnerability Analysis of Houses Built of Mixed Materials	53
	A. Wood Frame House with Concrete Block Facade	54
	B. Block and Wood Frame Wall Construction	57
	Analysis of Local Building Skills	59
VI.	ANALYSIS OF THE POTENTIAL FOR HOUSING MODIFICATION	68
	General Considerations	68
	Economic Considerations	69
	Material Considerations	71
	Parameters of Technology Transfer	74

Page

VII. RECOMMENDATIONS FOR A COMPREHENSIVE PROGRAM FOR HOUSING IMPROVEMENT 78

Objectives 78
Goals 78
Methodology 79
Target Groups 80
Implementation and Cost Reduction Strategies 81
Work Plan 83
Duration of the Program 84
Recommendations for the Involvement of Specific Groups 84

APPENDICES:

I. Recommended Training Aids for a Housing Improvement Program 88

II. Proposed Curriculum for Instructors 92

III. Proposed Curriculum for Home Builders 94

IV. Commercially Available Hurricane Fasteners 96

V. Suggested References 97

VI. Disaster Mitigation Information Resource Organizations 100

FIGURES:

1. Recent Hurricanes in the Dominican Republic 7
2. Hurricane Risk Areas in the Dominican Republic 8
3. Housing Vulnerable to Hurricanes in the Dominican Republic 9
4. Priority Areas for Strengthening Housing to Resist Hurricanes 10
5. Tectonic Map of the Dominican Republic 12
6. Seismic Risk Areas in the Dominican Republic 13
7. Housing Vulnerable to Earthquakes in the Dominican Republic 14
8. Priority Areas for Strengthening Housing to Resist Earthquakes 15

TABLES:

1. Relative Value of Housing Improvements 70
2. Material Considerations 73

IMPROVEMENT OF RURAL HOUSING IN THE DOMINICAN REPUBLIC TO WITHSTAND HURRICANES AND EARTHQUAKES

I. INTRODUCTION

OBJECTIVES

The objectives of this report are:

A. To identify and analyze the basic, traditional shelter types found in the rural areas of the Dominican Republic and the construction techniques used;

B. To determine design changes, improvements in the construction process, and improvements in the use of local building materials which can make the shelter more wind and earthquake resistant, yet remain affordable to the rural poor;

C. To make recommendations for a program to disseminate information on safer construction.

BACKGROUND

Any improvement of traditional housing to make houses more resistant to hurricanes or earthquakes should be viewed as part of a comprehensive response to the overall housing problem in the Dominican Republic. The need and urgency for such improvements is made clear by the country's long history of hurricanes and earthquakes.

A recent report entitled "Dominican Republic, Shelter Sector Assessment"* details the existing housing shortage, points to the high number of substandard housing units, and correlates this shortage with a national economy that has considerable difficulty in resolving those problems. With a high level of unemployment and underemployment, and a slow rate of economic growth, there is little hope of eliminating these housing problems without economic assistance to the individual family. In addition, the rapidly inflating cost of construction puts the cost of simply replacing existing housing out of reach for the majority of citizens.

Housing problems are exacerbated by the periodic natural disasters which deplete large numbers of housing units and put further pressures on the limited resources available to the housing sector.

---

*Prepared for the Office of Housing, U.S.A.I.D., by PADCO International, 1980.

These conditions combine to provide a virtual imperative to systematically improve the existing housing stock to resist further natural disasters. A house that withstands a disaster represents not only a safe refuge for the family; it also eliminates the tremendous discontinuity and economic burden resulting from damage to the buildings, and represents a savings of building materials and scarce financial resources at the national level (and to potential relief agencies). Furthermore, adopting many of the improvements proposed in this report will prolong the life of the housing even without the occurrence of a natural disaster.

DEFINITION OF TERMS

Following are definitions of terms used in this report:

Housing Education Program - (HEP): This term is used to denote a program offering vocational training to homeowners or builders in how to build a safer or more disaster resistant house.

Design Changes: This term refers to the process of altering the design of a structure before it is built to make it more disaster resistant.

Retrofitting: This term refers to the process of installing additional supports or altering components of a building already erected in order to make it more disaster resistant.

Housing Modification: This term refers to changing the configuration of a house after it has been built to make it more resistant. Modification could include changing the pitch of the roof, adding an additional room, etc.

Risk: Risk is the relative degree of probability that a hazardous event will occur. An active fault zone, for example, would be an area of high risk.

Vulnerability: Vulnerability is a condition wherein human settlements or buildings are exposed to a disaster by virtue of their construction or proximity to hazardous terrain. Buildings are considered vulnerable if they cannot withstand the forces of high winds or earthquakes. Communities in unprotected, low-lying coastal areas exposed to hurricanes, or in seismic areas where a large proportion of the structures cannot withstand the effects of an earthquake, are considered "vulnerable communities".

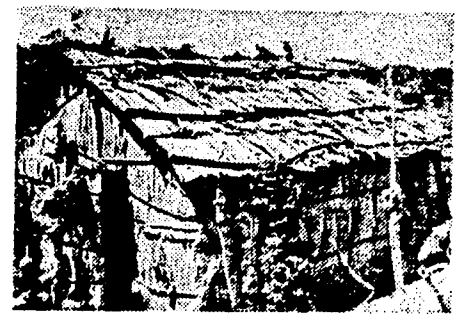
Disaster Resistant Construction: The term "disaster resistant" is used to denote the degree to which a structure can be made more resistant (or safe) to certain natural phenomena. The term recognizes that no building can be considered totally safe, but that certain steps can be taken to improve performance or survivability.

II. RISK AND VULNERABILITY IN THE DOMINICAN REPUBLIC

BASIC BUILDING TYPES

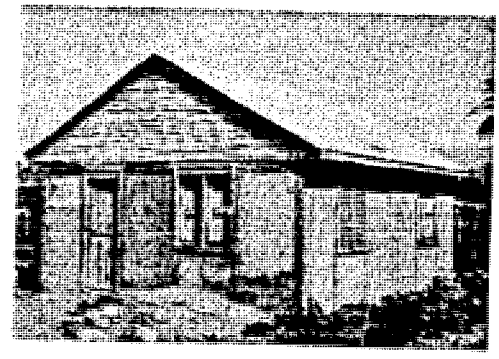
There are five basic traditional building styles found in the rural areas of the Dominican Republic. These are:

A. Yagua: Yagua houses are built of flattened stems of palm leaves. The stems are fastened to a lightweight wood frame.

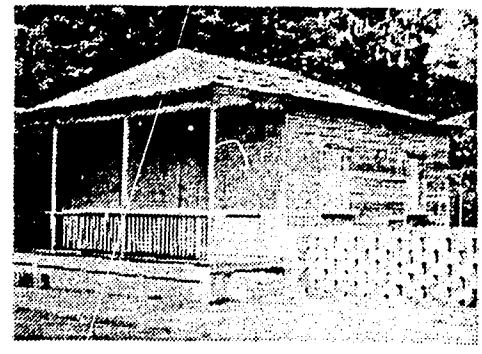


B. Tejamaní (Wattle-and-Daub): Tejamaní houses are made of a wood pole frame with cane woven between the vertical posts. Some are covered with mud to seal the walls.

C. Concreto Armado (Poured-in-Place Concrete): These houses are made by pouring thin walls of concrete between a wooden frame.



D. Casa de Madera (Wood Frame House): Wood frame houses use both pine boards and palm wood siding.



E. Casa de Bloque (Concrete Block): These houses are built of concrete block masonry.

Most of these housing types are found throughout the country, although concreto armado houses are usually found mainly in the southwest, yagua houses in the northeast, and tejamaní throughout the west. Generally speaking, the tejamaní and yagua construction represent the housing used by the lowest income groups, while concrete block is the material favored by those with considerably more income (although it is not completely out of reach for low-income families).

The most favored roofing material is corrugated iron sheeting (laminated with and known locally as zinc) and, for some block houses, reinforced concrete slab roofs. In some areas, grass or palm leaf roofs are still found, although this type of roofing material is rapidly being replaced by the corrugated iron sheets. In a few areas, corrugated asbestos cement sheets are also found, but these are used primarily in urban areas.

There are only slight variations of floor plan or style, these occurring due to the availability of materials and cost of construction.

DETERMINANTS OF VULNERABILITY

The extent to which a house is vulnerable to a disaster is a function of four factors: the design and configuration of the house, the quality of the workmanship, the strength of the materials, and the relative safety of the site. In general, buildings made of lightweight materials are more susceptible to damage from high winds, while buildings made of earth, block or similar materials are more susceptible to damage from earthquakes. Thus, the houses most vulnerable to hurricanes are those of yagua, the lightweight wood frame homes, and those of tejamaní construction. Houses made of unreinforced or poorly constructed concrete block and poured-in-place concrete are also vulnerable.

Roof configuration and construction are very similar for all types of housing. In most cases, the roof is not properly anchored and braced and is potentially the weakest part of all rural houses.

In areas of seismic activity, the most vulnerable houses are the unreinforced or poorly constructed concrete block house and the concreto armado buildings. Theoretically, these types of housing should be fairly easy to reinforce to a basic standard of earthquake resistance, and most block houses do use adequate iron reinforcement. However, the quality of masonry workmanship and detailing is very poor, thus these buildings are particularly vulnerable.

Poor siting conditions account for perhaps the greatest number of houses vulnerable to disasters. There are many houses along the country's north and south coasts that are exposed to severe damage from hurricanes. The extensive damage caused by Hurricane David to the coast of Peravia and San Cristóbal are proof of the problem.

The other area of considerable concern is the houses sited on hillsides in earthquake risk areas. In particular, the mountainous areas of La Vega contain large zones of unstable soils and a high number of houses that do not sit on flat, safe sites. In an earthquake it is probable that land slippage would cause many houses to collapse. Those houses set on posts of varying lengths are especially vulnerable.

Again, it is important to remember that "risk" means the chance that some type of event like a hurricane could strike an area; "vulnerability" refers to the possibility of a building or settlement being damaged by that event. Thus, if a strong building is sited in a high risk area, it may not be vulnerable.

HURRICANE RISK AND VULNERABILITY

The Dominican Republic is located in one of the most active high wind regions. Within the last century, 12 major hurricanes and numerous tropical storms have struck the country. The casualties and widespread damage in each hurricane have underscored the vulnerability of the population and shown that the housing stock of the vast majority of the population cannot withstand the forces of high winds. Almost 80% of the people in the Dominican Republic live in non-engineered structures. Even within the larger cities such as Santo Domingo, Santiago, San Cristóbal, etc., engineering and architectural input into housing construction is minimal.

Hurricanes threaten housing in four ways:

- -- Damage or collapse resulting from the forces of high winds;
- -- Inundation from storm surges (popularly known as tidal waves) affecting low-lying coastal areas;
- -- Inundation from flooding caused by the high rainfall accompanying the storm; and
- -- Damage resulting from landslides, mudslides, or other displacements caused by supersaturation of soils by high rainfall.

All of these threats exist in the Dominican Republic and no area is without at least one of these hazards.

Figure 1 depicts the tracks of hurricanes which have struck the Dominican Republic in the last century. Figure 2 shows those areas that are susceptible to various hurricane threats. Damage caused by storm surges, flooding or landslides is primarily a siting problem and thus is beyond the scope of this report.

Figure 3 shows the areas where large concentrations of housing vulnerable to high winds are located. By comparing Figure 3 to the zones identified in Figure 2 as at risk from high winds, the areas where modifications to housing designs and retrofitting measures should be taken can be established.

By examining demographic distribution and density, as well as areas of population growth, the priority areas for establishing a Housing Improvement Program to increase wind resistance can be identified. These are shown in Figure 4.

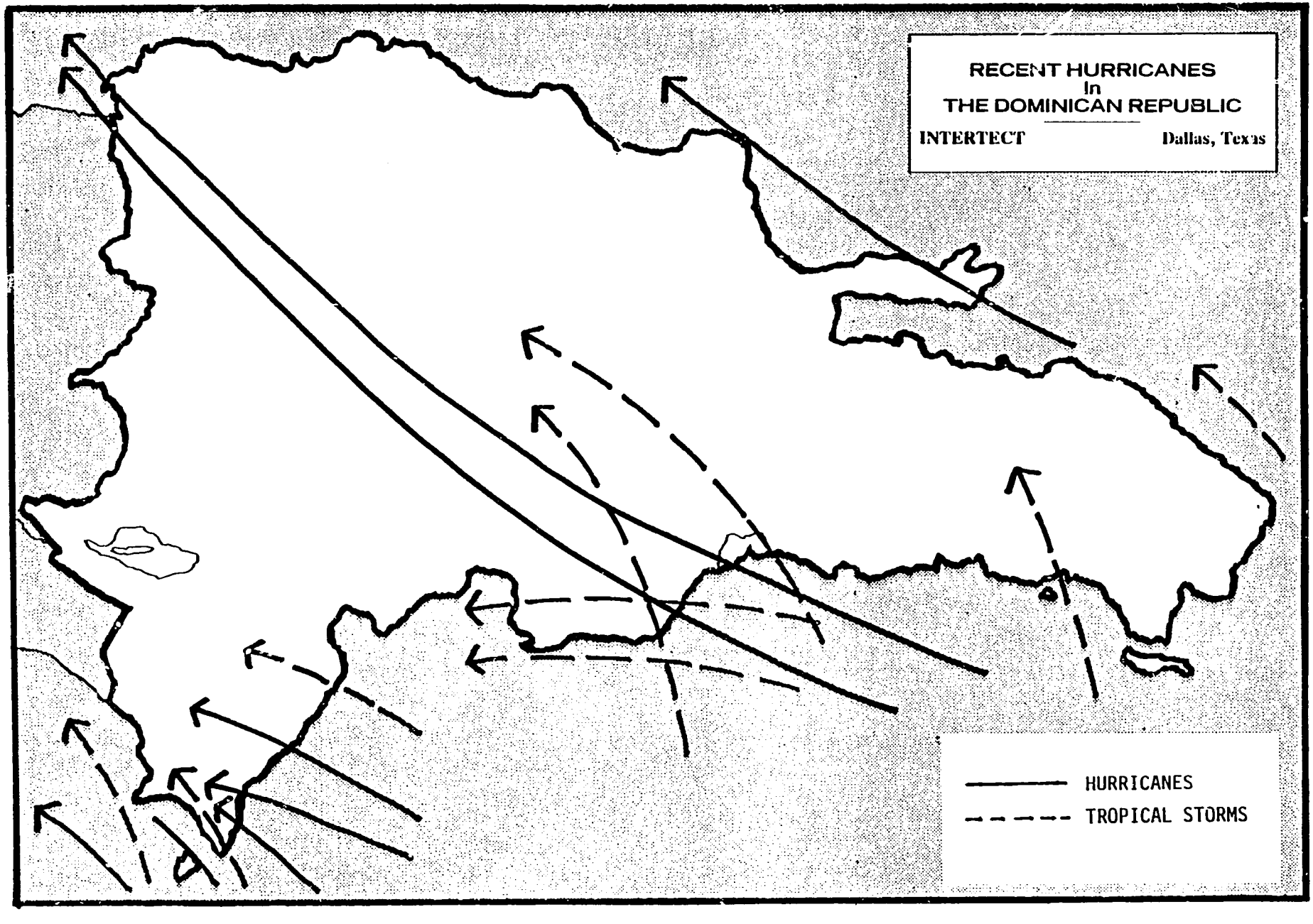

RECENT HURRICANES
In
THE DOMINICAN REPUBLIC
INTERTECT
Dallas, Texas
HURRICANES
TROPICAL STORMS

Figure 1

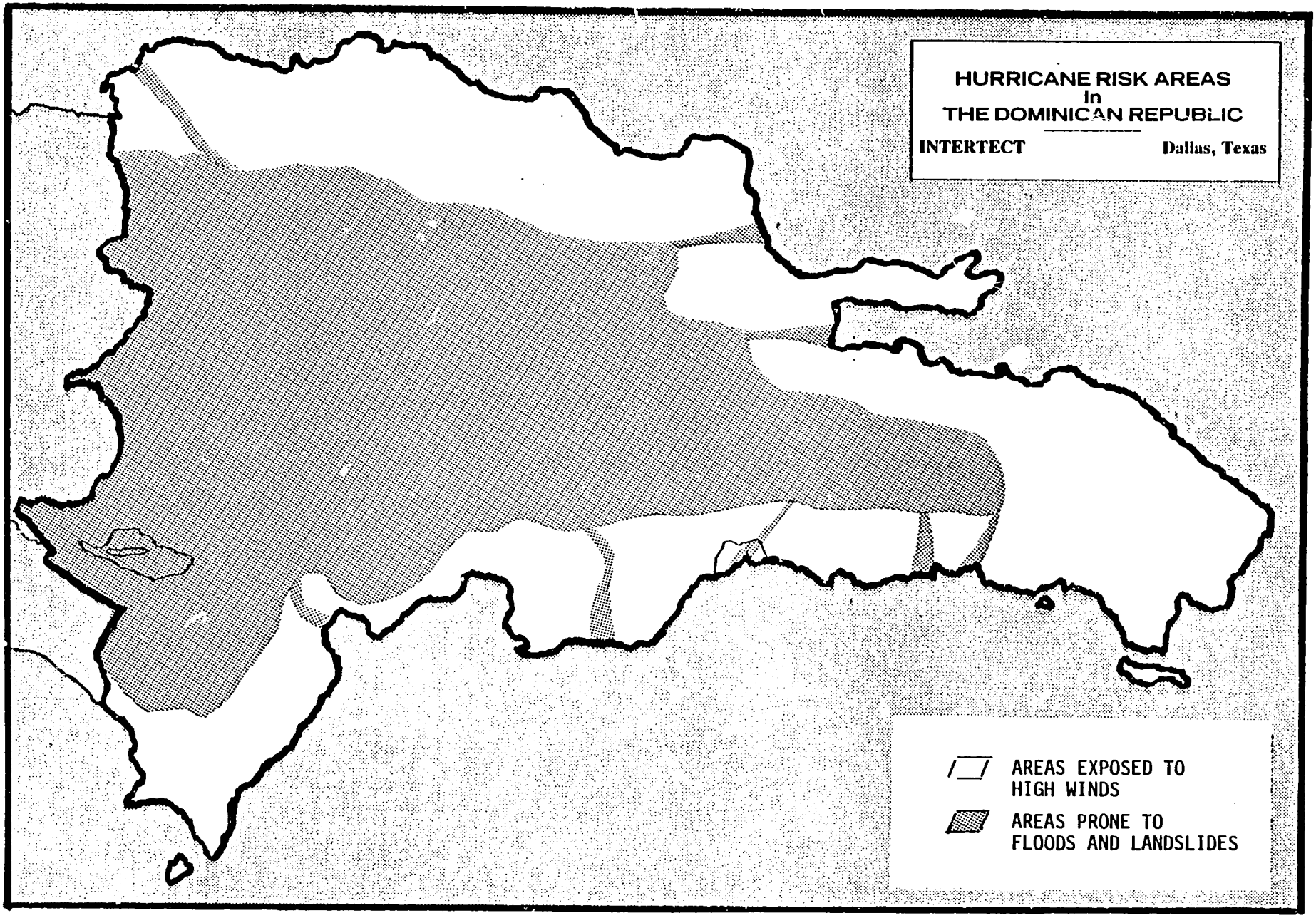

HURRICANE RISK AREAS
In
THE DOMINICAN REPUBLIC
INTERTECT
Dallas, Texas
AREAS EXPOSED TO
HIGH WINDS
AREAS PRONE TO
FLOODS AND LANDSLIDES

Figure 2

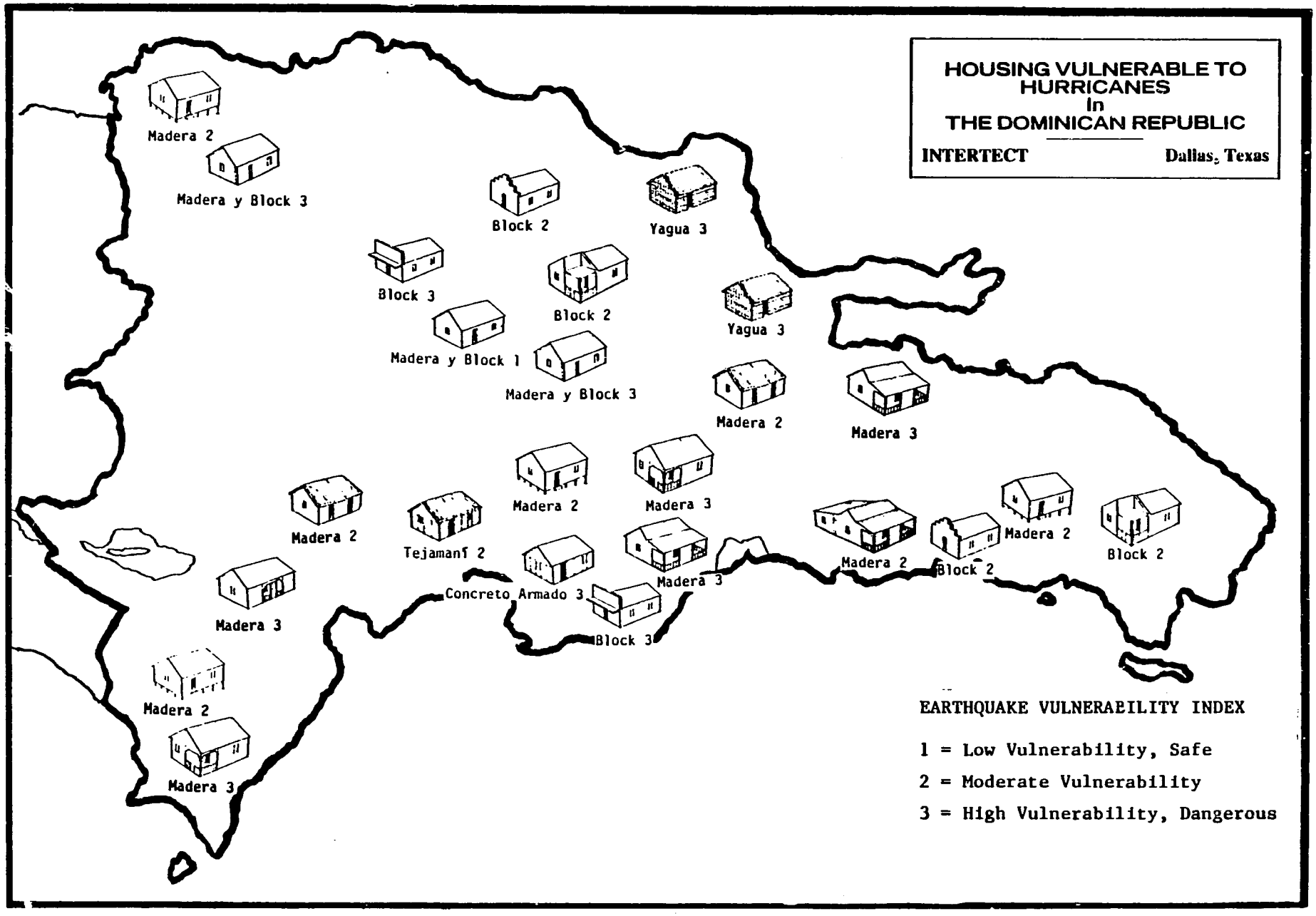

HOUSING VULNERABLE TO HURRICANES
In
THE DOMINICAN REPUBLIC
INTERTECT
Dallas, Texas
Madera 2
Madera y Block 3
Block 2
Yagua 3
Block 3
Block 2
Yagua 3
Madera y Block 1
Madera y Block 3
Madera 2
Madera 3
Madera 2
Madera 3
Madera 2
Tejamanil 2
Madera 2
Block 2
Madera 2
Block 2
Madera 3
Concreto Armado 3
Madera 3
Madera 3
Block 3
Madera 2
Madera 3
EARTHQUAKE VULNERABILITY INDEX
1 = Low Vulnerability, Safe
2 = Moderate Vulnerability
3 = High Vulnerability, Dangerous

Figure 3

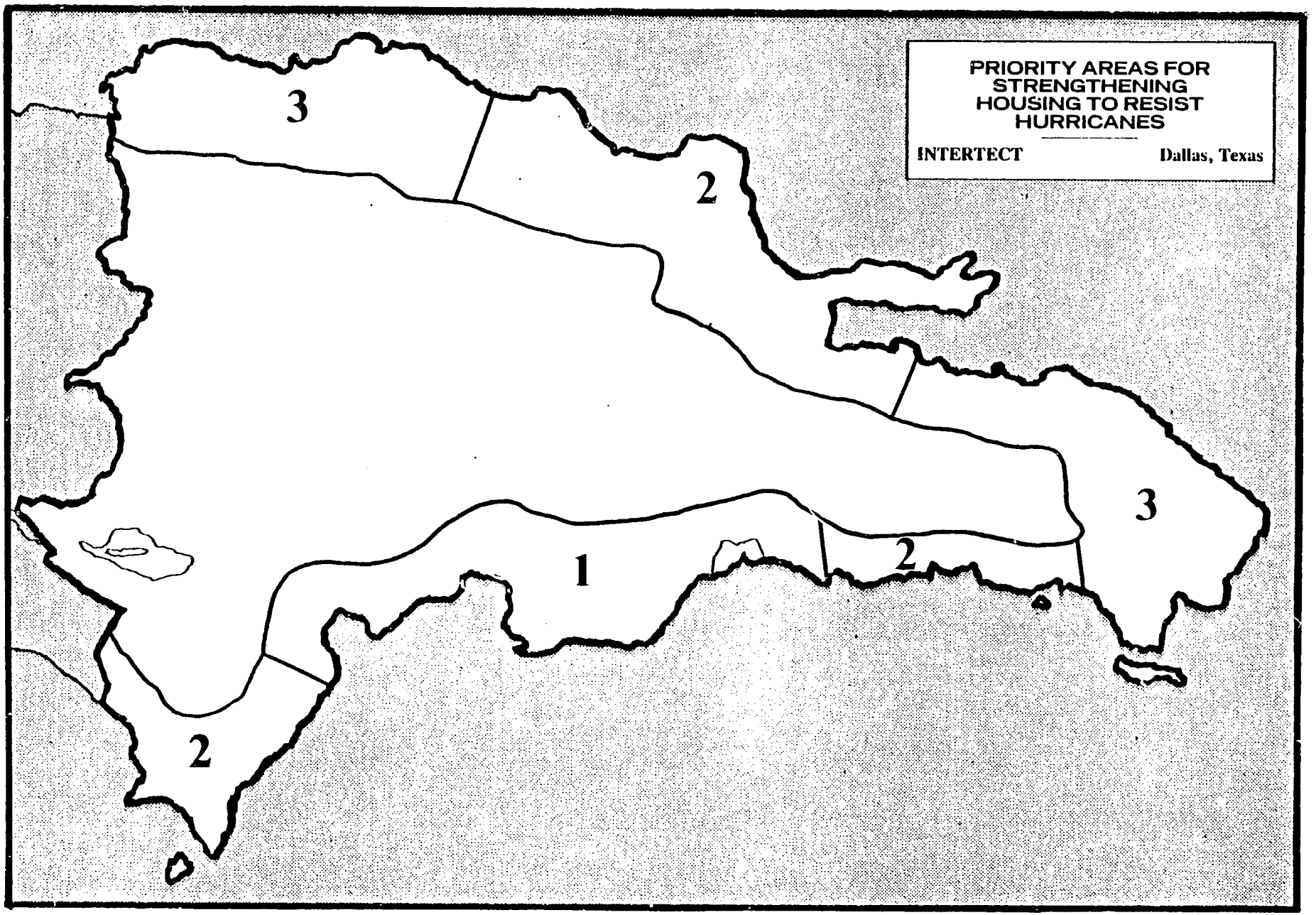

PRIORITY AREAS FOR
STRENGTHENING
HOUSING TO RESIST
HURRICANES
INTERTECT
Dallas, Texas
3
2
1
2
3
2

Figure 4

EARTHQUAKE RISK AND VULNERABILITY

The Dominican Republic is situated on the northern edge of the Caribbean Plate, close to where it abuts the North American Plate (see Figure 5). It is the relative movement along this jointure or fault that causes the earthquakes which periodically affect the country.

