IMPROVEMENT OF VERNACULAR HOUSING IN JAMAICA TO WITHSTAND HURRICANES AND EARTHQUAKES

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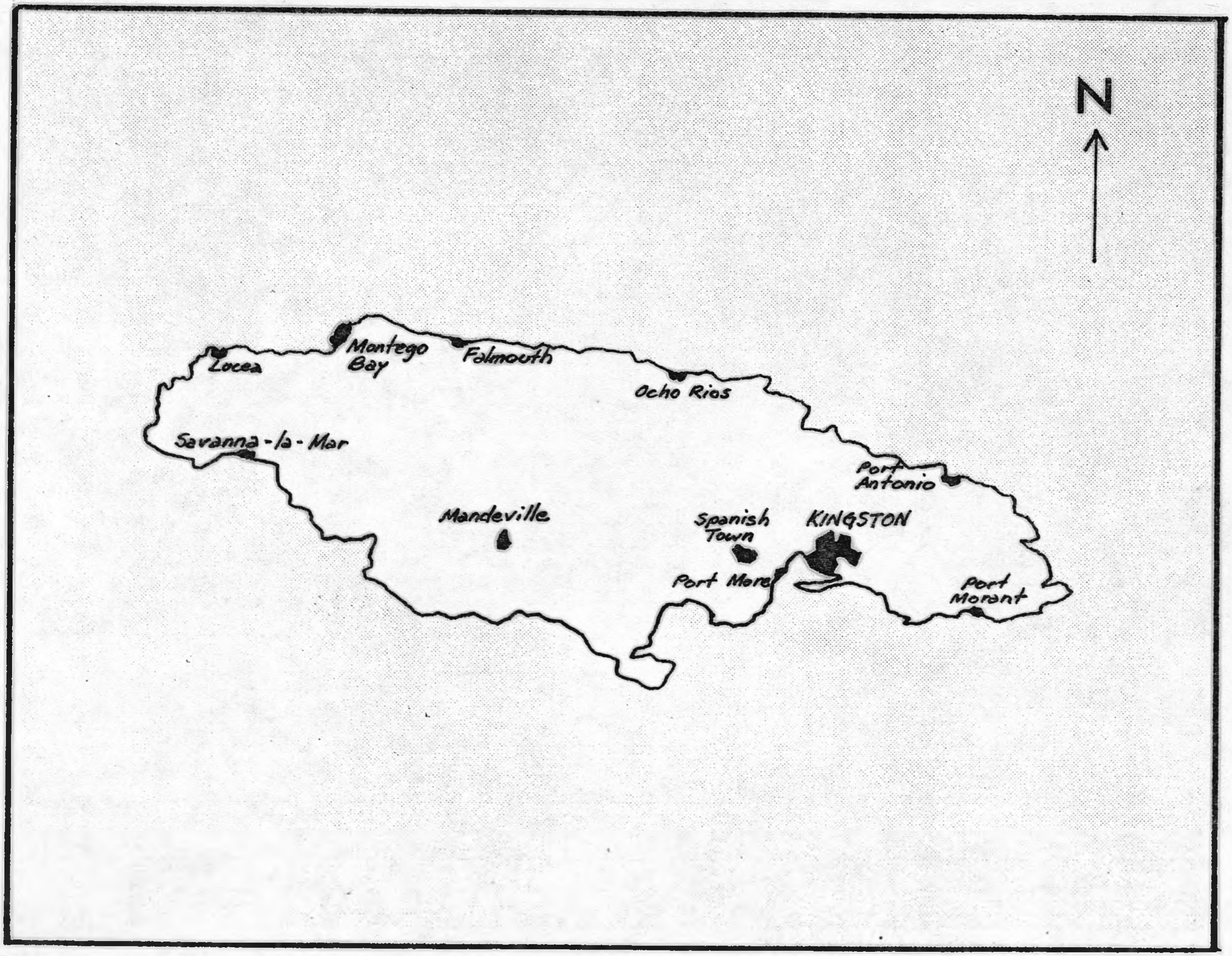
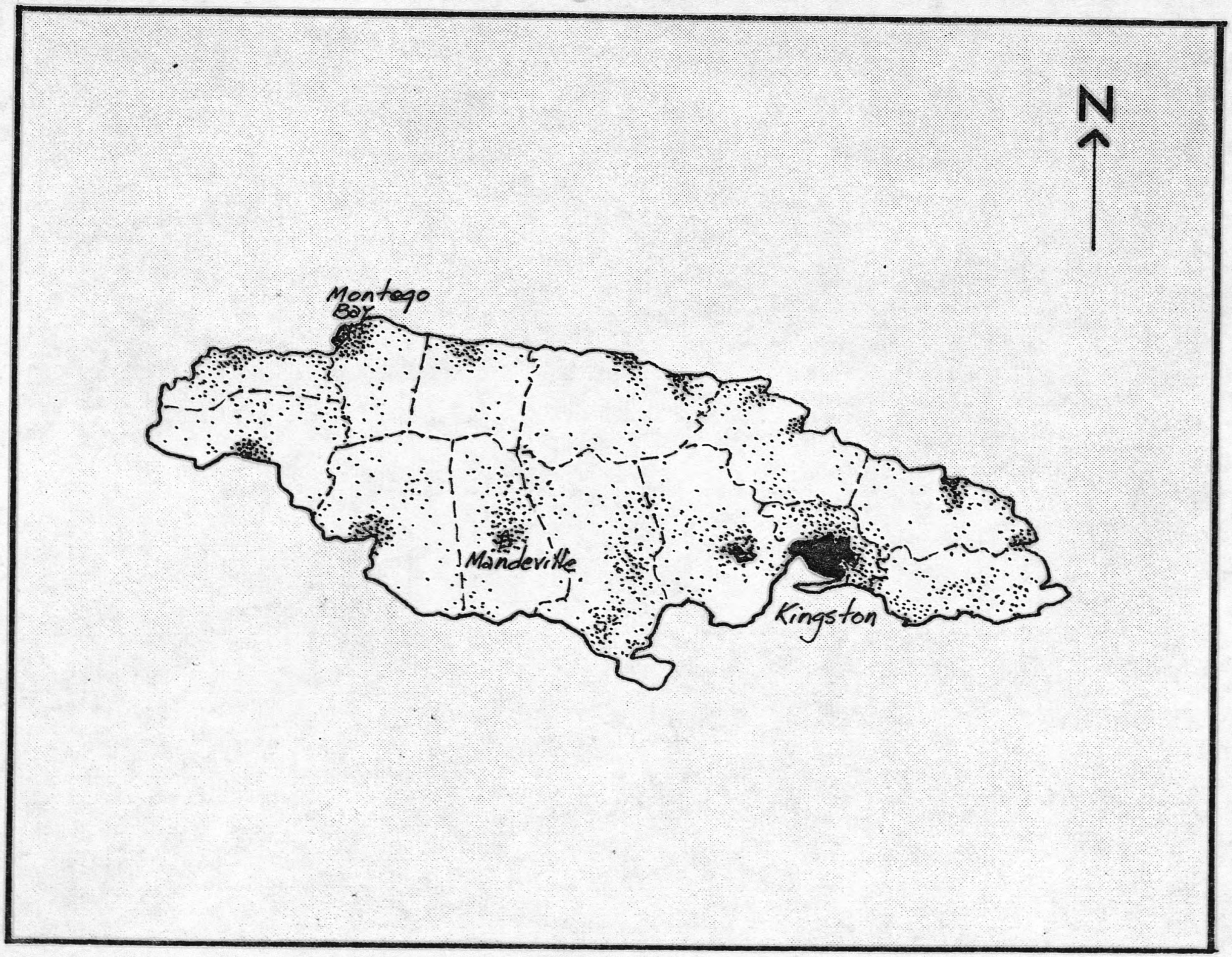


Figure 2 **Population Distribution**



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IMPROVEMENT OF VERNACULAR HOUSING IN JAMAICA TO WITHSTAND HURRICANES AND EARTHQUAKES

I. INTRODUCTION

BACKGROUND

In the spring of 1981, the Jamaican Office of Disaster Preparedness & Emergency Relief Coordination (ODIPERC) recognized that the majority of the 2.2 million Jamaicans reside in houses highly susceptible to hurricanes and earthquakes. Most of these buildings do not meet the standards of the existing Kingston Building Code or of the proposed National Building Code. It was further recognized that the majority of the people reside in non-engineered buildings, i.e., buildings which are constructed by the owners or by local building tradesmen without extensive architectural or engineering input and without use of disaster resistant construction techniques.

In August 1981, INTERTECT was retained by the Office of Foreign Disaster Assistance and the Office of Housing of the Agency for International Development to assist ODIPERC by conducting a survey of the vulnerability of non-engineered housing in Jamaica to the forces of hurricanes and earthquakes. The objectives of this study were:

A. To survey the vernacular housing of Jamaica and the construction techniques/methodologies used in order to:

   1. Classify the various buildings types, and

   2. Analyze the relative vulnerability of each type of building to hurricanes and earthquakes.

B. To determine design changes, improvements in the construction process, and improvements in the use of local building materials that can make housing more wind and earthquake resistant, yet remain affordable to the majority of people residing in these buildings.

C. To make recommendations for dissemination of information on safer construction for:

   1. Short-notice or emergency situations (including instructions that can be disseminated when a hurricane threatens, methods for improving safety, and techniques for reducing damage and strengthening buildings to better withstand hurricane and earthquake forces);

   2. Medium-term, self-help actions (including suggestions on how existing buildings can be improved and made safer through modification or retrofitting measures as part of normal upgrading and maintenance); and

   3. Long-term, comprehensive actions (including recommendations on how to influence the design and construction of new non-engineered houses).

D. To develop information on non-engineered construction and the vulnerability of vernacular housing which can assist ODIPERC in preparing their input into national housing policy aimed toward the protection of buildings and settlements.

KEY ISSUES

The improvement of vernacular housing to better withstand hurricanes and earthquakes should be viewed as part of a comprehensive response to the overall housing problem in Jamaica. The need and urgency for such improvement is made clear by the country's long history of hurricanes and earthquakes, in conjunction with current problems in the housing sector.

Recent reports entitled Jamaica Shelter Sector Assessment[1] and A Study of Housing in Jamaica[2] detail the existing housing shortage, point to the high number of substandard housing units, and correlate this shortage to national economic problems. The demand for housing has been estimated at approximately 10,000 new units per year.[3] The principal approaches used by the government (housing schemes, loans and guarantees) together meet only 18% of the annual demand, and the current housing deficit has been estimated to be in excess of 100,000 units.[4] If a major disaster were to occur, the sudden need for replacement housing could conceivably double or even triple the existing shortfall.

With the high level of unemployment and underemployment and the slow rate of economic growth, there is little hope of eliminating these housing problems without increased emphasis on upgrading the existing housing stock and the provision of assistance to families on an individual basis.

This upgrading can be viewed in terms of its advantages vis-a-vis disasters as well as its contribution to the resolution of existing housing problems. In terms of disasters, by emphasizing modification and upgrading, the number of units lost to a disaster will be lowered and the reconstruction burden on both the government and the people will be reduced. A house that withstands a disaster not only represents a safe refuge for its occupants, but also eliminates the tremendous discontinuity and economic burden resulting from damage to the building, and it represents a savings of both building materials and financial resources for the individual owner. For the government, it represents a lessening of the foreign exchange problem and reduction of further strains on a reconstruction economy.

Upgrading is cheaper than replacement of substandard units, and many of the measures taken to improve disaster resistance will help make the housing more livable as well as more durable. Furthermore, upgrading places the majority of the burden on the homeowner rather than on the government, thereby enabling policy-makers to spread financial resources to a greater number of beneficiaries.

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[1] Prepared by the Office of Housing, AID, 1977.

[2] Prepared for the Ministry of Public Service, Sept. 1976.

[3] Ibid.

[4] Ibid.

POLICY ISSUES

With these concerns in mind, a number of issues have arisen during the course of this study which may require policy decisions. These include:

A. The need for an agency within the government to be assigned responsibility for this sector of housing;

B. The need to rationalize building enforcement and regulation procedures to deal with upgrading of the vernacular housing stock;

C. The need for the housing sector to prepare for the rapid delivery of large numbers of new housing units in the event of a major disaster through the preparation of national reconstruction policies, streamlined delivery systems for new housing, and predetermined modes of response for the repair of damaged buildings.

DEFINITION OF TERMS

The following are brief definitions of the terms used in this report:

A. Design Changes: the process of altering the design of a structure before it is erected to make it more disaster resistant.

B. Disaster Resistant Construction: a term 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.

C. Housing Education Program: a program offering instruction to homeowners or builders on how to build a safer or more disaster resistant house.

D. Housing Modification: changes in the configuration of an existing building to make it stronger. Modifications might include changing the pitch of the roof, adding a room, etc.

E. Housing Schemes: a term used in Jamaica to denote conventional housing projects where a large tract of land is acquired, services are installed, and a group of houses are constructed on the site.

F. Nog: a type of construction system using a wood structural frame to support masonry work used as infill.

G. Non-Engineered Buildings: those structures built either by homeowners or by local building tradesmen such as carpenters and masons without formal architectural or engineering inputs into the design or construction process. For the purposes of this report, the term only includes those structures which could be considered <u>formal</u> houses; it does not include the temporary, makeshift dwellings often used by transients or families in squatter settlements prior to the construction of a more formal house. Buildings erected under housing schemes or those built according to plans or drawings prepared by housing institutions (e.g., the National Housing Trust) are also not included in this report.

H. <u>Retrofitting</u>: the process of installing additional supports or altering components of an existing building in order to make it more disaster resistant.

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

J. <u>Vernacular Housing</u>: indigenous modes and styles of housing using local traditions, skills and techniques. Non-engineered buildings, as well as structures from past eras when architectural and engineering inputs were minimal, are included in the term. Vernacular housing can be identified by a particular style or design of construction, by popular features, and/or by the building methods used.

K. <u>Vulnerability</u>: 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, lowlying coastal areas exposed to hurricanes, or in seismic areas where a large proportion of the structures cannot withstand the forces of an earthquake, are considered "vulnerable communities".

II. RISK IN JAMAICA

HURRICANE RISK

Jamaica is situated in one of the most active hurricane regions in the world. Within the last century, thirteen hurricanes and numerous tropical storms have struck the island.[5] The casualties and damage in each hurricane underscore the vulnerability of the population and show that a majority of housing cannot withstand the forces of high winds. Almost 70% of the 380,000 people in Kingston and 90% of the 1.5 million people in rural areas live in non-engineered structures.[6] Engineering and architectural input into housing construction for moderate- and low-income families, other than that provided by the various housing schemes, is minimal.

Hurricanes threaten housing in four basic 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 the soil by heavy rainfall.

All of these threats exist in Jamaica, and few areas are without at least one of these hazards.

Figure 3 depicts the tracks of hurricanes which have struck Jamaica in the last century. Figure 4 depicts a cross-section of a typical hurricane, showing the sectors of the storm system which produce the most damage. It can be seen from this drawing that the band of destruction can be fairly wide, often spanning a diameter of up to 100 miles. Figure 5 shows those areas that are susceptible to various hurricane threats in Jamaica. Damage caused by storm surges, flooding or landslide is primarily a siting problem and thus is beyond the scope of this report.

EARTHQUAKE RISK

Jamaica is situated near the northern edge of the Caribbean Plate, close to where it abuts the North American Plate (see Figure 6). It is the relative movement along this jointure or fault that causes the earthquakes which periodically affect the country.

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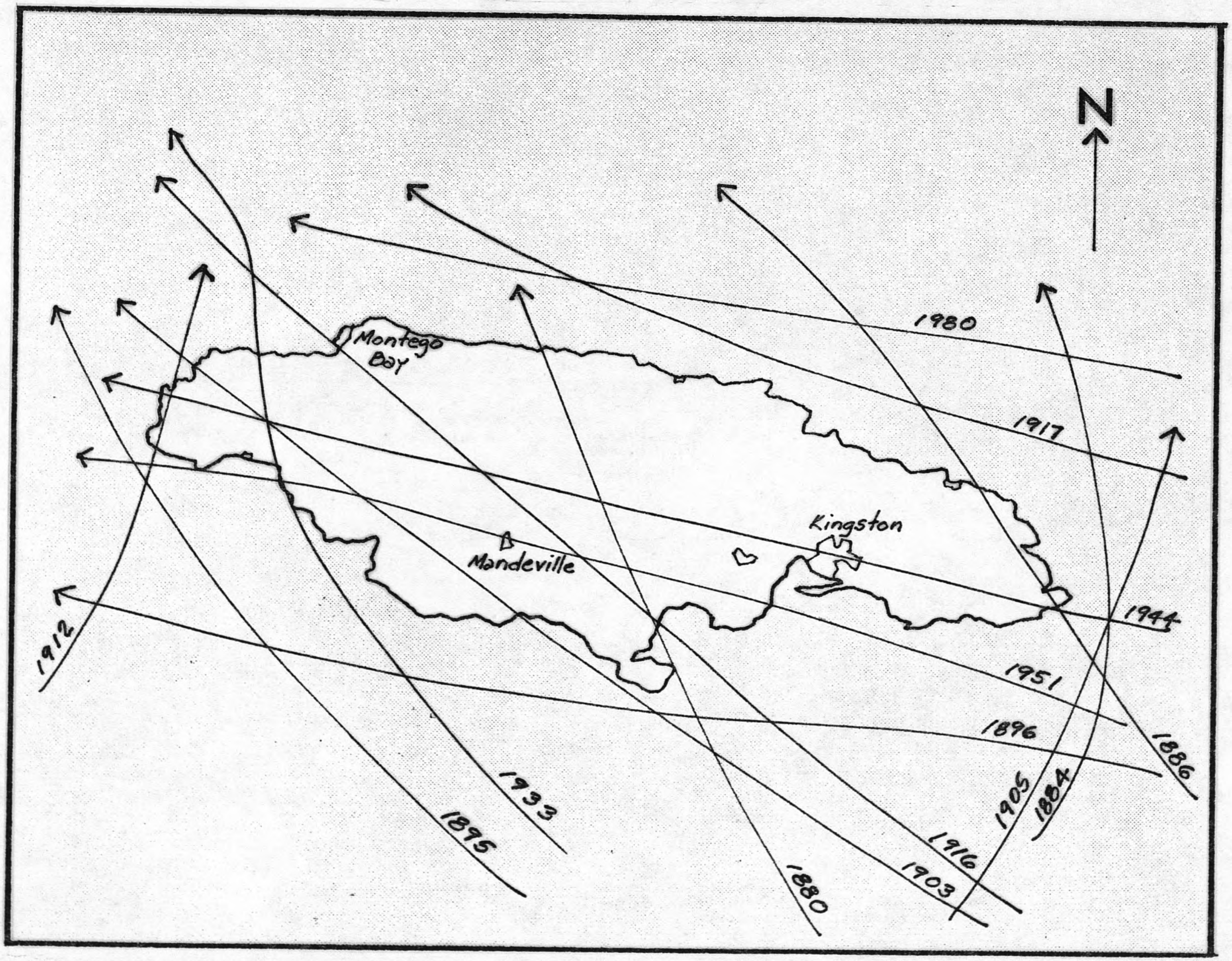
5 Disaster Catalogue: Jamaica, prepared by ODIPERC, August 1981; and Tropical Cyclones of the North Atlantic, NOAA, 1977.