While earthquakes can occur anywhere along the fault, as a general (although not absolute) principle the earthquakes will be stronger the closer they occur to a fault. This means that the northern coastal region and central portions of the country will experience more ground motion than other parts of the country. However, major fault systems exist throughout the Dominican Republic and any earthquake that occurs in the northern regions can trigger movement along a parallel fault farther inland.

Earthquakes threaten housing in three ways:

- -- Forces generated by ground shaking;
- -- Liquifaction of the soils, which is a condition where loosely-packed soils separate and behave similar to water, thus allowing buildings on the surface to partially sink or settle, damaging the structure in the process; and
- -- Secondary effects such as landslides or tsunamis (seismic-generated sea waves).

Damage from liquifaction and secondary effects is more related to siting than construction and thus is beyond the scope of this report.

Large portions of the non-engineered housing in the country are found in seismic areas and actions can be taken to strengthen this housing.

By locating the major fault systems and examining the history of earthquakes throughout the country, it is possible to identify the relative potential for recurrence of seismic activity. This information is represented in Figure 6.

By comparing Figure 6 to Figure 7 (which shows the housing types that are vulnerable to an earthquake), the communities which are most vulnerable can be identified.

By comparing these to demographic distribution, density, and growth, the priority areas for housing improvement programs can be identified. These are shown in Figure 8.

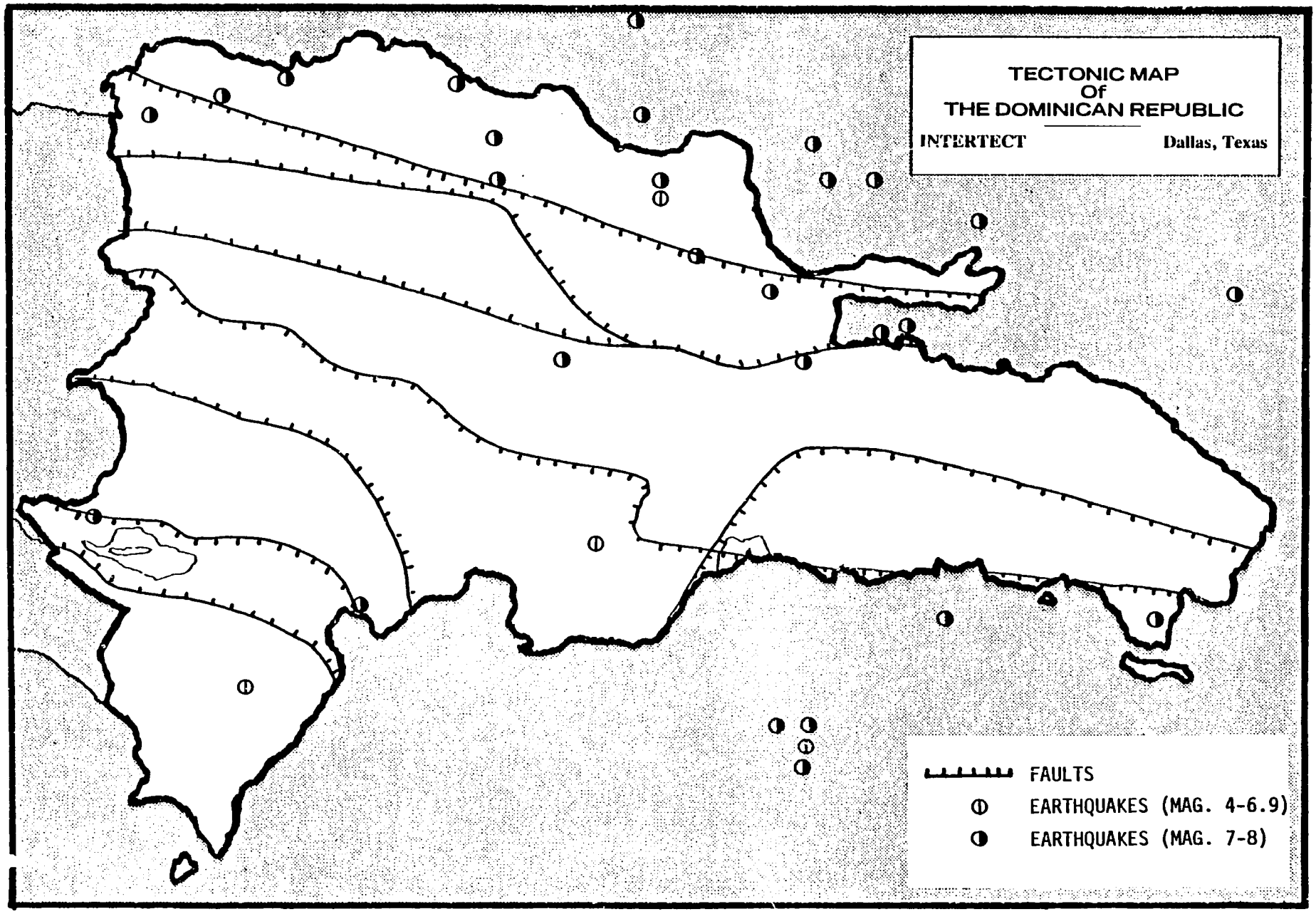

TECTONIC MAP
Of
THE DOMINICAN REPUBLIC
INTERTECT
Dallas, Texas
FAULTS
EARTHQUAKES (MAG. 4-6.9)
EARTHQUAKES (MAG. 7-8)

Figure 5

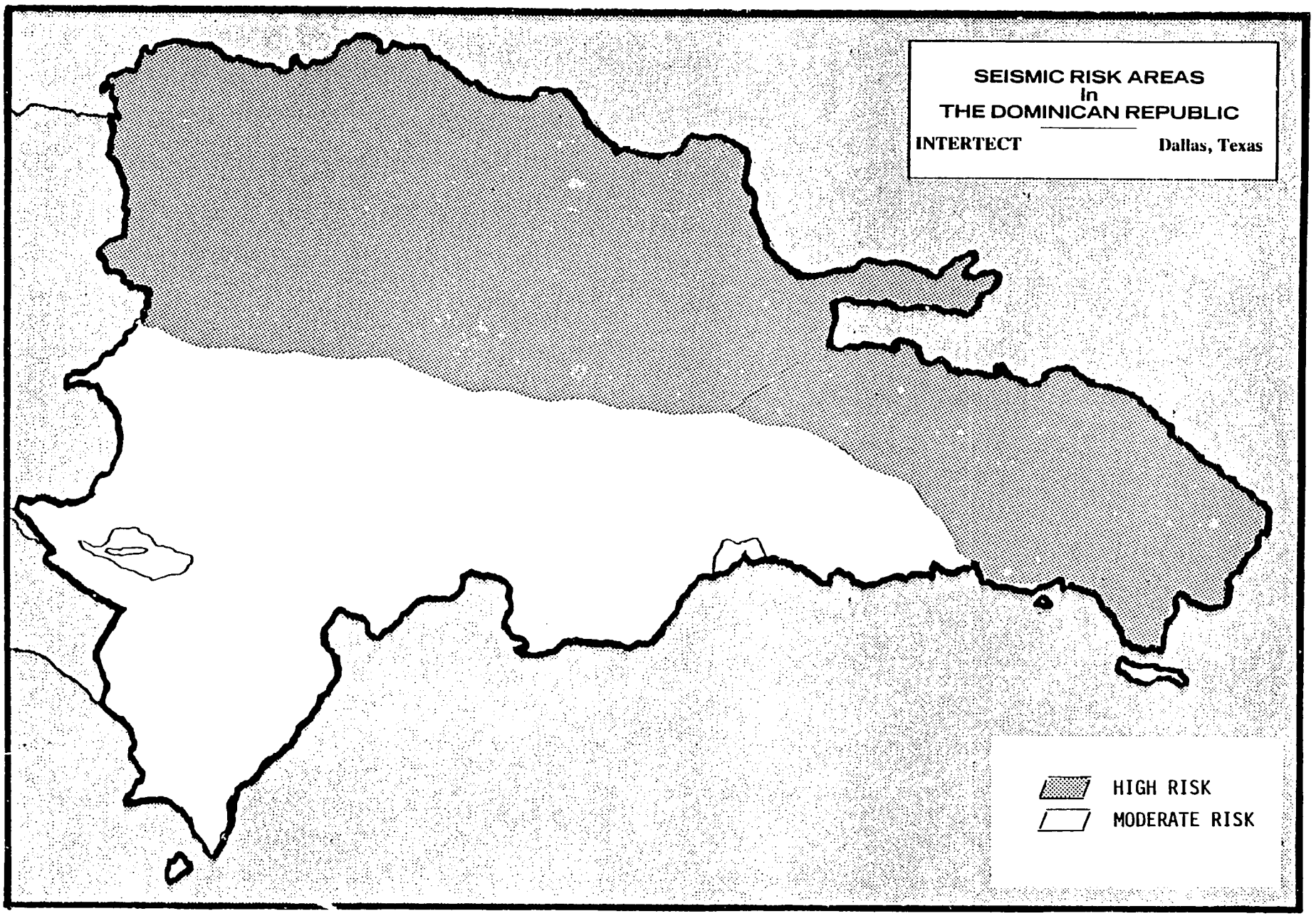

SEISMIC RISK AREAS
In
THE DOMINICAN REPUBLIC
INTERTECT
Dallas, Texas
HIGH RISK
MODERATE RISK

Figure 6

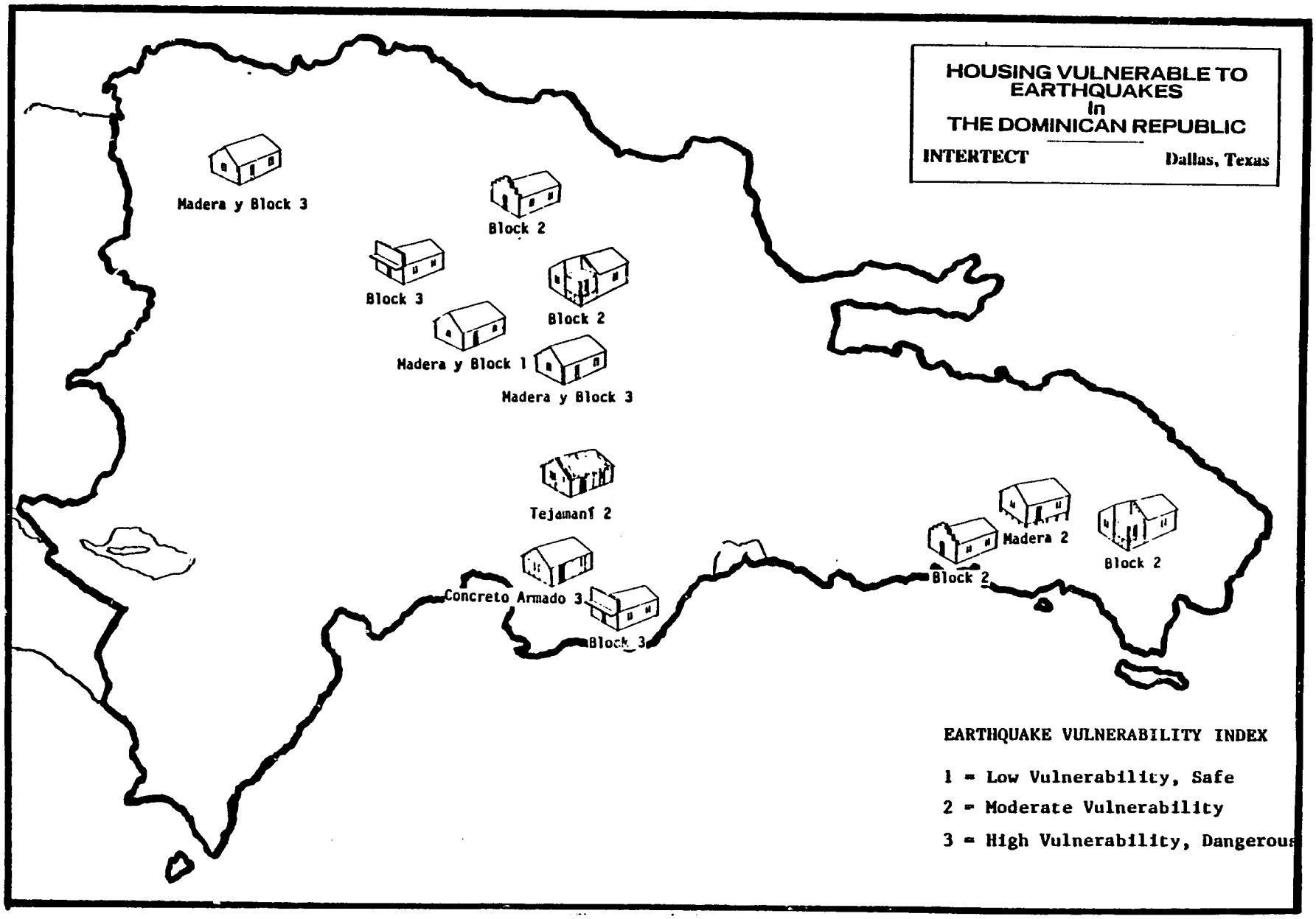

HOUSING VULNERABLE TO EARTHQUAKES In THE DOMINICAN REPUBLIC
INTERTECT
Dallas, Texas
Madera y Block 3
Block 2
Block 3
Block 2
Madera y Block 1
Madera y Block 3
Tejamanf 2
Concreto Armado 3
Block 3
Madera 2
Block 2
Block 2
EARTHQUAKE VULNERABILITY INDEX
1 = Low Vulnerability, Safe
2 = Moderate Vulnerability
3 = High Vulnerability, Dangerous

Figure 7

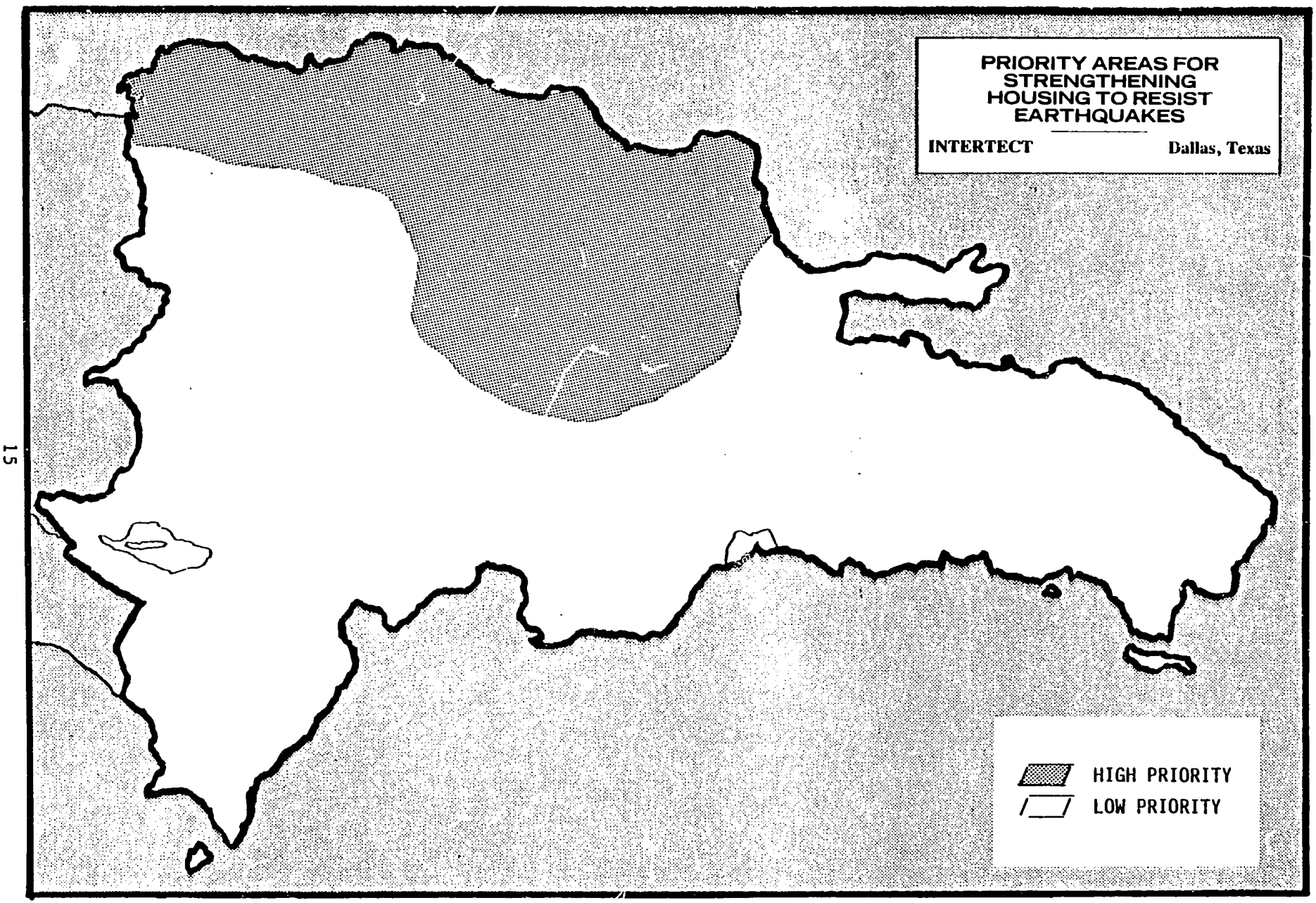

PRIORITY AREAS FOR
STRENGTHENING
HOUSING TO RESIST
EARTHQUAKES
INTERTECT
Dallas, Texas
HIGH PRIORITY
LOW PRIORITY

Figure 8

III. TRENDS IN HOUSING

AREAS OF NEW HOUSING CONSTRUCTION

As is common in Latin America, the urban centers in the Dominican Republic are growing the most rapidly and the rural provinces are experiencing the greatest emigration. Surprisingly, it is the secondary cities that are experiencing the most growth, not the two largest cities (Santo Domingo and Santiago). This is because a balance has been reached (or nearly so) between people migrating to the largest cities and people migrating from these to other countries. Thus, Santo Domingo and Santiago are stepping stones to leaving the Dominican Republic.

A very large proportion of the new construction in all urban areas is concrete block and therefore not considered vulnerable or in need of improvement. Nevertheless, there are large numbers of houses in every urban area that are threatened (due to poor construction) and could benefit from structural improvements. Especially vulnerable are the new low-quality houses being constructed on the periphery of the coastal cities, as well as many older deteriorating houses within the centers of these cities.

In the rural areas, even in those communities that are statistically experiencing out-migration, there is new housing construction. This occurs where families are replacing old uninhabitable houses or building additions to houses (usually as a separate smaller building to the rear of the original) or where children have married, started a family and elected to remain in the community.

MATERIAL CONSIDERATIONS

Material availability, cost and preference vary from region to region and determine the predominant types of buildings in each area. The following is a summary of an assessment of these material considerations.

A. San Cristóbal, Peravia: Cement and concrete block are available and the preferred materials for housing. Wood, imported and domestic*, is available but very expensive. Materials for tejamaní and thatch for roofs are available on a limited scale, but use of these materials in this area is rare.

B. Azua, Barahona, Pedernales, Baoruco: Cement and concrete block are available, especially in population centers, but are relatively expensive. Domestic wood is scarce in desert areas, although more available in the mountains*. Materials for tejamaní and thatch are available but popular only in the poorest rural communities. New wood frame houses are being built but exclusively of domestic wood with palm board siding. Families are switching from thatch to zinc roofing when they can afford it.

---

*The use of domestic wood is officially discouraged and prohibited in order to reduce deforestation and to conserve natural resources. However, virtually all new housing built without support of formal housing assistance (loans, agency support, etc.) uses locally acquired wood.

C. Northwest Area: Materials and availability are generally the same as in Azua, Barahona, etc. Tejamaní is used also, but given a mud finish. There is generally less use of cement and concrete block.

D. North and North Central: Concrete block is very popular. No concreto armado was observed and virtually no tejamaní as found in the west. Instead, an all-yagua house is common in rural areas; domestic wood is used for the frame.

E. East: Concrete block and wooden houses predominate with only a few wood frame and thatch buildings. Many houses were built by the sugar plantations and no strong indigenous style has evolved.

In general, zinc is available in all of the country, but in remote rural areas it is far from the distributor and thus more expensive and less used. Domestic wood, where used, is virtually never sawn or planed; instead it is rough-cut or, in some cases, branches are used. Imported wood was never observed being used in new construction outside of the externally-funded projects in the hurricane-affected areas.

IMPACT OF THE 1979 HURRICANE RECONSTRUCTION PROGRAMS

The purpose of this section is to examine the effectiveness of hurricane housing reconstruction programs and their contribution to the reduction of vulnerability through introduction of modifications and innovations in construction. Different approaches are often chosen to meet different needs at different times. Thus, while the objective of long-term vulnerability reduction may not have been achieved by all the programs, it does not mean that these programs did not meet other needs that were just as important at the time.

A number of innovations and modifications to housing and to construction techniques were introduced as a result of reconstruction efforts after the 1979 hurricanes. As is common when there are several relief agencies working in the housing sector, different approaches and methods were used. Whether these changes became a permanent part of the building process depended upon the number of houses built, how the changes were introduced, and the extent to which the purpose of the modifications was explained.

The smallest degree of modification occurred with the distribution of a limited amount of materials to families for repair of their houses (mainly the roof structure and roofing).

It is, of course, not possible to compare the repaired houses directly with their original construction, but the assessment made for this study estimates that few real structural improvements were made to the repaired houses. Regular dimensional wood replaced irregular, random-sized poles for the structure and a nominal diagonal brace was placed in the roof plane. The latter cannot be considered an improvement since the majority of houses not affected by the hurricane also had such bracing. Apparently, most of the new zinc is of 30-gauge.

A thorough survey of the agencies involved in materials distribution and repair was not undertaken, but the information available suggests that no extensive effort was made to modify the basic houses under repair.

Projects that built entire houses generally erected houses of a higher standard than those destroyed. For example, all-wood or tejamaní houses were replaced with houses that were made of either half-cement block and half-wood, all concrete block, or concreto armado. It appears that virtually all of these programs had input from technicians such as engineers or architects and that indeed the houses are safer than those destroyed.

In one program, conducted by Catholic Relief Services, extensive efforts were made to teach improved construction techniques to local builders, and a number of design changes and modifications were introduced. CRS also produced a series of pamphlets on improved construction which were widely circulated during early reconstruction efforts.

In all projects, however, even more improvements could have been made in terms of wind and earthquake resistance. The principles of improved construction developed by Catholic Relief Services were either not distributed early enough to have an impact on all the projects or were not entirely accepted. They definitely did have an impact, though, in several project sites, particularly those that received financial support from CRS. Perhaps the concepts adopted most widely were improvements in bracing; those least adopted pertained to the anchoring of the roof structure to the wall structure.*

---

*For more complete information on the impact of the CRS housing education/reconstruction project, see their "Second and Final Progress Report", Catholic Relief Services/Dominican Republic, Apartado 1457, Santo Domingo, D.R., July 29, 1981.

IV. THE TRADITIONAL BUILDING PROCESS IN THE RURAL AREAS

There is no single, definitive process of construction. It depends upon many factors including geographic area, whether the setting is rural or urban, the wealth of the family, availability of materials, construction skills of the builder, and time of year as it relates to available income and time to devote to construction. Nevertheless, a profile of the building process for the home of a typical low-income family can be drawn.

When the homeowner decides to build a house and has acquired a site, the size, floor plan and building materials are determined. Then the building materials are acquired, perhaps by gathering some wood or thatch available locally at no or minimal cost. More commonly, though, the materials are purchased from various sources. A carpintero (carpenter) or albañil (mason) will then be hired for a fixed price to build the house. Construction requires approximately one month's time. In some cases, a second tradesman may be hired to install a concrete floor with a hard cement topping.

THE ROLE OF THE ALBAÑIL AND CARPINTERO

The majority of housing in low-income communities is built under the supervision of a construction tradesman, although tejamaní and yagua are typically owner-built. In the case of wooden houses, this tradesman will be a carpintero; in the case of block houses, he will be an albañil. This person may or may not be a full-time builder, but usually he has had considerable previous experience and is someone in whom the homeowner-to-be has sufficient trust.

Once the contract has been made, construction labor may be provided in one of two ways. First, the tradesman may simply contract with other tradesmen, who usually have less training, to assist with construction. This is usually the case in the construction of a block house. The other more widespread method is through participation of the family members, with the father and one or more of the sons helping. This is especially the case in the construction of wooden and tejamaní structures.

There are, of course, many variations regarding the role of the tradesman. Sometimes he will be asked to furnish all of the construction materials as well as labor. At the other extreme, the tradesman might only be hired for a very short time to do the critical steps of laying out the posts and building the roof superstructure, while the owner completes the house. Only in the very poorest of the rural areas is it common for individuals to rely solely on their own labor and skills for complete construction.

The importance of tradesmen should be taken into consideration by any agency seeking to initiate a housing improvement program. Any such program should emphasize teaching these tradesmen how to build a better house -- as well as the public at large. While certain general promotional activities are necessary in order to create an atmosphere of acceptance for any proposed changes, programs that encourage self-help construction by families without the participation of a tradesman will generally find it difficult to achieve lasting changes.

FINANCING

There are no financing mechanisms available to the majority of very low-income rural dwellers. Construction commences when the family has obtained or saved the cash available to purchase the materials and hire the labor. There are few options on materials and usually the least expensive that are locally available are chosen.