6 Interpolation of 1970 census data.

Figure 3 Hurricane Tracks 1880-1980



Source: NOAA, 1977

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Figure 4 **Cross Section of a Typical Hurricane**

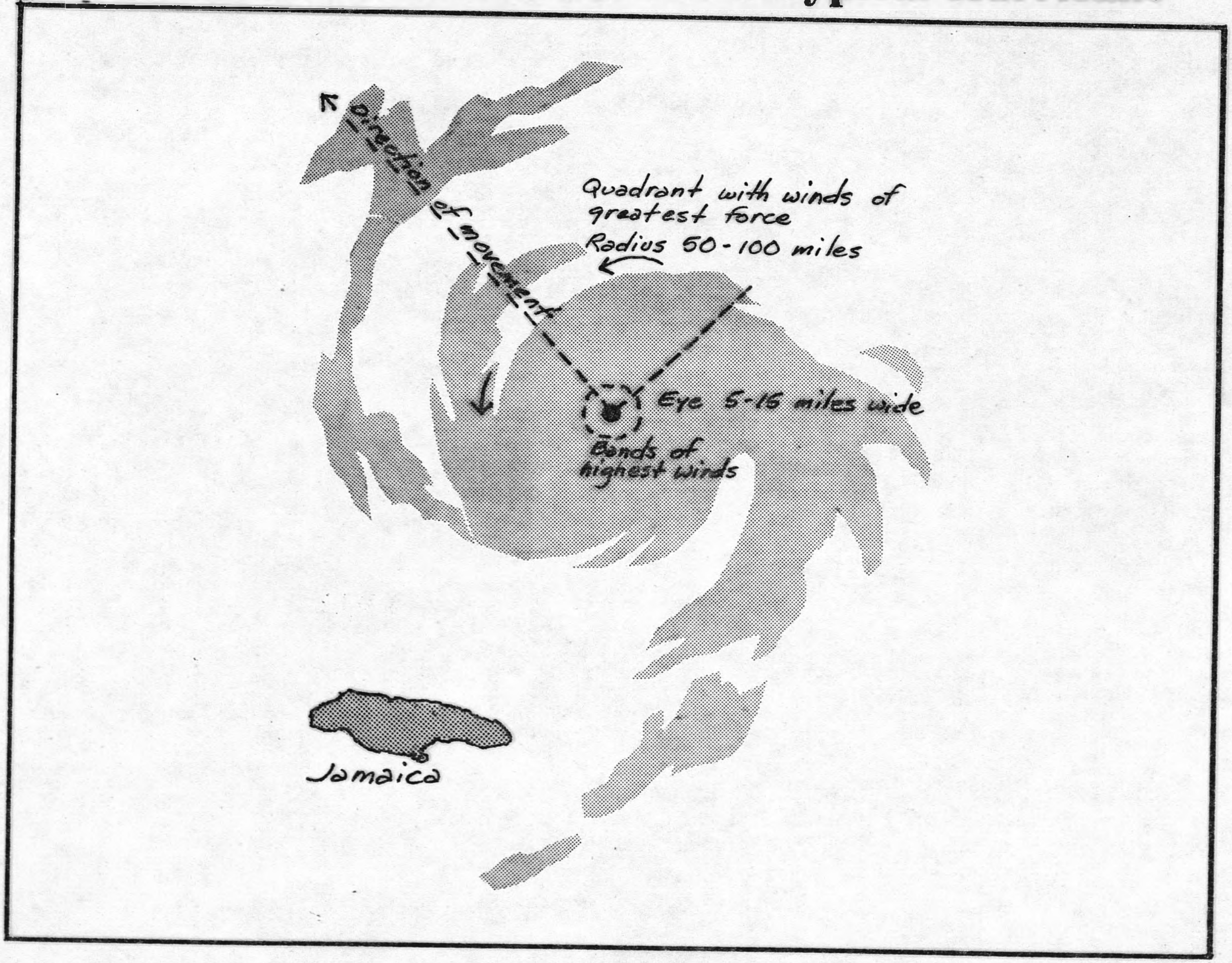

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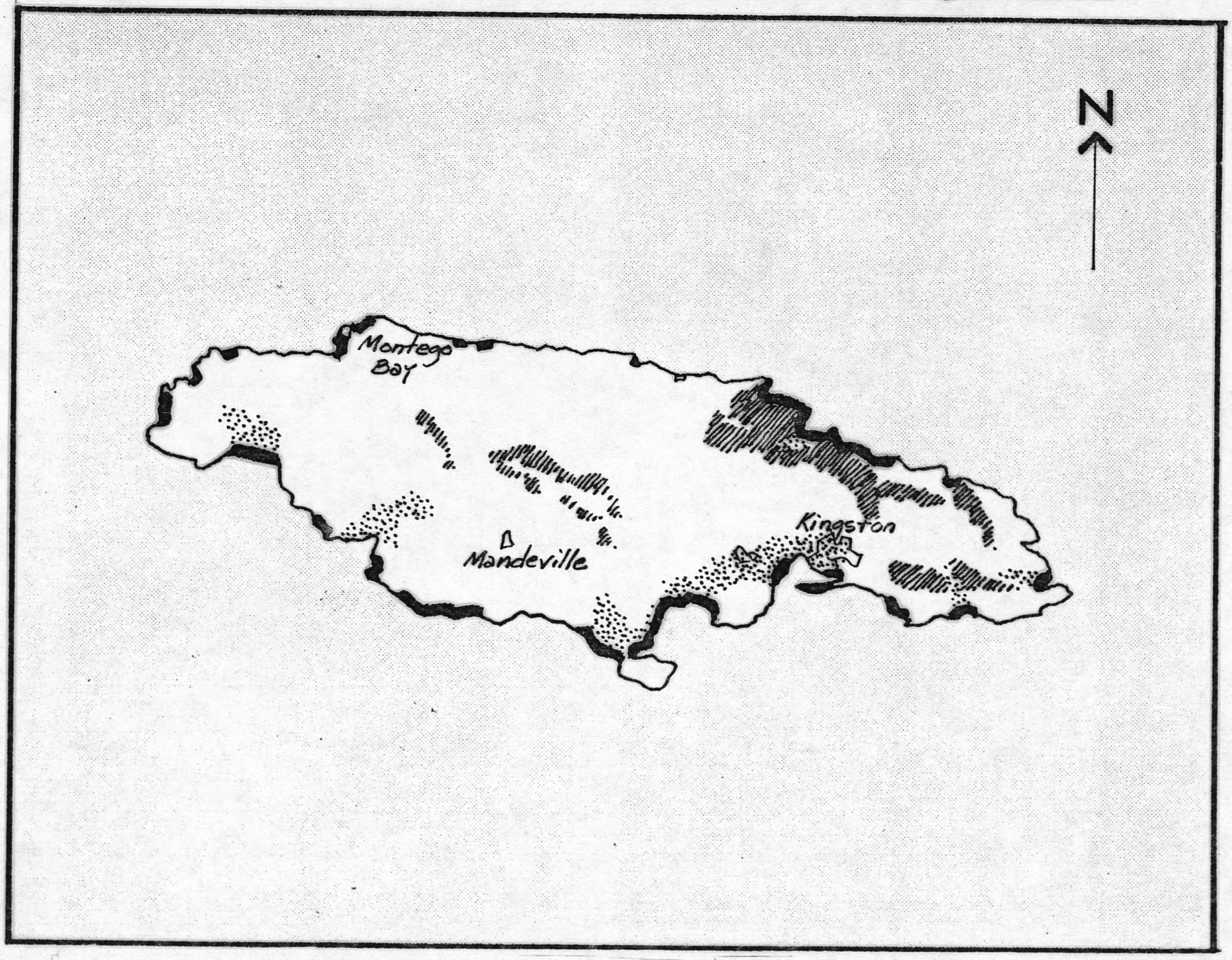
Figure 5 Hurricane Hazards in Jamaica



Storm Surge Hazard

Mudslide Hazard

Flood Hazard

Source: ODIPERC, 1981

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Earthquakes threaten housing in three basic ways:

--- Forces generated by ground-shaking;

--- Liquifaction of the soils, a condition where loosely packed soils separate and behave similarly to water when shaken by an earthquake, thus allowing buildings on the surface to partially sink or settle, damaging them in the process; and

--- Secondary effects, such as landslides or tsunamis (seismically-generated sea waves).

Damage from liquifaction and secondary effects is of major concern in Jamaica due to the types of soil. Major damages from liquifaction occurred in the great Port Royal earthquake of 1692, and the extensive damage to port facilities in Kingston in 1907 are attributed to this phenomenon.

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 presented in Figure 7. However, this chart only shows recently recorded data and should only be considered as an indication of where current activity is being felt. It is important to remember that an event could occur at any time in an area not now active (e.g. the 1957 earthquake near Montego Bay, a previously inactive area) and that Jamaica is relatively small, thus a very large magnitude earthquake in the more active eastern zone could possibly be felt throughout the island.

ESTABLISHING PRIORITY AREAS FOR VULNERABILITY REDUCTION

As a general rule, comprehensive vulnerability reduction efforts should be initiated in areas where there are certain indicators that such efforts will succeed. Among the indicators are areas where new construction is occurring (such as the growth areas around cities and towns), areas where agricultural activities are strong and where migration from rural to urban areas is minimal, and areas where a threat from a disaster is perceived as being a major problem to the majority of homeowners within the region. Thus, by examining demographic trends and density, and areas of economic growth, priority areas for establishing vulnerability reduction efforts can be identified. These are shown in Figure 8.

Figure 6 Tectonics of the Caribbean Basin

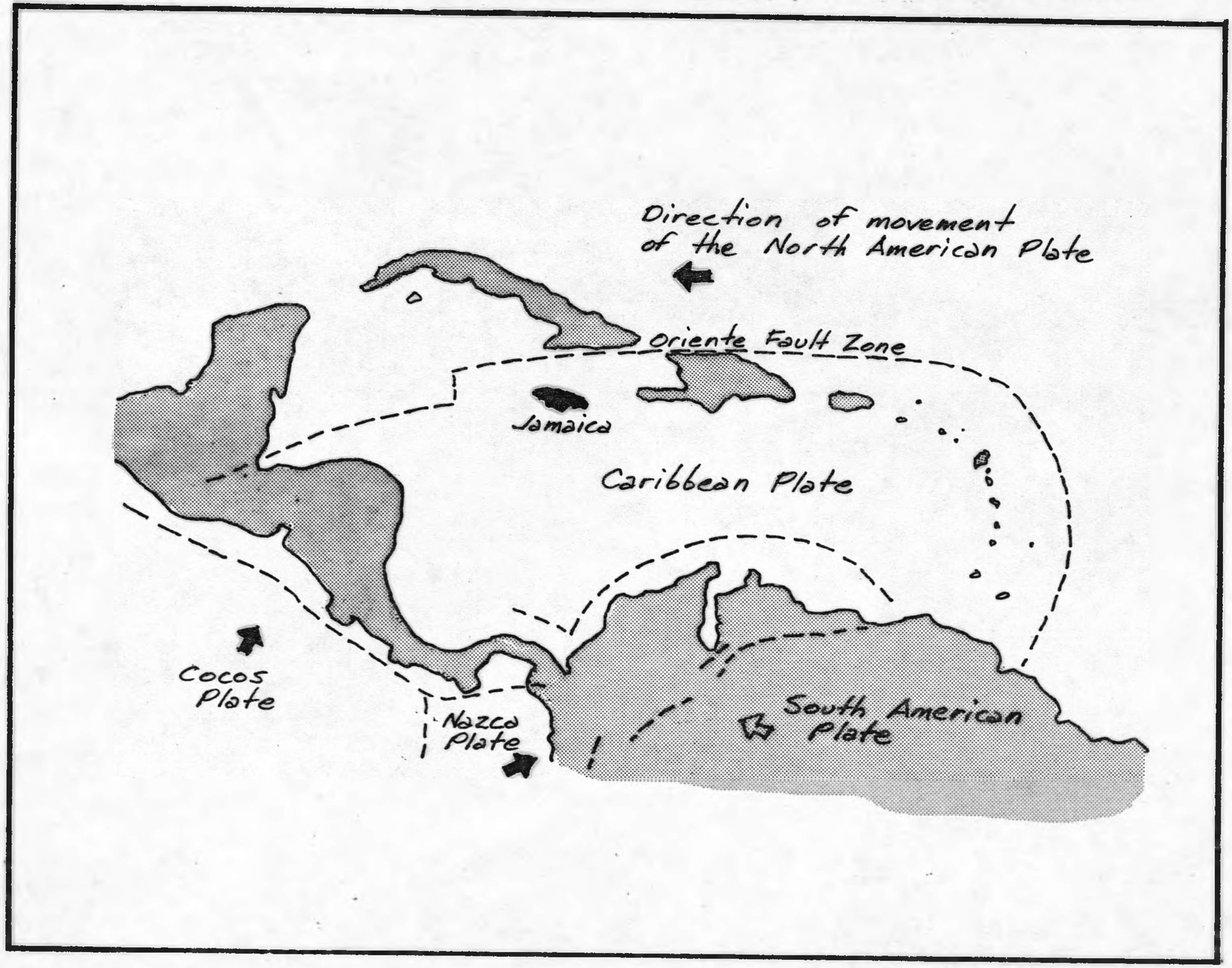

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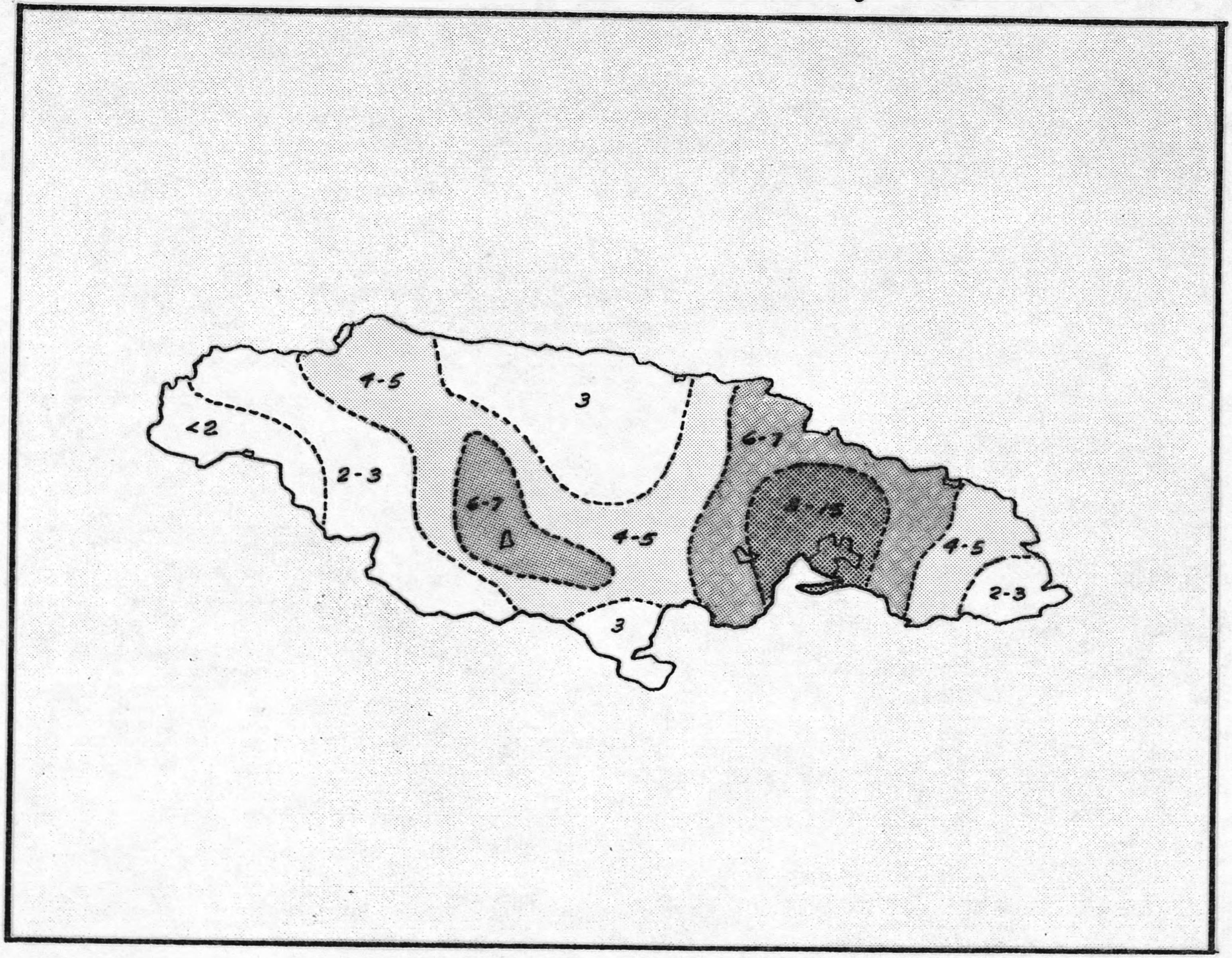
Figure 7 Seismic Activity in Jamaica



Numbers indicate average number of Earthquakes per century over Intensity VI.

Source: Pereira, 1981

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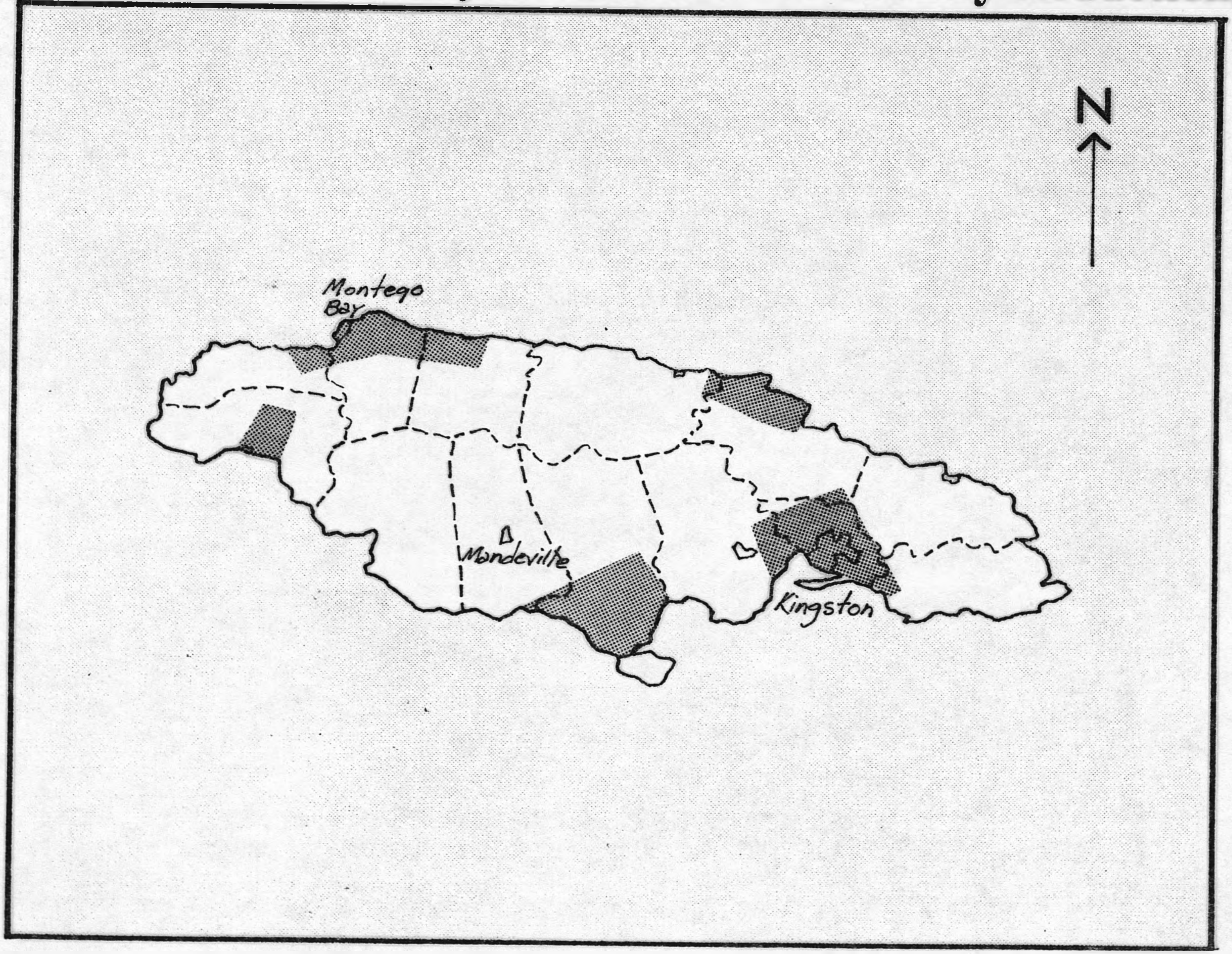
Figure 8 Priority Areas for Vulnerability Reduction



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III. HISTORY OF VERNACULAR HOUSING IN JAMAICA

EVOLUTION OF VERNACULAR HOUSING

Jamaica contains a wealth of architectural history, charm and distinction. While the Great Houses of the Georgian and Victorian periods are the primary buildings of historic and architectural significance, the country retains a simple yet dignified vernacular style. While most of it is humble and unpretentious, the buildings represent a unique form of building expression and provide a significant link to various eras in the history of the country.

Many of the building forms and features still found today in traditional and vernacular architecture date back to specific periods in the history of Jamaica when building construction activities were influenced by other events. The most significant historical periods in the evolution of vernacular housing were the Falmouth and North Coast sugar boom, the Crown Rule period, the rise of Kingston, and the late Colonial period.

A. The Falmouth Period (1790-1820): No other era had as much influence on vernacular housing as did the rise to prominence of Falmouth and the other north coast towns during the period of the great sugar boom. The architecture of the period is distinctly Georgian and is a unique style still found today. In recalling the period, most people remember the Great Houses of the sugar plantations. While these were indeed important, there were also smaller buildings, especially merchants' houses in the cities and public buildings, which also helped to establish the architecture of the period.

It was during this period that most of the building techniques found in vernacular housing today were introduced. The techniques of stone masonry, wood frame construction, wattle-and-daub, Spanish wall, and nog construction were all utilized during this era and adapted from their English origins to the Jamaican climate and environmental demands.

That the building styles and methods were distinctly English cannot be doubted. What little influence remained from the Spanish period was eliminated at this time; and even wattle-and-daub construction, which many historians have linked to African origins, clearly shows many of the techniques used in Wales and other parts of the United Kingdom during this same period.

There were no architects and few engineers in Jamaica at this time, so patterns and designs were obtained from England and modified for the conditions in Jamaica. Thus, while many of the buildings owe much in form, style and design to the Georgian period, they remain distinctly Jamaican. Many of the adaptations were to make the houses more resistant to high winds and hurricanes. Especially notable were the practices of using hipped roofs, sashed windows, storm shutters, and only minimal eaves along the roof edges. These features were so successful in protecting the buildings against hurricane damage that they have remained popular even to the present day, although many people do not recall their origins.

B. <u>The Period of Crown Rule</u>: From the 1830's to the 1860's, Jamaica underwent a period of major reorganization. With the decline of the plantations, the collapse of the sugar market and the emancipation of slaves, the society that had existed at the height of the Georgian period disintegrated and was forced to change dramatically. This period, often referred to as the "dark age of Jamaican history", saw a decline in construction of larger, more formal buildings and a proliferation of construction of marginal and poor quality buildings by the newly emancipated blacks. Most of the buildings were wattle-and-daub or timber frame and continued to follow construction techniques that had been developed during the Georgian period, although construction was of poor quality and few of these buildings survive today.

With the imposition of Crown Rule in 1865 after the Morant Bay Rebellion, a new period of prosperity began. Bananas were introduced, enabling small, marginal farmers to find enough profit to construct more formal houses. As the economy expanded and more people were able to accumulate excess capital, a new wave of construction occurred. Many of those building for the first time desired more permanent houses than those of wattle-and-daub or wood frame; yet stone construction or brick (which had been introduced at mid-century) was too expensive. Nog construction, a cheap form of building with stone, was ideal, and many of the homes of this period were built using this method. Wattle-and-daub and Spanish wall construction were still used by the poor, and wood frame buildings retained some degree of popularity in all economic groups.

The new buildings retained many of the features which had been developed during the Georgian period, although they were scaled down considerably in size because of the rising cost of building materials. Distinctive designs of the period were the "L" and "U" shaped floor plans; and bay windows and "gingerbread" decorations on the front of the house were popular features. Builders continued to use storm roofs (although the term "storm roof" faded from popular usage) and gabled roofs became more popular.

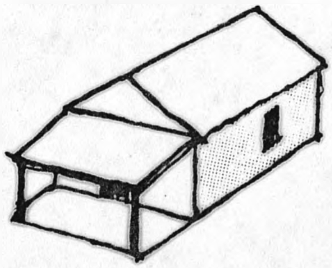
C. <u>The Rise of Kingston (1872-1914)</u>: In 1872, the capital was permanently transferred from Spanish Town to Kingston. This new capital flourished and architecturally it became the trendsetter for the rest of the country, also developing its own unique style and type of construction.