PERCEIVED VALUE OF VARIOUS BUILDING MATERIALS

Increased access to building materials that are considered more desirable by the public (for reasons of durability, lower maintenance, or safety) can be used as an incentive for introducing change in housing. Thus, it is important to identify the trends and directions of new construction. Clear patterns are discernable that indicate what materials people will be building with in the near future.

A. Roofs: There are three basic roof systems found in the Dominican Republic: thatch, zinc roofing sheets, and cement slabs. For low-income families, it is nearly universal to aspire to own a house with a roof of zinc sheets. The majority of roofs observed during this study were covered with sheets of zinc and virtually all new construction used this material. In some of the hurricane repair programs, thatch was replaced with zinc or aluminum sheets. Of the individual houses observed under construction, only a handful were using thatch. A housing improvement program should include the assumption that an evolution to more zinc roofing is going to take place.

B. Walls: The trends in wall construction materials are more complex. Approximately half the new construction in rural areas is of concrete block. The consensus of people interviewed is that concrete block is generally the preferred material and that more people would build with it if they could afford the additional cost. (Under some circumstances it is less costly than other acceptable alternatives).

The preference for concrete block is essentially based on the implied higher status of the owner, and it is assumed to be safer in high winds.

In the area around Baní, concreto armado is actually preferred over the concrete block for many of the same reasons (as well as being cheaper in both materials and labor to build). Based on current observations of the extent of use of concreto armado, it is not possible to make clear projections on its future use. The process is now limited primarily to the Baní area. However, because this method is in most cases cheaper than the block or a "formal" wood house, its popularity is likely to increase.

In the poorest rural areas of the north, northwest and southwest, a significant amount of new construction continues to utilize traditional designs and local materials found in those areas. These are the poorest regions, thus changes to housing utilizing commercial materials or costly components are not as prevalent as in the more developed central, south and eastern areas. And because of the slower economic development, changes will be more difficult to initiate here.

C. General Material Preferences: In rural areas, the selection of building materials is usually a function of economic resources. There seems to be a very strong preference among low-income rural people for concrete block houses with zinc roofs.* Next in declining order of preference are:

-- Sawn and planed wood siding with zinc roof;

-- Tablas de palma siding with zinc roof;

-- Tablas de palma with thatch roof; and

-- Tejamaní with thatch.

In the areas around Baní, a concreto armado house with zinc roof would rank equal to, or slightly less than, concrete block.

MATERIAL COSTS

Until the last decade, wood frame housing was fairly cheap. Due to extensive deforestation, however, the Government imposed a ban on cutting timber, and a substantial portion of the wood used in the country today is imported. Therefore, concreto armado and concrete block housing is on a par with the cost of wooden housing and in some cases may even be cheaper, depending upon transport costs of the basic materials, price fluctuations of the reinforcing rods, and the amount of labor by the owner.

The following costs are typical (all costs in pesos):

A. Cement: About $5 per bag near the capital. Farther out, the price inflates rapidly.

B. Concrete Block: A block 6"x8"x16" costs 32¢ each delivered in most areas. Labor to lay one block ranges from 8¢-18¢. With mortar, each block costs 45¢-60¢, in place. A block made on site with a self-help process costs 12¢-20¢ depending upon the size of the block and the process used.

C. Wood (Imported): Rough-sawn low-grade wood costs 65¢ per board foot. Planed wood costs 75¢-90¢ per board foot.

---

*Even more preferred is a concrete block or concrete house with a concrete roof. However, this class of construction goes beyond the focus of this study.

D. Wood (Domestic): Domestic, unsawn, good corner posts cost $3 - $5 each; lesser posts cost $2 each.

E. Palm Board Siding: Boards about 2½" wide, 10' - 12' long cost $5 per dozen.

F. Zinc: 30-gauge sheets 3'x6' cost $4.50 - $5.50 each. 26-gauge sheets cost $6 - $8 each.

G. Nails: $35 - $40 for 100 pounds.

H. Roofing Nails (Galvanized): $65 for 80 pounds.

I. Thatch: 100 fronds of palm cost $4 - $5 (including yagua)

J. Sand and Gravel: $8/$M^3$ delivered.

K. Labor: Carpenters are paid approximately $9/day or $200 - $300/house.

L. Roof Costs (Including new zinc, wood, nails and wire):

$13.5 per sq. meter for zinc with sawn imported timber;
$10 per sq. meter for zinc with rough-cut imported timber;
$6.25 per sq. meter for zinc with domestic wood.

M. Wall Costs: Concrete block (blocks, rebar, cement mortar) excluding foundation: $8.25 per sq. meter;
Concreto armado: $6.70 per sq. meter;
Tejamani: $1.90 per sq. meter;
Yagua: $1.10 per sq. meter;
Wood frame with sawn timber siding: $11.10 per sq. meter;
Wood frame with palm board siding: $6.70 per sq. meter.

Roof and wall costs are based on the average costs of materials only and represent a structure 6m x 6m. This is a shell only, complete with the usual floor, wall and windows common to that type of structure, and with minimal wind resistant reinforcement.

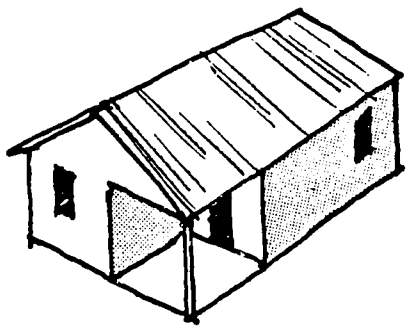
V. COMMON HOUSING TYPES AND THEIR VULNERABILITY

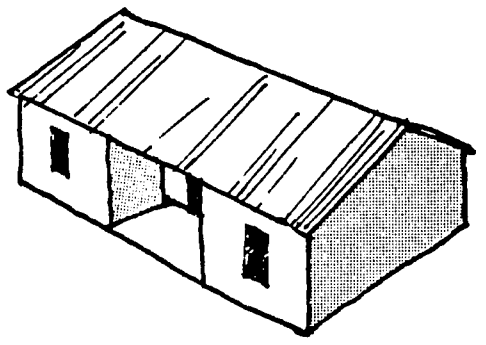
The purpose of this chapter is to identify the most common types of non-engineered houses, to identify the structural problems of each type, and to determine their relative vulnerability to both high winds and earthquakes. Options for improving the structural performance of each building type are then considered.

PROBLEMS COMMON TO ALL BUILDING TYPES

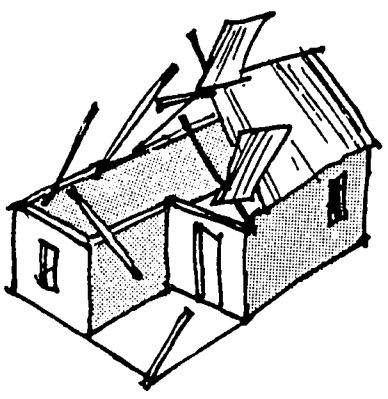
There are a number of problems common to all types of housing in the Dominican Republic. The following list describes some of the more popular features and housing styles that have been identified as being dangerous in either hurricanes or earthquakes.

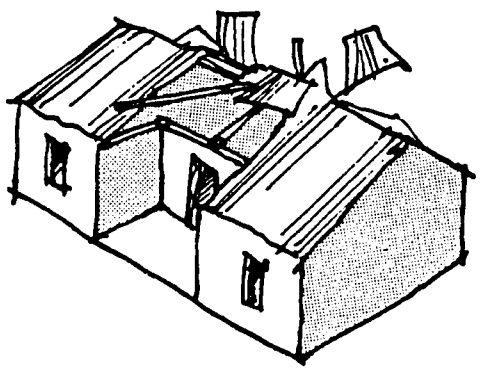
A. Problems in Basic Configuration: There are numerous variations of porches or open rooms being built into or added onto a house. Two of the most popular variations are illustrated below:



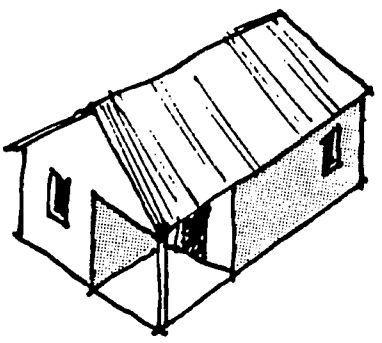


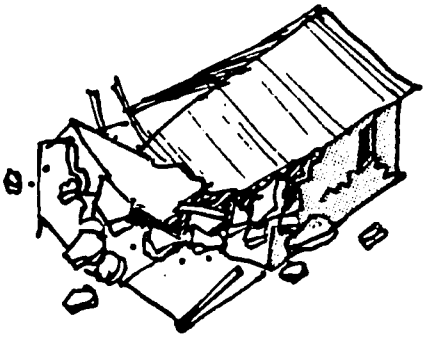
Both configurations present special design problems in hurricanes. High winds will be concentrated in these openings and will be deflected upwards, lifting the roofs off the buildings.



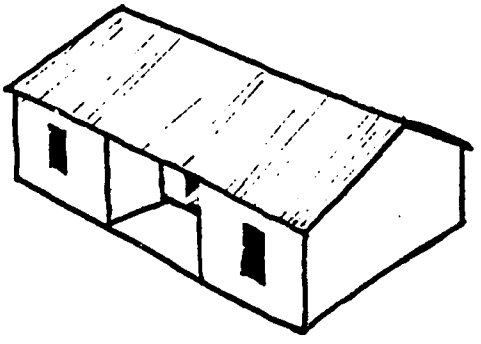


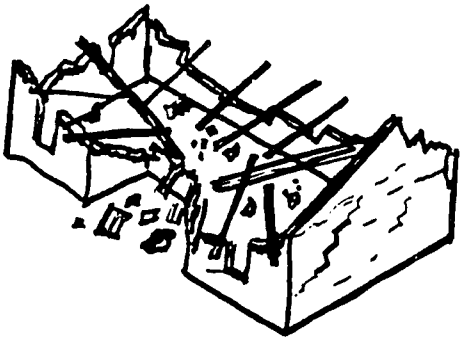
In earthquakes, these configurations are also dangerous if the houses are made of heavy material such as concrete block or concreto armado. The first house is dangerous because the floor plan is in the form of an "L"; this is considered to be one of the most dangerous shapes for buildings in earthquake zones because the parallel walls of the house are of unequal weight and length. In an earthquake, the house would twist on the foundations and collapse inward.



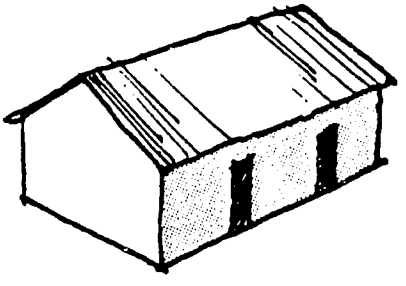


The second house is also difficult to balance properly and any failure of the structure is likely to occur in these open areas, which are usually where the doors of the building are located.

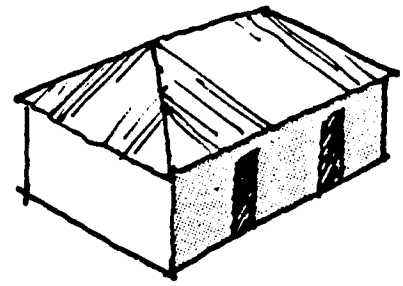




B. Roof Configuration: The majority of rural housing utilizes a gable roof such as the one illustrated in the figure below.

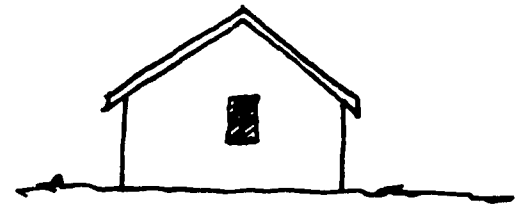


For both hurricane and earthquake resistance, a hipped roof such as that illustrated below is preferred.



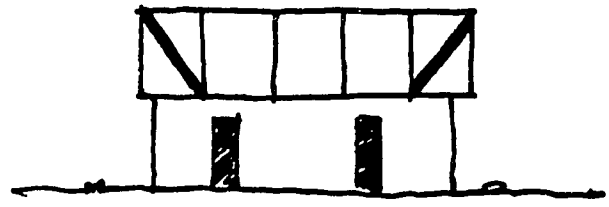
A gable roof may be used, however, if the angle of inclination of the roof is approximately 30° to 40°,

NO



YES

and if the roof trusses are adequately braced so that they do not collapse when forces are applied along the longitudinal axis of the house,

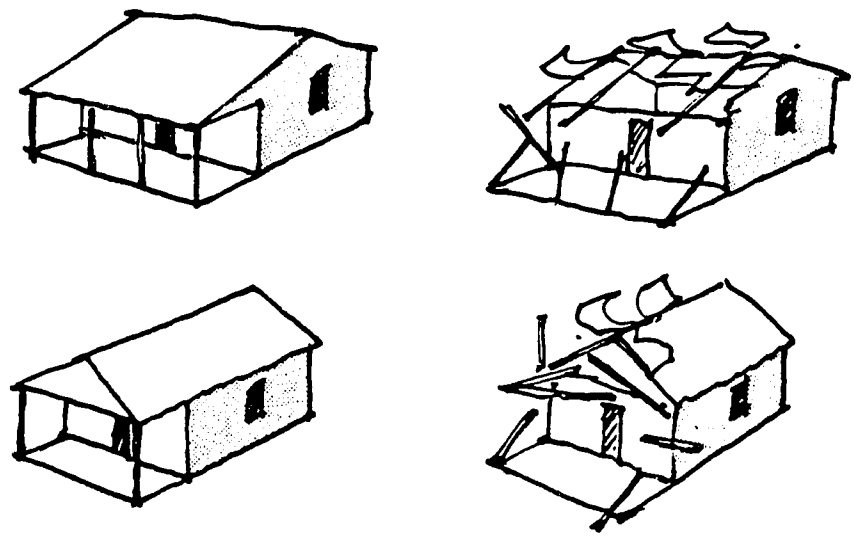


and provided that the gable is sufficiently reinforced so that it does not fail and collapse when pressures are exerted from either an earthquake or hurricane.

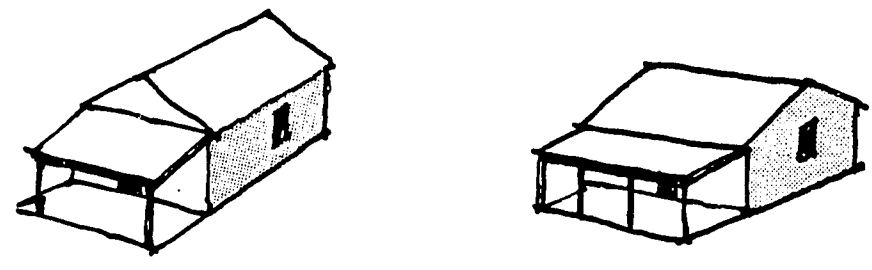
For the most part, the roofs of most rural houses meet the first criteria. Only in a few cases (normally on concrete block houses using zinc roofs) are the angles of inclination less than 30°. The lack of roof truss reinforcing and poorly-built gables are common to all types of buildings.

C. Porches: A popular feature of buildings in any hot climate is the porch which provides shade and an area to work or sit, and helps cool the building. The manner in which porches are constructed, however, can contribute directly to the vulnerability of a house. If the porch is attached to the roof structure and traps winds underneath, the entire roof can be lifted off the house.

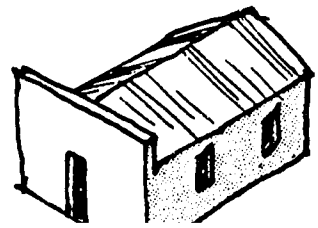
Two popular porch configurations and their patterns of failure are illustrated below:

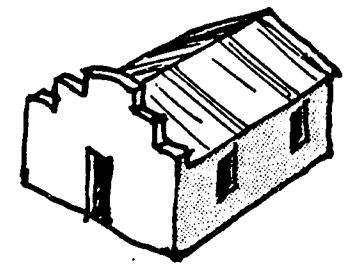


If these configurations are to be used, the connections between the porch and walls and roof structure must be designed in such a way that the porch can "break away" from the main structure of the house without severely damaging the rest of the house.



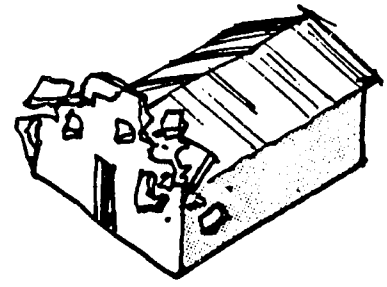
D. <u>Ornamental Facades Made of Concrete or Block</u>: A popular building feature found in many of the peri-urban areas and in rural towns is a concrete ornamental facade. Several of the more popular designs are illustrated below.



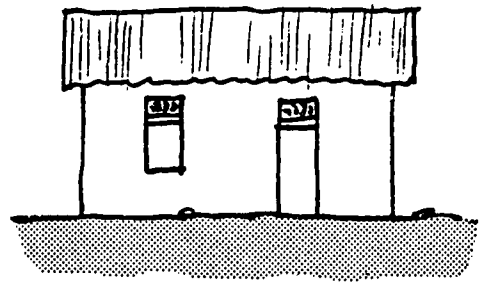


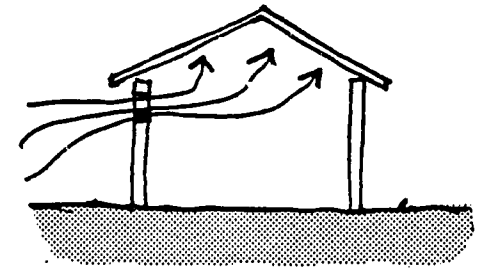
These facades are normally found on concrete block houses, although wooden houses often have a facade added to the side facing the street, especially if the building serves as a store as well as a house.

Unless properly reinforced, these facades are extremely dangerous in both earthquakes and hurricanes. When they fail, they collapse into the house or immediately outside, endangering the building's exit and contributing to its collapse.



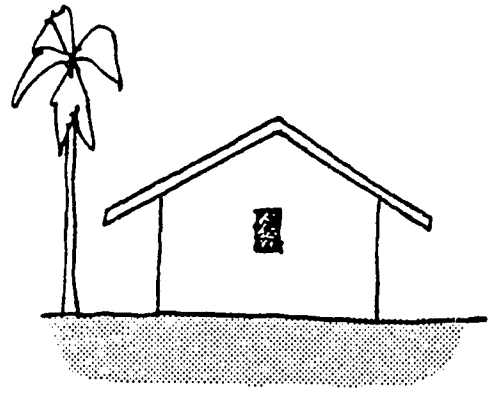
E. Transoms and Other Openings: Popular features designed to cool houses are open transoms above doors and windows and air vents in the gables of wooden and block houses. Unless these openings are completely sealed off during a hurricane, winds can enter the building, increasing the outward pressures on the walls and roof.

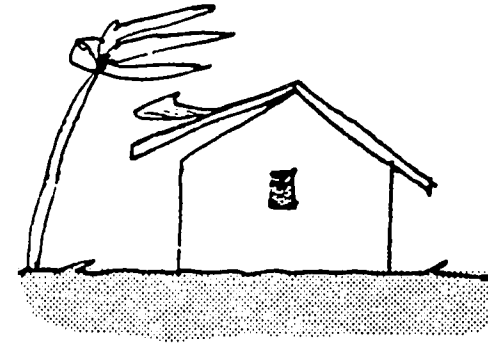




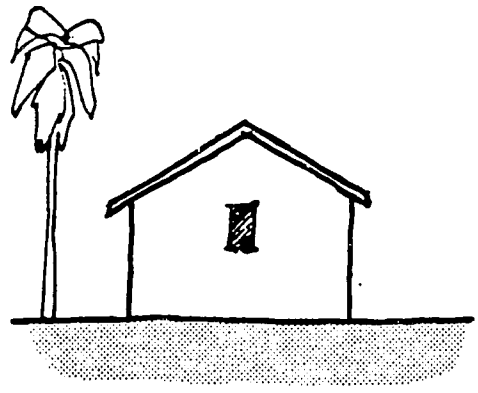
In theory, it should be possible to board up these areas before a hurricane, especially if adequate warning is given. In practice, however, when a warning is received, wood becomes scarce and it may be difficult to obtain the materials necessary to seal off these areas. The ideal solution is to install shutters which can be closed when a hurricane approaches. For the upper air vents, boarding them up is probably the only realistic choice.

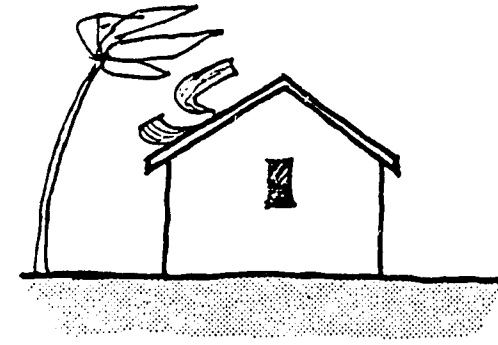
F. Roof Eaves: Another popular feature of housing in the Dominican Republic is the extension of the eave of the roof outward from the house to provide shade and cooling. These long eaves present two problems in high winds. First, the traditional design allows air moving upward to be trapped underneath the eaves and contributes to the uplifting forces which can lift the roof off the house.



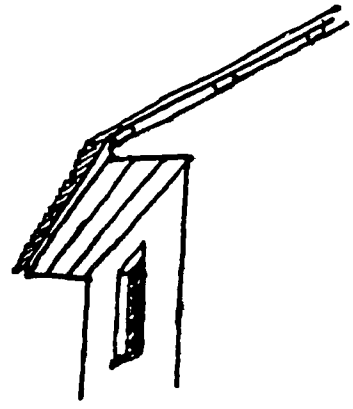


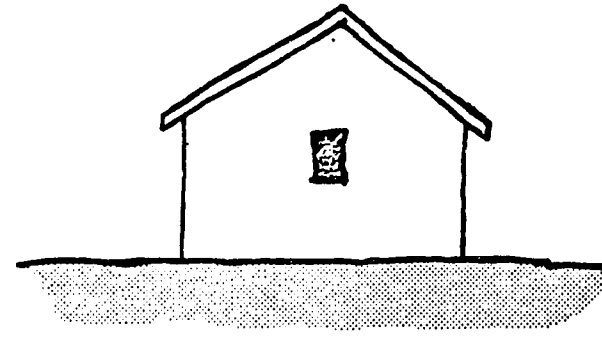
Second, the design of most of the houses in the rural areas leaves a gap between the roof and the wall. This is to allow air to move into the house for cooling purposes. But during high winds this same detail will allow winds to enter the house and increase the outward pressures on the walls and uplift of the roof.





The best solutions to these problems are to reduce the overhang to 50cm. or less and to seal the eave to prevent wind from entering under the roof. This will also help reduce the uplifting forces at the edge.





G. Poor Fastenings of the Roof to the Walls: In almost every type of rural building in the Dominican Republic, the roofs are inadequately fastened to the walls. This presents problems in hurricanes, when the roof can be lifted completely off the building, and in earthquakes when the rocking motion of the roof can create additional loads on the walls, contributing to their collapse. In the coastal areas, it is especially important that the roof trusses be securely fastened to the frame of the house. This can be accomplished by tying with wire, by using hurricane straps made from strips of zinc sheeting, or by using commercially available hurricane fasteners. (See Appendix IV)

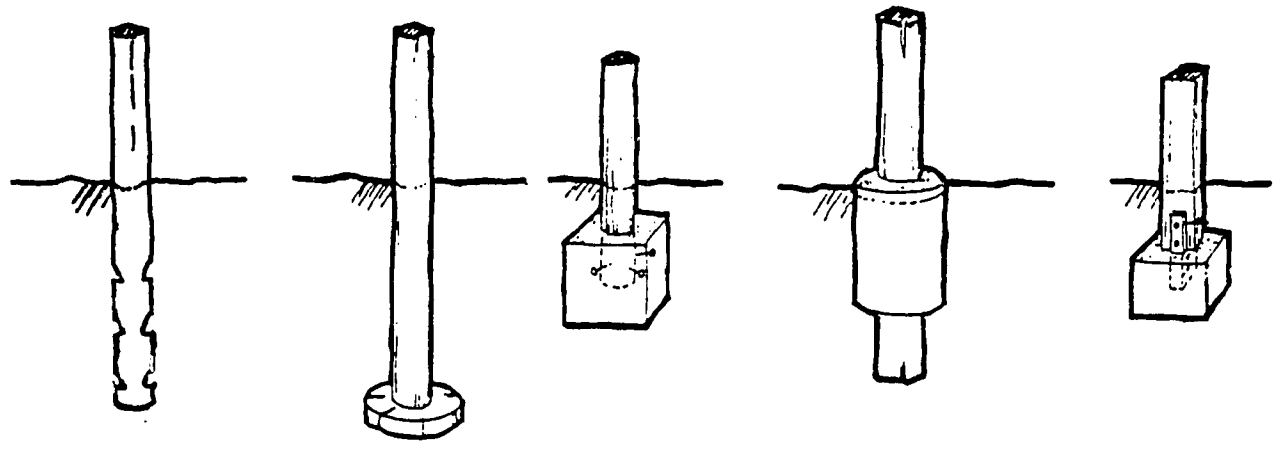
The importance of adding these fasteners should not be underestimated. Recent studies have shown that by adding one appropriate fastener at every location where the roof joins the wall, survivability of even marginally-built buildings can be improved substantially.*

H. Poor Connections Between Walls and Ground

In hurricane-prone areas, a good wall-to-ground connection is important for two reasons: to provide support to the vertical elements of the building and to anchor the building securely to the ground. This is especially important in light-weight buildings, i.e., those made of wood, tejamaní or yagua.

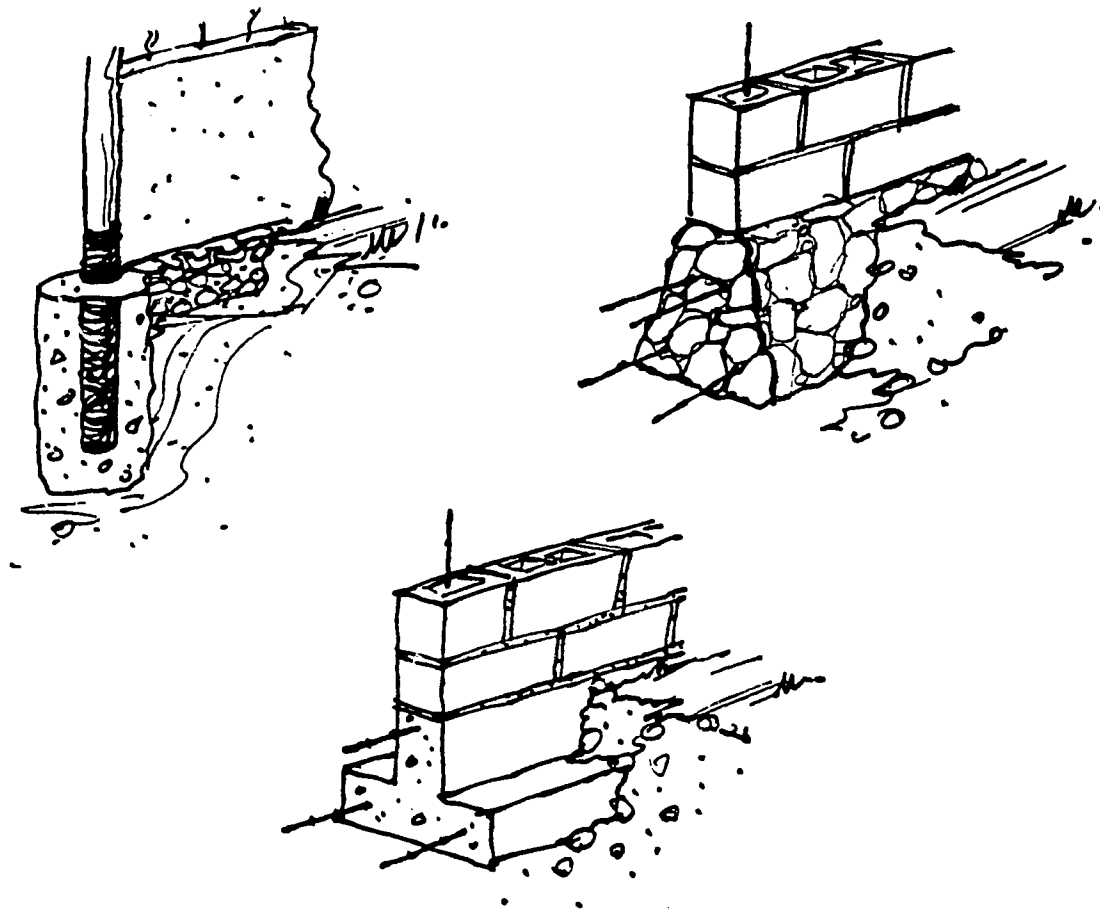
In earthquake regions a good wall-to-ground connection is important to provide additional strength to the vertical elements of a building. It also helps distribute the weight of the walls.

Wood columns should be treated with an adequate wood preservative and placed in the ground to a sufficient depth to provide friction and resistance against uplift. A number of footings can also be incorporated in the design of the building to help reduce uplift. Several of these are shown in the figure below.



*"A Guide for Improving Masonry and Timber Connections in Buildings", Vol. 3, Building to Resist the Effect of Wind, BSS100, National Bureau of Standards, Washington, D.C., 1977.

For buildings with concrete or block walls, a rock foundation is required in order to help stabilize and support the building. The designs shown below should be used with houses made of concrete block, concreto armado, block, or other masonry work.



In most cases, builders have to compromise between these recommendations and other concerns such as climatic comfort, day-to-day household requirements, etc. Choosing the best structural improvements that will yield the most safety for the least investment is difficult and complex. The most important modifications are those which will provide the most protection. For hurricane resistance, the most important considerations are:

--- Strong connections from the roof to the ground;

--- Roof pitch of 20°-35°;

--- Modest overhanging eaves;

--- Strong braces in the corners of the walls.

For earthquake resistance, the most important considerations are:

--- Lightweight roof;

--- Strong, reinforced walls;

--- Relatively low walls (no more than 1.7 meters);

--- A balanced house using a strong configuration (square or rectangular).

SITING

Site selection and positioning of a house can play an important role in the safety of a building. Families and communities need to decide carefully where they will build, considering both site (the plot of land on which the building will be located) and position (the exact placement of the building on the site, e.g., which way the building will face and how far it will be from each of the site's boundaries and adjacent buildings).

A. Size: At the very least, the site must be big enough for the building being planned, plus some room around the building to provide separation between buildings on adjacent lots. Generally the minimum separation recommended is approximately 1 meter along each side of the building. In urban areas, extra land may be required for health, safety, transportation, or other needs.

B. Soils: Possibly the most important consideration in site selection is that the soil must be able to support the building. Almost any ground can be built on, but the nature of the site chosen will affect the simplicity or complexity of the foundation, the cost of construction in both labor and money, and the durability of the building.

1. Rocky soil provides the strongest support, usually more than is necessary for a one-story building. But, while it is extremely stable, it can be very difficult to excavate.

2. Hard-packed clay is generally the best soil for one-story buildings. It is strong but easy to work with.

3. Soft black soil, drained marshland and "made" earth (fill that has been collected and packed) are satisfactory soils for construction. However, buildings constructed on these soils should be built on concrete foundations or raised platforms. In addition, buildings on these soft soils should be made with the lightest suitable materials available. Black topsoil contains decayed organic material that makes it soft, particularly when moist. In areas where such soil goes more than 30-45 cms. deep, it must be removed before construction can begin. Otherwise it will almost certainly shift under the foundation and cause wall cracks or collapse of the building.

4. Sand and gravel should be avoided, especially near fault zones. They can support about half as much weight as clay but are subject to shifting or slippage (particularly if the site is not on level ground) and liquefaction in earthquakes.

Each type of soil has very definite limits to the weight it will support. Generally, one-story buildings will be well within these limits except in the case of buildings with cement block walls on the weaker soils.

C. Drainage: Builders should consider how well the land is drained; water seepage can destroy even the strongest foundation if it is not controlled or planned for. Wet or damp floors can make a building uncomfortable and unhealthful.

Whenever possible, marshland or any ground that lies underwater for extended periods of time should be avoided for construction purposes.

Low-lying land and land that may be exposed to short-term flooding should be avoided. However, when there is no choice, this land can sometimes be improved by digging a trench about 25 cms. wide and 10-15 cms. deep around those sides of the building site that will not drain. These trenches should lead far enough from the planned position of the building to keep water from rising to the foundation depth.

If the dark topsoil in low-lying areas is more than 30-45 cms. deep, every effort to locate a different site should be made, since removing this topsoil for a firm foundation will be expensive and can make effective drainage more difficult.

High, dry ground is usually best as a building site since it is not subject to water seepage. However, the ground can be too high:

1. If the ground is also hilly, the excavation needed to produce a level area for the foundation may be too difficult or too expensive;

2. If there are heavy rainfalls, rapid drainage may cause erosion, ground slippage or landslides that can result in the building's collapse or burial. In most cases, a retaining wall and carefully planted vegetation (trees, shrubs, etc.) can solve these problems, but both alternatives can be expensive;

3. If high ground is exposed to high winds or storms, the building may be vulnerable to collapse or loss of roof.

The ideal site for any building is on dry soil safe from flooding and sheltered against ground slippage, strong winds, and storms.

D. Considerations for Disaster Protection:

1. Earthquakes:

   a. Select relatively flat sites but avoid narrow ridges, steep slopes, narrow valleys and sites near cliffs or large gullies (i.e., within 150 meters).

   b. Select sites with hard bedrock at or near the surface.

   c. Select sites where landslips are unknown in the immediate area.

   d. Select sites where there is no sign of active faulting. Avoid offset rock layers, rows of ponds or swamps, and deep or long cracks in the ground.

2. Hurricanes:

   a. Cyclones, hurricanes and typhoons are often accompanied or followed by heavy rains. Select land away from the seacoast, flood plains and lakesides.

   b. Build above the expected flood or storm surge heights.

   c. Watch for conditions such as:

      --- Upstream development (e.g. irrigation or deforestation) that may generate more surface water into the construction area;

      --- Diversion of upstream drainage into downstream catchment areas causing overloading of drainage channels adjacent to the site;

      --- New building at the foot of slopes receiving direct surface run-off which will spill on either side and cause erosion.

   d. Consider wind risks such as exposure, orientation and location of major tree growth.

   e. Groups of houses should be staggered so that they do not increase the wind velocity. Natural shelters or windbreaks should be used, if possible. Long narrow valleys which funnel the wind should be avoided.

3. Tsunamis: These sea waves induced by undersea earthquakes are a danger to certain coastal communities. Low-income families are particularly vulnerable if living close to the beach, and their residential areas are best located well away from the paths of tsunami waves. These can be mapped by analysis of past damage plotted on contour maps.

4. Storm Surges: Select land well away from the coast or on high land above the maximum predicted height of the storm surge or "tidal wave". (See also "Floods".)

5. Landslides: Slippage of land may occur as a result of heavy rains or earthquakes. Local geographical conditions determine the severity of risk.

   a. Avoid areas where deforestation has occurred.

   b. Avoid steep sites near known fault lines in earthquake areas.

   c. Avoid areas next to cliffs or at the foot of steep slopes where slips and rockfalls are a possible danger.

6. Floods:

   a. Avoid floodplains and particularly the floodway.

   b. Avoid edges of inland lakes.

   c. Avoid low-lying coastal areas, wetlands and sandbars at lagoon mouths.

   d. Avoid tight settlements in narrow defiles upriver.

   e. Avoid downstream banks and floodways below dams (particularly in earthquake-prone areas).

   f. Avoid high water table areas.

   g. If such areas must be used, then protective measures (e.g., channelization, ponding areas, floodwalls, etc.) will be required to reduce the level of risk. At the lowest of prevention levels it will be necessary to prepare escape routes at high level and well above early water heights. The cost of undertaking these measures is likely to rule out the use of a particular site for low-income family occupancy.

VULNERABILITY ANALYSIS OF THE BASIC HOUSING TYPES

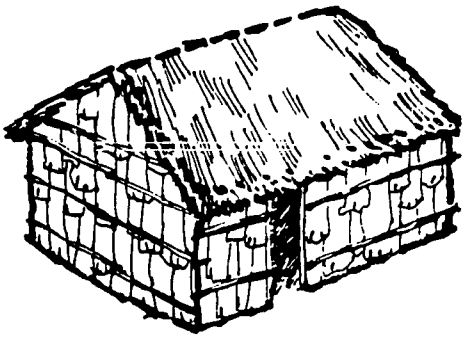
The following is an analysis o. .e principal housing types found in the Dominican Republic. Primary emphasis is on the wind resistant potential of each structure, as hurricanes and wind storms are the greater hazard due to their frequency. However, the earthquake resistant potential is also discussed.

Most recommendations for making the structures more disaster resistant can be incorporated at little or no increase to the total cost of the building.

It is important to remember that the most critical features in making a house disaster resistant are the configuration of the house, the configuration of the roof, attention to detailing, and the quality of workmanship. All of these features are more important than the materials that are chosen; for it is not the materials that are used, but rather how they are used, that is important.

A. Yagua House

1. Basic Configuration:



2. Location: North Central Zones

3. Variations: Variations of the basic yagua house include yagua walls with a grass roof and occasionally a zinc roof. Some wood or wattle-and-daub houses use yagua for the roof covering.

4. Construction: Yagua construction is the simplest and least expensive of the traditional houses. It is also one of the most regional house forms.

The basic material of the house is yagua, which is made from the stems of large palm leaves that have been flattened into sheets. These sheets can be up to 30cm. wide and 1.8 meters long. Yagua is used for both wall and roof coverings.

In the construction of yagua houses, a wooden frame is erected with posts approximately 1 meter apart that are set into the ground about 45cm. Lightweight branches are run horizontally about 30cm. apart and nailed to the posts. The yagua is woven through this horizontal structure.

5. Roof: The roof structure is a lightweight system of rafters roughly aligned with the posts and cross-branches about 50cm. apart. Several layers of yagua are lashed down to the cross-branches for the covering. Frequently, concrete blocks, tires or other fairly heavy objects are placed on the roof to help hold it down.

6. Size: The average size of a yagua house is 3 x 5 meters.

7. Vulnerability: The hurricane resistance potential of this type of structure, even if properly built and reinforced, would be low. Structural performance can be improved, although the building cannot be made airtight or sufficiently strong to withstand extremely high winds (over 100 mph), and collapse of a high percentage of houses exposed to high winds would still be expected. If all the basic rules are followed, however, some reduction in vulnerability could be achieved.

8. Weak Points: The principal weak points of the yagua houses are the connections of the roof to the wall posts and the weak fastenings of all wood in the corners. Typically, vines or thin ropes are used to bind joints and these deteriorate rather quickly. The wood posts of the building frame also deteriorate rapidly, especially the portions in the ground.

9. Modifications For Wind Resistance: Because the owners of *yagua* houses are very low-income families, it will be extremely difficult for them to economically justify extensive modifications to their houses. Thus, any proposed changes must be virtually without cost to the owners. The following suggestions can make these houses safer to a limited extent, but it should be pointed out that the relative cost benefit to the owners would be minor.

   -- Wood treatment should be used on all posts placed in the ground.

   -- The primary columns (corners and columns in the middle of each wall) should be buried a minimum of 50cm. and should be notched for increased anchorage.

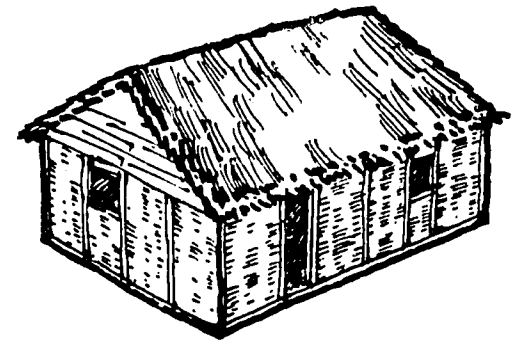
   -- Diagonal or cross-braces should be added between all the primary columns of the buildings, especially in the corners.

   -- All connections should be strengthened by using metal wire to help bind the posts. This is especially important at the corners.

10. Modifications for Earthquake Resistance: Because of the very lightweight characteristic of the *yagua* house, it would be fairly safe in earthquakes and no modifications are required.

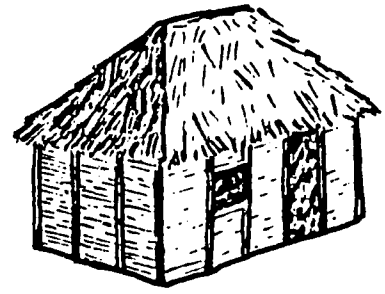
B. Tejamaní (Wattle-and-Daub) House:

1. Basic Configuration:



2. Location: Azua
Northwest

3. A Popular Variation:



4. Construction: In tejamaní construction, a wooden frame is erected and bamboo, sticks or cane are woven between the vertical columns to form the wall. Sometimes a mud plaster is applied to both sides of the walls. The plaster is a mixture of clay and organic fiber, usually grass or straw. Occasionally the wall is finished with an application of a cement-sand plaster or lime wash over the outside.

5. Roof: Structures of this type normally have a thatch roof, although in recent years a number of these roofs have been converted to zinc.

6. Size: Houses built of tejamaní are usually fairly small; rarely do they exceed 4 x 5 meters.

7. Vulnerability: Tejamaní houses along the south coast were severely damaged by Hurricane David. In almost every case, the houses were damaged beyond repair, and residents were forced to rebuild an entirely new structure. The primary causes of structural failure were separation of the roof from the walls (caused by uplifting on the roof's surface as well as uplift under the eaves of the roof) and collapse of the walls resulting from lack of reinforcement at the corners and lack of strength in the columns due to deterioration of the wood in the ground. There was little evidence of explosion, indicating that the houses were not airtight, nor did they offer much resistance to the forces of the winds when blowing directly on the walls.

8. Weak Points: The weak points of the house are the wood columns, the corners (which have no diagonal reinforcement), and the connection between the roof and walls.

9. Modifications for Wind Resistance: In order to improve the wind resistance of tejamaní houses, the following actions are recommended:

   -- Use wood treatment for all parts of the house that are placed on the ground. (Use of motor oil with an insectide would be a low-cost method).

   -- The primary columns (corners and columns in the middle of each wall) should be buried a minimum of 50cm. and should use some form of anchoring device.

   -- Cross-braces of wire should be placed between all the primary columns of the building.

   -- Wood braces should be placed in the roof framing.

   -- The roof - wall connection should be strengthened by using metal straps or wire to help bind the roof to the wall, especially at the columns.

   -- In existing houses, replace corner posts that are rotten.

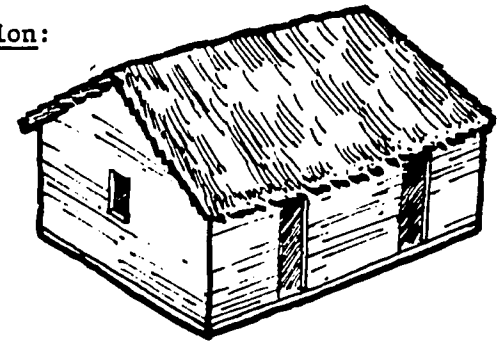
   The hurricane resistance potential of tejamaní, if properly built and reinforced, would be moderate. Structural performance can be improved, although due to the type of construction, the building cannot be made airtight or sufficiently strong to withstand extremely high winds (over 100 mph), and structural damage can still be expected. If all the basic rules are followed, however, a substantial improvement in the performance in high winds will be attainable.

10. Modifications for Earthquake Resistance: In terms of vulnerability to earthquakes, tejamaní structures are relatively safe. A key weakness is still the columns where they are placed in the ground. In a strong motion earthquake, the columns may break and displacement or collapse of the walls will result. By following the recommendations outlined above, the earthquake resistance potential of tejamaní houses can be increased substantially.

    It should be pointed out that, even though extensive structural damage may result from either hurricanes or earthquakes, the potential for serious injury resulting from collapse of these buildings is relatively minor. The structure is lightweight and, because it is woven together, big chunks will not come flying off to cause major harm to the occupants.

C. Wood Frame House With Palm Board Siding

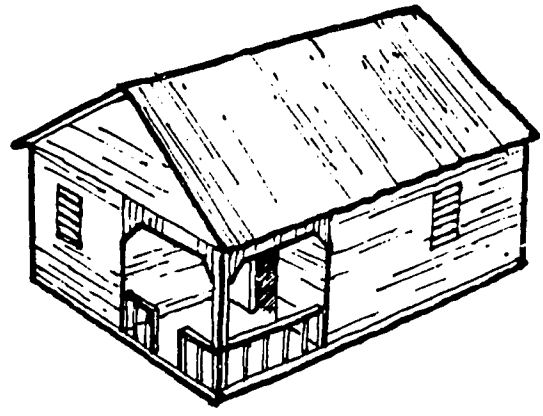
1. Basic Configuration:

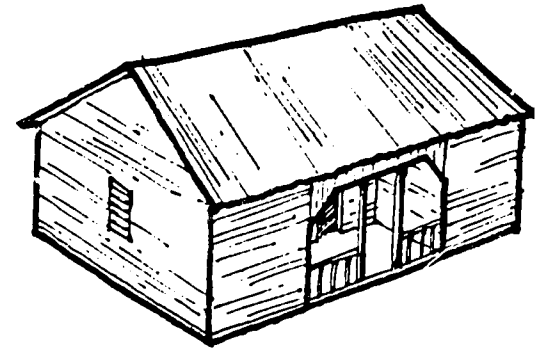


2. Location:

Nationwide

3. Variations:





4. Construction: The palm board house is one of the most popular housing forms in the rural areas of the Dominican Republic. A wood frame is constructed (often with hand-hewn boards) and siding made from the outer surfaces of palm trees is nailed to the frame. Because palm wood is flexible, small vertical strips of wood are added as stiffeners to keep the boards from moving apart and to add strength.

Houses of this type are fairly low-cost and, since the hurricanes, are being built in great number.

5. Roof: The gable roof is the predominant configuration and zinc is the preferred cover. In some cases, a truss system is used.

6. Size: The size of a wood frame house is usually from 3' x 5' meters to 4' x 6' meters.

7. Vulnerability: These houses were heavily damaged in the hurricane. A substantial portion of these houses lost part or all of the roof; and extensive failure at the ground level, caused by deteriorated columns in the ground, was noted. These structures are vulnerable to winds pushing the long walls, and a large number of houses were damaged in this manner. In areas along the coast, a number of failures at the corners were also noted.

8. Weak Points: The weak points of the structure tend to be the fastening of the roof sheeting and the roof truss; the connection between the roof system and the walls; the flexibility of the palm boards, especially when stiffeners are not properly placed or when no interior wall has been added; and the point at which the wall posts are placed in the ground.

   Another popular feature which caused extensive damage was the open transom above doors and windows. Wind penetrated these transoms and increased the upward pressure on the roof.

9. Modifications for Wind Resistance: In order to improve the structural performance of palm board housing in high winds, the following actions are recommended:

   -- Use a hipped roof configuration, rather than a gable roof.

   -- Use more nails to secure the zinc sheeting to the roof frame.

   -- Use metal straps to help secure the roof frame or truss to the walls.

   -- Keep all overhangs to 50cm. or less.

   -- Seal eaves to prevent wind from entering under the roof.

   -- Add diagonal braces to the wall frame, especially in the corners and in the roof framing.

   -- Place additional stiffeners vertically to help reinforce the siding.

   -- Board up transoms in high winds.

   -- Treat all wood that is placed in or on the ground with preservatives to reduce deterioration.

   -- Anchor the columns and place all corner posts a minimum of 1 meter into the ground.

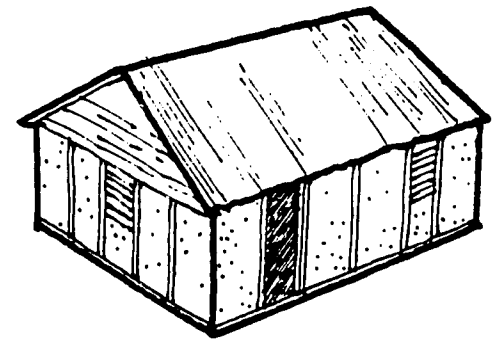
   -- In existing houses, replace corner posts that have rotted.

If these recommendations are carried out, the potential for this type of structure to resist high winds will be substantially increased. If properly built, this type of structure will provide moderate safety in hurricanes.

10. Modifications for Earthquake Resistance: The earthquake resistance potential of this type of structure is very high, and the recommendations made further increase the earthquake performance. The only major type of damage that would occur in an earthquake would be collapse of the structure at the base due to deterioration of the wood columns. Diagonal bracing and the wood treatment recommended earlier would make earthquake damage almost negligible.

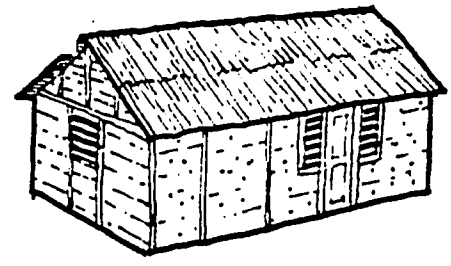
D. Concreto Armado (Poured-in-Place Concrete) House

1. Basic Configuration:



2. Location: Baní
Azua

3. A Popular Variation:



4. Construction: Concreto armado houses are constructed by building a wooden frame, placing the columns approximately 1½ meters apart. When the frame has been completed, wide boards are attached to each side of the columns and concrete is poured between the two boards.*

As soon as the concrete has set, the boards are moved to another part of the frame and the process is repeated until the entire wall is completed.

The concrete panel is reinforced and held in place by stapling barbed wire between the columns.

5. Roof: Concreto armado houses usually have corrugated iron roofs and use a gable design. In some areas, grass or palm leaf roofs are still used, but this practice is becoming rare.

---

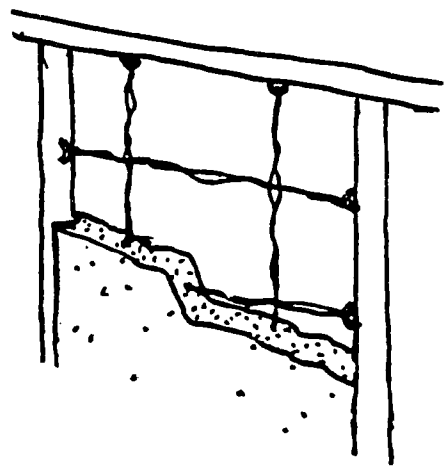
*Since Hurricane David, the majority of builders have been using 4' x 8' sheets of plywood.

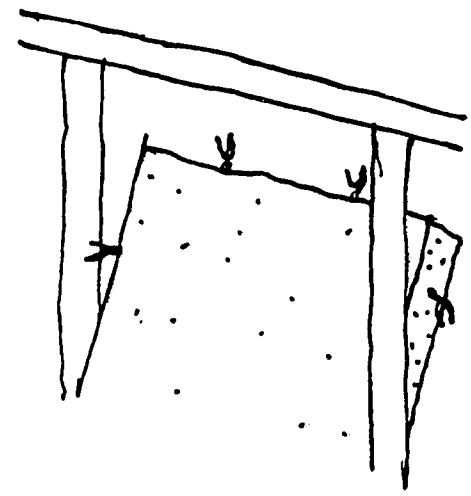
6. Size: Houses built in this manner are usually fairly small, between 3-4 meters wide and 5-6 meters long.

7. Vulnerability: Concreto armado houses were extensively damaged in the hurricane. Damage included separation of the roof from the walls, failure of the gables and failure of the walls themselves. The latter damage -- failure of the walls -- was due to separation of the concrete from the wooden columns. Even those houses that had been reinforced with barbed wire cross-braces suffered this type of damage. Studies of damage to this type of structure show that there was a high percentage of explosive damage (caused by differential pressure pulling the house outward).

8. Weak Points: Common features of concreto armado houses are louvered windows and small louvered openings around the doors. In high winds, louvers allow excessive amounts of wind through the windows, thereby increasing the pressure which creates explosive effect.

   Other weak points of the structure include the connection between the roof frame or truss and the wooden ring beam atop the concrete wall; the gable at each end of the structure; and the connections between the concrete panels and the wooden columns.





9. Modifications for Wind Resistance: The following actions are recommended in order to improve structural performance in high winds:

   -- Use a hipped configuration for the roof.

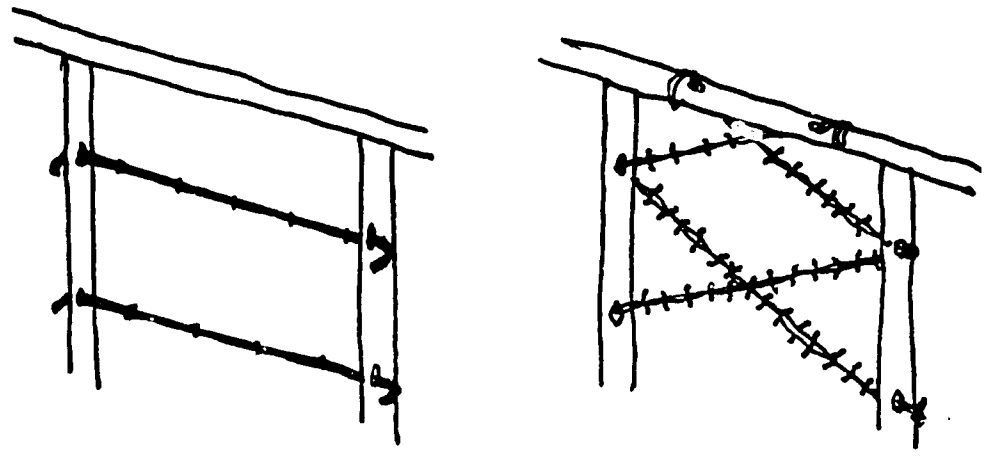
   -- Improve the connections between rafters and ridge pole and at top sill plate.