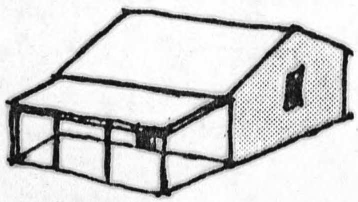
At the end of the 19th century, brick factories had been set up and Kingstonians rapidly developed a liking for this material. By 1907, nearly half of the buildings in Kingston were made of brick and many two- and three-story structures, especially along the waterfront, had been erected.

Catastrophe followed. On the afternoon of January 14, 1907, a massive earthquake shook Kingston. The brick houses toppled and fell, killing almost a thousand persons. The era of unreinforced brick masonry was over; in its place, builders developed an adaptation of nog construction. Brick nog used a wood frame to reinforce the wall and wire crossbraces to reinforce the frame (see Chapter IV). For the next thirty years, this was the most prevalent form of construction for moderate and middle-income housing in Kingston and other major cities, and today these houses still make up much of the housing stock in Old Kingston and West Kingston.

Many popular features which are still used in larger houses became popular during this period. Of special interest is the veranda. The word "veranda" is derived from the Indian word meaning protection or shelter from the sun or rain. During the Georgian period, small verandas were often placed on the second story of larger buildings in the towns to provide cover for sidewalks as well as a porch for the upper floor. In Kingston, one-story houses with verandas became very popular. Usually the roof was extended and supported by columns, and a large open area was created as a "social area" on the front of the house. So popular were verandas that almost no formal house today is without one.

The screened and open veranda subsequently adopted was relatively well-suited to the hurricane environment. Instead of extending the roof out over the veranda, a small, relatively flat-pitched roof was attached to the house (see below). This type of roof was designed because only short lengths of timber were available, but the design proved useful since the main roof of the house would remain intact if the veranda roof was blown off by high winds.[7]





7 "Vernacular Housing: A Stylistic Base?", Neil O. Richards, Jamaica Architect, Issue 8.

At the turn of the century, a new building material was introduced that was to have a profound influence on housing. Cement was introduced for the construction of several government projects and quickly found acceptance as an ideal material for making mortar. In 1902, a small cement plant was established. After the 1907 earthquake, the use of cement in masonry construction was encouraged and, by the 1930's, cement block construction was becoming popular. In the following years, this was to become the most popular type of building material for all types of construction.

During the first quarter of the 20th century, concrete nog was developed. Basically, a house was erected with a timber frame and infilled with panels of concrete. Internal partitions and floors were made of wood, the latter being constructed at about two feet above ground level and supported on concrete piers.

D. The Late Colonial Period (1945-1964): The period between World War I and World War II was marked by a growing economic stagnation and an increase in many of the social and economic hardships on the people of Jamaica. Concerned by labor disturbances in the West Indies, a Royal Commission was sent to inquire into the status of the islands. However, before the report was published, world war became a reality.

The war had the effect of drawing attention to the West Indies, partly as a result of growing criticism of Britain's treatment of her colonies, and partly because of concern over the poor conditions brought to light by the Royal Commission. Great Britain realized that, if it were to expect support from the colonies for the war effort, concessions would have to be made for the economic betterment of the colonies.

In 1940, a summary of the Commission's recommendations was published and the first Colonial Development & Welfare Act was passed which guaranteed funds for economic development in the West Indies. The first act was little more than a promise of better treatment in the future; but immediately after the war, a second act was passed, increasing dramatically the amount of money available for development. A Colonial Development Corporation and an Anglo-American Caribbean Commission (later reorganized as the Caribbean Commission) were established. These were to play an important part in providing a framework for the long-needed social and economic development of the area as a whole.[8]

In terms of housing, the importance of these developments was due to the acceptance by the Colonial government of responsibility for the provision of housing for certain groups of low-income families. Prior to this, the only official intervention in housing was in Kingston via the building code.

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[8] History of Jamaica, Clinton V. Black, Collins Press, London, U.K., 1965.

Early housing efforts by the government concentrated on providing housing for indigents and for seasonal agricultural workers on the sugar estates. With the help of architects from the Colonial Office, schemes were developed to acquire land and erect housing for workers. This approach has become the standard method through which the government provides housing.

In 1951 Jamaica was struck by Hurricane Charlie which caused extensive damage on the south coast, especially in Kingston. In order to help low- and moderate-income families rebuild, a Hurricane Housing Organization (HHO) was formed. Wooden houses, designed as interim structures (although many remain in use today) were provided throughout the disaster-affected area. Reconstruction loans and grants were also provided by the Organization. As the extent of the damage, as well as the general poor state of housing throughout the island, became known, the HHO was reorganized and eventually became the Housing Ministry. In regions outside of the hurricane-affected areas, new emphasis was given to building houses meeting the newly recognized housing demand. Land was acquired or provided by the government and housing schemes were conducted throughout the island.

Two important contributions to vernacular housing were made during this period. First, because cement could be manufactured in Jamaica at a relatively low cost, cement block construction was adopted by the colonial government as the primary method of constructing low-income housing. With heavy government emphasis on block, and by purchasing large quantities of blocks for its own projects, the overall cost of this material remained low and affordable to low and moderate-income families, especially those in the towns and cities. Thus, more and more people began to build with block.

Second, with the growing popularity of block, the government recognized the need for adopting suitable construction standards that would ensure safety. In 1953 a standard configuration and uniform sizes for residential blocks were adopted, along with requirements for reinforcment. Government-financed block construction followed these standards and, through widespread use, almost every block building made today (including most low-cost housing) continues to follow these norms. Thus, the basic features of contemporary block and steel housing evolved during this period.

By the end of the period, wattle-and-daub, Spanish wall and even stone nog buildings were on the wane. Brick nog construction, so popular in the aftermath of the Kingston earthquake, died out altogether by 1950. Wood frame houses were still built, although in many areas they became smaller and were used more for transient housing or interim buildings.

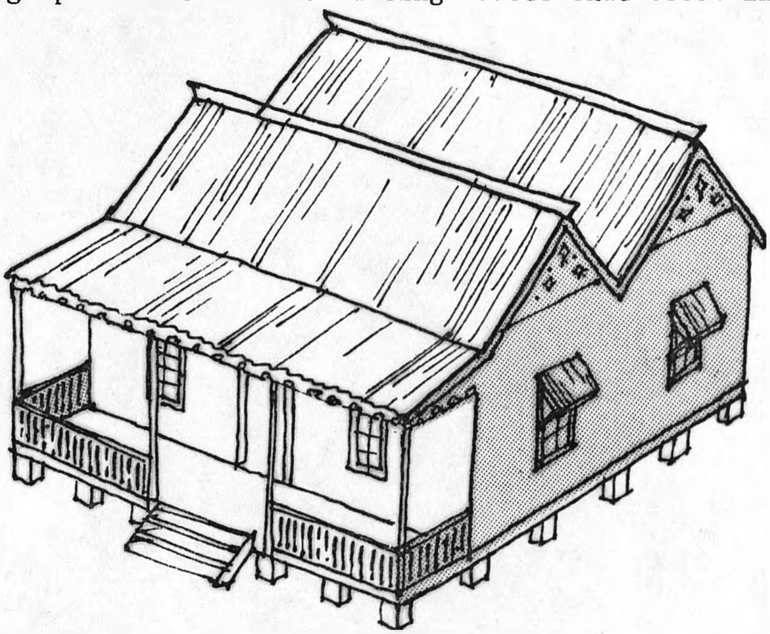
The designs and features of the buildings continued to reflect the style of those structures erected in previous building eras, but many ornamental facades and detailings disappeared from new construction. New designs and features introduced during this period were flat sloping roofs for block houses and louvered windows which soon became standard for almost all new construction.

HURRICANE AND EARTHQUAKE ARCHITECTURE

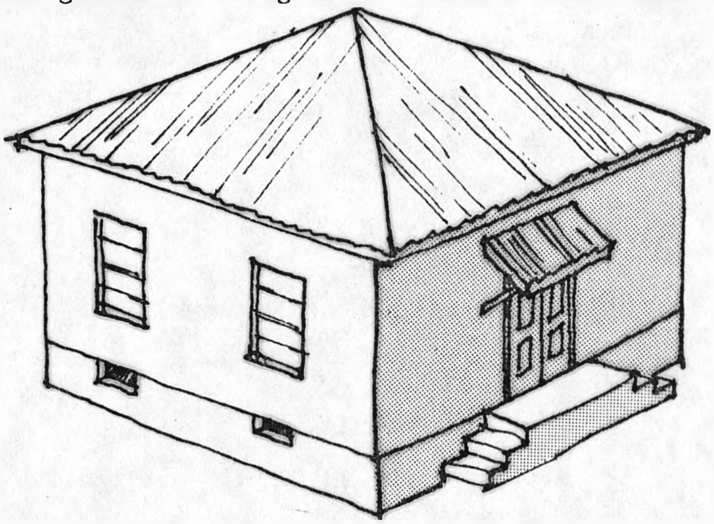
The principles of disaster resistant construction today were not thoroughly understood by the early builders in Jamaica. However, through trial-and-error and common sense, many techniques and features were developed to reduce damage from the storms and earthquakes that struck periodically.

Early settlers realized that hurricanes were the most prevalent threat. They also found that the Georgian patterns and designs sent from England were susceptible to high winds. Thus, a number of features were incorporated into these designs to improve the resistance of their homes. Among the features that were adopted and that are still used today are:

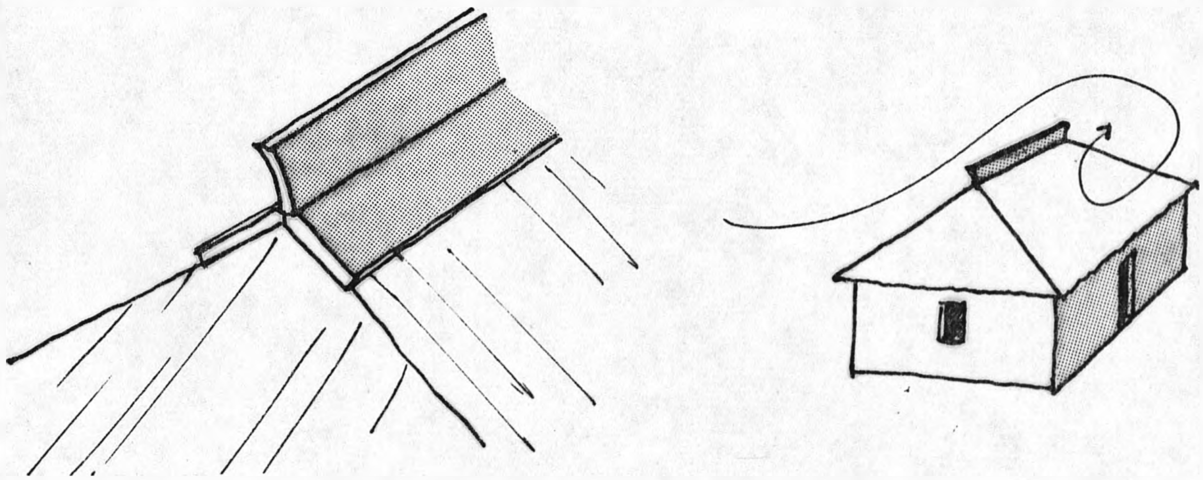
A. Double (Storm) Roofs: The use of storm roofs (i.e., a single roof over each major room or portion of the house) was an early adaptation to hurricanes. It offered two advantages. By using shorter timbers, the strength of the roof frame was increased. And if the roof was blown off one part of the building, other rooms were still protected by their own roofs. Although unknown at the time, the wind flow characteristics of a double roof are ideal for breaking up the suction and lifting forces that occur in high winds.



B. Hipped Roof: Early builders recognized that a hipped, rather than gabled, roof configuration offered the best adaptation for survivability in high winds and for interior comfort. The hipped roof configuration was not only used as a single roof, but also in the double (storm) roof design. The configuration is strong due to its shape. Without understanding the physics involved, it is surprising that the early builders utilized the high roof pitches that were common. This may have been a concession to the climate; but for whatever reason, the high pitches (30°-35°) often found on these roofs are now recognized as being ideal for hurricane conditions.



C. Roof Combs (Crown Pieces): An ornamental comb or crown was often placed on the ridge of the roofline. The purpose was usually to cap the roof so that it would not leak. However, these combs serve as "spoilers", creating turbulence at the peak and thereby helping to break up the suction and lifting forces on the roof.



D. Minimal Eaves: Early builders recognized that large overhanging roofs or eaves would be subjected to uplifting forces from winds deflected up from the walls. Thus most of the houses were built with only a minimal roof overhang.

E. Hurricane Straps: The practice of fastening the roof frame securely to the building was first seen in Jamaica in the mid-1700's.

F. Building Configuration: Early builders recognized fairly quickly that the strongest practical shape to resist hurricane winds was a relatively square building. In early construction, most small buildings were square, and even the larger ones tended to be not overly long and narrow.

G. Sashed Windows: Sashed windows (designed to slide vertically in the window frame) were a popular feature in Georgian architecture, and their advantages as a means of relieving pressure inside a house during a hurricane were quickly realized.

H. Storm Shutters: The use of storm shutters to help protect those inside a house from flying debris was one of the first adaptations to hurricanes found in vernacular architecture.

Unlike hurricanes, earthquakes were infrequent; thus the ability to adapt architecture on the basis of trial-and-error and visual observation of the effects of an earthquake was not possible. There were no records concerning damages, types of buildings reconstructed, or modifications made as a result of the Port Royal earthquake in 1692. So, prior to 1907, builders in Jamaica knew very little about how to strengthen a house to improve its performance in an earthquake. The major concern was still hurricanes and high wind storms and, while tremors had been felt throughout the island, the only adaptation was to build structures whose upper portions were lighter than the lower portions.

Several changes were introduced as a result of the 1907 Kingston earthquake. Nog construction demonstrated its survivability and it was quickly realized that the framing system of nog offered many advantages. The few buildings that used cement mortar also exhibited a higher degree of survivability than those with lime or other traditional mortars; thus cement mortar became popular. Other techniques (such as internal reinforcement, balance, use of ring beams, etc.) were not recognized until very recently.

CONTEMPORARY NON-ENGINEERED HOUSING

Contemporary non-engineered housing can be divided into three classifications: rural, urban yard, and urban single-family housing. While the housing types and construction methods used are similar, there are distinct characteristics that are important to note.

A. Rural Housing. Important characteristics of rural housing include:

1. The majority of people still using traditional construction methods, as well as the majority of older traditional buildings, are found in rural areas.

2. The majority of rural housing is single-family.

3. The size of new rural houses is usually very small. This is due in part to lack of resources, the cost of land, and uncertainty concerning land tenure.

4. In rural areas, the owner-contractor relationship is still strong. The skills of the contractors, however, are not as good as those of urban contractors.

5. Wood is still the primary structural component used in new housing. Nog and wood frame houses still account for a substantial amount of new construction in rural areas, although these methods are rapidly being replaced by reinforced concrete block construction (known locally as "block and steel").

6. The most prevalent styles now found are those developed during the Crown Rule period. Newer construction, especially that

of the last 10 years, is along lines established during the late Colonial period.

7. The most popular roofing material in the rural areas is zinc sheeting.

B. Urban Housing. The principal characteristics of urban construction are:

1. Almost all new construction is of block and steel.

2. The majority of non-engineered buildings are occupied by more than one family. (Tenement yards are discussed later.)

3. Houses in the urban areas tend to be slightly larger than their rural counterparts, especially the older buildings.

4. The majority of people residing in non-engineered housing are renters. Repairs, maintenance and upgrading will therefore be more difficult.

5. The most prevalent style of older buildings is that of the post-earthquake Kingston period. The majority of buildings in the older parts of the city are made of brick nog. The newer houses have no distinct style and are expanded and adapted to whatever land is available.

6. Almost all new construction in urban areas is on the periphery of the cities. Few new houses are erected in the older sections (although additions are made to older buildings).

In Kingston, many of the urban poor live in two distinct patterns of settlement: urban tenement "yards" and squatter settlements.

C. Yards. Tenement yards date back to the 18th century when landlords rented small rooms to transient slaves sent to work in the city. After emancipation, the practice of renting to transients continued, but families rather than individuals moved into the yards. Today these yards make up a large portion of the slum housing available to new arrivals as well as to the very poorest families in the urban sector.

The older tenement areas are usually located in the central city. The areas are physically deteriorated, overcrowded, and lacking in community facilities, although water and electricity are usually available. The areas are characterized by a large number of families living in an enclosed yard in close proximity and sharing basic services such as a standpipe, kitchen, and toilet facilities. Almost all of the occupants of yards are renters.[9]

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[9] Jamaica Shelter Sector Assessment, Office of Housing, AID, 1977, p. 36.

There are two types of tenement yards: tenant yards which are owned by individual (usually absentee) landlords, and government yards where the government is the landlord. A study of yards in 1970 indicated the following characteristics:[10]

1. Design: The size of the lot may range from one acre to a narrow strip of land. The number of households and separate dwellings generally ranges from eight to thirteen. A household often occupies only one room.

   The siting of the rooms in the tenant yard depends on the presence or absence of the landlord. If he resides on the site, he usually occupies the front house and tenants live in the lanes (footpaths) behind his house, with their entrance to the yard via a side gate. In the yard, there are several clusters of tenant buildings separated by zinc fences. This cluster of houses between zinc fences represents a yard. In some cases, there may be several yards behind a landlord's house. (See illustration on following page.)

   Government yards, on the other hand, typically consist of one or two long buildings subdivided into rooms with each family occupying one unit. It is interesting to note that many government yards originated as a result of a desire to provide temporary housing in the aftermath of a catastrophe such as a flood or hurricane. (See illustration on following page.)

2. Sociological Characteristics: Tenement yards exhibit certain unique sociological characteristics that are important to note, including:

   a. High Mobility Among Residents. Surveys have shown that persons living in tenements constantly move from one yard to another. Few live in any yard longer than five years (the average number of years is slightly higher in government yards).

   b. High Degree of Social Interaction Among Residents. It has been observed that the level of interaction in a tenement yard is very high, with people sharing many activities and participating in social activities. Observers have indicated that the yard serves an important function in helping to socialize migrating Jamaicans into the Kingston and wage-earning culture.

      Because of the high density, the yard demands a higher degree of communal life than any other form of living in Jamaica. Dwellers depend upon each

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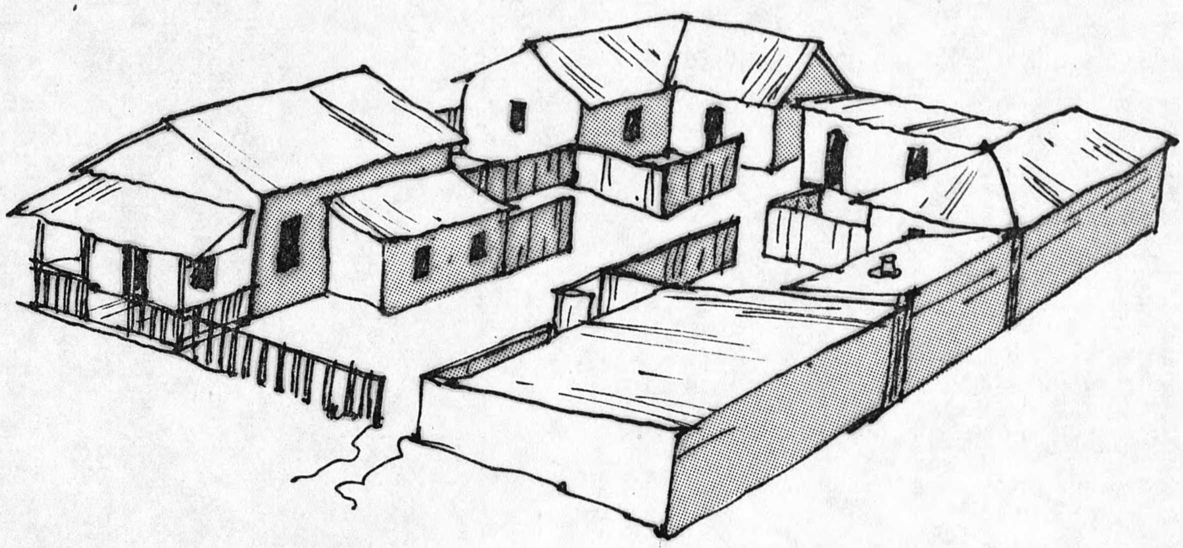
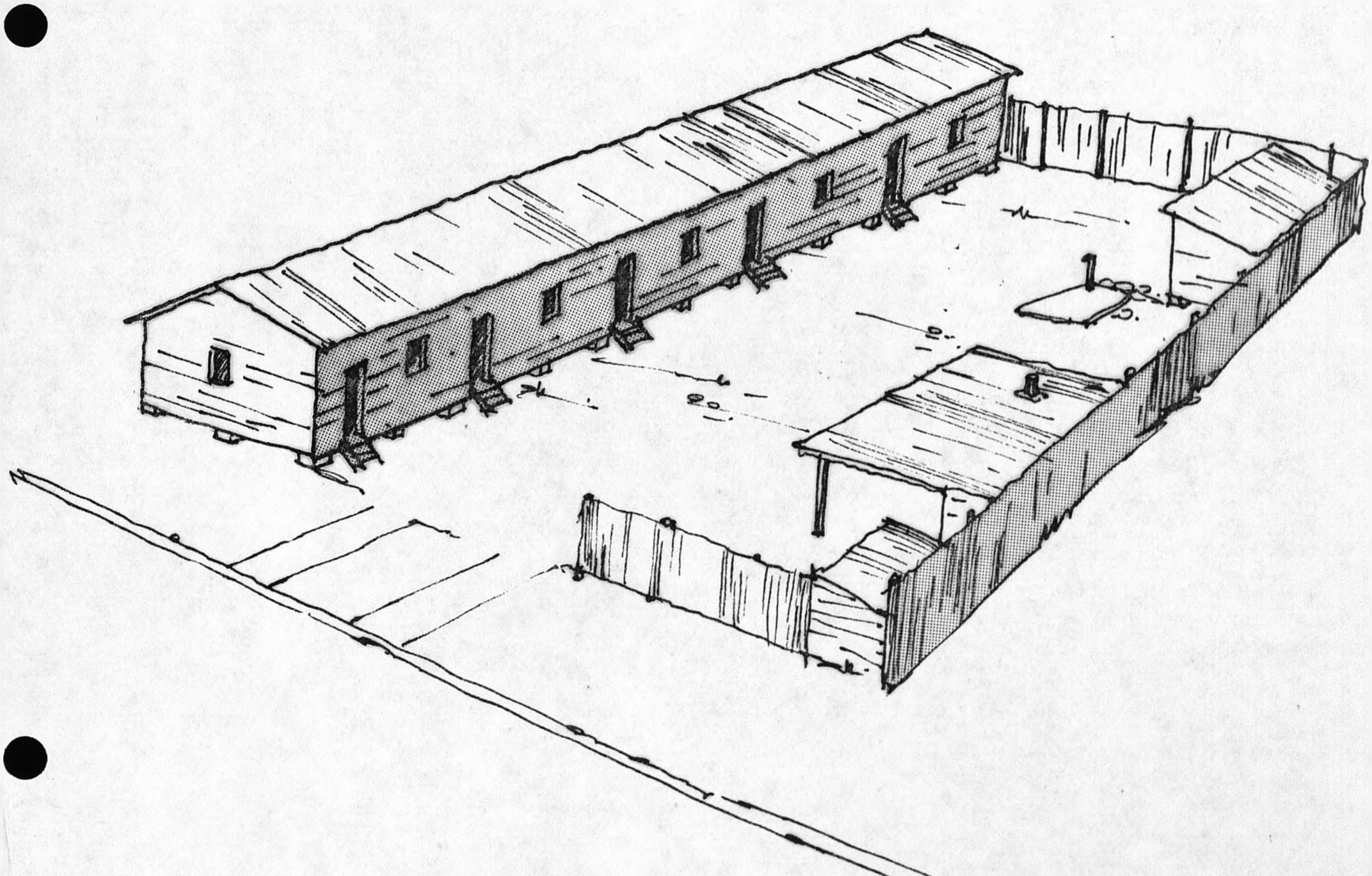
10 A Study of Yards in the City of Kingston, Erna Brodber, Working Paper No. 9, Institute of Social and Economic Research, University of the West Indies, Mona, Jamaica, 1970.