   -- Use more nails to secure the metal sheets to the roof trusses.

-- Tie the roof rafters to the ring beam by use of metal straps, or wire, giving special attention to the corners.

-- Close off the eaves of the structure to reduce uplift under the overhang.

-- Use iron rebars for reinforcing the concrete panels. If this is not possible, it is recommended that, at a minimum, barbed wire cross-braces be used.



-- Use shutters to help close off louvered windows during periods of high winds.

-- Treat wood posts before placing them into the ground.

-- Use anchors at the base of all posts in the ground, and bury the posts to a minimum of 1 meter.

-- Use diagonal bracing in the roof structure.

-- Use a wooden gable. In a hurricane, the concrete would tend to break away from the beams it rests on and would fall into the house.

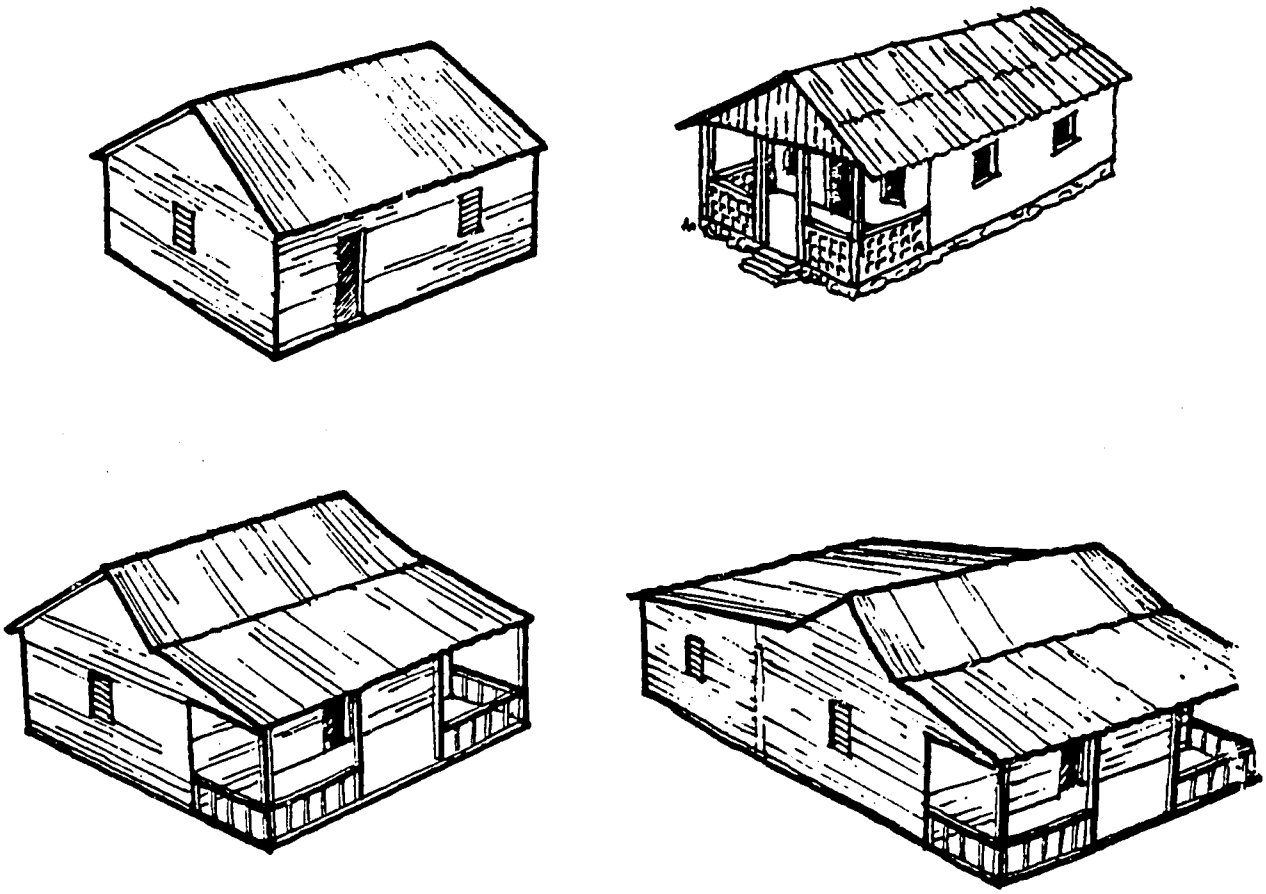
-- Place diagonal braces at each corner to hold the corners together.

If the above recommendations are carried out, the wind resistance potential of concreto armado structures will be substantially increased. If properly reinforced, this type of building can be made moderately wind resistant.

10. Modifications for Earthquake Resistance: Concreto armado structures may have excellent potential for resistance to earthquakes. The most important features to consider are the connections between the wooden columns and the concrete panels.

E. Wood Frame Housing With Sawn-Board Siding

1. Basic Configurations:



2. Location: North, Central, South, East

3. Construction: The wood frame house is one of the most popular building types in the Dominican Republic and is especially popular with moderate-income families in small towns. The house offers the advantage of making additions easy and is well suited to the climate; if maintained properly, it will last for several generations.

There are many variations of wood frame houses, although in the rural areas the types illustrated above are typical.

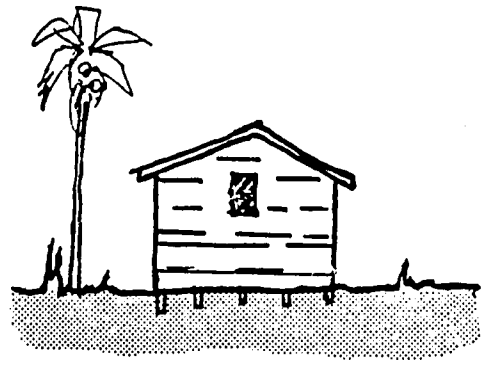
Wood frame houses at one time were very reasonably priced and affordable to almost all income groups. In the last decade, however, with the tightening of controls over the lumber industry and the prohibition on cutting wood without a permit, this type of house has become more expensive because of the difficulty in obtaining lumber. At the present time, it is almost as economic to build a house of concrete block or concreto armado as of wood.

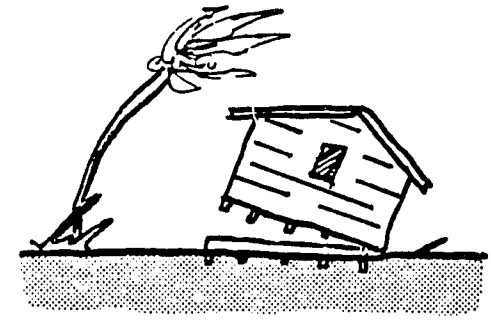
4. Roof: The preferred roof covering for wooden houses is zinc. Thatch is only used on a few houses in very remote areas.

5. Size: Sizes vary from 3 x 5 meters to 5 x 15 meters.

6. Vulnerability: The damage caused by Hurricane David consisted mainly of roof separation and displacements caused by a lack of diagonal reinforcements in the walls. In those houses which have louvered windows, a high percentage also showed damage caused by the differential in pressure pushing out on the walls until portions of walls separated at the corners. This type of damage was especially prevalent along the south coast.

Many wood frame houses rest on concrete slabs and are anchored in the ground only by the corner posts of the frame. During the hurricane, this proved to be insufficient anchorage and many houses with strong roof-wall connections and other proper detailing were lifted out of the ground and toppled over.





7. Weak Points: Typical weak points of wood frame houses are the connections between the roof sheeting and roof trusses, the connections between the roof trusses and the walls, and the anchoring systems.

8. Modifications for Wind Resistance: The following actions are recommended in order to improve the structural performance of wood frame houses in high winds:

   -- Use a hipped roof configuration.

   -- Use more nails to secure the roofing sheets to the roof frame or truss.

   -- Use metal straps to secure the roof trusses to the walls.

   -- Reduce the overhang to 18" (46 cm.) or less.

   -- Seal the eaves of the house to prevent the trapping of air under the overhang.

   -- Board up louvers during periods of high wind.

   -- Place diagonal braces in the corners to reinforce the house at these points.

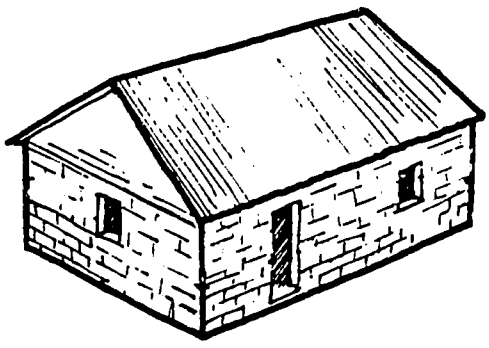
   -- Anchor the structure securely by placing anchoring devices on all columns placed in the ground.

   If these recommendations are carried out, the potential for this type of structure to resist high winds will be substantially increased. If properly built, this type of structure will provide moderate safety in hurricanes.

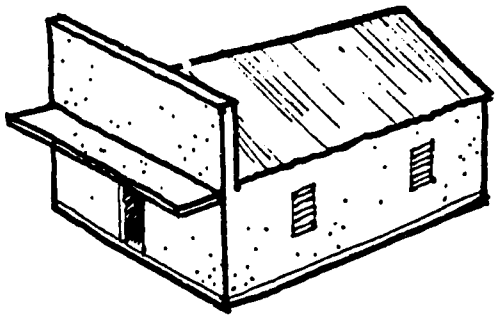
9. Modifications for Earthquake Resistance: The earthquake resistance of wooden frame housing is very good, and by following the recommendations above, the margin of safety will be increased. The only major type of damage that should occur in an earthquake would be collapse of the structure at the base due to deterioration of the wood columns. Diagonal bracing and the treatment of all wood in or on the ground would make earthquake damage almost negligible.

F. Concrete Block Housing

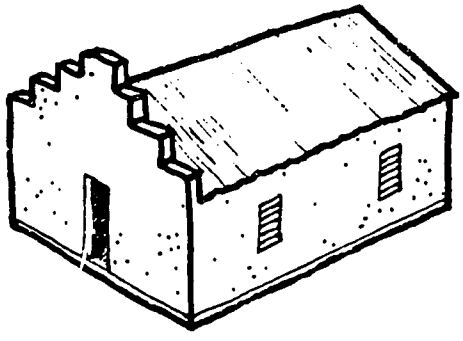
1. Basic Configurations:



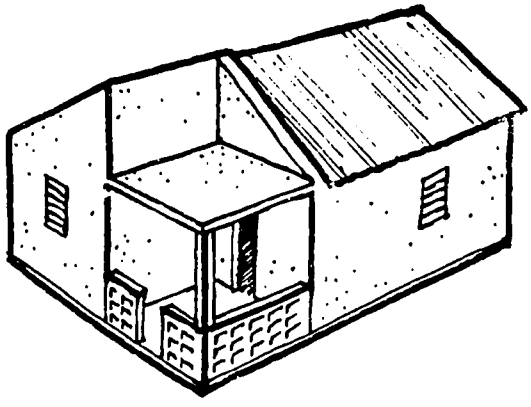
A



B



C



D

2. Location: Nationwide

3. Construction: Concrete block is potentially one of the safest materials in terms of resistance to both high winds and earthquakes. If properly reinforced, a concrete block house can withstand the tremendous forces of earthquakes and windstorms.

The reinforcement normally used for block houses in the Dominican Republic is the placement of iron reinforcing rods vertically in the corners and walls at various intervals and horizontally at the top of the walls. These are anchored in a foundation made by cementing a rock base in the ground on which the walls rest.

The strength of any block house depends on the amount of reinforcement at the corners, the amount of vertical and horizontal reinforcing in the building and whether the house is properly balanced.

4. Roof: The roofs of most block houses in the Dominican Republic are covered with zinc. These sheets are attached to wood purlins which are fastened to the walls by bending a portion of the iron rebar used in the reinforcing columns or ring beam around the base of the truss. Roofs almost always use a gable configuration.

5. Size: Concrete block houses are found in many various sizes. The smallest are approximately 3 x 5 meters with the larger approximately 5 x 8 meters.

6. Vulnerability: The principal damage to a simple block house would be the separation of the roof from the wall (due to a poor connection of the roof frame to the wall) and, in some cases, damage caused by the wind pushing against an unreinforced or poorly reinforced wall, causing collapse due to excessive wind pressure on the outer surface of the wall. In those cases where houses use louvered windows, excessive pressure can build up inside the house with the walls being forced outward.

7. Weak Points: Many block houses in the Dominican Republic have rather ornate facades and concrete porches on the end of the house facing the street. While these entryways are both aesthetically and climatically pleasing, in both high winds and earthquakes, these entrances are dangerous. The porches permit excessive amounts of wind to create uplift under the gable end of the house (thereby lifting the roof off the structure). High winds or earthquakes can topple the false facades either onto the roof (collapsing the portion near the door) or in front of the house (collapsing the concrete awning and endangering the primary exit of the house). In extreme cases, the facades could pull away the end walls and precipitate collapse of the entire structure.

8. Modifications for Wind Resistance: In order to improve the structural performance of concrete block housing in high winds, the following actions are recommended:

   -- Use a hipped configuration for the roof.

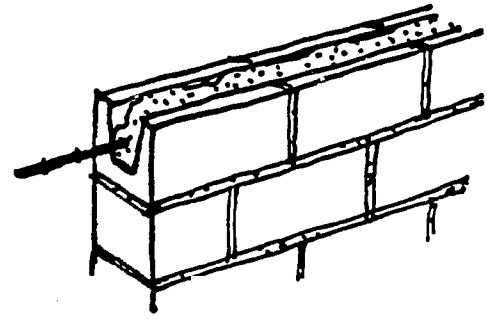
   -- Use a roof pitch between 30° - 45°.

   -- Increase the number of nails used to attach the metal sheets to the roof frame.

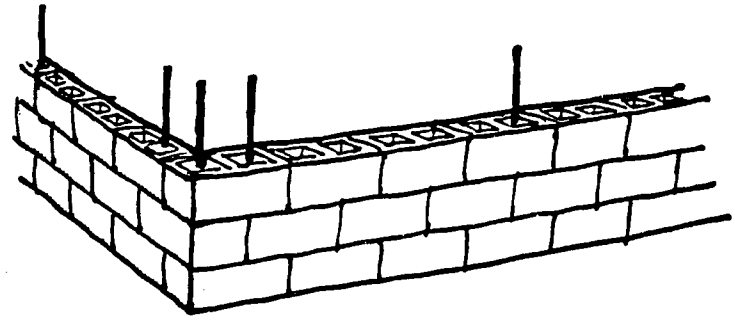
   -- Seal off the eave of the roof and reduce the overhang to less than 18" (46 cm.)

-- Fasten the wooden roof truss more securely to the ring beam of the walls by using special anchors, and double the number of anchors on each connection.

-- Reinforce the center of the wall horizontally with a ring beam made by cementing iron rebars in a course of "U" shaped blocks.



-- Use vertical reinforcing rods at an interval no greater than 80cm. and grout fill block cores.



-- Design front porches so that they are structurally independent of the roof and can break away without further damaging the roof of the house.

If the recommendations outlined above are incorporated into the design of concrete block houses, the wind resistance of the structures will be excellent and only minor damage should occur in future storms.

9. Modifications for Earthquake Resistance: The recommendations above also apply to construction of earthquake resistant housing. In order to be earthquake resistant, special attention needs to be given to the reinforcing of columns and ring beams of the structure. The building features in "B" - "D" above would be extremely dangerous in an earthquake and should be avoided in the more active seismic zones.

VULNERABILITY ANALYSIS OF HOUSES BUILT OF MIXED MATERIALS

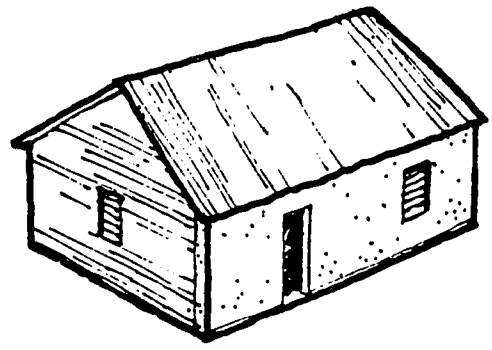
In any community, it is common to find variations of housing styles which display a mix of the basic building types. This is especially common in towns and peri-urban areas and along major roadways where different cultural and economic influences converge.

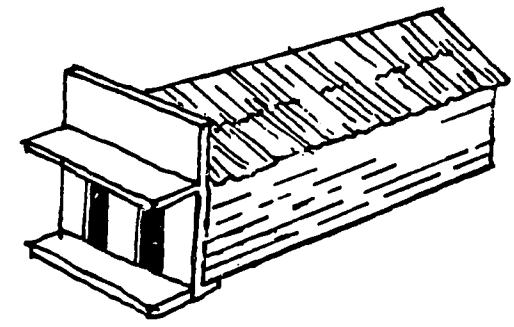
The mix of building styles often represents an evolutionary change in the buildings, with lightweight, less durable materials being replaced gradually by heavier, more permanent materials. Moreover, this style of building often represents an attempt by the homeowner to demonstrate economic achievement by using a more prestigious building material.

The following is a summary of characteristics of the most common mixed structures and their vulnerability.

A. Wood Frame Houses With Concrete Block Facades

1. Basic Configurations:





2. Construction: This type of construction is the most popular mixed building type in the Dominican Republic and is especially popular with moderate income families in small towns. There are many variations in the facades, although most all have fairly high cornices extending above the roof line.

This type of construction normally uses sawn timber for both the frame and outer covering. Only rarely is palm board siding used.

The block facade is normally placed on the short end of the building, although in some rural areas it may be placed on the longer side.

Only in a few cases will the house evolve much further than this. Usually, if the owner decides to build a complete block house, the mixed structure will be torn down and completely replaced by the new block building.

3. Roof: The roofs for this type of house are zinc, in a gable configuration. When the facade is placed on the end wall of the building, the peak of the roof may be fastened to the facade.

4. Size: Sizes of these structures vary between 4 x 6 meters to houses as large as 5 x 15 meters.

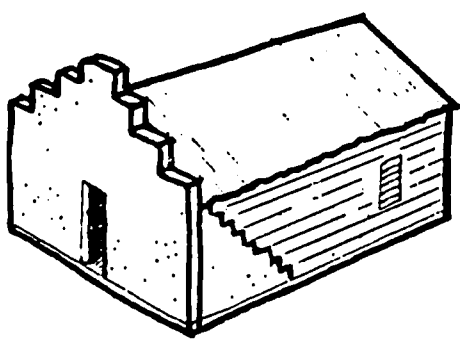
5. Vulnerability: The most vulnerable and dangerous parts of this building are the block wall and the facade above the roof line. In both earthquakes and hurricanes, the facades can collapse. This is especially dangerous because the collapse occurs at the primary exit of the building. Another serious problem is a result of the disproportionate weight of the block wall compared to the wooden walls. If strong forces are applied and the block wall fails, it is likely to demolish the entire structure when it collapses.

6. Weak Points: The typical weak points of this type of construction are: the connections between the wooden walls and the concrete block walls; the connection between the gable facade and lower portion of the wall; the lack of adequate reinforcing in the concrete wall; and the lack of adequate foundations for the concrete wall.

Weak points in the wooden portion of the building include: poor roof-to-wall connections, poor roof-sheeting-to-truss connections, and poor wall-to-ground connections.

7. Modifications for Wind Resistance: Buildings using a combination of materials in this manner are difficult to balance and construct so that they resist high winds. It is unlikely, however, that this type of construction can be prevented. Therefore, the following steps should be taken to improve building performance:

- Build diagonal supports of block to buttress the facades and wall.
- Avoid using excessively high cornices on the facades of the building.
- Do not build concrete porches or overhangs.
- Ensure that an adequate exit is built at the rear of the building (the end opposite the block facade).
- Use adequate iron rebars to ensure that the structural integrity of the facade is maintained.
- Place the facade and its supporting buttress on a strong, solid foundation.
- Increase the angle of pitch of the metal roof to 45° (thus, if portions of the cornice break off, they are less likely to fall into the building).
- Use an "Alamo" (stair-step) facade.



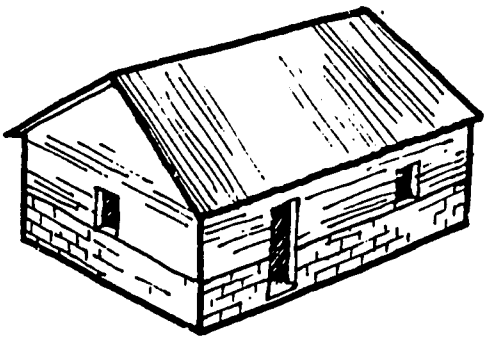
-- Follow the recommendations for improving the wind resistance of wood frame houses.

Even if the recommendations outlined above are incorporated in the design of these houses, the wind resistance of the buildings will be only marginal.

8. Modifications for Earthquake Resistance: These types of buildings are extremely dangerous for areas with high seismic activity. In these zones, this type of construction should be discouraged. The recommendations above will help to make the building less dangerous, but the buildings would not be considered earthquake resistant.

B. Block And Wood Frame Wall Construction

1. Basic Configuration:



2. Construction: This type of building is one of the safest types of buildings in both high winds and earthquakes. It combines the aesthetic and safety features of both block and wood frame houses. If properly reinforced, it can withstand tremendous pressure from high winds. These buildings are rarely subject to failure caused by uplifts. Because of the low center of gravity and the lightweight upper structure of the building, it is particularly resistant to earthquake tremors.

   Block and wood houses are normally built by more affluent low-income families. If the masonry work is good and the wood frame is fastened securely to the block part of the wall, the building will be fairly safe.

   Construction details are similar to both the wood frame and concrete block house. Iron rebars are used to provide wall-to-ground connections and anchorage and to reinforce the wall vertically in the corners and center of the wall. A wood plank is placed horizontally along the top of the last course of block and the iron reinforcing rods are passed through the wood and bent over to fasten the wood frame to the block wall. The remainder of the house is then built of wood in the same manner as a wood frame house. To provide rigidity for the frame, wooden diagonal braces are placed in the corner.

3. Roof: Zinc roofs are used. In most cases, gable configurations are also found.

4. Size: Size varies between 3 x 5 to 4 x 6 meters.

5. Vulnerability: As long as the quality of workmanship is good and the concrete blocks are properly reinforced, these houses are considered fairly disaster resistant.

6. Weak Points: Typical weak points of this type of building are:

   -- The connections between the zinc and the roof frame;

   -- The connections between the roof and the walls;

   -- The connections between the wood frame and the block wall;

   -- The lack of adequate reinforcing in the blocks;

   -- The improper use of mortar to bond blocks horizontally;

   -- Excessive openings under the roof line of the building;

   -- Poor foundations and connections between the foundation and block wall.

7. Modifications for Wind Resistance: The following steps should be taken to secure the roof:

   -- Increase the number of nails fastening the zinc sheets to the roof trusses.

   -- Encourage the use of the hipped roof configuration;

   -- Use hurricane straps to fasten the roof frame to the wall.

   The following steps should be taken to improve the strength of the walls:

   -- Increase the number of connections between the wood frame and the block wall.

   -- Ensure that the blocks are securely fastened to the foundation and adequate rebars are used.

8. Modifications for Earthquake Resistance: By virtue of their design and construction these buildings are considered earthquake resistant. The recommendations offered above will further enhance their performance. It is important to re-emphasize, however, that the quality of workmanship on this type of building is the most important factor in making the building safe.

ANALYSIS OF LOCAL BUILDING SKILLS

Often the structural integrity of a building during windstorms and earthquakes can be improved substantially simply by improving the quality of workmanship and detailing when the building is erected. In studying the rural buildings of the Dominican Republic, it was striking to note many of the inherent building weaknesses caused by poor workmanship. The low quality of the masonry and carpentry skills of those who erected the buildings should be a major concern of housing improvement efforts.

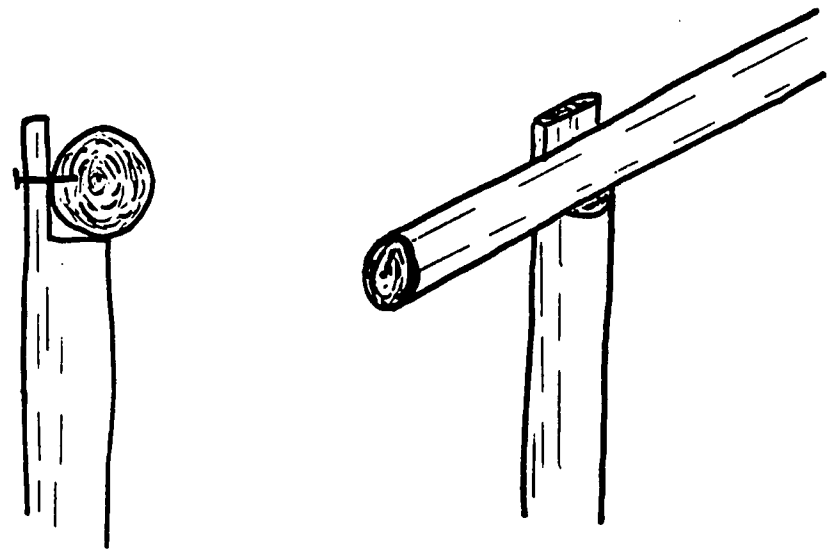
Of particular concern are the following:

A. Vertical Alignment of the Building Frame: Many rural houses that use wood posts are erected with these posts out of vertical alignment. This means that a portion of the weight is off-center when an earthquake or windstorm places additional loads on the walls; thus, the possibility of collapse is increased. While the use of unplaned, rustic wood makes it difficult to completely overcome the problem, certain basic skills can be demonstrated (such as the use of a plumb and lowering the center of gravity) which can help reduce the severity of the problem.