TENANT YARD



GOVERNMENT YARD



other for material and emotional assistance, and a high degree of social interaction is thus an inevitable feature of the yard.[11]

c. Female Orientation. A unique aspect of yard society is that the majority of persons responsible for paying the rent are female. Even though men often live permanently in the household, they normally have established a live-in relationship with the women who (even though they may bear the men's children and live in a husband-wife relationship) are still considered the heads of the households.

3. Vulnerability of the Yards: The majority of structures in yards are poorly built. The materials utilized are usually salvaged or available at little or no cost from construction sites, and only in a few cases are the buildings more than semi-permanent. There are no standard features of yard buildings. While some degree of protection from high winds may be afforded by the close proximity of the buildings, the flimsiness of construction will precipitate widespread losses in a hurricane. In an earthquake, even yard buildings made of block are likely to experience a high percentage of failure because little reinforcement has been used in their construction. The lightweight ramshackle yard buildings made of wood or zinc sheets, however, are unlikely to cause major injuries in a tremor.

Upgrading of the yards will be extremely difficult due to the social and economic characteristics of the people and the high density in each yard. A major obstacle in many yards is that absentee landlords won't make improvements because the tenants won't pay rents and the tenants won't pay rents because the houses are not maintained.

There does appear to be adequate land for redevelopment within the urban centers and, through a careful program of upgrading and redevelopment in urban areas, the vulnerability of people currently living in yards could be substantially reduced.

D. Squatter Settlements. The squatter settlements of Jamaica also have distinct characteristics. Squatters normally occupy (or capture) land and build a house to secure the site. They often locate on government land near gullies, in railroad rights-of-way, or on public lands. They also invade private land if it is perceived that owners may not react.[12]

Squatters usually build one-room shelters of wood and erect a fence around their yards. The first squatters in an area capture as much land as they are able and then rent portions to other squatters. Density increases as the land is divided into smaller plots for rental purposes. Additions and improvements to dwellings occur as tenure becomes more secure.[13]

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11 Ibid.
12 Jamaica Shelter Sector Assessment, Office of Housing, AID, 1977, p. 44.
13 Ibid.

Squatter settlements are found surrounding all the major cities in Jamaica. The people who move to the squatter areas normally come from rural areas but, in the cases of Kingston and Montego Bay, some of the squatters are inner-city residents who have moved to outlying areas in pursuit of land and their own single-family home.

Studies of squatter settlements conducted in conjunction with squatter upgrading projects by the Ministry of Housing show that:

1. Squatter settlements are more male-oriented, with the head-of-household being identified as male in more than half of the cases.

2. Squatter settlements are less dense than yards. Structures usually have only one family per house and only one house per site.

3. There is less mobility among the population of squatter settlements than in the yards. People occupying the land will continue to do so as long as tenure is permitted.

4. Facilities and infrastructure are not communal (except for water standpipes).

5. Buildings are usually upgraded to more permanent housing. The designs and patterns followed usually are similar to those established in the late Colonial Period. Almost all permanent buildings that evolve in these squatter settlements are of block and steel.

6. There is a much lower level of interaction among neighbors than in the yards; yet there is a high degree of community participation.

7. There is a high degree of political activism, and many squatter settlements have aligned themselves as a unit with one political party or another.

Squatter settlements are highly vulnerable to both hurricanes and earthquakes. The quality of construction is fairly poor, and even block and steel buildings are susceptible to damage. In a 1972 study of squatter settlements, it was found that 58% of the people that had reasonably secure tenure were interested in borrowing to upgrade their homes.[14] However, squatters do not have access to credit because of lack of legal tenure, so they are obliged to concentrate on very low-cost improvement measures rather than actions which could be taken to significantly reduce vulnerability. If major vulnerability reduction efforts are to be successful, some form of credit for home improvements will be required for squatters.

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[14] A Preliminary Outline of the National Program of Urban Upgrading, Orlando Patterson, Ministry of Housing, Jamaica, 1972.

CONTEMPORARY SEMI-ENGINEERED HOUSING

The government, as well as a number of low-cost housing corporations, has chosen the approach of using conventional housing projects or schemes as the method of providing housing for low-income families. The buildings erected in these schemes have utilized a variety of industrialized building systems, especially prefabricated and panel construction methods. The primary objective of these schemes is to deliver basic, durable housing to low-income families at the lowest possible price.

The building types normally erected in schemes do not fall under the purview of this study; however, any study of vulnerability of housing in Jamaica would be remiss in not addressing several key points regarding scheme housing. First, many of the projects have been built on land that is vulnerable to earthquakes and hurricanes. The sites chosen are often marginal lands that are easy to acquire at a low cost. With this in mind, the housing erected on these sites must be given special protection and attention. Little of either is evident. Many sites vulnerable to flooding have only marginal protection in the way of river embankments or sea walls; or houses are built on sites that are simply impossible to protect from storm surges or floods. Because the government has created these settlements and directed their development, it bears a special responsibility to prepare adequate protection and, in those settlements where protection is impossible, to develop adequate evacuation plans and construct secure evacuation routes. The most notable case in point is Portmore.

In regard to the houses, there appears to be an assumption that the use of concrete and steel in any form produces a building secure against disasters. In the course of this study, many of the building systems used appeared to be vulnerable to both hurricanes and earthquakes. Experience from other countries has demonstrated the weaknesses inherent in many of the construction systems now utilized in Jamaica. Of special concern are post-and-panel construction (in both hurricanes and earthquakes) and tilt-up or concrete panel construction (in earthquakes). It is important that the government undertake a thorough review of the vulnerability of these buildings and take steps to remedy the problem before a disaster occurs.

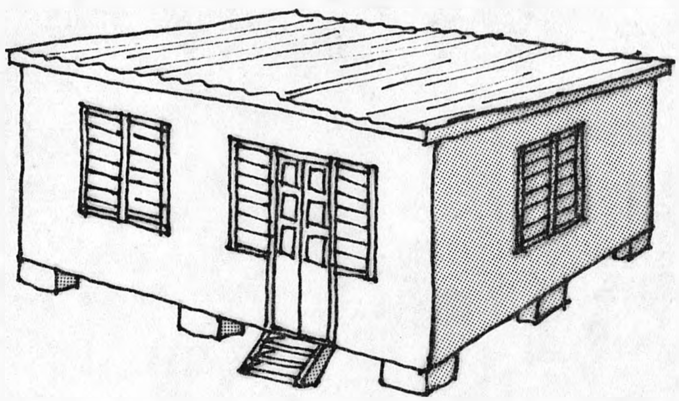
IV. VULNERABILITY ANALYSIS OF VERNACULAR CONSTRUCTION

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.

POPULAR HOUSING DESIGNS

The following drawings illustrate popular designs found in vernacular housing throughout the country. The materials used in the houses vary and are discussed in detail later in the chapter.

A. Basic Rectangular Configuration (Flat Roof)



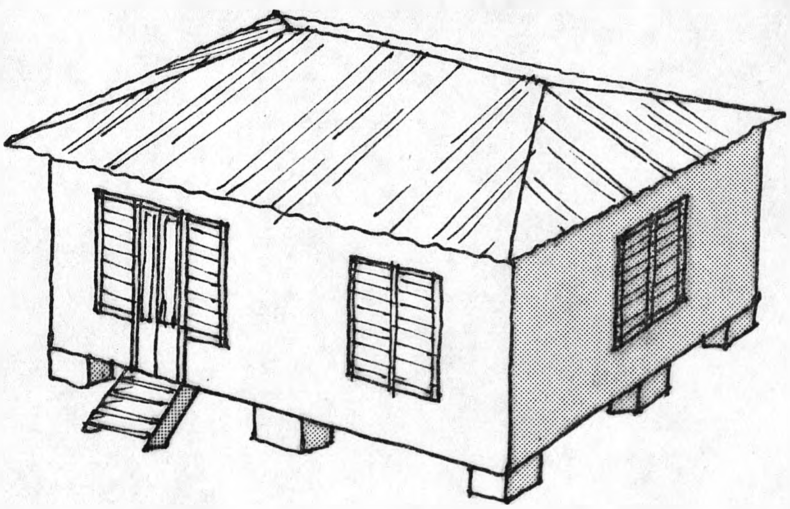
Wall Materials Often Used:

- Wood frame
- Nog
- Spanish wall
- Wattle-and-daub

Period: Contemporary

Comments: Likely to roll over in hurricanes unless securely fastened to ground

B. Basic Rectangular Configuration (Hipped Roof)



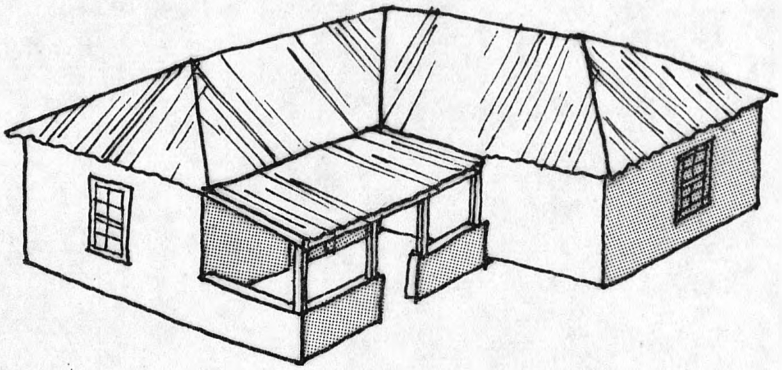
Wall Materials Often Used:

- Wood frame
- Nog
- Spanish wall
- Wattle-and-daub

Period: Crown Rule; Contemporary

Comments: Older nog and Spanish wall buildings vulnerable to both hurricanes and earthquakes

C. L-Shaped Configuration (Hipped Roof)



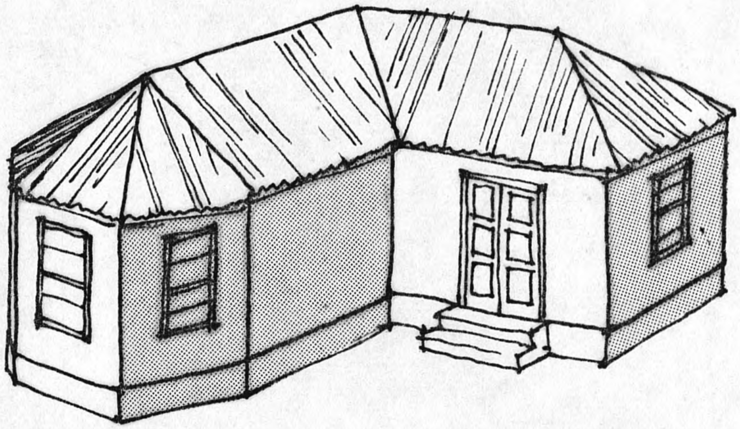
Wall Materials Often Used:

Wood frame
Nog

Period: Crown Rule

Comments: Nog buildings vulnerable to both hurricanes and earthquakes

D. L-Shaped Configuration (Bay Windows)



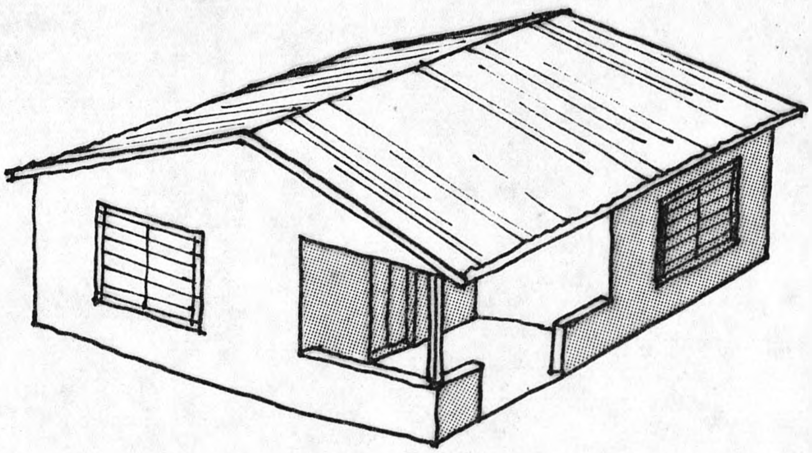
Wall Materials Often Used:

Block
Nog
Wood frame
Wattle-and-daub
Spanish wall

Period: Crown Rule; some in later periods

Comments: Highly vulnerable design

E. L-Shaped Configuration (Overhanging Porch)



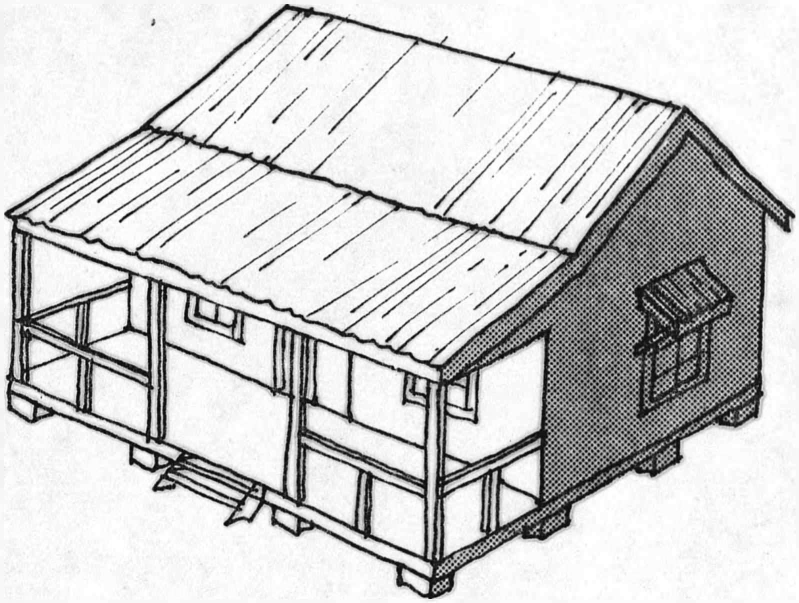
Wall Materials Often Used:

Block
Nog

Period: Contemporary

Comments: Vulnerable to wind damage; very vulnerable to earthquakes

F. Square Configuration (Veranda)



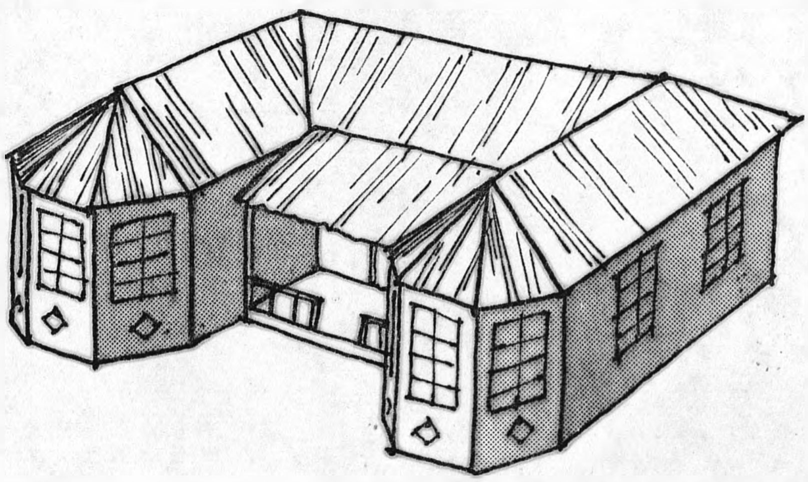
Wall Materials Often Used:

Wood frame

Period: Crown Rule; a few in later periods

Comments: If built with break-away veranda, design is fairly safe

G. U-Shaped Configuration (Bay Windows)



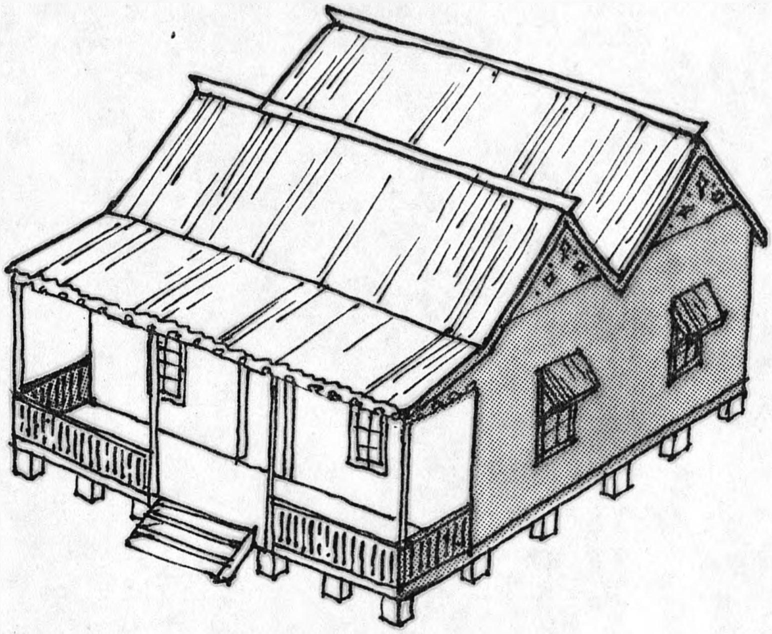
Wall Materials Often Used:

Nog
Block
Spanish wall
Wood frame

Period: Crown Rule; some in later periods

Comments: Highly vulnerable design

H. Rectangular Configuration (Double Roof)



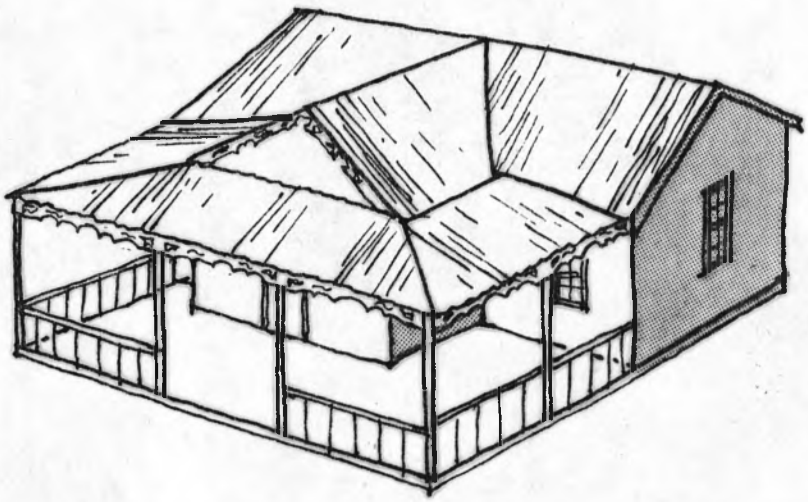
Wall Materials Often Used:

Wood frame
Nog
Mixed

Period: Georgian

Comments: Double (storm) roof excellent for wind resistance

I. T-Shaped Configuration (Break-away Veranda)



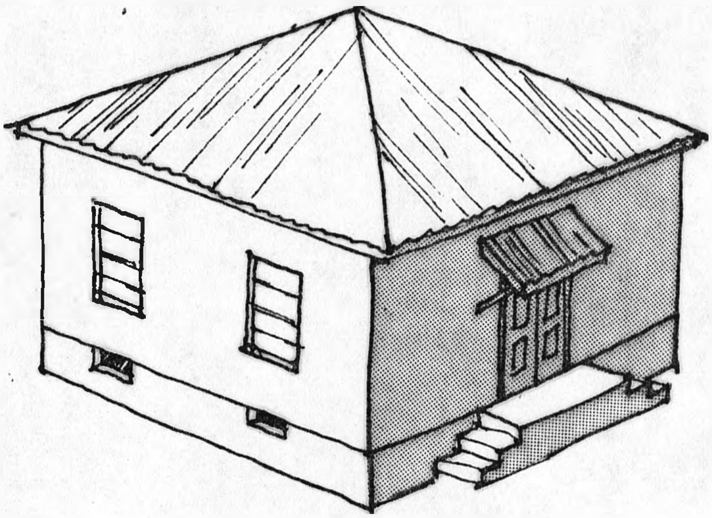
Wall Materials Often Used:

Wood frame
Nog

Period: Kingston

Comments: Verandas usually designed to break away without damage to roof

J. Square Configuration (1 1/2-Story with Rock Foundation)



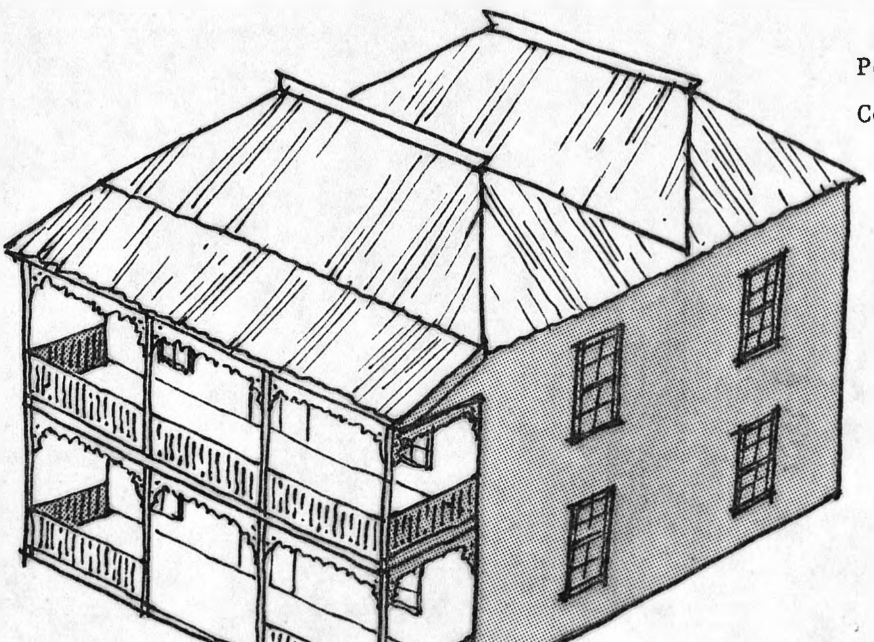
Wall Materials Often Used:

Lower part stone; Upper part wood frame

Period: Georgian

Comments: Fairly resistant to high winds; vulnerability to earthquakes dependent on construction of stone foundation

K. Rectangular Configuration (2-Story, Urban Areas Only)



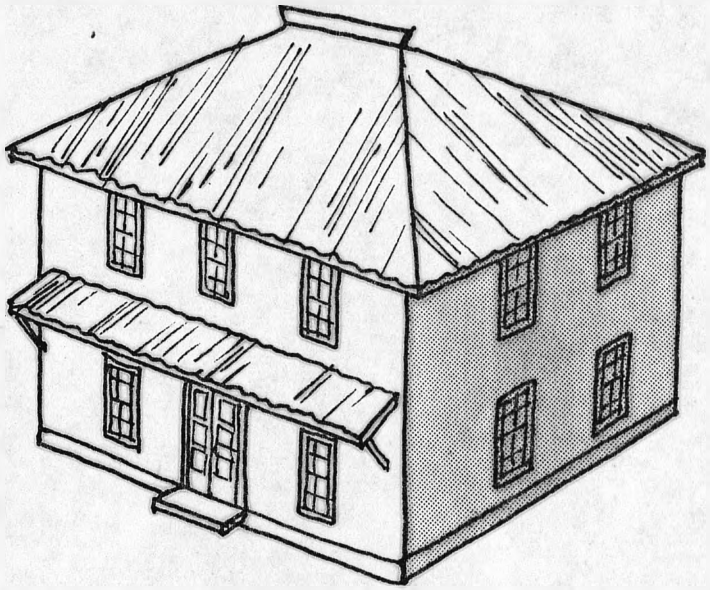
Wall Materials Often Used:

Wood frame

Period: Georgian

Comments: Moderately vulnerable to earthquakes due to age

L. Two-Story Hipped-Roof Townhouse



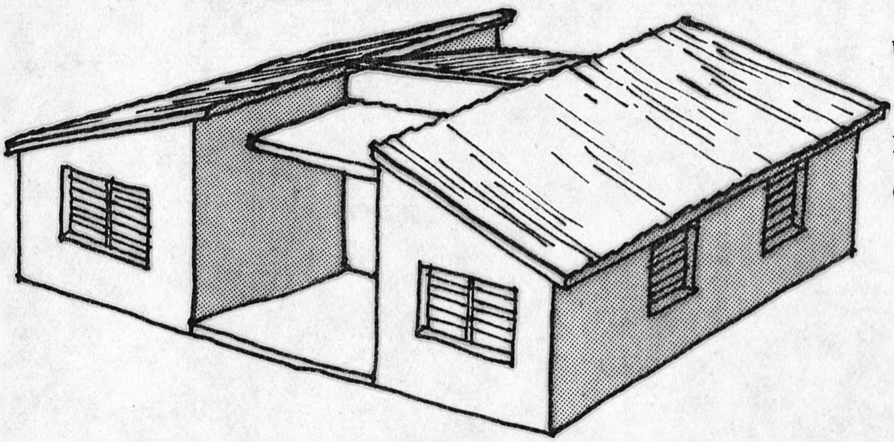
Wall Materials Often Used:

Wood frame

Period: Georgian; some built in later periods

Comments: Moderately vulnerable to high winds due to age

M. Shed Roof



Wall Materials Often Used:

Block and steel

Period: Contemporary

Comments: Highly vulnerable to earthquakes

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 workmanship; the strength of the materials used; 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 heavier materials such as rock, block or concrete panels are more susceptible to damage from earthquakes.

Vulnerability to hurricanes is a function of:

--- Configuration of the building

--- Configuration of the roof

--- How well the building is tied together

--- How securely the roof is tied to the walls

--- How well the building is anchored to the ground

Thus, the buildings most vulnerable to hurricanes are lightweight wood frame homes and those of older nog, wattle-and-daub, and Spanish wall construction where wood may have deteriorated and weakened the walls. Houses made of unreinforced or poorly constructed concrete block are also vulnerable.

Roof configuration and construction are very important considerations for all types of housing. If the roof is not adequately attached and braced, and has a large overhanging eave, it is potentially the weakest part of the house.

Vulnerability of housing to earthquakes is determined by many of these same factors plus several others. In addition to configuration and structural integrity (such as continuity of bracing), other determinants are:

--- Site (should be flat with stable soils)

--- Foundation (should be strong and level)

--- Balance (parallel walls should be of equal size and weight)

--- Center of gravity (walls should be low; roof should be lightweight)

--- Reinforcement in the walls (adequate vertical, horizontal and diagonal reinforcing should be placed in each wall)

In areas of seismic activity, the most vulnerable houses are the unreinforced or poorly constructed concrete block, nog, and concrete panel 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 some buildings may be 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 due to proximity to the ocean where wave action can damage the buildings. In addition, the widespread practice of using stilts for houses on hillsides exposes the houses to total collapse in both hurricanes and earthquakes.

Again, it is important to remember that "risk" means the chance that some type of event like a hurricane might 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.

VULNERABILITY ANALYSIS OF THE BASIC CONSTRUCTION TYPES

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

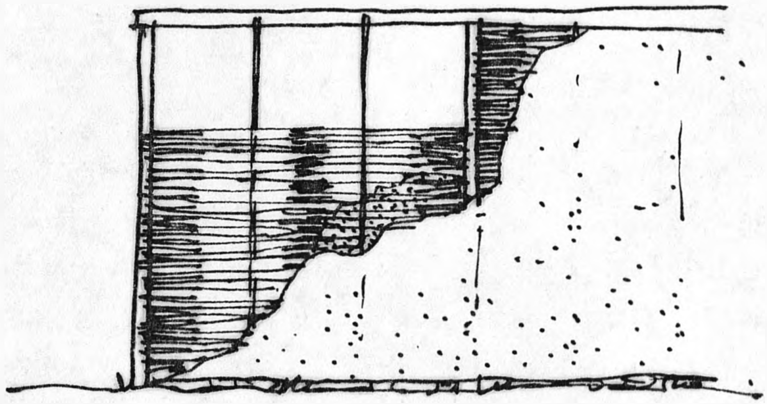
Most recommendations for making the structures more disaster resistant can be incorporated at little or no increase to the total cost of new construction, but some modifications to certain existing building types are both expensive and technically difficult. Thus, recommendations are divided into two categories: simple low-cost changes which could be carried out in an emergency, and more sophisticated actions that can be carried out over a longer period of time.

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 quality of workmanship. All of these features are more important than the materials which are chosen. For it is not the materials that are used, but rather how they are used, that is important. Any type of structure can be made safe if it is designed properly and fastened together securely.

A. <u>Wattle-and-Daub Construction</u>

Wattle-and-daub construction is one of the early forms of building and dates back to the earliest settlements, having been used by the Spanish and English colonists. Some historians believe that the method is reminiscent of African building methods, but the form and features of Jamaican wattle-and-daub clearly follow European lines and methods. Many older wattle-and-daub buildings are found along the North Coast, in the eastern mountains, and in the south between Malvern and Lionel Town. Many people still live in wattle-and-daub structures, but only a few are still being built, mainly in Manchester and Clarendon.

1. <u>Construction</u>: In wattle-and-daub construction, a wooden frame is erected and bamboo, sticks, or cane are woven between the vertical columns, then covered with mud to form the wall. Usually a plaster is applied to both sides of the walls. The plaster is a mixture of mud and lime, usually with an application of a cement-sand mix or lime wash over the outside.



2. <u>Roof</u>: Structures of this type normally have a zinc roof, although in past years a number had wood shingles.

3. <u>Size</u>: Houses built of wattle-and-daub are moderately sized, averaging about 15 x 35 feet.

4. <u>Vulnerability</u>: The older wattle-and-daub houses are very vulnerable to hurricanes because of deterioration of their wood frames. If damaged, the houses will be beyond repair and residents will be forced to rebuild an entirely new structure. The primary causes of structural failure are separation of the roof from the walls (caused by uplift 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. Normally there are few explosions because the houses are not airtight.

5. Other Weak Points: The weak points of the house are the wood columns, the corners (which have inadequate diagonal reinforcement), and the connections between the roof and the walls.

6. Modifications for Wind Resistance: In order to improve the wind resistance of wattle-and-daub houses, the following actions are recommended:

   a. Emergency measures

      --- Increase the number of nails used to fasten the zinc to the roof frame.

      --- Place wood braces 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.

      --- Board up the windows in a hurricane.

      --- Place heavy objects such as bricks on the roof to break up suction created by the wind.

   b. Progressive upgrading measures

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

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

      --- The primary columns (corners and columns in the middle of each wall) should be buried a minimum of 24 inches and should use some form of anchoring device.

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

   The hurricane resistance potential of wattle-and-daub, 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 its performance can be attained.

7. Modifications for Earthquake Resistance: In terms of vulnerability to earthquakes, wattle-and-daub structures are relatively safe. The principal weakness is still the columns 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 wattle-and-daub 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 structures are lightweight and, because they are woven together, big chunks will not come flying off to cause major harm to the occupants.

B. Spanish Wall Construction

Spanish wall construction is one of the oldest types of building methods used in Jamaica. Introduced in the 1700's, the technique was employed for construction of secondary buildings, barns and other non-residential construction prior to its introduction into housing. Because it was cheap and easy to build, it gained popularity, and the majority of small residential rural buildings of the mid-1800's utilized this method. A small number of people still reside in these buildings, but no new construction has been seen in recent years.

1. Construction: Spanish wall houses are constructed by erecting a wooden frame with vertical columns three to four feet apart. Boards are then attached to the inside of the columns and small, flat rocks are cemented vertically to form a section of the wall. When the section is completed, the back boards are moved to another part of the frame and the process is repeated until the entire wall is completed. A diagonal brace is usually placed in each corner, and the upper part of the frame serves as a ring beam for the structure.

2. Roof: Spanish wall houses usually have zinc roofs, although a few still use wood shingles.

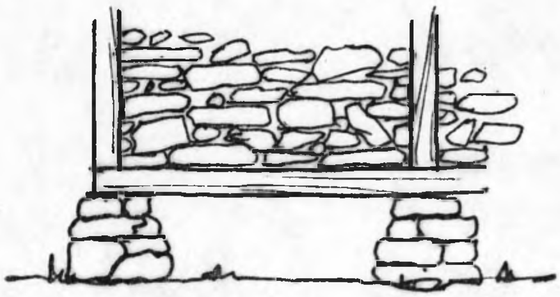
3. Size: Houses built in this manner are usually fairly small, between 10-15 feet wide and 15-20 feet long.

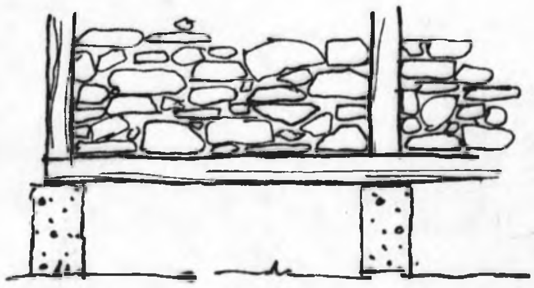
4. Vulnerability: The strength of Spanish wall houses depends on the strength of the frame and the connections between walls. Expected damage includes separation of the roof from the walls, failure of the gables, and separation of the walls. Wall failure is usually a result of deteriorated wooden columns.

5. Other Weak Points: Another weakness of Spanish wall construction is deterioration of the mortar. In high winds, weakened walls may collapse from the pressure of wind gusts.

   Other weak points in high winds include the connections between the roof trusses and the wooden ring beam atop the wall, and the gables at each end of the structure.

   Many Spanish wall buildings are placed on footings or stilts rather than on a solid foundation. These buildings will totally collapse in an earthquake.





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

   a. Emergency measures

      --- Use more nails to fasten the zinc sheets to the roof trusses.

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

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

      --- Seal the area beneath the walls with rocks and mud.

      --- Board up windows in a hurricane.

   b. Progressive upgrading measures

      --- Add storm shutters to help close off windows during periods of high wind.

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

      --- Place all walls on a solid rock or poured concrete foundation.

      --- Use diagonal bracing in the roof structure.

      --- Place diagonal braces on the top of the frame in each corner to tie the walls together.

      --- Replace stone gables with wooden gables. In a hurricane, the rock panels would tend to separate from the beams on which they rest and could fall into the house.

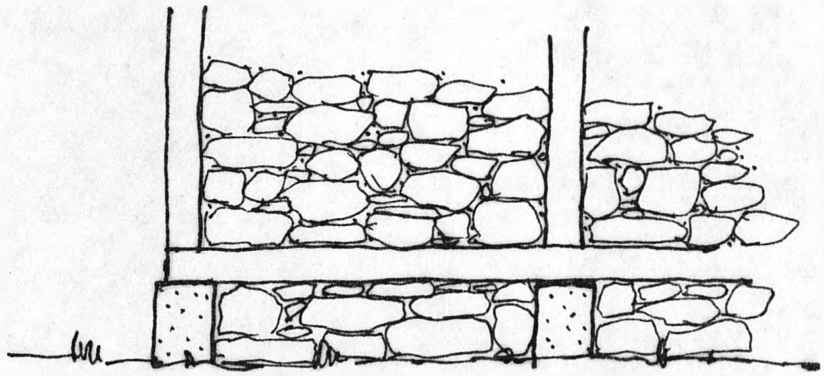
   If the above recommendations are carried out, the wind resistance potential of Spanish wall structures will be substantially increased. If properly reinforced, this type of building can be made moderately wind resistant.

7. Modifications for Earthquake Resistance: Structures using Spanish walls can be excellent in terms of resistance to earthquakes because the frames can provide good bracing for the walls. The most important features to consider are the condition of the wood, the connections between the walls, and the strength of the foundation.

C. Stone Nog Construction

Stone nog houses date back to the 18th century and at one time were the most prevalent form of housing. Today many people still live in these buildings, but only a few new ones are built each year. They are found throughout the country in both urban and rural areas, both on the coast and in the western mountains.

1. Construction: Stone nog walls are built with a segmented wooden frame with vertical columns 3-4 feet apart. When the frame has been completed, a rock infill is cemented inside each section of the frame. As soon as one section has set, the process is repeated until the entire wall is completed. Corners are usually reinforced with a wooden diagonal brace. The walls normally rest on blocks or concrete footings, although some do sit on stone or poured concrete foundations.



The mortar of the older stone nog buildings was often made of mud, burnt marl, and fibers such as horse hair. More recently, lime and mud or cement and sand mortars have been used. The sand and cement mortars have weathered well, but the lime and mud show much deterioration.

2. Roof: Stone nog houses usually have zinc roofs, although older buildings may use wood shingles.

3. Size: Houses built in this manner are small to medium in size, between 10-20 feet wide and 30-40 feet long.

4. Vulnerability: Stone nog houses can be extensively damaged in hurricanes. Expected damage includes separation of the roof from the walls, failure of gables, and failure of the walls themselves. Failure of the walls is generally a result of deterioration of the mortar or the wooden frame. Studies of damage to this type of structure show that there is a high percentage of collapse due to buildings being blown off their footings.

5. Other Weak Points: Louvered windows are commonly used in stone nog houses. In high winds, louvers allow excessive amounts of wind through the windows, thereby increasing the pressure which pushes upward on the roof, lifting it off the walls.

Other weak points of the structure include the connection between the roof trusses and the wooden ring beam atop the wall, gables at each end of the structure, and connections between the walls at the corners.

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

a. Emergency measures

--- Use more nails to fasten the zinc sheets to the roof trusses.

--- Fasten the roof rafters to the ring beam with metal straps or hurricane fasteners, giving special attention to the corners.

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

--- Seal open spaces beneath walls with rock and mud.

--- Board up windows in a hurricane.

b. Measures for progressive upgrading or new construction

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

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

--- Place each wall on a solid concrete and stone foundation and tie the wall to it with steel bars buried in the concrete and bent tightly onto the wood frame.

--- Place diagonal braces in the roof frame of gabled roofs.

--- Use diagonal bracing to reinforce each vertical column, not just the corners.

--- Tie corners together by fastening a diagonal brace onto the top of the frame.

--- Replace nog gables with wooden gables. In a hurricane, nog gables would tend to break away from the beams they rest upon and could fall into the house.

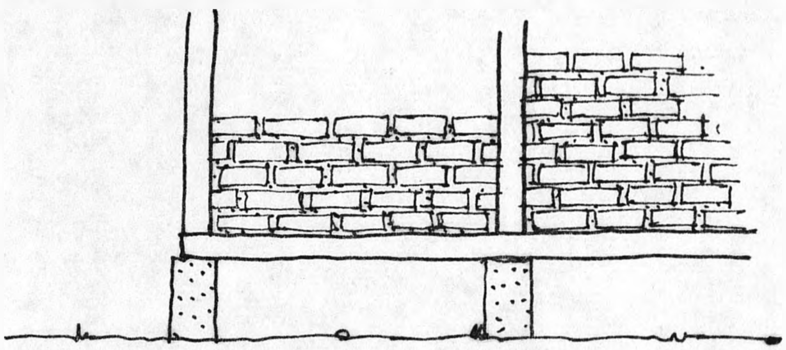
If the above recommendations are carried out, the wind resistance potential of stone nog structures will be substantially increased. If properly reinforced, this type of building can be made moderately wind resistant.

7. Modifications for Earthquake Resistance: Stone nog structures can be excellent structures for resistance to earthquakes if properly built and maintained. The most important features to consider are the connections between the walls, the condition of the wood supports, and the placement of the buildings on a solid concrete and stone foundation.

D. Brick Nog Construction

Brick nog was an outgrowth of stone nog and unreinforced brick construction. The latter had gained popularity, especially in the urban centers, at the turn of the century; but the 1907 Kingston earthquake and the high losses suffered by unreinforced brick buildings led to widespread adoption of nog techniques. As hardwoods became more difficult to obtain and cement blocks became more available, brick nog construction ceased, but large numbers of people in the older sections of Kingston and other cities still live in brick nog buildings. Many tenements are of nog.

1. Construction: Brick nog houses are constructed by building a wooden frame, placing the columns 3-4 feet apart. When the frame has been completed, standard fired bricks are cemented into the frame using a cement and sand mortar. Construction uses standard masonry techniques, the only difference being the wood structure used for reinforcement. Most walls are placed on foundations made of brick, stone or poured cement.



2. Roof: Brick nog houses usually have zinc roofs, although a few use wood shingles.

3. Size: Houses built in this manner vary greatly in size and many are two-story.

4. Vulnerability: Brick nog houses are fairly secure in hurricanes. Expected damage includes separation of the roof from the walls and failure of the walls themselves. The latter damage is usually a result of separation of the bricks from the wooden columns, but this is not too common. In earthquakes, building damage is generally a result of poor foundations and poor connections between walls and between walls and foundation.

5. <u>Other Weak Points</u>: Louvered windows are common features of brick nog houses. In high winds, louvers allow excessive amounts of wind through the windows, thereby increasing the upward pressure on the roof, causing roof loss.

Another weak point is the connection between the roof and the wooden beams atop the wall.

6. <u>Modifications for Wind Resistance</u>: The following actions are recommended in order to improve structural performance in high winds:

a. <u>Emergency measures</u>

--- Use more nails to fasten the zinc sheets to the roof trusses.

--- Tie the roof rafters to the ring beam with metal straps or fasteners.

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

--- Seal open spaces beneath walls with rock and mud.

--- Board up windows in a hurricane.

b. <u>Progressive upgrading measures</u>

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

--- Treat wood posts before placing them in the walls or foundation.

--- Place each wall on a solid concrete and stone foundation and tie the wall to it with steel bars buried in the concrete and bent tightly onto the wood frame.

--- Use diagonal bracing in the roof structure.

--- When gables are used, build them with wood. In a hurricane, the bricks can break away from the beam they rest upon and could fall into the house.

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

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

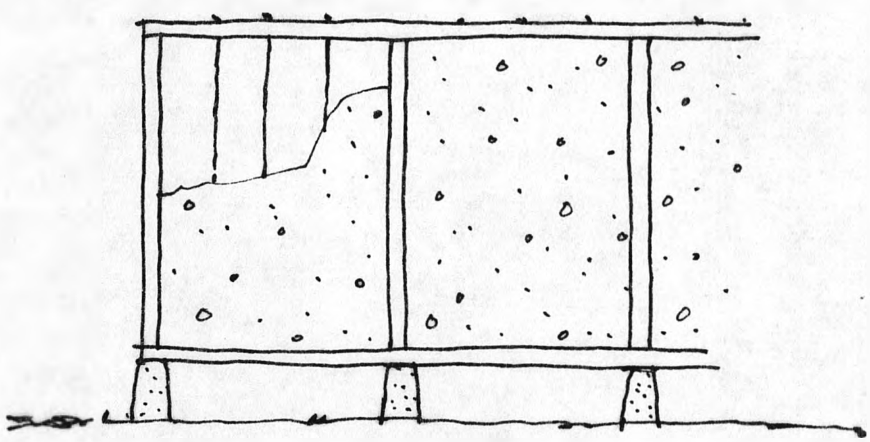
7. <u>Modifications for Earthquake Resistance</u>: Brick nog structures are excellent for resistance to earthquakes. The most important features to consider are the condition of the wood, the connections between the wooden columns, the condition of the brick infill, the placement of the walls on a solid foundation, and adequate strength in the center of the walls.