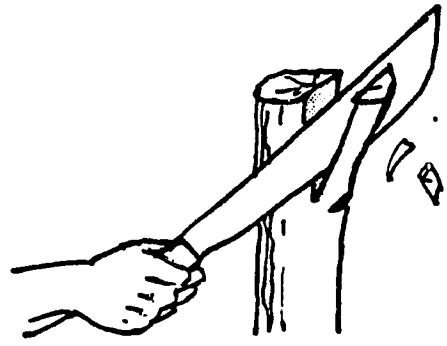
B. Carpentry: Basic carpentry skills are very poor. Areas requiring special attention are:

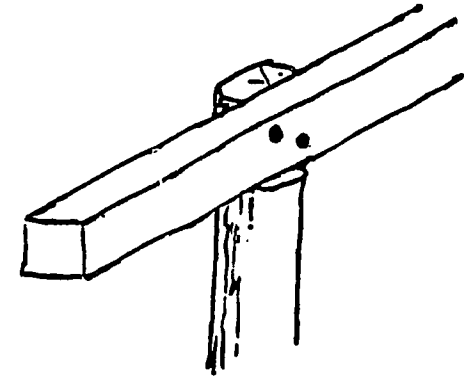
1. Joints: A key problem in many of the wooden joints is the lack of friction between wood pieces. This is especially a problem where whole or unplaned rustic wood is used.

Joints such as the one demonstrated below are common-place.



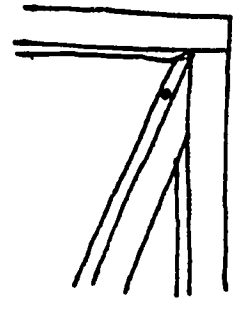
Simple techniques for shaving and squaring the wood to increase the strength of the joints should be demonstrated.

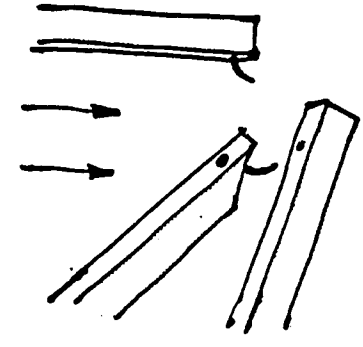




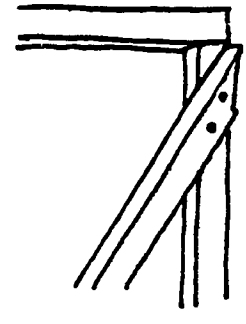
The use of nails is especially poor when one piece of wood is attached to another. Often wood which is structurally important is nailed in tension rather than shear. When forces are applied, the nail will slip out and separation will occur.

NO

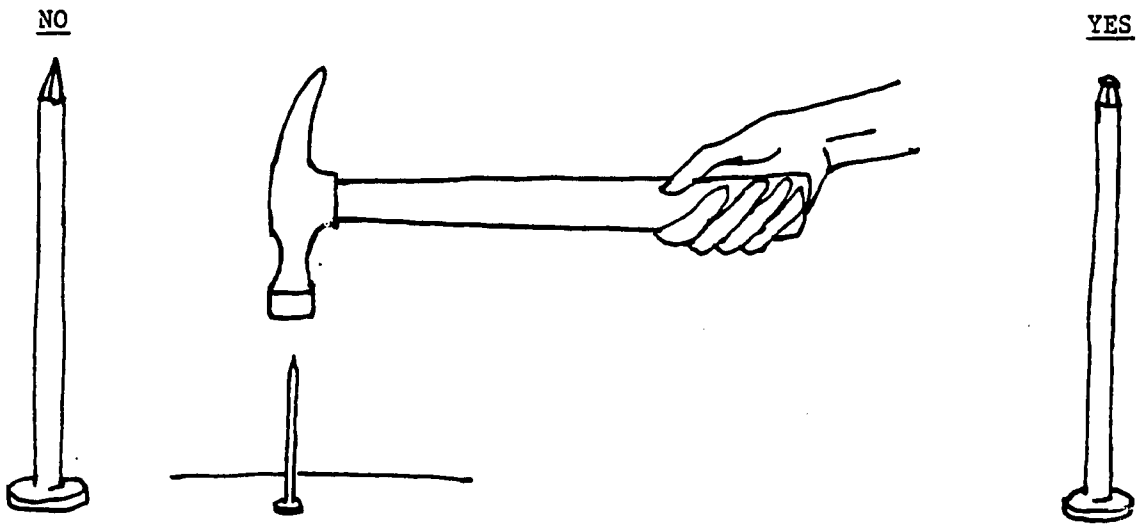




YES

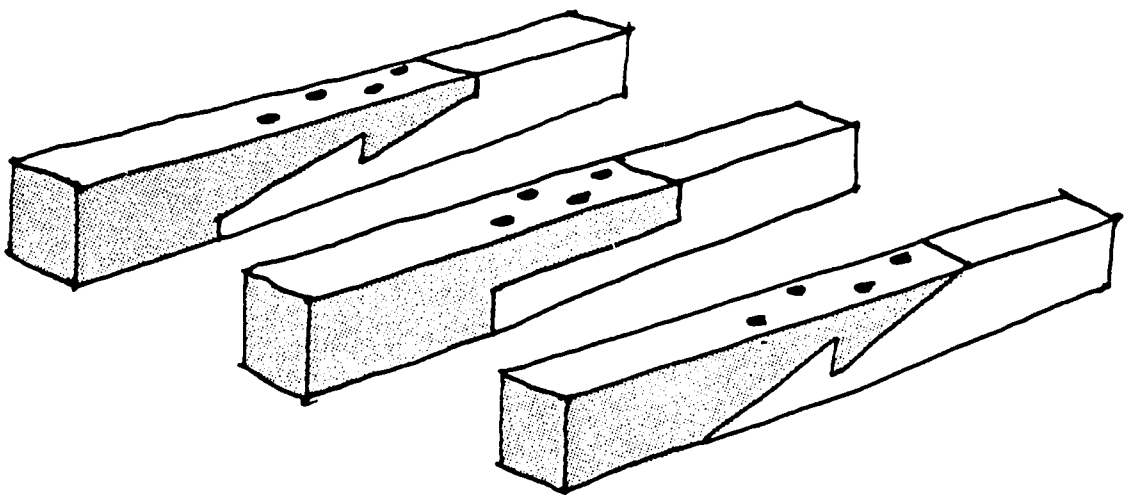


Furthermore, nails are often placed in the wood in such a manner as to split the wood or so that they give little additional strength to the joint. Simple techniques (such as flattening the point of a nail to prevent splitting, the drilling of guide holes, and in-line arrangements) can greatly strengthen the mating of wooden pieces and reduce damage to the wood.



2. Splicing: Splicing (the connection of two pieces of wood to make one continuous piece) is a major problem area, especially in houses which use rustic wood. Many splices are held together only with a nail. Few use joints that would add strength to the detail.

The following splices should be demonstrated:



3. Poor Connections Between Wood and Concrete: A common problem noted throughout the country was the poor quality of connections between wood posts and concrete blocks or concreto armado partitions. Experience from the 1979 hurricanes indicated that many buildings collapsed as a result of these poor connections. In some cases, it was observed that the manner in which the connections were made actually decreased the strength of the walls.

4. Wood Preservation: A problem common to many of the houses built in the last several decades is deterioration in the structural wooden components. Due in large part to the use of softer woods (mentioned earlier), the problem is especially critical where portions of the building frame are placed in the ground. In the recent hurricanes, many buildings sheared off from their footings in the high winds. While additional braces in the wall can help provide stability for the building above ground, unless the wood is properly treated when it is placed in the ground, little can be done to improve the overall resistance of the building to high wind forces.

The problem of deteriorated wood is particularly critical in concreto armado buildings. Failure (due to either high winds or earthquakes) of the wooden supports in the frame of this type of construction could mean that entire panels would separate from the frame and fall in on the occupants.

The cost of wood treatment is relatively minor and many low-cost methods are available. One effective measure is to char the portions of the wood that will be placed in the ground. By burning a protective charcoal barrier around the base, the wood will be protected from insects as they cannot eat through charcoal. Other effective low-cost measures are immersion of the wood in a bath of aceite quemado or crankcase oil (adding an insecticide such as aldrin or dieldrin can further increase the effectiveness of this method) and thorough painting of the exposed surfaces with such commercially available wood treatments as creosote or pentachlorophenol.

C. Problems in Concrete Construction: The strength of concrete is principally a function of the proportions of the materials (aggregates) used in the mix, the methods of making the mix, and the curing process. Serious faults in making concrete in the Dominican Republic are improper mix proportions and poor techniques in preparing the mix.

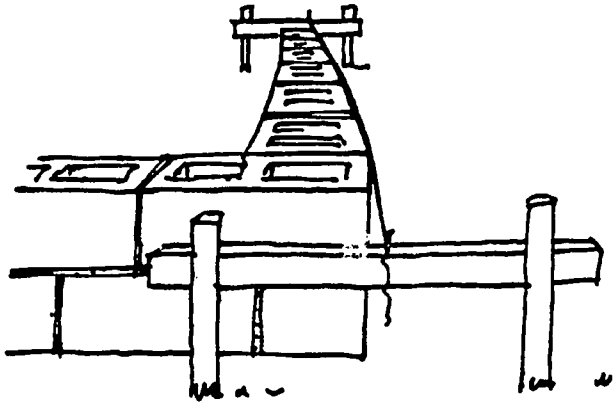
The first problem is a tendency to use less cement in the mixture than is safe for structural purposes. This is done intentionally as a means of economizing on the cost of concrete, but results in weak cement work and components.

A more serious problem is the tendency to use far too much water in the mixture. There are two reasons for this practice. It is felt that the wetter the mix, the easier it is to handle; and some builders assume the wetter mixture is actually stronger.

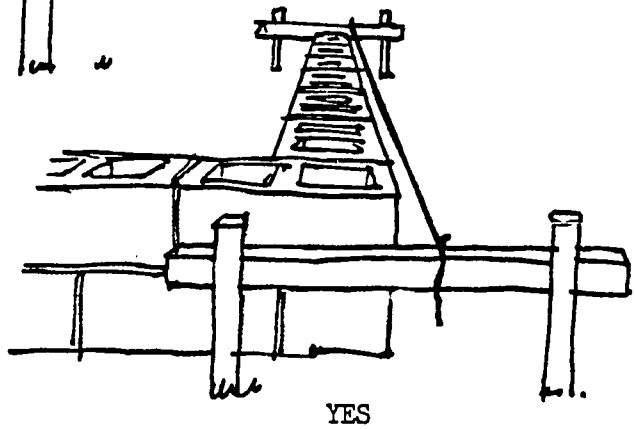
Additional improper practices observed include preparing the mix directly on loose ground (thereby introducing organic matter into the mix which further reduces the strength of the concrete) and the practice of using very dirty water filled with organic matter which also weakens the concrete. These two problems, however, would be relatively minor were it not for the already poor concrete mix.

A practical test which demonstrates proper consistency of concrete mix is the slump test. This and other good practices are presented in the VITA Village Technology Handbook.*

D. Masonry Work: Two problems in the masonry work were consistently noted. The first is that many walls display a slight bulge outward in the center. This is due to the local masons' practice of placing each block on the course immediately adjacent to the guidestring. Thus, each block slightly pushes the string a bit further out and, by the time the course is completed, the wall bulges out slightly from the true course of the line. The proper technique for utilizing a guideline in masonry work should be demonstrated.



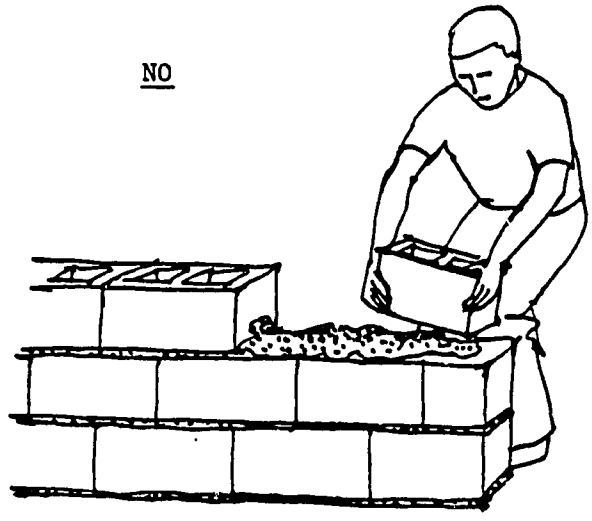
NO

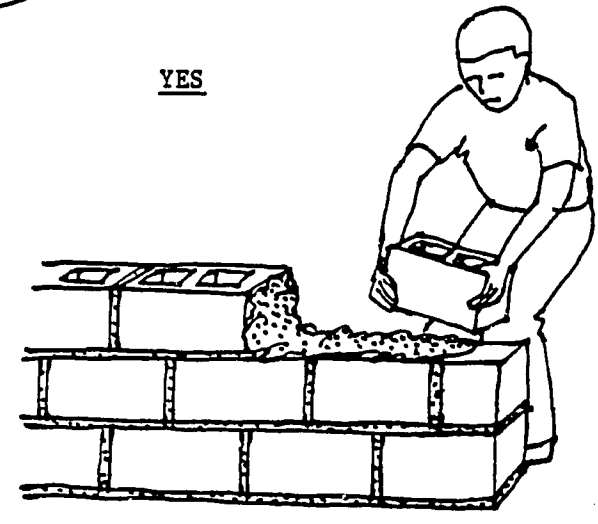


YES

*"Concrete Construction", Village Technology Handbook, VITA, Mt. Rainier, Maryland, 1978, pp. 285-301.

The second problem is the common practice of using insufficient mortar between concrete blocks on the same course. Even in several reconstruction programs initiated after the recent hurricanes, this deficiency was noted.

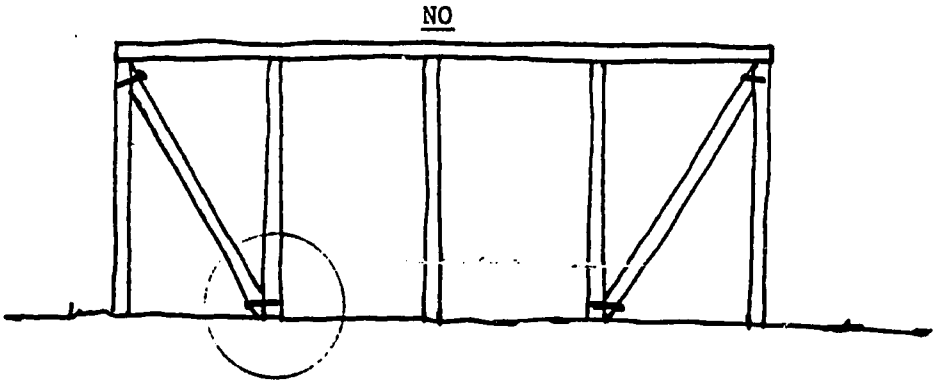


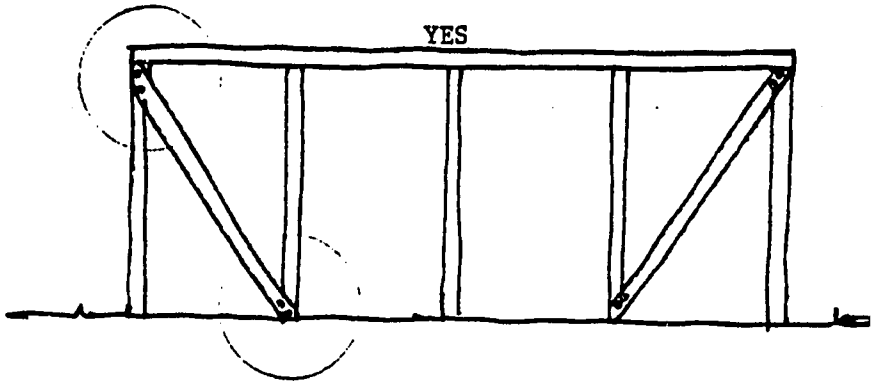


It was the failure of masons to put sufficient mortar between the blocks to bind them together that caused a disproportionately high number of concrete block buildings to fail during the recent hurricanes. In an earthquake, such masonry work would be extremely dangerous.

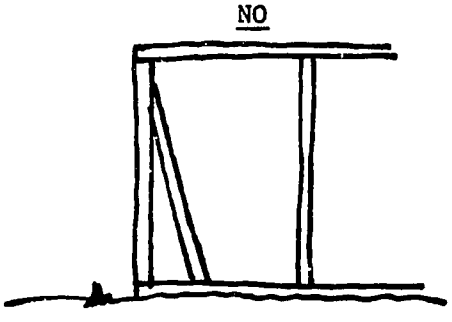
E. Poor Use of Bracing: In almost every type of house, some attempts have been made by the builders to provide structural reinforcement to the building frame and other load-bearing components. Yet, in almost every case these efforts do not provide adequate protection. Common problems include:

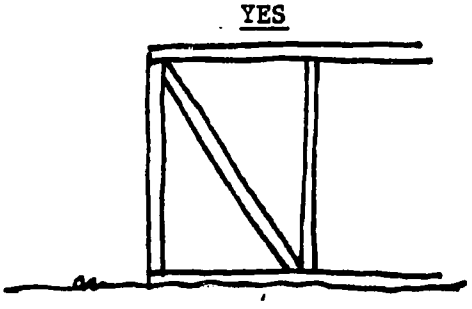
1. The placement of braces in tension held on by nails where they can easily separate.





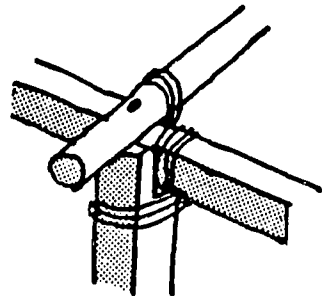
2. The placement of braces at angles which are insufficient to provide adequate rigidity or resistance, and the placement of supports in such a manner that they do not adequately carry or distribute loads.



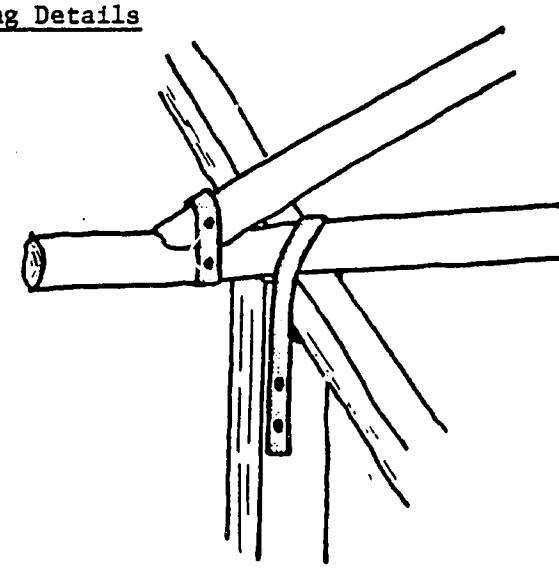


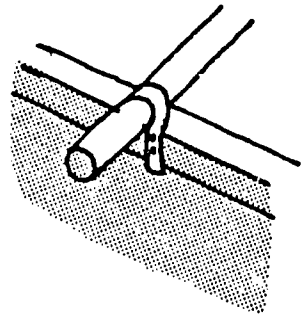
An additional problem was noted in the placement of braces in the roof frame. Often the brace used to support the frame is attached to the peak of the roof and then attached diagonally to the nearest adjacent wall. When forces are applied, this transfers the highest forces directly to one wall, thereby creating asymmetrical distribution of the forces and contributing to the collapse of the wall.

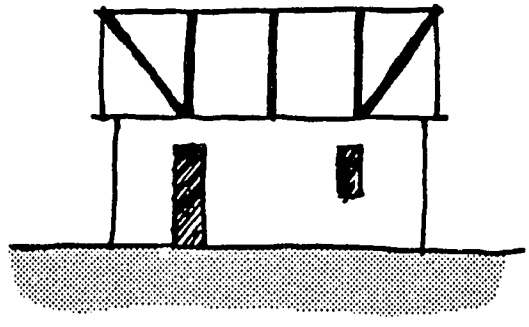
A general explanation of the principles of reinforcement and distribution of loads should be a part of any program designed to improve basic building skills.

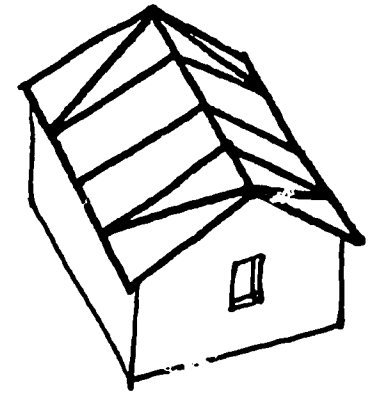


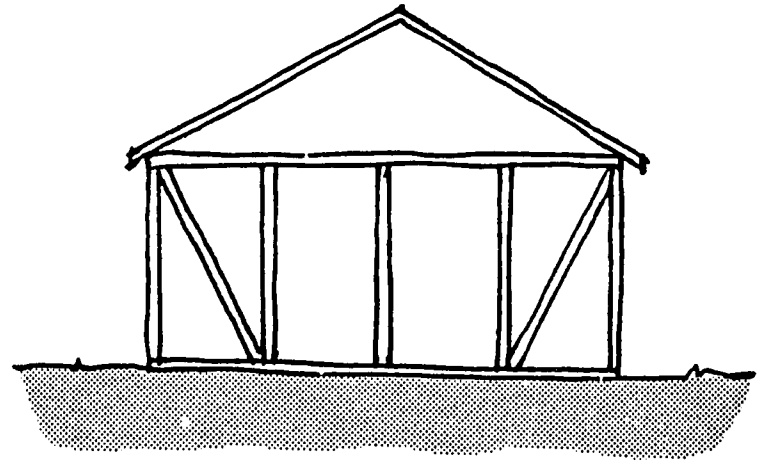
Bracing Details

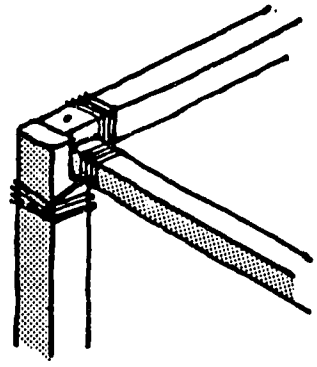


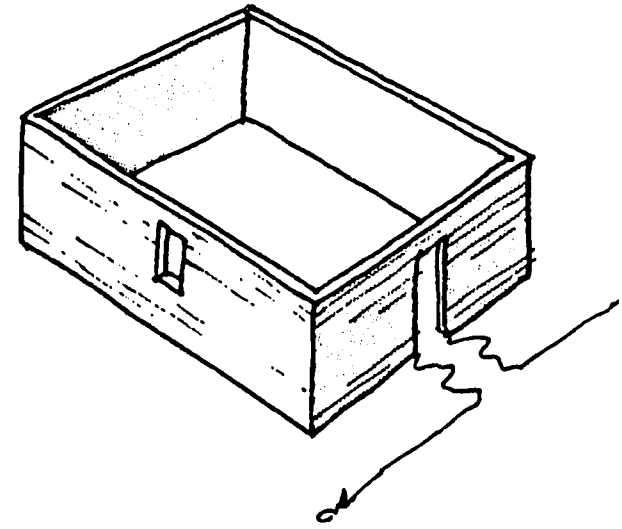


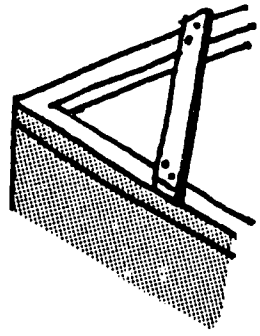


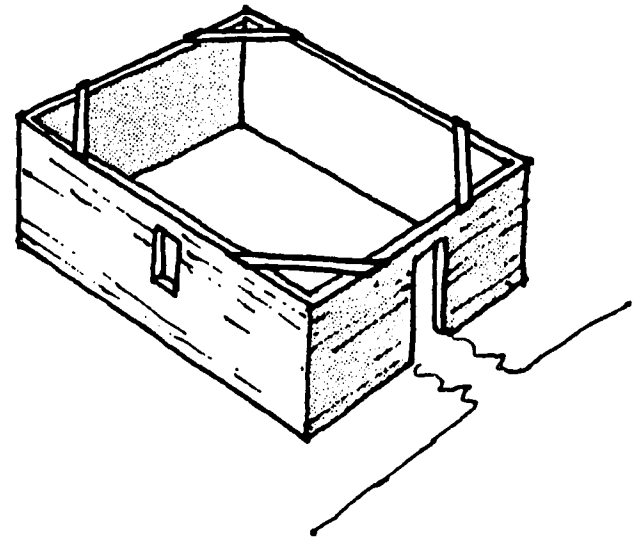












VI. ANALYSIS OF THE POTENTIAL FOR HOUSING MODIFICATION

GENERAL CONSIDERATIONS

Experience has shown that there are economic indicators of the points below which families in certain income groups are unable to participate meaningfully in any housing improvement activities. In order to determine where those points are, and how appropriate strategies can be developed to encourage broader participation at every income level, it is important to identify the reasons why a family will modify or improve their house and under what conditions they will be willing to do so.

An improvement in housing can be viewed as an investment in either time, materials or money in the building. For a family to be willing to make a further investment in its house, they must:

- Perceive a threat to the building or to their safety;
- View the structure as permanent;
- View the structure as having some value.

Housing improvement includes four types of activities. They are:

A. Design Changes: The altering of the design of the structure before it is built to make it more disaster resistant. Design changes are usually the least expensive form of housing improvement but apply only to new construction. For the design changes to become a part of the normal building practice, housing education efforts must be concentrated on the local building tradesmen.

B. Retrofitting: The process of installing additional supports or components to a building already erected in order to strengthen the structural integrity of the building. If the support or component can be attached to the building without reconstruction, the retrofit would be relatively inexpensive; but if a wall must be opened in order to place the component, the retrofit could be rather expensive and difficult. Retrofitting can usually be accomplished on an aided-self-help basis. Education efforts are aimed at the public in general.

C. House Modifications: The altering of the basic configuration of a house once it has been built to make it better withstand external forces. Modification activities could include changing the pitch of the roof, reducing the height of the walls, or adding a room. Housing modification is usually considered expensive and requires extensive technical supervision at each site.

D. Conversion: A change of materials used for the walls or roof of the house. The most common conversions are changes of roof coverings, usually from thatch to corrugated metal sheets, and a change from using rustic wood to sawn boards. Conversions can be a means of improving the durability of a house and its disaster resistance potential at a moderate cost. An opportunity to convert materials has also been shown to be an excellent incentive to participate in housing improvement activities. Conversions can usually be carried out on a self-help basis and aimed at the public in general.

ECONOMIC CONSIDERATIONS

The means of strengthening a house to make it more disaster resistant can be classified according to cost. In general, the four groups of options are:

A. No-Cost Options: These include changes in the design of the building before it is erected which require no additional costs, changes in the materials used, retrofitting the building with locally available materials that can be obtained at no cost (such as cane, bamboo, etc.) or that can be salvaged from other building sites (such as left-over wood, tin sheets, plastic, etc.).