E. Concrete Nog Construction

1, Construction: Concrete nog walls are built by erecting a wooden frame, placing the columns 3-4 feet apart. When the frame has been completed, wide boards are attached to each side of the columns and concrete is poured between the boards. As soon as the concrete is 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 either by stapling barbed wire between the columns or by using iron reinforcing rods.

The foundations for most concrete nog houses are made of concrete which is poured after the frame has been built.



2. Roof: Concrete nog houses usually have zinc roofs.

3. Size: Houses built in this manner are usually fairly small, between 10-15 feet wide and 15-20 feet long.

4. Vulnerability: Concrete nog houses can be extensively damaged in hurricanes. Expected damage includes separation of the roof from the walls, failure of gables, and failure of the walls themselves. Failure of the walls is usually a result of separation of the concrete panels from the wooden columns, due to insufficient strength of the bond between the panel and frame. Even those houses that have iron rebars suffer this type of damage unless there is adequate fastening of the concrete panel to the frame. Studies of damage to this type of structure show that there is a high percentage of explosive damage (caused by differential pressure pulling the house outward).

5. <u>Other Weak Points</u>: Most concrete nog houses have louvered windows. 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, and the gables at each end of the structure.

6. <u>Modifications for Wind Resistance</u>: The following actions are recommended in order to improve structural performance in high winds:

a. <u>Emergency measures</u>

--- 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 with metal straps or wire, giving special attention to the corners.

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

--- Place diagonal braces atop the frame at each corner to tie the corners together.

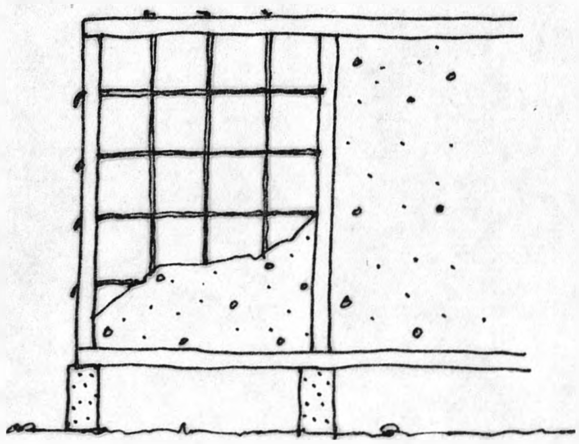
--- Board up windows in a hurricane.

b. <u>Measures for progressive upgrading or new construction</u>

--- Use a hipped roof configuration.

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

--- Use iron rebars for reinforcing the concrete panels.



--- Treat wood posts before using them in the frame or placing them in/on the ground.

--- Place each wall on a solid concrete and stone foundation and tie the wall to it with steel bars buried in the concrete and bent tightly onto the wood frame.

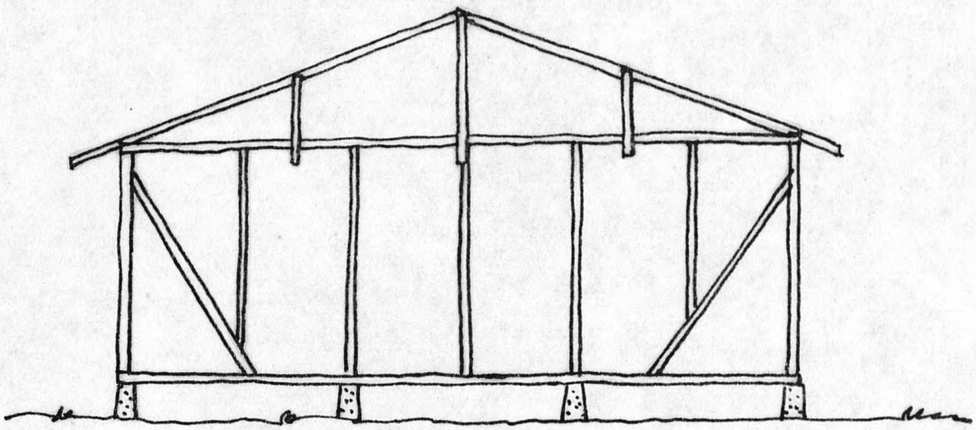
--- Use diagonal bracing in the roof structure of gabled roofs.

--- Replace nog gables with wooden gables. In a hurricane, the concrete would tend to break away from the beams it rests upon and could fall into the house.

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

7. Modifications for Earthquake Resistance: Concrete nog structures can be excellent for resistance to earthquakes. The most important considerations are the condition of the wood, the strength of the foundation, and the connections between the wooden columns and the concrete panels.

F. Wood Frame Construction



1. Construction: The wood frame house is one of the most popular building types in Jamaica and is especially popular with low-income families in rural areas where land tenure cannot be secured. The house offers the advantages of ease in building additions and suitability to the climate. If maintained properly, it will last for many years. Because it is lightweight, it can be moved if necessary.

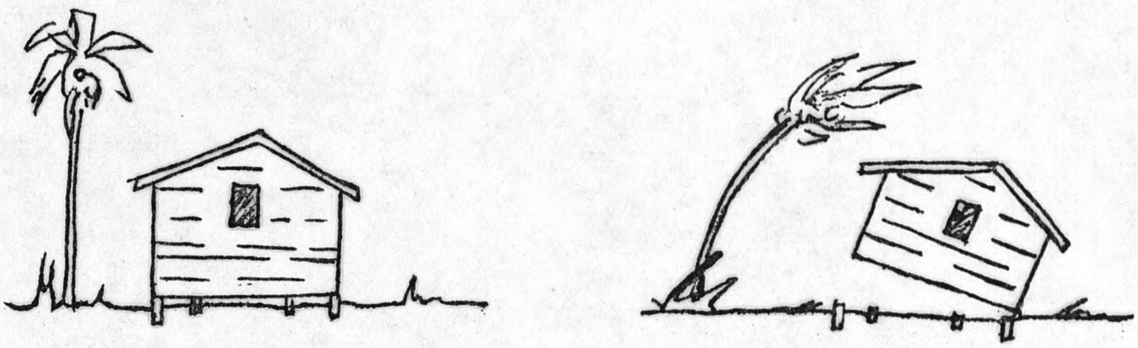
   Wood frame houses at one time were very reasonably priced and affordable to almost all income groups. In the last decade, however, this type of house has become more expensive because of the cost of lumber (most of which is now imported from Belize). In some areas it is almost as expensive to build a house of wood as it is to build one of block and steel.

2. Roof: The preferred roof covering for wooden houses is zinc.

3. Size: Sizes vary from 12 x 15 feet to 15 x 50 feet.

4. Vulnerability: The most common damage caused by high winds is roof separation. In those houses which have louvered windows, damage may be caused by differential pressure pushing out on the walls until portions of the walls separate at the corners.

   Many wood frame houses rest on concrete blocks or feet and are anchored to the ground only by the corner posts of the frame, if at all. This is insufficient anchorage for hurricanes, and the houses will be lifted off the ground and toppled over.



5. Other 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 connections between the building and the ground.

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

   a. Emergency measures

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

   --- Seal the area below the house with rocks and mud to prevent uplift.

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

   --- Seal the eaves of the house to prevent wind from entering under the overhang.

   --- Board up windows during periods of high wind.

   b. Measures for progressive upgrading or new construction

   --- Use a hipped roof configuration.

   --- Place diagonal braces on top of the frame at each corner to tie the walls together.

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

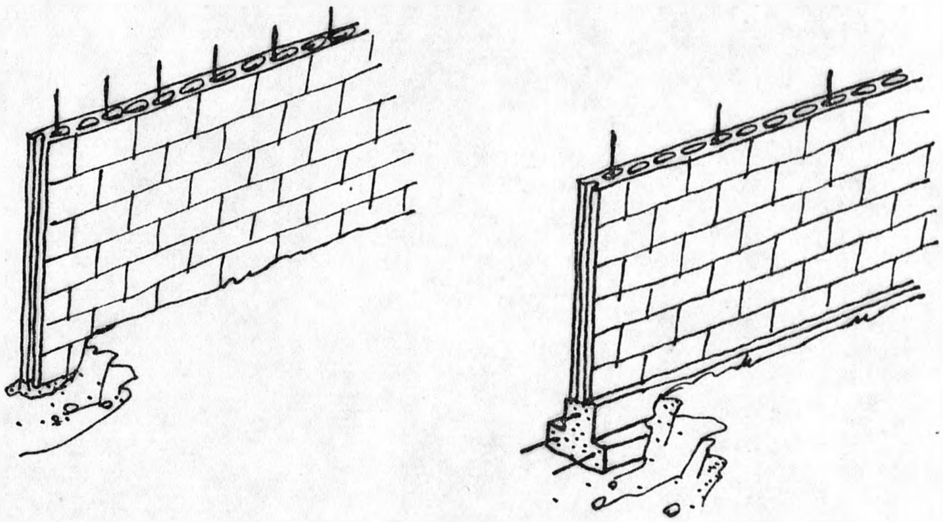
If these recommendations are carried out, the potential for this type of structure to resist high winds will be substantially increased. If properly built, this type of structure will provide moderate safety in hurricanes.

7. <u>Modifications for Earthquake Resistance</u>: The earthquake resistance of wood 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.

G. Concrete Block and Steel Construction

If properly built, a concrete block house can withstand the forces of both earthquakes and windstorms and is the safest form of construction used in Jamaica.

1. Construction: The reinforcement normally used for block houses in Jamaica is more than adequate. Usually iron reinforcing rods are placed vertically in the corners and walls at no more than 18" intervals. At the top of the walls a ring beam is made of poured concrete. Foundations are made by cementing a course of blocks slightly below ground on which the walls rest.



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

2. Roof: The roofs of most block and steel houses in Jamaica are zinc, although more and more concrete roofs are being built. The zinc sheets are attached to wood purlins which are fastened to the walls by bending a portion of the steel used in the reinforcing columns or ring beam over the base of the truss. Roofs use "shed" (flat, sloping roof), gable and hipped configurations.

3. Size: Concrete block houses vary in size. The smallest are approximately 12 x 20 feet with the average being approximately 15 x 30 feet.

4. 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 cases where houses use louvered windows, excessive pressure can build up inside the house, usually resulting in loss of the roof. Explosions occur only to very poorly built structures.

5. Other Weak Points: Many block houses in Jamaica have large overhanging eaves. In high winds, the eaves trap excessive amounts of wind underneath, creating uplift under the edge of the roof and thereby contributing to roof damage or loss.

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

   a. Emergency measures

      --- Use more nails to attach the metal sheets to the roof frame.

      --- Seal the eaves of the roof.

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

   b. Measures for progressive upgrading or new construction.

      --- Use a hipped roof configuration.

      --- Use a roof pitch between 30°-40°.

      --- Reduce roof overhangs.

      --- Replace flat roofs with hipped roofs.

      --- Design verandas 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 wind storms.

7. <u>Modifications for Earthquake Resistance</u>: 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.

8. <u>Discussion of Block and Steel Building Standards</u>: Many observers have noted that the standard method of building a block and steel wall in Jamaica is overdesigned for the type of building normally erected (small, one-story structures). The recommended method was adopted from the California Building Code for Earthquake Areas and, if properly built, provides excellent protection in both earthquakes and hurricanes.[15] Numerous reports advocate reduction in the amount of steel used and change in the method of constructing corner columns and horizontal bond beams. They claim that this would lower the cost of construction at only a marginal reduction of safety, if any.

   Advocates of the present method feel that the low quality of masonry work justifies an overuse of reinforcing steel and point out that the "U" blocks needed for the proposed method of construction are not now commonly available in Jamaica.

   An analysis of comparable block and steel structures made with each method points out that savings in total cost of building with the new method represents only a 5% decrease in cost over the existing method when used in small buildings (approximately 15 x 25 feet) and only a 2% reduction in moderate-sized houses (20 x 40 feet).

   For hurricane protection, an additional aspect of the existing method should be considered. When the top course of the wall is complete, it is common to leave a number of the rebars projecting from the top so that the roof can be attached. In the new method, anchors can be cemented into the tie beam, but they only extend into the wall several inches and are far less secure than the rebars presently used.

   Thus, in terms of all-round protection from disasters, the authors of this report recommend that the present method be retained.

   Of great concern, however, is the present method of building foundations. It is strongly recommended that increased emphasis be placed on construction of low-cost yet strong foundations as shown on page 70.

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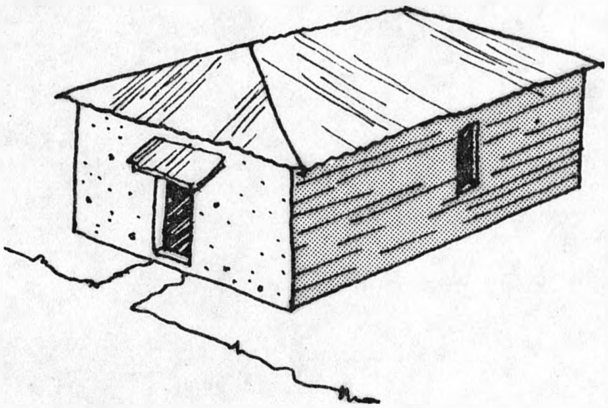
[15] An excellent discussion and analysis of the method is found in <u>A Study of Housing in Jamaica</u> (prepared for the Ministry of Public Service, Sept. 1976), pp. 79-94.

VULNERABILITY ANALYSIS OF HOUSES BUILT OF MIXED MATERIALS

It is common to find variations of housing types which display a mix of the basic building types. This mix 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 may represent an attempt by the homeowner to demonstrate economic achievement by using a more prestigious building material.

The following is an analysis of the most common mixed structures and their vulnerability.

A. Wood Frame House with Concrete Block or Nog Facade



1. Construction: This type of mixed construction is found most often in the newer buildings in towns and urban areas. There are many variations in the facades, although almost all of the newer buildings use block while the older ones use some type of nog.

   This type of construction normally utilizes a wooden frame and wood siding on all sides except the principal public (or entrance) side of the building. The block or nog facade is normally placed on the side facing the street.

   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.

2. Roof: The roofs for this type of house are zinc.

3. Size: Sizes vary between 12 x 20 feet to houses as large as 20 x 50 feet.

4. Vulnerability: The most vulnerable and dangerous parts of these buildings are the block or nog walls. In both earthquakes and hurricanes, these facades push on the weaker wooden parts of the building, contributing to their 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 or nog as 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.

5. Other Weak Points: The typical weak points of this type of construction are the connections between the wooden walls and the block or nog walls, deterioration of the wood in the nog facades, and the lack of adequate foundations for both block and nog walls.

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.

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

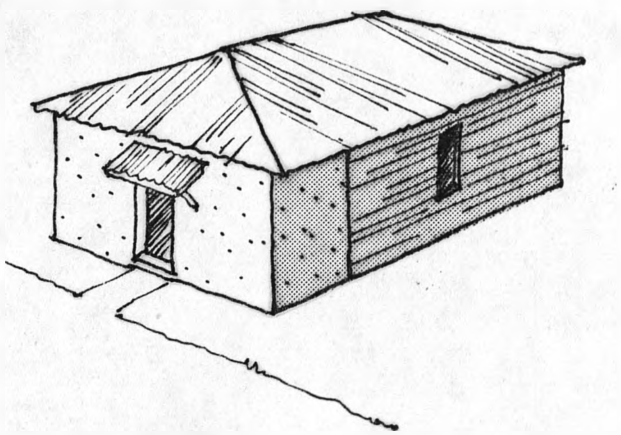
a. Emergency measures

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

--- If nog or block wall could easily topple, place wooden braces on the outside to help support it.

b. Measures for progressive upgrading or new construction

--- Place the facade and its supporting buttress on a strong, solid foundation.



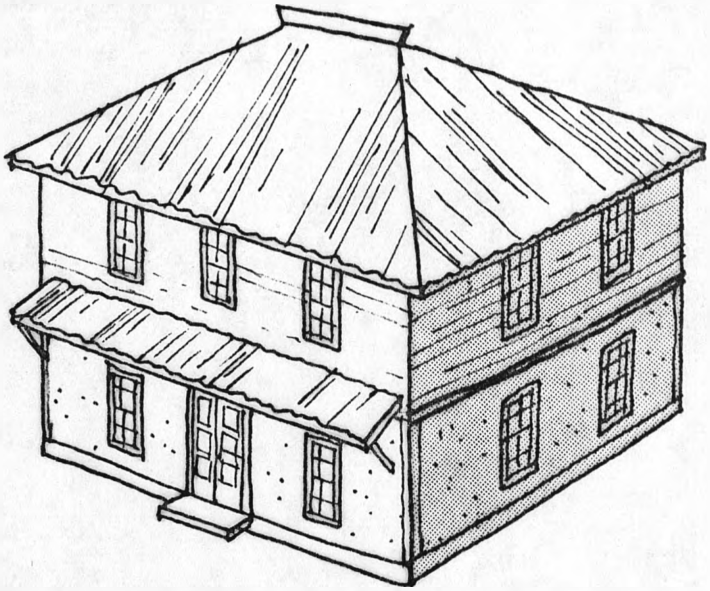
--- Ensure that an adequate exit is built at the rear of the building (the end opposite the block or nog facade).

--- Build diagonal supports of block to buttress the facades and wall.

If the recommendations outlined above are incorporated in the design of these houses, the wind resistance of the buildings will be fairly good.

7. Modifications for Earthquake Resistance: These types of buildings are moderately dangerous in earthquakes. The recommendations outlined above will help to make the houses less dangerous, but they would not be considered earthquake resistant. Especially important are foundations for the masonry wall and diagonal reinforcements or buttresses.

B. Rock and Wood Frame Construction



1. Construction: Buildings of this type are older two-story buildings found in the coastal towns and cities. Lower portions of the structures were built using one of several rock construction techniques (e.g. rubble walls, stone nog, "pointings"*, or in some cases Spanish wall) while the upper portions are wood frame construction.

   Construction details borrow from both wood frame and various rock wall techniques. When stone nog or Spanish walls are used, wood frames provide wall-to-ground connections and anchorage, and vertical reinforcement in the corners and center of the walls. When conventional rock wall construction is used, no reinforcement is used; but great attention to construction details is evident, especially in the corners.

   Mortars vary, according to the age of the building. Georgian-era structures often have a mortar made of mud, burnt marl and horsehair. Later techniques included lime and mud and, more recently (from the 1900's) cement mortars. A wood plank and 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 corners.

2. Roof: Both zinc and wood shingle roofs are used. A variety of configurations are found. Storm roofs were popular at the time of construction and many are still used.

3. Size: Size averages about 20 x 50 feet.

4. Vulnerability: Houses of this type are generally older, two-story structures found in urban areas. If properly built and maintained, this type of building can be relatively safe

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* "Pointings" is a form of stone masonry work where the mortar is left jutting out of the seams between the stones for decorative purposes.

in high winds; although in earthquakes, poorly constructed rock walls will exhibit a high proportion of failure. Many of these buildings are quite old (over 150 years) but were well-built and their overall vulnerability depends upon how well they have been maintained, the condition of the wood, and the soundness of the original design. If the masonry work is good and the wood frame is fastened securely to the lower rock portions of the wall, the buildings will be fairly safe. Because of the low center of gravity and the lightweight upper structure of the buildings, they can be particularly resistant to earthquake tremors.

5. Other Weak Points: Typical weak points of these buildings are:

   a. Inadequate fastening of zinc sheets to the roof frame.

   b. Connections between the roof and walls.

   c. Connections between the wood frame and rock walls.

   d. Deterioration of the wood frame in the Spanish wall and nog construction.

   e. Deterioration of the mortar.

   f. Poor foundations and deterioration of the bond between the foundation and the rock wall.

6. Modifications for Wind Resistance: The following actions should be taken to increase wind resistance:

   a. Emergency measures

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

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

   b. Progressive upgrading measures

      --- Increase the number of connections between the wood frame and rock walls.

      --- Ensure that the mortar in the rock walls is maintained or patched.

      --- Replace deteriorated wood that is used structurally.

7. Modifications for Earthquake Resistance: Despite their size and two-story construction, these buildings can be made more resistant to earthquakes. The recommendations above will further enhance their performance. Especially important are the replacement of deteriorated wood in nog and Spanish wall

constructions and the strengthening of rock wall and wooden upper structure connections. It is also important to re-emphasize that the quality of workmanship is a vital factor in making these buildings safe.

POPULAR BUILDING FEATURES

A. Features and Practices Which Reduce Vulnerability

1. Storm Roofs: Many older buildings in Jamaica still utilize a double roof system, that is, an individual roof over every major room or section of the building. In the early days these were referred to as either "hurricane" or "storm" roofs and were a specific adaptation to the Jamaican environment. This type of roof offers excellent protection in high winds and continued use should be encouraged.

2. Hipped Roofs: The majority of buildings outside Kingston use peaked roofs. Many of these are "hipped" roofs which offer excellent protection in high winds. Continued use of hipped roof configurations should be encouraged.

3. Hurricane Straps: In many older buildings, the practice of using metal straps to fasten the roof trusses to the building was fairly common. In recent years, this practice seems to have disappeared, and planners should encourage a return to the use of these straps.

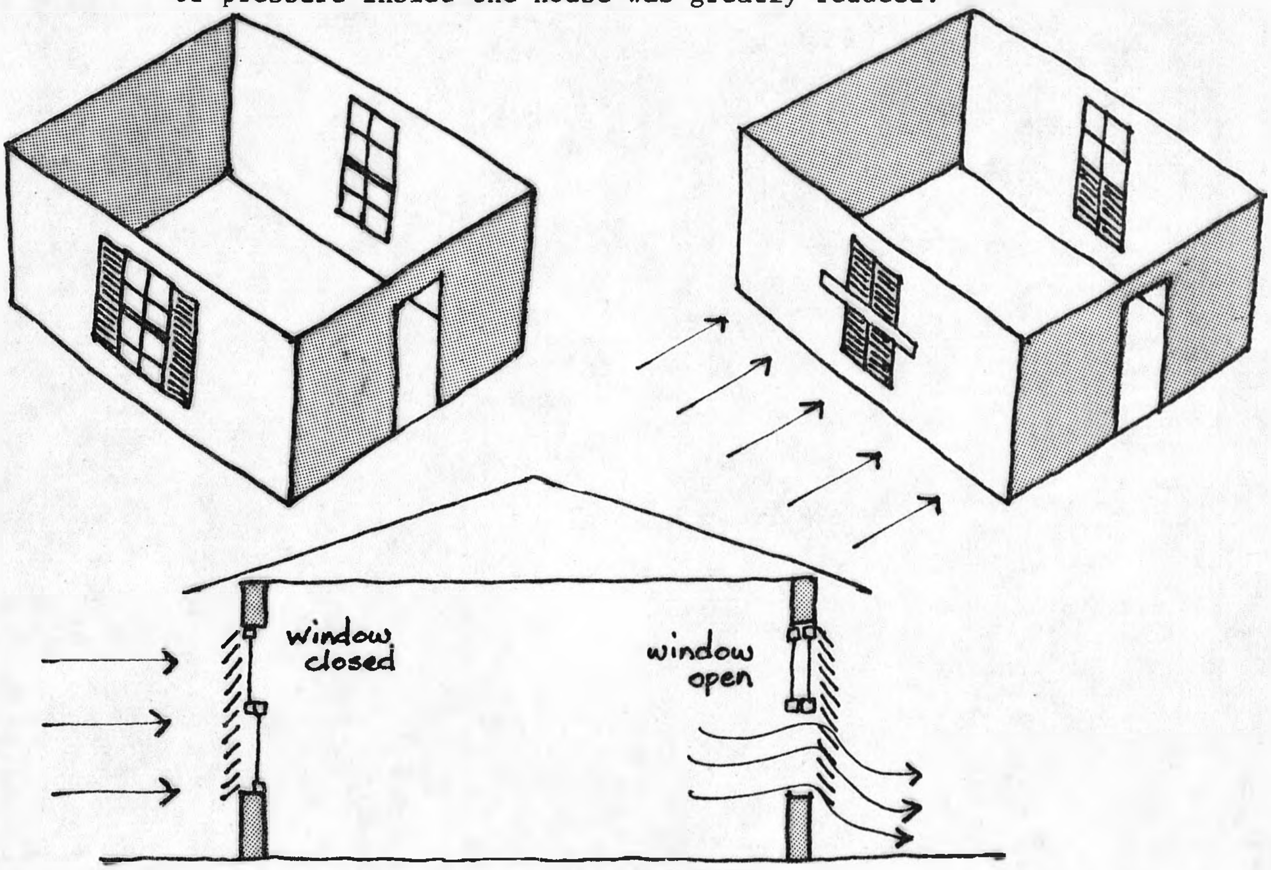
4. Small Eaves: The roofs of many older homes project only a few inches over the sides of the walls. This reduces uplift under the eaves and damage to the roof. Where shading is required for windows, breakaway awnings can be used, as is the practice in many of the older Jamaican homes.

5. Stone Foundations: Many of the older buildings, especially those constructed during the Georgian period, used stone foundations. When heavier wall construction is used, this not only helps to prevent cracking and settling in earthquakes and hurricanes, but it also helps strengthen the walls by distributing the weight and preventing air from getting under the house to lift upwards on the building.

6. Low Center of Gravity: Many early buildings were built so that the weight of the structure was distributed with heavier construction materials at the base and progressively lighter materials as the height increased. In part, this was due to architectural and engineering techniques of that period. The practice offers excellent protection against earthquakes and hurricanes, and should be encouraged, especially for two-story buildings.

7. Storm Shutters and Sash Windows: A feature of many of the early buildings in Jamaica, storm shutters and sash windows were an ideal adaptation to the hurricane environment. The drawing on the next page illustrates the principles behind their construction. When a hurricane threatened, the storm shutter was closed over the window. The shutter protected the opening from flying debris and the downward deflection of the panels prevented rain from entering the window.

The sash window provided an excellent seal against wind and rain. As the storm grew stronger, the pressure inside the house could be equalized to that of the air rushing by outside by opening the windows on the lee side while keeping the storm shutters closed. By keeping the leeward windows open, the threat of "explosive effect" caused by a buildup of pressure inside the house was greatly reduced.



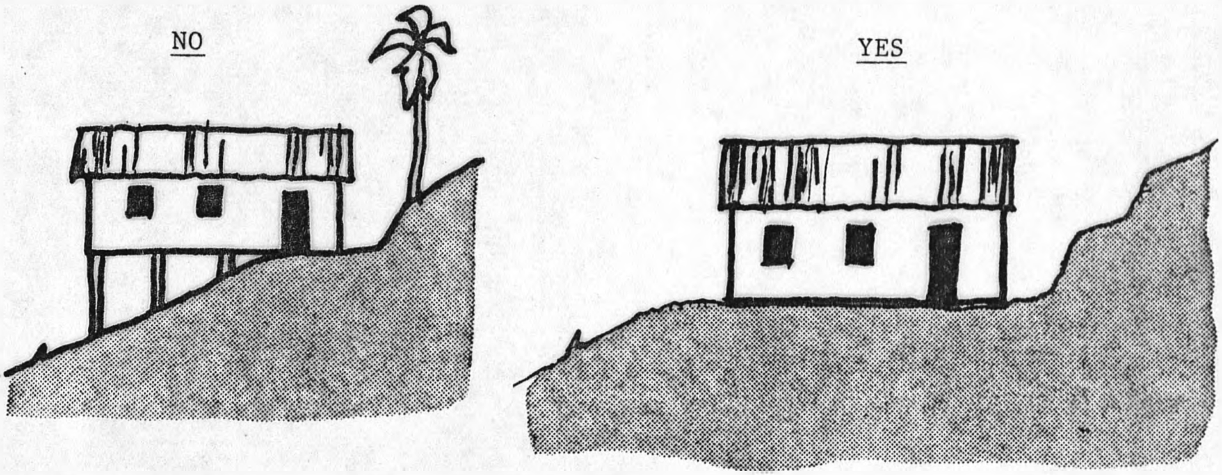
B. Features and Practices Contributing to Vulnerability

1. Flat or Slightly Pitched Roofs: In recent years the flat "shed" roof has become popular. This configuration is especially vulnerable to damage in hurricanes. The low pitch increases suction and uplifting forces, and the normally large overhang associated with this type of roof lends itself to uplifting at the edges.

2. Louvered Windows: Louvered windows, particularly those made of glass or flimsy metal, can be dangerous in hurricanes. Vibrations caused by high winds can often cause metal fatigue, destroying the louvers and permitting excessive amounts of wind to enter the house. Glass louvers can be shattered by flying debris, injuring persons inside the house. If louvers are used, storm shutters should be added.

3. Verandas: Many of the designs used for verandas in Jamaica can contribute to extensive damage to a building, particularly if the veranda is formed by extending the main portion of the roof over the edge of the house. Breakaway verandas, such as those illustrated in other parts of this report, should be used.

4. Stilts: A common practice throughout Jamaica is the placement of houses built on hillsides on stilts. In hurricanes, this allows strong winds deflected up the hill to lift the building off its foundation. In earthquakes, the stilts create special problems in stabilizing the under portions of the building, and they are very likely to collapse. Where possible, houses on hillsides should be placed on firm ground, levelled by cutting into the hillside. For stone, concrete nog, or block and steel buildings already on stilts, a built-up foundation should be made by pouring concrete panels between the stilts.

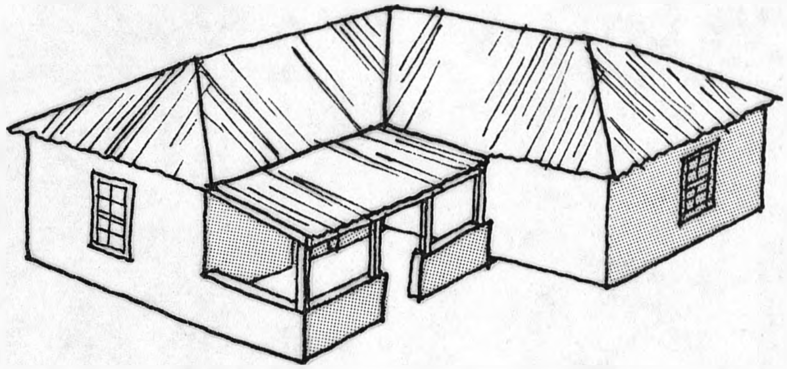


5. Concrete Footings: Many of the smaller buildings using a wood frame are placed on footings made of concrete or stone. In some cases, there is some provision for anchoring the frame to the footing, but usually the building simply rests on the footing. In hurricanes, fast-moving turbulent air can pass under the structure, lifting it off the footings and contributing to its collapse. In earthquakes, the ground motion is likely to shake the footings underneath the building, thereby collapsing the walls. For wooden buildings, strong wall-to-ground connections are needed; for buildings such as nog and Spanish wall types, a complete and solid rock and/or poured concrete foundation is required.

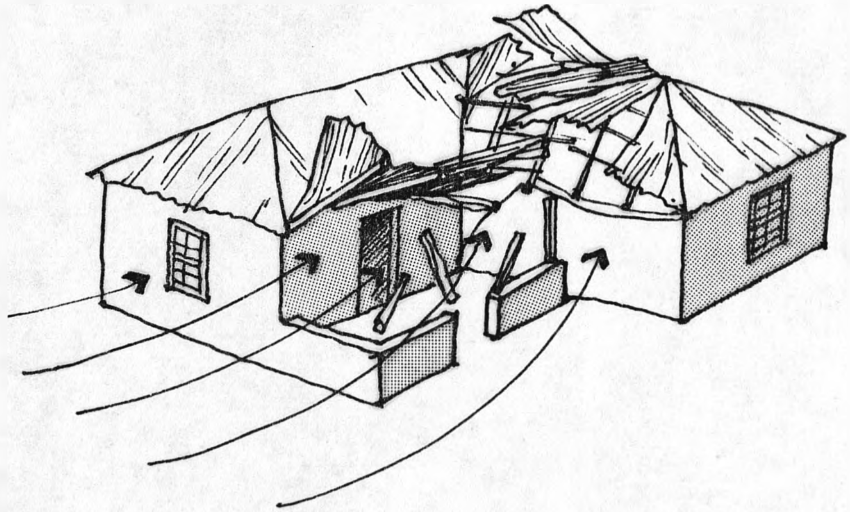
PROBLEMS COMMON TO ALL BUILDING TYPES

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

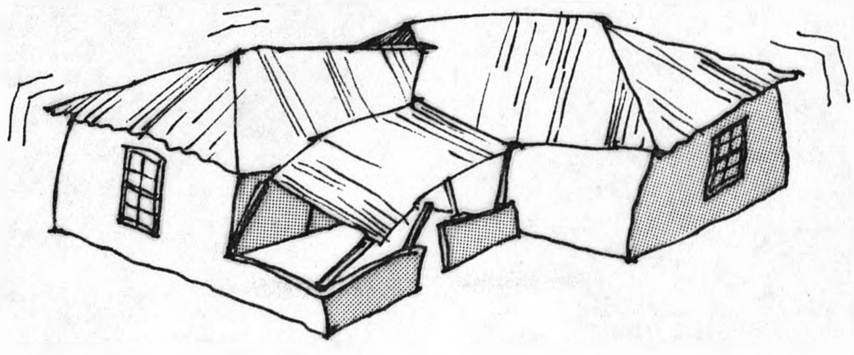
A. Problems in Basic Configuration: Many houses built during the Crown Rule Period have an "L" or "U" shaped floor plan, such as the design illustrated below.



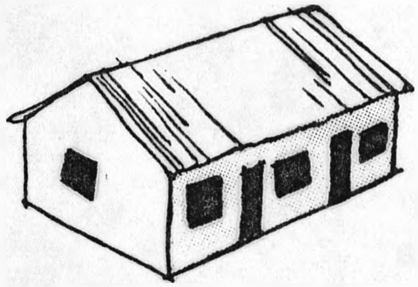
This configuration presents special problems in hurricanes when high winds concentrate in the center and are deflected upward, lifting the roofs off the buildings.



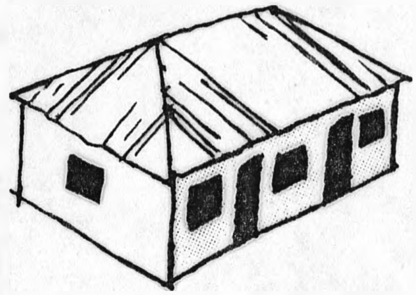
In earthquakes, this configuration is also dangerous, especially if the house is made of heavy material such as concrete block, nog or Spanish wall. The parallel walls of the house are of unequal weight and length and, in an earthquake, the house would twist on its foundation and collapse inward.



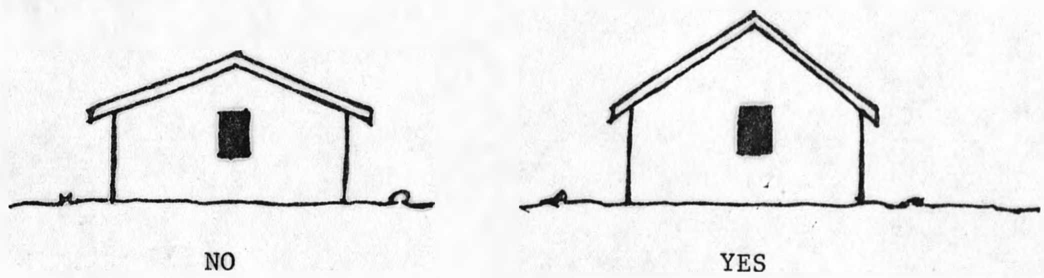
B. Roof Configuration: Many buildings in Jamaica utilize a gable roof such as the one illustrated in the figure below.



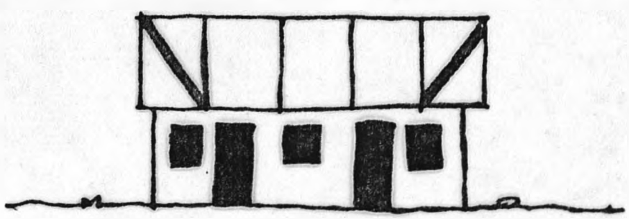
For both hurricane and earthquake resistance, a hipped roof such as that illustrated below is preferred.



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



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,

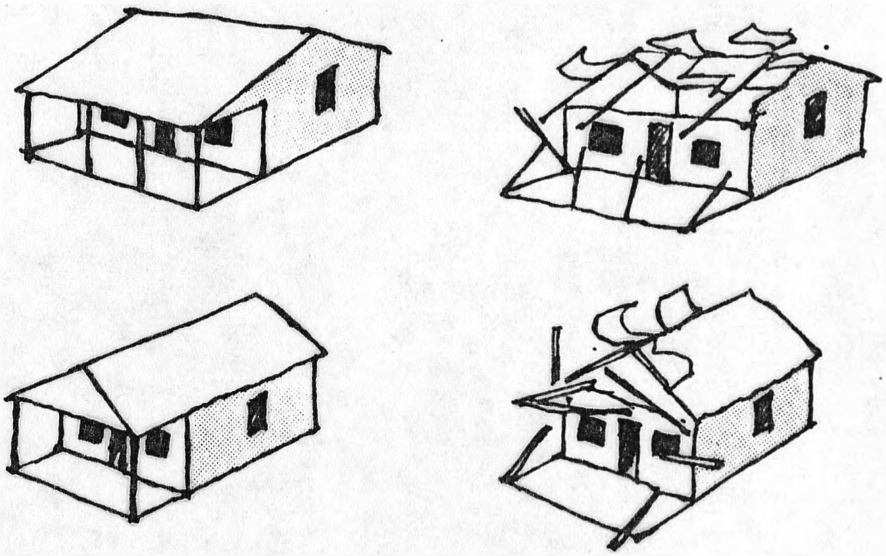


and provided that the gable is sufficiently reinforced so that it does not fail and collapse when pressures are exerted from either an earthquake or a hurricane.

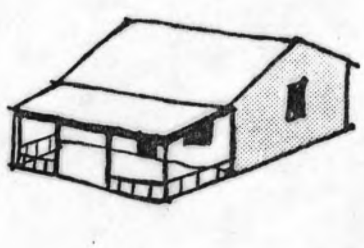
For the most part, the roofs of most rural houses meet the first criterion. Only in a few cases (normally on block and steel houses using zinc roofs) are the angles of inclination less than 30°. The lack of roof truss reinforcing and poorly-built gables are common to all types of buildings.

C. Verandas: The manner in which a veranda is contructed affects the vulnerability of a house. If the veranda is attached to the roof structure and traps wind underneath, the entire roof can be lifted off the house.

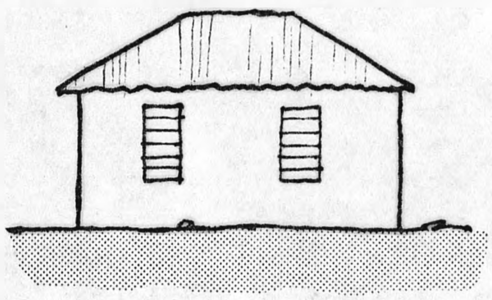
Two popular verandas and their patterns of failure are illustrated below.

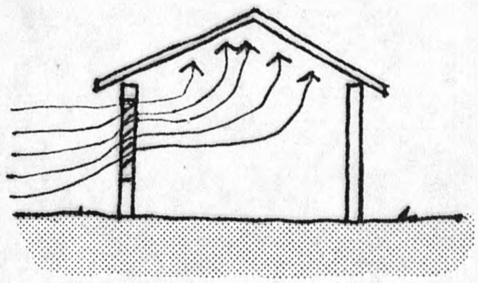


If these configurations are to be used, the connections between the veranda and walls and roof structure must be designed in such a way that the veranda can break away from the main structure of the house without severely damaging the rest of the house.



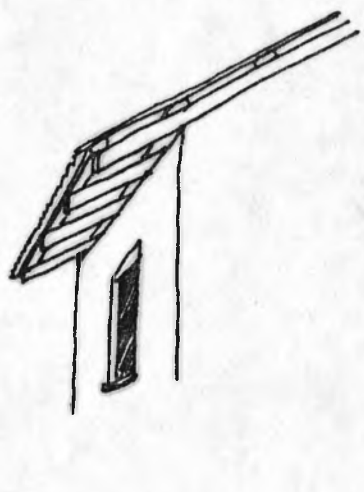
D. <u>Louvers</u>: Unless louvers are completely sealed off during a hurricane, excessive wind can enter the building, increasing the upward pressures on the roof.

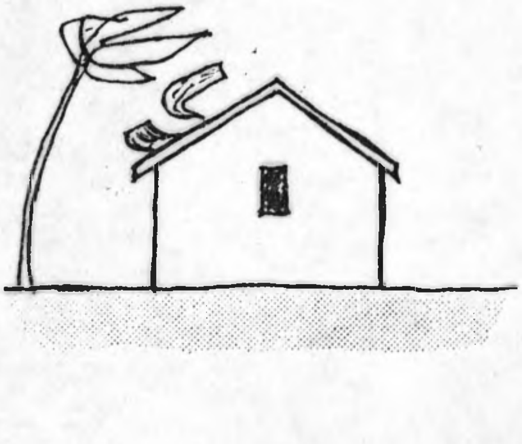




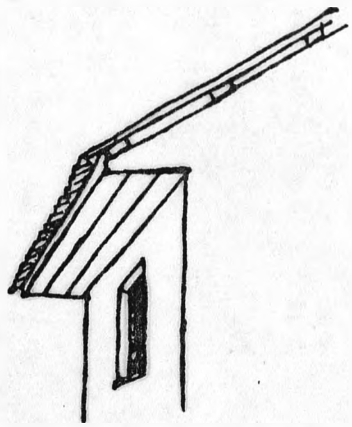
In theory, it should be possible to board up these areas before a hurricane, especially if adequate warning is given. In practice, however, when a warning is received, wood becomes scarce and it may be difficult to obtain the materials necessary to seal off these areas. The ideal solution is to install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

E. <u>Open Spaces</u>: Many houses in the rural areas leave open space between the roof and walls. This allows air to enter the house for cooling purposes. But during high winds this space permits excessive amounts of wind to enter the house and increase the outward pressure on the walls and roof.





The best solution to this problem is to seal the eave as illustrated below. This will also help reduce the uplifting forces at the edges.



F. Poor Fastenings of the Roof to the Walls: In almost every type of non-engineered building in Jamaica, the roofs are inadequately fastened to the walls. In hurricanes, the roof can be lifted completely off the building, and in earthquakes the rocking motion of the roof can create additional loads on the walls, contributing to their collapse. It is especially important that roof trusses be securely fastened to the frame of the house. Wire, hurricane straps made from strips of zinc sheeting, or commercial hurricane fasteners may be used.

The importance of these fasteners should not be underestimated. Recent studies have shown that adding one fastener at every point where the roof joins the wall can substantially improve the survivability of even marginally-built structures.[16]

G. Poor Connections Between Walls and Ground: In hurricane-prone regions, 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 particularly important in nog buildings.

In earthquake areas, a good wall-to-ground connection is important to provide additional strength to the vertical elements of a building.