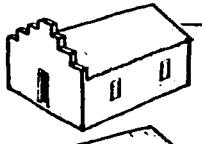
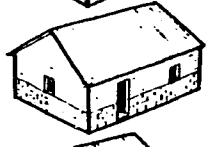
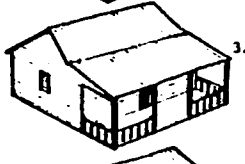
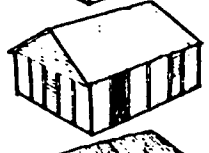
B. Low-Cost Options: These include all of the above plus changes in the design which do require the use of additional, although low-cost, materials; retrofitting measures such as the placement of additional supports or braces to strengthen a wall or roof are also considered low-cost options.

C. Moderate-Cost Options: These include conversions to different materials such as a change of roof, the modification of the design or the house with extensive structural modifications. Generally, moderate-cost options apply to buildings that utilize more permanent materials such as sawn timber, poured-in-place concrete, or concrete block.

D. High-Cost Options: High-cost options include extensive conversion of materials and significant design modifications. Any modifications wherein parts of the wall must be broken into and rebuilt would be considered high-cost options. Likewise, replacement or reconstruction of large portions of the building (such as one wall, a room, or portions of the foundation) would be considered high-cost options.

A comparison of the above factors can provide an indicator as to the most appropriate types of action to initiate for families residing in different types of housing found in the rural areas, and can provide an indicator of the point below which housing improvement activities are no longer cost-effective. This information is summarized in Table 1.

TABLE 1: RELATIVE VALUE OF HOUSING IMPROVEMENTS

TYPE OF BUILDING AND VULNERABILITY RATING* TO HURRICANES (H) AND EARTHQUAKES (E)	THREAT AS PERCEIVED BY OCCUPANTS	RELATIVE PERMANENCY AS PERCEIVED BY OCCUPANTS	RELATIVE INVESTMENT AS PERCEIVED BY OCCUPANTS	TYPE OF IMPROVEMENTS POSSIBLE	PERCEIVED COST OF IMPROVEMENTS RELATIVE TO OCCUPANT INCOME	RELATIVE VALUE OF IMPROVEMENTS AS PERCEIVED BY OCCUPANTS	LIKELIHOOD OF OCCUPANTS UNDERTAKING IMPROVEMENTS WITHOUT SUPPORT	LIKELIHOOD OF OCCUPANTS PARTICIPATING IN ORGANIZED HOUSING IMPROVEMENT PROGRAM
 1. CONCRETE BLOCK								
H - 2-1	H - 1	PERMANENT	HIGH	DESIGN CHANGES. . . .	LOW.	MODERATE	HIGH	HIGH
E - 2-1	E - 1			RETROFIT.	LOW.	HIGH	HIGH	HIGH
 2. BLOCK AND WOOD FRAME WALL								
H - 1	H - 2	PERMANENT	HIGH	DESIGN CHANGES. . . .	LOW.	HIGH	HIGH	HIGH
E - 1	E - 1			RETROFIT.	LOW.	HIGH	HIGH	HIGH
 3. WOOD FRAME WITH SAWN BOARD SIDING								
H - 3	H - 2	SEMI-PERMANENT PERMANENT	MODERATE TO HIGH	DESIGN CHANGES. . . .	LOW.	MODERATE	MODERATE	HIGH
E - 1	E - 0			RETROFIT.	LOW.	HIGH	HIGH	HIGH
				MODIFICATION.	HIGH	MODERATE	MODERATE	MODERATE
4. WOOD FRAME WITH BLOCK FACADE								
H - 2	H - 2	PERMANENT	HIGH	DESIGN CHANGES. . . .	LOW.	MODERATE	MODERATE	MODERATE
E - 3	E - 2			MODIFICATION.	HIGH	MODERATE	LOW/MODERATE	MODERATE
				CONVERSION.	HIGH	LOW.	LOW.	LOW
 5. CONCRETO ARMADO								
H - 2-3	H - 2	SEMI-PERMANENT PERMANENT	HIGH	DESIGN CHANGES. . . .	MODERATE	LOW/MODERATE	LOW.	MODERATE
E - 2-3	E - 1			RETROFIT.	LOW.	MODERATE	MODERATE	HIGH
				MODIFICATION.	HIGH	LOW.	LOW.	LOW
6. WOOD FRAME WITH PALM BOARD SIDING								
H - 3	H - 2	SEMI-PERMANENT	MODERATE TO HIGH	DESIGN CHANGES. . . .	LOW.	MODERATE	MODERATE	HIGH
E - 1	E - 0			RETROFIT W/BRACES, STRAPS, SEAL EAVES. .	LOW.	MODERATE	MODERATE	HIGH
				MODIFICATION.	HIGH	LOW.	LOW.	LOW
				CONVERSION OF ROOF. .	MODERATE	HIGH	LOW.	HIGH
				ROOF PITCH.	HIGH	LOW.	LOW.	LOW
7. TEJAMANÍ								
H - 3	H - 3	TRANSITIONAL	LOW TO MODERATE	DESIGN CHANGES. . . .	LOW.	LOW.	LOW.	LOW
E - 1	E - 0			RETROFIT W/BRACES . .	MODERATE	MODERATE	MODERATE	MODERATE
8. YAGUA								
H - 3	H - 3	TRANSITIONAL	LOW	DESIGN CHANGES. . . .	LOW.	LOW.	LOW.	LOW
E - 1	E - 0			RETROFIT W/BRACES . .	MODERATE	LOW.	MODERATE	LOW

* VULNERABILITY RATING:

1 - Low
2 - Moderate
3 - High

The purpose of this Table is to give the planner an awareness of some of the difficulties that may be encountered in offering housing improvements to occupants of each type of building. A family's willingness to participate in a program will depend on how great they perceive the risk to be and the relative value of putting time and money into improving their house. For example, a family living in a yagua house that is very vulnerable but not too dangerous in a hurricane considers the house to be only an intermediate home and therefore will probably not be willing to invest much in modifying the building, no matter how low in cost the improvements are.

For families residing in the buildings listed on the lower half of the chart, recommendations for improvements to their houses need to be either no-cost or low-cost solutions. Moderate or high-cost solutions will be rejected or require a subsidy. It would be reasonable to expect that, for the 31 percent of the nation's households that earn less than RD$100 per month, a maximum of RD$10 might be available for home improvements. For the 49 percent of households earning between RD$101 and RD$300, perhaps as much as RD$50 could be available for home improvements.

MATERIAL CONSIDERATIONS

The willingness and ability of families to improve their housing may be dependent upon the availability, and continuing availability, of the materials and components necessary at an affordable price. Ideally, housing improvements that are advocated for a particular type of building should be the no-cost options for the specific type of structure. There are, however, points beyond which safety cannot be reasonably assured without additional components which must be obtained at some degree of cost. Whether or not this cost is affordable to the homeowner is relative to the economic status of the family. What may be a high-cost option for people residing in one type of building may be a low-cost option for others.

Housing program planners can use the provision of increased access to highly desirable materials or components as an incentive to encourage housing modification. For example, for an opportunity to obtain corrugated metal roofing sheets at a subsidized price, the owners of houses with thatch roofs may be willing to purchase other low-cost components, such as hurricane fasteners, to further strengthen their buildings. In other cases, a price reduction for a particular material may be enough incentive for people to acquire and use the material.

Program planners should consider a variety of methods for reducing the cost of building materials in the rural areas. Among the various possibilities are:

-- Subsidies

-- Collective purchases

-- Local manufacture

-- Material trade-ins (purchase by the housing agency of materials such as wood that are being replaced)

-- Payment of transport costs

Table 2 lists the materials that would be needed in housing improvement programs and summarizes some of the factors concerning their use. The Table is designed to show which materials can be used with each type of building and, more importantly, what the current availability and costs are. Two important columns to compare are "D" (Type of House) and "G" (Relative Cost of the material to the occupant of that type of building). From the chart it can be seen that, even though some materials (e.g. the iron rebar that could strengthen a concreto armado building) may be low-cost to a housing agency, the relative cost to the homeowner would be fairly high and thus would probably require a subsidy under a housing improvement program.

It should be remembered that, when a new building material or component is introduced, its acceptability may be dependent upon its continued availability. Many housing improvement efforts have failed because inadequate attention was given to establishing a permanent marketing system for key materials and components.

TABLE 2: MATERIAL CONSIDERATIONS

MATERIAL OR COMPONENT (A)	USE (B)	USE AS A HOUSING IMPROVEMENT MEASURE (C)	TYPE(S) OF HOUSE (D)	CURRENTLY IN USE (E)	POPULARITY (F)	RELATIVE COST (TO USERS) (G)	POSSIBLE COST REDUCTION MEASURES (H)	AVAILABILITY (I)	COMMENTS (J)
1. CONSTRUCTION WIRE	To fasten roof to walls and strengthen connections in wood joints	Can be used in new construction and as a retrofit measure	Yagua Tejamanil Concreto Armado Wood Frame	Moderate Yes Yes Yes	High High High High	Moderate Low Low Low	Collective purchase; subsidy	Good in all areas	
2. BARBED WIRE	To reinforce concreto armado	Additional wire can strengthen panels in new construction	Concreto Armado	Yes	High	Moderate	Collective purchase; subsidy	Good in areas where used	
3. HURRICANE STRAPS (Self-made)	To fasten roof frame to wall	Can be used in new construction and as a retrofit measure	Tejamanil Wood Frame Concreto Armado Concrete Block	Limited mainly to houses built after 1979 hurricanes	Low Low Low Low	Low Low Low Low	Provide free	Good	Many straps currently in use are improperly fastened.
4. HURRICANE FASTENERS (Commercial)	To fasten roof frame to wall and to strengthen roof trusses	Can be used in new construction and as a retrofit measure	Wood Frame Concreto Armado Block	Limited No Limited	High ---- High	Low Moderate Low	Collective purchase; provide free	Poor	Not now commercially available, but could be manufactured as a cottage industry.
5. GUSSETS	To strengthen wood joints and splices	Can be used in new construction and as a retrofit measure	Wood Frame Concreto Armado Block	Limited No Limited	Moderate ---- Moderate	Moderate Low Low	Collective purchase; subsidy	Poor in rural areas	Available in cities; could be manufactured as cottage industry.
6. WOOD PRESERVATIVES	To reduce deterioration of wood in the ground	Should be used in new construction and to treat wood replacing existing posts	Yagua Tejamanil Concreto Armado Wood Frame	No No Limited Yes	---- ---- High High	Moderate Moderate Moderate Low to moderate	Collective purchase; subsidy; provide transport	Poor in remote rural areas	Increased use nationwide should be promoted. Especially critical in concreto armado frames.
7. WOOD (Rustic or salvagable)	For building frame, roof frame, supports and braces, and siding	Needed for new construction and for reinforcement of existing buildings	Yagua Tejamanil Concreto Armado Wood Frame	Yes Yes Yes Yes	High High High High	Low Low Low Low	None required	Fair in all areas but the southwest	
8. WOOD (Sawn timber boards)	For building frame, roof frame, supports and braces, and siding	Needed for new construction and for reinforcement of existing buildings	Tejamanil Wood Frame Concrete Block Mixed Construction	Limited Yes Yes Yes	Moderate High High High	High Moderate Moderate Moderate	Subsidy; provide transport	Poor in southwest, east	Wood costs are inflating rapidly as local forests are depleted.
9. CEMENT	To make blocks, mortar for block houses, and concrete for concreto armado wall panels	Needed for new construction and for reinforcement of masonry work on many existing buildings	Concreto Armado Block Mixed Construction	Yes Yes Yes	High High High	Moderate High High	Collective purchase; subsidy Pay transport costs	Good in all areas	
10. IRON REBARS	To reinforce concrete block and concreto armado	Used in new construction, modifications, some retrofitting	Block Concreto Armado Mixed Construction	Yes Limited Yes	High Low High	Moderate High Moderate	Collective purchase; subsidy Provide transport	Poor in remote rural areas	Increased usage to reinforce concreto armado panels should be promoted.
11. BLOCK	Used in wall construction, to build buttresses for block facades	Used in new construction and to modify existing buildings	Block Mixed Construction	Yes No	High ----	High Moderate	Local manufacturing subsidy; reduce size of block	Good in all areas but cost increases with distance from capital	Many modifications to the basic block can be introduced to strengthen block housing.

PARAMETERS OF TECHNOLOGY TRANSFER

The successful transfer of housing improvement technology, and its continued use as a part of the normal building process after the technology transfer efforts have ceased, are dependent upon several factors. These are:

A. The Overall Context in Which the Changes are Presented: In most cases, changes to housing will not be accepted solely on the basis of a perceived threat of disaster. In order for changes to be acceptable, they must have broader benefits. Among the possibilities are:

- Reduction of construction costs
- Reduction of maintenance costs
- Prolongation of the life of the building
- Increased value of the building

When introducing change, these other benefits must be emphasized as strongly as the safety aspects.

B. Compatibility With the Local Building Process: Any improvements must be compatible with traditional building processes. Not only must they utilize the materials already in use and familiar within the community, but they also must be implementable within the range of skills and tools available to the local building craftsmen.

C. Cultural Acceptability: Housing improvements must fit within a broad context of cultural acceptability. To an extent, this is where appropriate technology becomes important. Changes being introduced must not only be desirable and of value to the people; they must be appropriate within the cultural context of the community.

The cultural acceptability of an innovation is often difficult to determine. Housing planners should remember that a family's house often represents more than shelter. For example, in terms of function, it may be used for storage of tools, materials, or harvest; in terms of status, it represents a family's place in the community. Thus, any changes that are introduced must be viewed against this background, and promotional efforts must emphasize compatibility with the existing traditions and each family's aspirations.

D. Motivation: Motivation is an additional factor relating to overall acceptability of housing improvements to increase safety. If people do not perceive some degree of danger from a natural disaster, they are unlikely to be willing to undertake any measures to improve safety.

During this study, it was observed that owners of houses on sites that were obviously vulnerable to high winds were very conscious of that vulnerability. In the southern coastal towns as well as on the northern coast, people were aware of the risk from hurricanes, while persons in the central mountain zones were concerned also with the possibilities of landslides and flash flooding.

Throughout the country, however, there is not a widespread concern about seismic risk or vulnerability. Even among building professionals, there appears to be little concern or awareness of the seismic threat. Because damaging tremors have not occurred in recent history, convincing the average person that such a threat exists will be difficult. Therefore, most housing improvement efforts should concentrate on the potential for improving the wind resistance of buildings and should emphasize the use of those construction techniques which will improve both wind and earthquake resistance.

E. Promotional and Educational Approach: Housing improvement activities should use a variety of promotional and educational approaches. The methods chosen must be compatible with the ways in which persons in that particular society normally acquire knowledge. For example, formal classroom teaching is an ineffective way of teaching persons who do not have extensive experience in that environment.

The level of literacy, especially among the adults of the western half of the country, is quite low, in many cases well under 50%. Most who have attended school dropped out by the fourth year and have had little opportunity to practice the skills acquired through a formal education. Most learning takes place by word of mouth or by apprenticeship. Because the persons in these areas acquire most of their knowledge through visual experiences, the most effective media for transfering information will be films and slides. For large group presentations, posters and pamphlets that depict the information in pictures will be the most effective.

In the construction trades, carpenters and masons learn their skills through apprenticeship. They work for other carpenters or masons until they have learned the trade well enough to go out on their own. In the traditional apprentice arrangement, there is no formal classroom training.* Because the

---

*It should be noted, however, that there are regional vocational training schools for high-school-age students. These are in the larger cities of the country and are run by the army. The courses include training in construction skills. But few graduates of these programs return to the rural areas as, once they have acquired new skills, they are more likely to migrate to the city.

skills required to become a mason or carpenter of traditional building can be acquired through demonstration and practice, there is little reason to expect carpenters or masons to be any more literate than the average adult in these rural areas.

The implications of these findings are:

1. For general promotional activities, non-formal promotional means will be necessary.

2. The training and instructional activities for building tradesmen should approximate as nearly as possible the traditional setting for learning. This means that full-scale building activities should be undertaken and that information about how to build better components or building details should be demonstrated through the use of models. (Full-scale models of joints are suggested, and scale models of houses demonstrating correct placement of braces are recommended).

F. Available Time: Housing improvement activities must be timed to coincide with periods when people have the time to devote to construction and with a time of year when construction will not be hindered by climate or rains.

In rural areas of the Dominican Republic, there is a time between planting and harvest that is generally free. It is referred to as tiempo muerto and the timing varies slightly depending upon the crop. This time is the best for conducting a housing improvement program.

G. Critical Mass: In order for a change to become an established norm in local building practice, a certain minimum number of families must utilize the improvements in their houses. This number is critical for two reasons. First, few families in traditional societies like to have a house which is "different"; therefore, building or installing modifications to a significant number of houses lessens the reluctance to be first. Second, in order for local craftsmen to continue a new practice, it must become routine, and the various adaptations required by different structures, materials and circumstances must be worked out. By using new or modified techniques in a fairly large number of buildings, the craftsmen are provided with adequate opportunities to work out these details, and using the new methods becomes routine.

The actual number of buildings required to attain this "critical mass" cannot be precisely determined and varies depending on the community, location, and type of improvement that is being proposed.

As a general rule, in larger communities where housing is fairly concentrated and communities are fairly close-knit, approximately 5% of the buildings should be modified in order to initiate a continuing process. In areas where the housing is more dispersed and there is less communication between families, the required percentage would be much larger. In these areas, program planners should concentrate on houses in highly visible locations (for example, along major roads or pathways, or near where people gather periodically for events such as weekly markets).

VII. RECOMMENDATIONS FOR A COMPREHENSIVE PROGRAM FOR HOUSING IMPROVEMENT

The following is a suggested plan for a comprehensive set of activities designed to improve housing in the rural areas of the Dominican Republic, to introduce safer construction techniques, and to establish these techniques as a part of the normal building practice.

The quality of housing in the rural areas can be upgraded. Interest is high throughout the country and the recent hurricanes have given added emphasis to the need for change. Thus, a comprehensive program of housing improvement can have a substantial impact.

OBJECTIVES

The overall objective of the Housing Improvement Program is to increase the level of safety in rural housing in specified priority areas which are most vulnerable to hurricanes and earthquakes.

Specific objectives include:

A. The introduction and establishment of safer building methods which are affordable to the majority of homeowners living in each of the primary types of buildings found in the rural areas.

B. The creation of a "critical mass" of houses which utilize the new building techniques, in order to establish the continuing use of these techniques and procedures.

C. The improvement of traditional housing in such a manner that the overall cost of housing to the homeowner can be reduced.

D. The establishment of a focal point for housing improvement activities and a repository of technical resources within the government so that housing improvement activities can be perpetuated.

GOALS

The overall goal of the Housing Improvement Program is to reduce the level of vulnerability, and the number of homes specifically vulnerable to different types of disasters, to a measurable extent within a five-year period. Specific goals for each community include:

A. Modification to a safe minimum standard of 10% of the new housing built in the selected target communities within a five-year period.

B. Retrofitting of 20% of the existing rural housing in the selected target communities within a five-year period.

C. Establishment of selected cottage industries to produce and supply components required for modification and retrofitting of the rural housing in that area.

D. Establishment of a National Housing Information Center with a reference library and the capability of providing technical assistance to implementing agencies as well as responding to requests from the public for information about improving traditional houses in the rural areas.

METHODOLOGY

In order to implement housing improvement activities, a four-phased program is recommended.

A. The first step is to select and capacitate the organizations that will implement the program. Because the activities should commence simultaneously in scattered locations, it will be necessary to identify a number of organizations that can implement the proposed activities. These groups in turn will be responsible for promotional activities and for training builders in their assigned communities. Thus, specific training must be given to the implementors in how to promote and demonstrate the housing improvement technology and how to train the builders.

B. The second step is to develop financial strategies to aid those who will require financial assistance in order to build or modify their houses. Specific activities should be aimed at involving the institutions that provide loans or financial assistance, and methods for lowering the cost of building materials in the rural areas should be explored.

C. The third step is to train local builders in how to use the safer building techniques. This will require a combination of training approaches, including:

1. Theoretical training;

2. "Hands-on" practical training;

3. Construction of model houses;

4. After the initial training, opportunities for building with the new skills acquired should be arranged so that the builders can practice and develop confidence in their abilities. Limited supervision should be provided.

D. The fourth step is the development of public awareness about the program and the stimulation of a demand for the innovations. The promotional activities should commence as soon as the preparation of the implementing agencies is complete and should be carried out using a variety of public information methods including:

1. Public meetings

2. Posters and billboards

3. Radio programs

4. Programs for school children

Sample media that can be used for information dissemination are:

-- Posters

-- Comic books

-- Standardized cassettes that can be played on local radio stations.

-- Brief films and film strips that can be shown as public service announcements prior to the main features in rural movie theatres.

TARGET GROUPS

In order to increase the effectiveness of overall improvement activities, those groups and institutions that would be most receptive to the new ideas immediately should be identified and promotional efforts should be aimed initially at these groups.

It is recommended that housing improvement activities be specifically aimed at the following groups:

A. Young People Between the Ages of 18 - 30: This is the primary group involved in construction of new housing. Promotional activities should stress the long-term advantages of investing in housing improvements, and promotional media should depict the people in this age group.

B. Building Tradesmen: Emphasis should be placed on improving the skills of the building craftsmen. Without their extensive participation in the program, it is unlikely that the ideas will be perpetuated.

C. Voluntary Agencies: There are many voluntary agencies working in the country with varying degrees of experience in the housing sector. It is important that these agencies participate. Efforts should be undertaken to involve the voluntary agencies in all phases of implementation, and they should encouraged to participate in the establishment and continuing support of the National Housing Information Center.

D. Housing Finance Institutions: The Housing Improvement Program should try to help families obtain financial assistance from existing institutions. If adequate safety standards can be developed and met, it is possible that the lending institutions would extend financial assistance to more families in the rural areas. The Housing Improvement Program should ensure that financial institutions participate in the formulation of the overall program, and they should be encouraged to develop innovative financing mechanisms to help new builders willing to use the proposed improvements as well as the owners of existing buildings desiring to retrofit their houses. Specific financial institutions which should be encouraged to participate are:

1. Savings and loan associations;

2. Cooperatives that lend money for housing;

3. Private agencies or foundations that provide money for housing;

4. Other private institutions which finance housing.

IMPLEMENTATION AND COST REDUCTION STRATEGIES

In order to make housing improvement activities more desirable, and thereby increase participation, a number of cost reduction strategies and incentives should be explored. The following are recommended.

A. Cooperative Activities: One of the best means of lowering the cost of housing is for families to cooperate in the construction of new buildings. One method that can be employed is the formation of a group of 4 - 5 families to help each other build. The families collectively pay for the services of a mason or carpenter, trained in new construction methods, to supervise construction. The houses are built simultaneously so that they are all completed at approximately the same time (thereby lessening the possibility that one family would fail to assist the others once their house has been completed). Other forms of cooperative action can and should be developed and encouraged.

B. Increased Financial Assistance: Improving houses to a basic minimum standard may make some families eligible for financial assistance from lending institutions. By working with both the home builders and the lenders, program implementors may be able to arrange loans which otherwise would not be available. Program implementors should be encouraged to develop financial assistance strategies and/or work with the lending institutions in their areas to develop such programs. Possible activities include:

-- Loan guarantees

-- Subsidized loans

-- Soft loans

-- Revolving loans

C. Cost Reduction: In order to enable some families to participate, the cost of materials may have to be reduced. Program implementors should identify those materials which are critical and require cost reduction. The coordinating agency for the program should then help to identify methods that can be used to reduce material costs. Methods for reducing costs include:

1. Payment of transportation costs;

2. Local production of components;

3. Subsidies. In order to promote utilization of components such as hurricane fasteners or other relatively low-cost items, implementing agencies should be encouraged to distribute a limited number of these items free.

D. Use of Incentives: Incentives should be developed to help popularize the innovations and to stimulate demand. Among the possibilities are:

1. The awarding of certificates to builders who have completed the training courses, certifying their competence to build with the new methods.

2. The awarding of certificates or plaques to those houses which have incorporated a specified number of the proposed building improvements.

3. The awarding of plaques to community leaders who are responsible for encouraging a specified percentage of the buildings in their communities to meet minimum safety standards.

4. The designation and awarding of municipal prizes to those communities which attain certain levels of housing safety.

WORK PLAN

The following is a recommended task sequence for a comprehensive Housing Improvement Program:

A. Designate a Central Coordinating Agency: It is recommended that INVI be asked to serve in this role.

B. Prepare the Materials Necessary to Capacitate the Implementing Agencies: (a list of the materials required is provided in Appendix I).

C. Prepare the Instructional Materials Required to train the home builders (a list of the materials required is provided in Appendix I).

D. Develop Preliminary Guidelines for program implementation and minimum standards for buildings.

E. Invite Potential Implementing Agencies to a Workshop wherein the total housing improvement concept is presented and the guidelines and building standards can be discussed and reviewed.

F. Revise and Finalize the Program Guidelines and Building Standards, incorporating suggestions from the agencies.

G. Request Proposals From Potential Implementing Agencies: The RFP should permit flexibility, yet encourage the implementors to follow the guidelines and standards developed earlier.

H. Select the Implementing Agencies.

I. Conduct a Training Workshop for the Implementing Agencies' Housing Personnel: Training should stress use of the modification techniques, how to train home builders in these methods, and how to promote adoption of the methods to the general public.

J. Conduct a Workshop for Financial Institutions to acquaint them with the Housing Improvement Program and to encourage their participation.

K. Establish a National Housing Information Center: The Center should be organized with a complete technical reference library and should be staffed with personnel who can assist program implementors with specific housing problems. The Center should serve as a link to the professional and technical resources within the country and should serve to stimulate research and appropriate technology activities in support of the Housing Improvement Program.

L. Establish a Program Coordinating Committee: This Committee should be made up of representatives of each of the implementing agencies, A.I.D., and other selected agencies participating in the program. The role of the Committee is to advise and help coordinate activities (not to administer or govern the program).

M. Initiate Implementation Activities: During this stage the implementors commence their training and promotional efforts at the local level, while the central coordinating agency initiates nationwide promotional efforts in support of local activities.

N. Review the Program: The central coordinating agency should conduct periodic workshops to review the progress of the overall program. It is recommended that these be held at least on an annual basis.

DURATION OF THE PROGRAM

It is recommended that the initial program activities should last approximately five years. At the end of this period, continuing support should be provided for the National Housing Information Center. Specific programs of the implementing agencies can be considered on an individual basis.

RECOMMENDATIONS FOR THE INVOLVEMENT OF SPECIFIC GROUPS

A. Financial and Technical Support

1. A.I.D. Mission: Appropriate roles for the A.I.D. Mission in the proposed Housing Improvement Program are:

   (a) To provide technical and financial assistance to the program coordinator (INVI) and to stimulate interest in and support for the proposed activities.

   (b) To support preparation of the training aids required for technology transfer.

   (c) To provide technical assistance to help capacitate the implementing agencies.

   (d) To provide financial support to program implementors.

   (e) To provide financial and technical support to the central coordinating agency.

(f) To provide financial support to the National Housing Information Center.

(g) To provide references for the library of the National Housing Information Center.

(h) To encourage participation of other aid-giving agencies in support of the program.

(i) To serve as a link to technical assistance resources outside the Dominican Republic.

(j) To provide technical assistance to program implementors during field activities.

(k) To assist in overall coordination of the program.

2. Instituto Nacional de la Vivienda (INVI)

Appropriate roles for INVI are:

(a) To serve as the central coordinating agency for the program. In this role, INVI would:

-- Host and chair the coordinating committee.

-- Serve as overall coordinator of the implementing agencies.

-- Host the workshops outlined in the work plan.

-- House the National Housing Information Center and reference library.

(b) To serve as the administrating agency for the overall program.

(c) To serve as the "lead" agency and participate directly in implementation activities.

3. Peace Corps: The Peace Corps is considering an integrated rural development program. Housing improvement activities could easily be incorporated into this program. Other possible roles include support for technical assistance activities, support for training activities, and provision of instructors to help support program implementation efforts at the field level. In addition, the Peace Corps has access to an excellent technical reference library, and many Peace Corps publications could be used in support of the training programs.

B. Possible Agencies for Program Implementation

Each of the following agencies has resources that could aid the overall housing improvement effort, although not all could undertake a complete program in any one area.

1. CARE: Care is currently involved in housing activities and has had extensive experience in the hurricane reconstruction program. CARE worked through FEDOCOOP at the local level and has extensive resources that could be used in support of local activities. CARE is a potential program implementor.

2. CARITAS: CARITAS is currently working in the housing sector and plans to continue to support local parishes. They have teams of promotors and experience in development activities. CARITAS is a potential program implementor.

3. Catholic Relief Services (CRS): CRS was active in hurricane reconstruction efforts and demonstrated many of the building techniques that are suggested in this report. At present, they are not directly involved in housing or technical assistance activities but provide financial support to housing projects in the vicinity of San José de Ocoa. CRS could provide financial and technical support to program implementation efforts.

4. Federación Dominicana de Cooperativas (FEDOCOOP): FEDOCOOP is a large association of coops. Their financial orientation includes housing, and they worked with CARE in reconstruction efforts after the 1979 hurricanes. Possible roles include program implementation and financial assistance to homeowners.

5. Fundación de Desarrollo Comunitario (FUDECO): FUDECO is the Save the Children program in the Dominican Republic. They are doing appropriate technology/integrated development projects and are currently involved in limited housing activities. FUDECO is a potential program implementor.

6. Fundación de Desarrollo Dominicana (FDD): FDD is currently involved in housing activities and plans to continue. They have established teams of promotors in their project areas and have experience in finance and low-cost loans. They are potential program implementors.

7. Instituto de Agraria Dominicana (IAD): IAD is beginning a program of integrated rural development and plans include housing. Possible roles include program implementation and promotion.

8. Instituto de Desarrollo en el Sur Oeste (INDESUR): INDESUR is an arm of the Oficina Nacional de Planificación (ONAPLAN), the government's advocate and coordinator of integrated rural development. Headquartered in Azua, they are potential implementors.

9. Oficina de Desarrollo de la Comunidad (ODC): ODC also has a network of "promotores" whose role is to promote general development activities. Possible roles include promotion of housing improvement at the local level and community organization.

10. Secretaria de Estado de Agricultura (SEA): SEA also has a network of promotors that could assist the program, especially in the Southwest.

11. Secretaria de Estado de Salud Pública y Asistencia Social: The Secretaria has an extensive network of grass-roots-level "promotores" within a "Comité de Salud". Local Comités throughout the country promote general public health measures. These promotors could be used in either promotional or training roles.

12. Servicios Sociales de Iglesias Dominicanas (SSID): SSID is the Dominican development arm of the World Council of Churches. The agency has had limited housing experience but has established teams of promotors in various communities. Possible roles include program implementation and community organization.

13. Others: Other groups that could provide support to housing improvement activities are:

    (a) Colegio Dominicano de Ingenieros, Arquitectos y Agrimensores: technical assistance;

    (b) Desarrollo y Servicio: technical assistance, promotion;

    (c) Food for the Hungry International: technical assistance, implementation;

    (d) Tecnología Apropriada: technical assistance, technical references, assistance in training.

APPENDIX I:

RECOMMENDED TRAINING AIDS FOR A HOUSING IMPROVEMENT PROGRAM

Four separate sets of materials are required for the training activities related to a housing improvement program. Many of the materials and training aids recommended are already available or can be quickly adapted from existing resources. Also, many of the materials can be used interchangeably between sets.

A. Materials Required For Capacitation of Implementing Agencies and Instructors:

1. Concept Paper: A brief paper outlining the goals and objectives of the housing improvement program and describing the role of the agency and instructors in accomplishing these tasks.

2. Curricula for Instructors: The curricula should include course outlines and checklists for each class in the training program.

3. Instructor's Manual: The instructor's manual should include sections on construction techniques, building details, and instructional techniques.

4. Manual on Technology Transfer: This manual should include guidelines for training, including: how to prepare a class; how to effectively demonstrate building details; and how to prepare course outlines for topics not discussed.

5. Instructor's Versions of All Student Training Aids.

B. Materials Required for Training Home Builders:

1. Film - Wind Resistant Construction: A sixteen-millimeter, fifteen-minute film explaining hurricanes and wind forces and how they affect houses should be prepared.

2. "Instrucciones Para Construir Viviendas Mas Seguras y Resistentes" (Instructions for Building More Secure and Resistant Houses): This pamphlet produced by Catholic Relief Services and OXFAM should be used as a primary aid for persons who can read to introduce the basic concepts of wind resistant construction.

3. "Como Construir Una Casa Segura": This pamphlet should be prepared as a simplified version of "Instrucciones Para Construir Viviendas Mas Seguras y Resistentes", using drawings instead of text to convey the information about safe construction. It should be designed to use the same types and styles of drawings used in the film so that it can serve as a "memory aid" to the film.

4. "Casas Rurales En El Huracán: Problemas y Soluciones" (Rural Housing in Hurricanes: Problems and Solutions): this pamphlet, developed by INTERTECT for use with this program, should be used to introduce specific design problems in traditional housing.

5. "Como Construir Una Casa Segura de Madera" (How to Build a Safe Wood House): this pamphlet produced by Catholic Relief Services and OXFAM can be used for those building wood frame houses.

6. "Como Construir Una Casa Segura de Concreto Armado": this pamphlet produced by Catholic Relief Services and OXFAM can be used as a training aid for those building with the Concreto Armado process.

7. "Como Hacer Una Casa Segura de Bloques" (How to Build a Safe House of Blocks): this pamphlet produced by Catholic Relief Services and OXFAM can be used as a training aid for those building with concrete block.

8. "Como Hacer Una Casa Segura de Tejamaní" (How to Build a Safe House of Tejamaní): this pamphlet would be used as a training aid for persons building with tejamaní.

9. "Como Mejorar Una Casa de Yagua" (How to Improve Yagua Houses): this pamphlet would be a guide to simple improvements for yagua houses.

10. "Techniques of Concrete Construction": this pamphlet would be prepared from existing materials available from VITA and the International Office of the Dept. of Housing and Urban Development to demonstrate correct techniques for preparing and using cement and concrete.

11. Flip Charts: These charts would be developed to serve as instructors' aids in the classrooms. Some charts have already been developed by Catholic Relief Services and OXFAM which could be incorporated. It is recommended that these charts be prepared on cloth so that they can be used outdoors.

12. Scale Models of Each Housing Type: A scale model depicting the correct construction for each type of house should be produced. These would show the proper placement of braces and fasteners, and demonstrate correct techniques for joining and splicing wood and other materials.

13. Movable Model House for Demonstrating Principles and Placement of Braces: A model with movable parts should be developed which demonstrates the correct placement of braces. By first applying force to one corner or one side of the model, the mode of failure could be demonstrated. Next, a model brace would be placed in the appropriate place and the in-

creased resistance could then be demonstrated.

14. Model Wood Joints: Wood joints should be made which demonstrate the correct method of joining two or more pieces of wood. These should be full-sized models which can be duplicated by the students in the classes.

C. Recommended Materials for a Retrofitting Program:

1. "Como Mejorar su Casa" (How to Improve Your House): this pamphlet should be developed to guide homeowners in how to correctly place hurricane straps and fasteners and other devices designed to improve the structural integrity of a house.

2. "Instrucciones Para Construir Viviendas Mas Seguras y Resistentes" (Same as pamphlet in group B).

3. "Como Construir Una Casa Segura" (Same as pamphlet in group B).

4. "Como Cambiar Postes" (How to Change Wooden Posts): this pamphlet should be prepared to show the correct techniques for replacing rotten wood.

5. "Guia Para Evaluación de la Resistencia de Una Casa" (Guide to Evaluating Wind Resistance of a House): this checklist should be developed for use by instructors and home owners to evaluate the relative safety of a building. The checklist should be presented in a format using drawings rather than text.

6. Models of Retrofitting Details (attachment of fasteners, straps, etc.): Full-sized models demonstrating proper attachment of reinforcements and retrofitting measures should be prepared for use in classes to demonstrate the techniques.

D. Recommended Materials for Public Awareness and Promotional Activities:

1. Film: The sixteen-millimeter film described in group B should be used to help develop public awareness. A cut version of the film, lasting approximately five minutes, should also be developed as a "short" for use in rural movie theaters.

2. Audio Cassettes for Radio Programs: A series of audio cassettes should be prepared for distribution to rural radio stations describing the Housing Improvement Program and announcing specific activities that are about to commence.

3. Posters: A variety of colorful posters should be prepared to provide notice of housing improvement activities and

where interested parties can obtain information.

4. Safety Game: An effective technique for demonstrating vulnerability is the use of a game which incorporates a simple checklist. People can describe their houses to the person conducting the game, referencing a series of photographs or drawings. They receive points for safety measures taken. The total accumulated points determine whether or not a house is safe. Such a game can be based on a game developed for use in earthquake resistant construction programs in Guatemala.

APPENDIX II:

PROPOSED CURRICULUM FOR INSTRUCTORS

In order to orient and provide basic training to the instructors of the implementing agencies, the following one-week curriculum is recommended. This would be followed by actual construction of model buildings for the practical portion of the training. For a description of the training aids recommended for each segment, please refer to Appendix I.

1. Orientation:

   The orientation program would include a discussion of the overall goals and objectives of the Housing Improvement Program and the role of the implementing agencies and the instructors. The recommended training aid for this segment is the concept paper (A-1).

   Following the introduction, the film on safe construction techniques would be shown. This would be followed by a general discussion of housing improvement methods and means of economically introducing change in housing. The recommended training aid for this segment is the film (B-1).

   At the conclusion of the orientation, the pamphlet "How to Build a Safe House" (B-3) should be distributed.

2. Introduction to Safe Construction:

   A classroom discussion on how to build a safe house would be conducted. Detailed explanations of building techniques would be introduced. Recommended training aids are: the instructor's version of "How to Build a Safe House" (B-3); pamphlets on safe housing construction of particular building types (B-4 - B-9), to be distributed at the end of the class.

3. Introduction to Traditional Buildings:

   Students would be divided according to the type of building in their particular project area, and classes would be presented on that type of construction and how to build safely and/or retrofit that type of housing. Recommended training aid: instructor's version of the pamphlet "Rural Housing in Hurricanes" (B-4).

   The second half of the class would consist of a field trip with walk-around discussions of specific types of buildings. It is recommended that each group be limited to 5-7 students per instructor. During the walk-around inspection, each student would be asked to critique a house for safety. Recommended training aids are: checklists for building safety (C-5); "Rural Housing in Hurricanes" (B-4); and the pamphlet on construction of the specific building type (B-5 - B-9).

4. The same class as above would be repeated for a second type of house.

5. The same class would be repeated for a third type of house (if required).

6. Introduction to Training Techniques:

   This classroom instruction would include: introduction to the curriculum; techniques of instruction; information about which techniques to stress in the classroom and construction activities; introduction to the training aids and how to use them properly; introduction to preparation of classes and course outlines for topics not covered; the techniques of monitoring progress of students. Recommended training aids: Instructor's Manual; Manual of Technology Transfer; and Curriculum for Instructors.

7. Review:

   The final class would review the training procedures with the students. Following this, students would practice their presentation techniques and be critiqued by the program staff.

APPENDIX III:

PROPOSED CURRICULUM FOR HOME BUILDERS

The following curriculum is recommended for the training of home builders. The course would include one week of theoretical training and demonstrations followed by the actual construction of a demonstration house under the supervision of an instructor. For a description of the training aids recommended for each class, please refer to Appendix I.

A. <u>First Week: Theory and Demonstration</u>

1. Orientation:

The orientation would commence with the showing of the film on safe construction followed by a discussion of safe building techniques and opportunities. Training aids: film (B. 1) and posters (D. 3).

At the end of the class, the pamphlets about how to build a safe house (B. 2 - B. 3) would be distributed for review prior to the next class.

2. Introduction to Safe Construction:

The pamphlets about how to build a safe house (B. 2 - B. 3) would be reviewed with the students and followed by general discussion and a question and answer period. The course would follow a specified curriculum to insure that the basic principles were introduced and stressed. Recommended training aids: flip chart; instructor's version of how to build a safe house (B. 3); and the model for demonstrating principles of bracing (B. 13).

At the end of the class, the pamphlet "Rural Housing Problems in Hurricanes" (B. 4) would be distributed.

3. Field Trip:

A field trip to examine local buildings and construction techniques should be arranged as the third class. Students would be shown specific problems in the local housing and would be asked to critique houses themselves. Recommended training aids: instructor's version of the pamphlet "Rural Housing Problems in Hurricanes" (B. 4).

At the end of the field trip, the pamphlets on safe construction for the specific type of housing (B. 5 - B. 9) in that area would be distributed for review prior to the next class.

4. Field Trip:

A field trip to visit a house correctly built, demonstrating the proper construction techniques, would be arranged as the fourth class.

On site, the instructor would point out the specific improvements and the correct placement and construction of each. Recommended training aids: instructor's version of the building guide (B. 5 - B. 9) and model house of the particular building type (B. 12).

5. Detailing (Part I):

In this class, the proper methods of building specific structural components are demonstrated, including:

(a) Better Wood Joints

(b) Use and Placement of Braces

(c) Use and Placement of Fasteners

Recommended training aids: model houses (B. 12); model braces and wood joints (B. 13, 14); and an adequate supply of fasteners, tools and supplies for students to build practice models of the components.

6. Detailing (Part II):

In this class, the proper techniques for preparing and using concrete would be presented. In those areas where students would be building concreto armado houses, techniques for reinforcing and fastening concrete panels would be demonstrated. In those areas where cement block construction would be used, proper masonry techniques would be demonstrated. In those areas where wooden houses would be built, the proper techniques for building concrete footings for wood houses would be demonstrated.

7. Detailing (Part III):

Classes about specific building details used or recommended in a particular area would be demonstrated. Possibilities include: use of plumbs and guide strings for alignment of houses; wood preservation; carpentry techniques, etc.

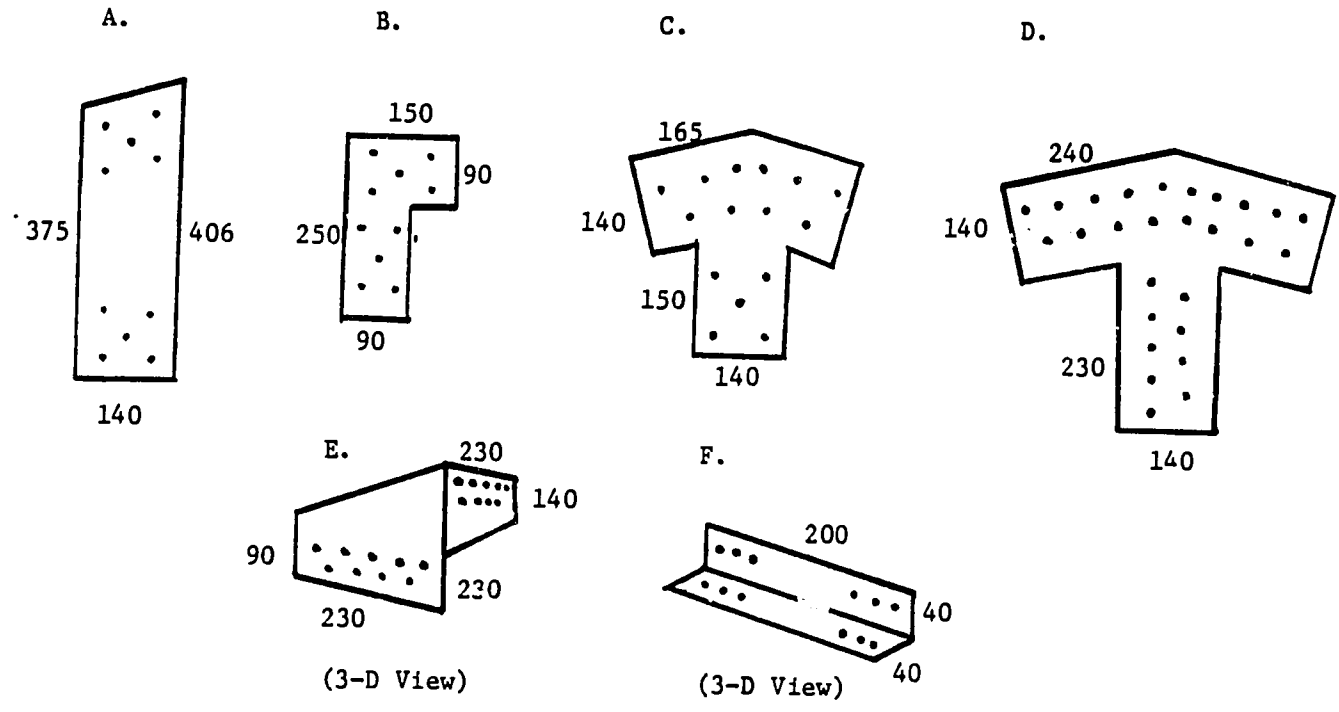
B. Second Week: Actual Construction Practice

Students should participate in the actual construction of a house using the new building methods. Implementing agencies should arrange for construction of model houses. Agencies should submit proposals on how this phase would be carried out as a part of their response to the request for proposals.

APPENDIX IV:

COMMERCIALLY AVAILABLE HURRICANE FASTENERS

The fasteners below are made of rigid galvanised steel and are specially designed for use in low-income houses. They are available from various suppliers in the Caribbean or from Ridout Industries in the U. S. All dimensions are in millimeters.



Types A - E are 4mm thick.

Type F is 2mm thick.

All angles are 15°, 75°or 90°, i.e., for a 15° roof pitch.

All holes in brackets are 5mm in diameter.

Estimated Quantities Required Per House:

	A	B	C	D	E	F	Nails
Moderate-sized house with solid floor	4	8	2	1	2	30	400
Small house with earthen floor	4	8	-	-	2	31	350

APPENDIX V:

SUGGESTED REFERENCES

1. Periodicals:

Disasters: The International Journal of Disaster Studies and Practice, International Disaster Institute, 85 Marylebone High Street, London W1M 3DE, U.K.
(Quarterly devoted to articles and information concerning all facets of relief, pre-disaster planning/mitigation, disaster case studies, etc.)

HABITAT News, United Nations Centre for Human Settlements (Habitat), Kenyatta Conference Centre, Room 1911, P.O. Box 30030, Nairobi, Kenya.
(Official newsletter of the UNCHS reporting on programs and activities of the U.N., governments and non-governmental organizations in the field of human settlements. Includes list of upcoming conferences/meetings, list of publications related to human settlements, project reports, articles on housing and planning issues, etc.)

TAICH News, Technical Assistance Information Clearing House, 200 Park Avenue South, New York, New York 10003.
(TAICH serves as an information clearinghouse on the socio-economic development programs abroad of U.S. voluntary agencies, missions, foundations and other non-profit organizations. This newsletter is an excellent resource for information on overseas development assistance projects, contacts and publications, upcoming meetings and conferences.)

VITA News, Volunteers in Technical Assistance, Inc., 3706 Rhode Island Avenue, Mt. Rainier, Maryland 20822.
(Articles on international information exchange, technology transfer/diffusion, rural development programs, appropriate technology, recent publications, networks and contacts. Excellent reference.)

Hazard Monthly, P.O. Box 34408, Bethesda, Maryland 20034.
(Newsletter devoted to articles and information on natural and manmade hazards. Includes information on workshops and meetings, reports on prevention and mitigation studies, program and system design, etc.)

2. General:

Oliver, Paul, "The Cultural Context of Shelter Provision", Disasters, Vol. 2, No. 2/3, pp. 125-128, 1978.

Snarr, D. Neil; Brown, E. Leonard, "Permanent Post-Disaster Housing in Honduras: Aspects of Vulnerability to Future Disasters", Disasters, Vol. 3, No. 3, pp. 287-292, 1979.

McKay, Mary, "The OXFAM/World Neighbors Housing Education Program in Guatemala Following the February 4, 1976 Earthquake", Disasters, Vol. 2, No. 2/3, pp. 152-157.

Cuny, Frederick C., Scenario for a Housing Improvement Program in Disaster-Prone Areas, INTERTECT, Dallas, Texas, 1978.

Davis, Ian, "The Modification of Unsafe Housing Following Disasters", Architectural Design/7/79, pp. 193-198.

Thompson, Paul, Report on the Post-Disaster Housing Training Program of Catholic Relief Services/Dominican Republic and OXFAM, INTERTECT, Dallas, Texas, 1979.

Vella, Jane K., Visual Aids for Nonformal Education, Center for International Education, University of Massachusetts, Amherst, Massachusetts, 1979.

3. References on Wind and Earthquake Resistant Construction:

43 Rules: How Houses can Better Resist High Wind, NBSIR 77-1197, U.S. Department of Commerce, National Bureau of Standards, Washington, D.C., May 1977.

Building to Resist the Effect of Wind, NBS Building Science Series 100:
- Vol. 1: Overview
- Vol. 2: Estimation of Extreme Wind Speeds and Guide to the Determination of Wind Forces
- Vol. 3: A Guide for Improved Masonry and Timber Connections in Buildings
- Vol. 4: Forecasting the Economics of Housing Needs: A Methodological Guide
- Vol. 5: Housing in Extreme Winds: Socio-economic and Architectural Considerations

U.S. Department of Commerce, National Bureau of Standards, Washington, D.C., May 1977.

Windass, Mark, "The Modification of Low-Income Housing to Resist Wind Following the Andhra Pradesh Cyclone", Appropriate Reconstruction Training & Information Centre (ARTIC), Vijayawada, A.P., India, 1978.

How to Build Storm Resistant Structures, Southern Forest Products Association, P.O. Box 52468, New Orleans, Louisiana.

Sinnamon, Ian T.; van't Loo, G.A., Cyclone-Resistant Rural Primary School Construction - A design guide, Educational Building Report 7, UNESCO Regional Office for Education in Asia, Bangkok, Thailand, 1977.

Design, Siting, and Construction of Low-Cost Housing and Community Buildings to Better Withstand Earthquakes and Windstorms, Building Science Series 48, Center for Building Technology, National Bureau of Standards, Washington, D.C., Jan. 1974.

Design for Tropical Cyclones (2 volumes), Department of Civil and Systems Engineering, James Cook Cyclone Structural Testing Station, James Cook University of North Queensland, Townsville, Australia, 1978.

Oakley, David, "Hurricane Resistant Design", Tropical Houses: A Guide to their Design, B.T. Batsford Ltd., London, 1961.

Eaton, Keith, "Connecting Brackets Used in St. Vincent", Earthquake and hurricane resistant low-income housing project, Overseas Division, Building Research Establishment, Garston, Watford, U.K., 1980.

PADCO, Inc., "Cyclone Resistant Masonry Construction", Sri Lanka Cyclone Study Technical Report No. 5, Office of Project Execution, U.N. Development Programme, New York, 1979.

_____, "Strengthened Wattle and Daub", Sri Lanka Cyclone Study Technical Report No. 6, U.N. Development Programme, New York, 1979.

Eaton, Keith, "Low-Income Housing and Hurricanes", Wind Engineering, Pergamon Press, Oxford, U.K., 1980.

Introduction to Wind Resistant Housing Construction: A Guide for Agencies in the Caribbean, INTERTECT, Dallas, Texas, 1979.

"Wind Resistant Block Houses: Basic Rules", INTERTECT, Dallas, Texas, 1979.

Series of training aids produced by Catholic Relief Services and OXFAM with the assistance of INTERTECT, Santo Domingo, Dominican Republic, 1980:

"Como Construir una Casa Segura de Madera" (How to build a safe wood house)

"Como Construir una Casa Segura de 'Concreto Armado'" (How to build a safe house using reinforced concrete)

"Como Hacer una Casa Segura de Bloques" (How to build a safe block house)

Windass, Mark, "Training Programs for Village Carpenters in Guntur and Krishna Districts Following the Andhra Pradesh Cyclone", Appropriate Reconstruction Training & Information Centre (ARTIC), Vijayawaya, A.P., India, 1979.

Mitchell, William A., A Model for Public Education on Earthquake Hazard Minimization in Turkey, Paper presented to National Council on Geographic Education, St. Louis, Missouri, November 24-26, 1977.

APPENDIX VI:

DISASTER MITIGATION INFORMATION RESOURCE ORGANIZATIONS

Office of Foreign Disaster Assistance
Agency for International Development
Washington, D.C. 20523

U.S.A.I.D. Mission

Centre for Information and Research on Disasters and Natural Hazards (CIRDNH)
Caulfield Institute of Technology
P.O. Box 197
Caulfield East
Melbourne, Victoria 3145
Australia

Ian Davis
Disasters and Settlements Group
Oxford Polytechnic
Headington Oxford OX3 OBP, U.K.

International Disaster Institute (IDI)
85 Marylebone High Street
London W1M 3DE, U.K.

INTERTECT
P.O. Box 10502
Dallas, Texas 75207

James Cook University of North Queensland
Department of Civil & Systems Engineering
Townsville, Australia

Natural Hazard Research Program
Department of Geography
University of Toronto
Toronto, Ontario, Canada

Technical Assistance Information Clearing House
American Council of Voluntary Agencies for Foreign Service, Inc.
200 Park Avenue South
New York, New York 10003

United Nations Disaster Relief Office (UNDRO)
Palais des Nations
CH-1211 Geneva 10, Switzerland

United Nations Development Programme
One U.N. Plaza
New York, New York 10017

Volunteers in Technical Assistance, Inc. (VITA)
3706 Rhode Island Avenue
Mt. Rainier, Maryland 20822