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

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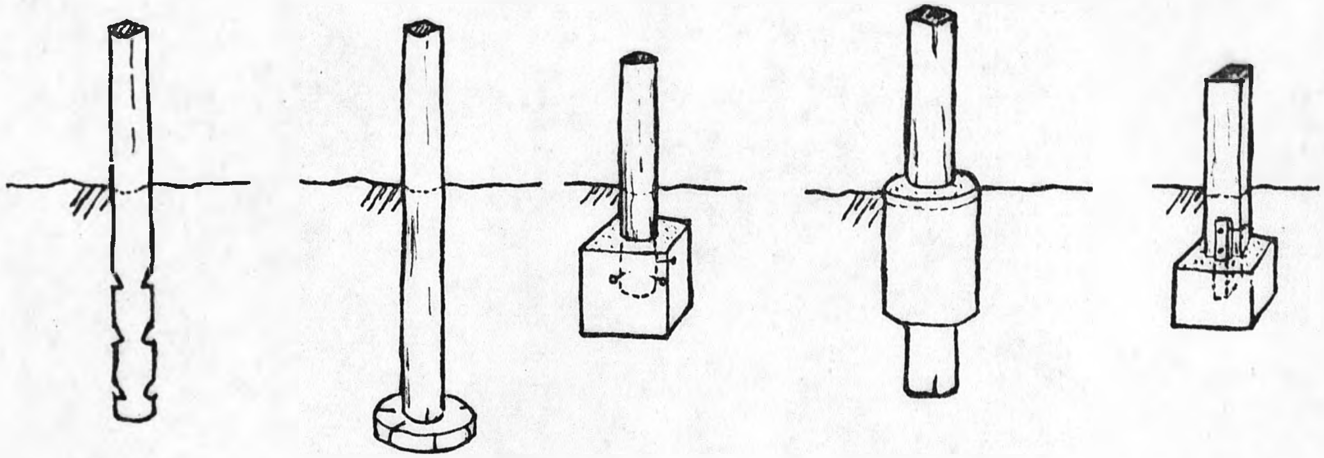
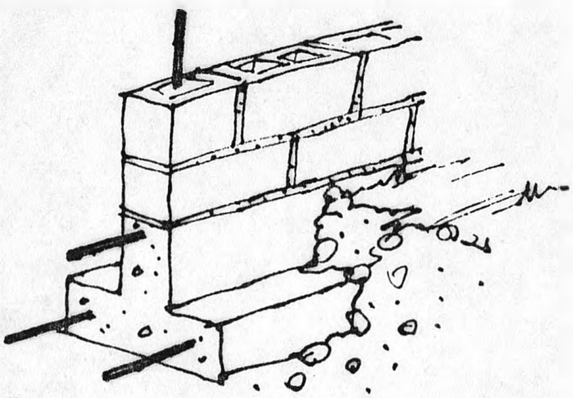
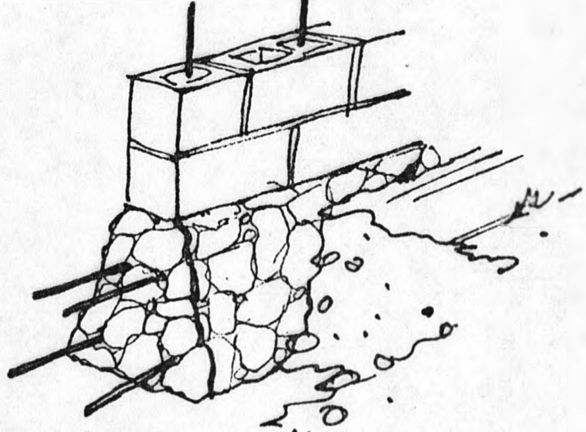
[16] "A Guide for Improving Masonry and Timber Connections in Buildings", Vol. 3, Building to Resist the Effect of Wind, BSS100, National Bureau of Standards, U.S. Dept. of Commerce, Washington, D.C., 1977.

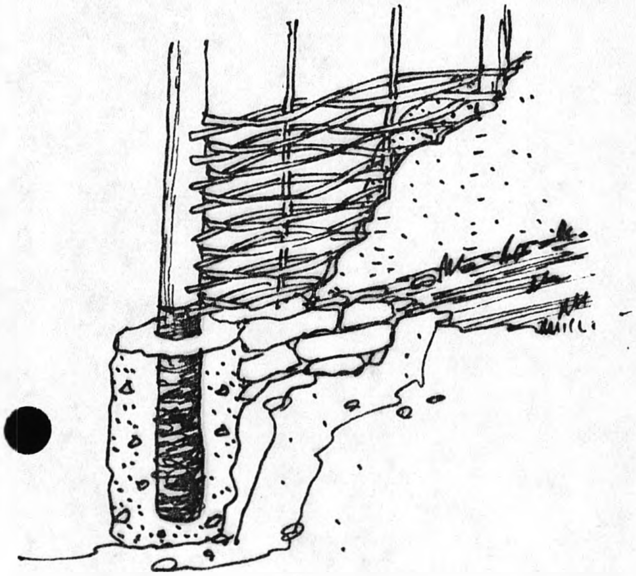
incorporated in the design of the building to help reduce uplift. Several of these are shown in the drawings below.

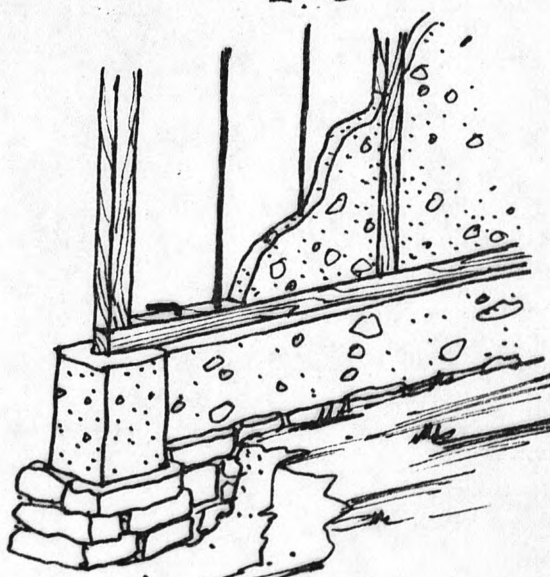


For buildings made of block, nog or Spanish wall, a rock foundation is required in order to help stabilize and support the building. The designs shown below should be used with houses made of block and steel, concrete nog, or wattle-and-daub.









SPECIAL PROBLEMS

There are a number of widespread general problems affecting vulnerability of vernacular housing which should be addressed in housing improvement activities. These are:

A. Siting: Improper siting and site development are major problems throughout Jamaica. As urbanization, rising land costs, and other pressures continue to mount, selection of adequate and safe sites for building will become extremely important. Long-term planning is required to identify future growth areas and to select strategies for land acquisition and development so that adequate housing can be provided.

Specific siting problems relating to vulnerability of the existing housing stock are:

1. Poor Site Selection. Many houses are built on sites that are directly exposed to high winds, flooding and landslides in hurricanes and to liquifaction and landslides in earthquakes.

2. Poor Site Preparation. If a house is built on a hazardous site, vulnerability can often be reduced through adequate preparation and development of the site and surrounding grounds. Wind forces can be reduced by building walls or planting shrubbery or small trees. Landslide potential can be reduced by terracing, excavating platforms for the buildings, and other suitable measures.

3. Poor Adaptation of the Building to the Site. Many homebuilders make no attempt to adapt the design of the building to the particular site. The most prominent example is the placement of buildings designed for construction on flat terrain on steep hillsides, supported by stilts.

4. Improper Matching of Building Type to Site. Vulnerability can often be reduced by simply selecting a particular building type for a specific site. In areas where liquifaction is a major threat, lightweight structures (i.e., those of wood or lightweight panel construction) should be used; while on solid ground in open areas exposed to high winds, heavier construction types (e.g., block and steel) should be erected.

B. Deterioration of Older Buildings: Almost 75% of all houses in Jamaica are over thirty years old. No measures are currently being taken to prevent deterioration of these buildings, other than limited maintenance by homeowners. For low-income families, the state of deterioration is becoming critical. Not only are the buildings becoming unlivable; they are also increasing in vulnerability to disaster events.

The state of deterioration is most rapid in buildings built since the turn of the century when softer, less durable woods were used. Many nog and Spanish wall structures erected prior to the introduction of cement are also showing signs of deterioration. Many of these houses would be fairly disaster resistant if adequately improved and maintained; yet without such a maintenance program, they will soon be beyond repair.

C. <u>Use of Soft Woods</u>: Until the 1920's, hardwoods were still relatively plentiful in Jamaica and were used in the construction of many of the vernacular buildings. When most of the good construction hardwoods had been depleted, people turned to softer woods such as pitch pine for construction. These softer woods deteriorated rapidly in the Jamaican climate. Where such woods have been used structurally, buildings which would otherwise be safe have deteriorated to a point where total collapse in high winds or earthquakes is possible.

The replacement of soft woods used structurally should therefore be a major concern in any housing improvement activities. For new construction, the use of soft woods as structural components should be discouraged (although they are suitable for siding and walls).

D. <u>Disappearance of Building Skills</u>: With rapid urbanization and the changes in building styles, many of the construction skills which were once evident in vernacular building are unused and forgotten. The excellent stonemasonry, carpentry and masonry skills exhibited in many of the older buildings are hard to find in newer construction. Any program of housing improvement and upgrading must concentrate on the retention of existing skills and upgrading of the level of craftsmanship within the building profession.

E. <u>Discontinuance of Hurricane Resistant Features</u>: In recent years, designers and builders have discontinued the use of many of the once popular and time-proven hurricane resistant construction techniques. It is important that these techniques be identified and recognized for the contribution they can make to reducing overall vulnerability, and emphasis should be placed on using these techniques in new construction.

V. LOCAL BUILDING PROCESSES AND PRACTICES

CONSTRUCTION IN THE RURAL AREAS

A profile of the building process for the home of a typical low-income rural family is as follows. When the homeowner decides to build a house and has acquired a site, the size, pattern, building materials and system of construction are determined. Then the building materials are acquired, normally by purchase from local sources. A carpenter or mason familiar with the construction system chosen is then hired for a fixed price to build the house. Construction requires approximately six weeks. In some cases, another tradesman may be hired to install a concrete floor or to build the roof, but generally one contractor does all the work.

The majority of housing in rural communities is built with at least some input from a tradesman, although some wood frame and nog houses may be owner-built. Building tradesmen are often not full-time contractors, but are usually persons with considerable previous experience and in whom the homeowner has sufficient confidence.

Contractors with a carpentry background are generally more plentiful than masons in rural areas and are used more often than masons due to the types of construction in these regions (e.g., wood frame and nog).

The tradesmen play many roles. Sometimes they are asked to furnish the construction materials as well as the labor. In other cases, tradesmen may only be hired for a short time to construct critical components or to demonstrate construction techniques.

The importance of tradesmen in the building process is a vital consideration in housing vulnerability reduction efforts. Any such program should focus on these tradesmen and emphasize the expansion of their skills and upgrading of their capabilities. While certain general promotional activities are required in order to create an atmosphere of acceptance for any proposed changes or modifications to buildings, programs that encourage upgrading of housing without the participation of tradesmen will generally find it difficult to achieve lasting change.

CONSTRUCTION IN THE URBAN AREAS

There is no single definitive process of construction in urban areas. It depends upon many factors including land tenure, financial status of the family, availability of materials, builder's construction skills, and the amount of time available to devote to construction. Generally, there is more owner participation in construction, especially in the squatter settlements. However, once land ownership or tenure is secure, building tradesmen are more evident in the construction process. Only in the very poorest of the urban areas is it common for families to rely solely on their own labor and skills for complete construction.

Contractors provide both carpentry and masonry skills. There is usually more call today for masons due to the popularity of block and steel. Contractors in the urban areas generally exhibit a higher level of skills (due to increased opportunities for work on more sophisticated buildings) and most are full-time builders. Unlike the rural areas, urban contractors are usually asked to supply the construction materials, as the practice of accumulating materials over a period of time and erecting the building at a later date is not generally followed in the cities (due at least in part to pilferage).

As in the case of the rural areas, it is very important that tradesmen be the focal point for housing improvement activities.

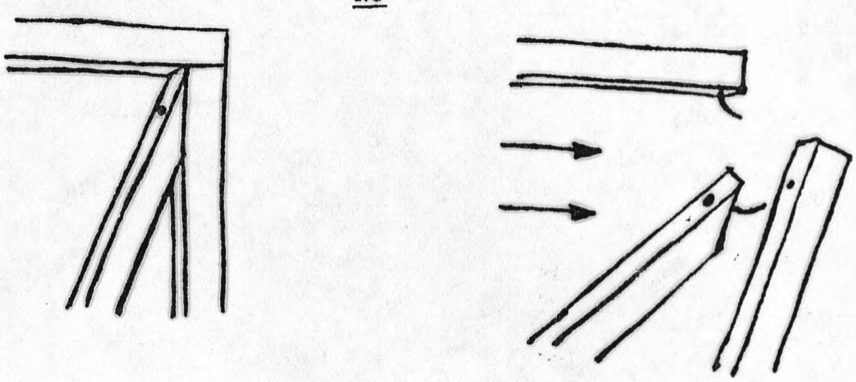
ANALYSIS OF LOCAL BUILDING SKILLS

The structural integrity of a building during wind storms and earthquakes can often be substantially improved simply by improving the quality of workmanship and detailing when the building is erected. In studying the skills of the builders of vernacular housing, a number of problems affecting the vulnerability of these structures were noted:

A. Carpentry Skills

1. Joints: The key problem in wooden structures is that many of the joints are weak, in terms of both design and fastening. Often wood which is structurally important is nailed in tension rather than in shear. Thus, when forces are applied, the nail will slip out and the joint will separate.

NO



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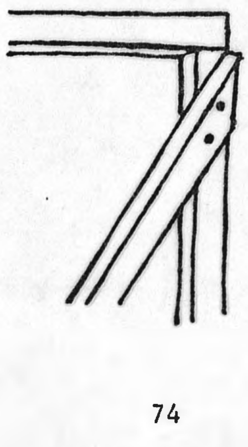
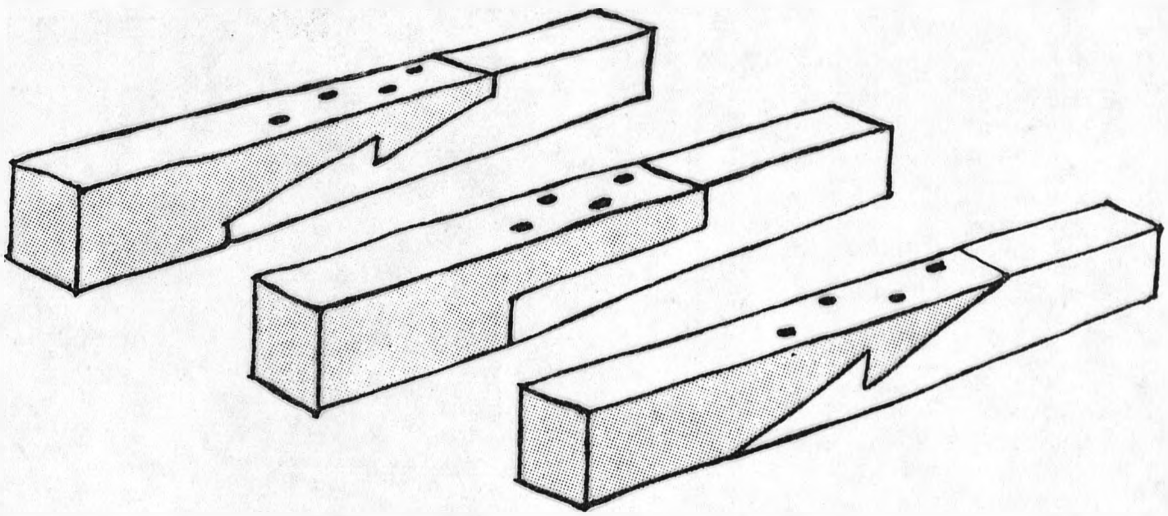


2. Splicing: The splicing of wood in wood frame and nog construction is a major problem. Many splices are held together only with a nail. Few carpenters use joints that would add strength to the detail. The following splices should be used.



3. Improper Use of Bracing: Structural reinforcements in the building frame do not provide adequate strength. Common problems include:

   a. The placement of braces in tension where they can easily separate.

   b. 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 distribute loads.

   c. The failure to use braces in critical parts of a building.

   d. The failure to use diagonal bracing in gabled roofs.

B. Problems in Masonry Construction

The strength of masonry is a function of the alignment of the wall (both vertically and horizontally), the strength of the mortar, and the strength of the blocks. A number of faults have been noted, including:

1. Poor Mortar: There is often a tendency to reduce costs in the mortar by using less cement in the mix. This reduces the strength of the bond. Likewise, there is a

tendency to make the mortar too wet in order to make it more pliable and easier to work with. This too reduces the bonding strength.

2. Poor concrete mix in the structural columns.

3. Poor connections between interior and exterior walls.

4. Insufficient mortar between blocks.

5. Unlevel masonry on each course.

6. Poor detailing around doors and windows.

7. Improper or insufficient foundations.

CONSTRUCTION COSTS

A list of prices for basic construction materials, current at the time of this report, is attached as Appendix IV. However, material prices are relative and may be affected by quantities purchased or transport costs. Furthermore, due to inflation, building costs are unlikely to remain fixed for any length of time.

What is evident from a survey of vernacular housing is the relative cost of buildings in relation to different building systems and the materials used. In descending order of cost, the costs of comparably-sized buildings can be listed as follows:*

1. Block and steel (most expensive)
2. Wood frame
3. Concrete nog
4. Stone nog
5. Spanish wall (least expensive)

The annual cost of building maintenance is another important consideration in examining overall housing costs. Listed below in descending order of costs are the types of buildings according to the level of periodic maintenance required in an average year. (The term "level of maintenance" is used rather than "cost of maintenance" because of the difficulty in equating cost inputs for indigenous materials which may be acquired for a variety of different methods and thus different costs.)

1. Wood frame (most annual maintenance)
2. Spanish wall
3. Stone nog
4. Wattle-and-daub
5. Concrete nog
6. Brick nog
7. Block and steel (least annual maintenance)

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*Brick nog and wattle-and-daub have been omitted as no new construction of these types is currently underway.

MATERIAL PREFERENCES

The preferred material for building walls and roofs varies with each region according to the availability of specific materials, costs, and setting. However, most building types can be found throughout the country. So thorough is the mix of types that only two distinct patterns of preference in vernacular housing are evident.

First, the overwhelming majority of people prefer to build a house of block and steel. In the past two decades, this type of construction has increased to the point where it is now estimated that almost half of all new building starts of non-engineered buildings are of block and steel. Even among persons building new houses, the majority use block and steel from the outset rather than using an interim building material. Most additions to existing houses are of block and steel (with the exception of wood frame houses), and experience from Hurricane Allen indicates that block and steel is the preferred type of replacement housing for destroyed homes.

Second, in western Jamaica, wood frame construction is the most prevalent type of new building and only a very small percentage of block and steel housing is erected. In part this is due to land tenure problems; but material costs for block and steel, as well as lack of experienced masons, also contribute to the preponderance of wooden buildings.

During this study, it was noted that many persons residing in deteriorated nog and wattle-and-daub houses were replacing these buildings with block and steel construction, even though nog and wattle-and-daub offer much reduced costs. This gives an indication as to the types of buildings that persons would rebuild in the likelihood of a disaster and what must be considered in vulnerability reduction efforts.

The significance of the demand for block and steel is that program planners in vulnerability reduction projects must find ways of replacing dilapidated and highly vulnerable buildings with structures that are the most expensive type of construction. Therefore, planners will have to concentrate on methods of reducing costs as a first priority.

The preference for block and steel is also significant in planning for post-disaster reconstruction. Planners should develop strategies and approaches for delivering block and steel housing, and explore various program models and cost-reduction approaches prior to the occurrence of a disaster.

REPLACEMENT VERSUS REPAIR

During the course of this study, an interesting trend was noted. Many people living in deteriorated buildings in the rural areas planned to build new replacement houses of block and steel rather than to repair existing structures. This is due in part to changing preferences in building styles and construction; but also to a very large measure it is due to the inability of the homeowners to obtain money for repairs or loans on any type of new construction other than block and steel.

Planners must therefore seek to broaden the programs offering funds for maintenance and repair of existing structures, as well as help facilitate the replacement of deteriorated buildings and encourage the use of safer construction techniques during repair and replacement.

VI. KEY ISSUES

HOUSING FINANCE

One of the major problems confronting vulnerability reduction efforts is that of housing finance. Numerous studies and reports have discussed in detail the difficulty low-income families have in obtaining money for new housing and home improvements. A far more critical problem in terms of vulnerability reduction is the inability of low-income families to obtain funds for maintenance or repair of deteriorated buildings. While some home improvement loans are available, they are normally for extensions or additions to buildings rather than for upgrading of the existing structure.

These problems are related to the issues of land tenure and ownership. Unless homeowners can obtain a clear or registered title, they cannot get credit. Furthermore, lending institutions will usually only make a loan on a block and steel building, not on other forms of vernacular construction.

The majority of low-income families are thus excluded from participating in the formal credit system. Unfortunately, informal credit systems (such as the "partner" system*) are inadequate to meet the demand for credit and people are forced to build marginal structures which increases their overall vulnerability.

LAND TENURE

The problem of land ownership and tenure is one of the major factors controlling the housing sector in Jamaica. The 1970 census reported that slightly more than half the people claimed to own their own house, but it was unclear how many of these persons actually own the land upon which the house is situated. Estimates of the percentage of population who actually own their home site range from 20% to 30%, although an accurate accounting is not possible at this time.

There are many contributing factors to this problem. Historically, it began with emancipation when freedmen moved off the plantations and began living and farming in the hills and undeveloped lands. Few people attempted or were able to obtain clear title to the land then, and succeeding generations have continued to live on and work the land without title.

A second contributing factor has been the periodic failure of the large plantations during later periods. When the plantations collapsed, many of the workers continued to live on the land, subdividing the estates into smaller plots (sometimes as small as five acres) and working them under a sharecropping arrangement. The landlords have long since ceased to exercise any interest in the land, and several generations may have passed without any movement to transfer title to the people now occupying it.

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* An informal savings arrangement where individuals contribute regularly to a common fund, then withdraw money on a rotating basis. The system is sometimes used to finance small home improvements.

A third factor is the extensive migration of Jamaicans to other parts of the world. Often those who left continued to hold their land in the hope that they would be able to reclaim it one day when they returned. Now, several generations later, there are problems of absentee ownership being shared by many heirs and, in many cases, no contact has been made with the owners in several decades.

A more modern contributing factor is the growth of squatter settlements around urban centers. The capture of land makes it virtually impossible to obtain a clear title unless the land is owned by the government and steps are taken by the government to transfer title to the occupants.

As mentioned earlier, the problem of land tenure has become the central issue in the housing sector for, without tenure, people cannot obtain the loans they need to produce standard buildings. In reality, there is probably very little that can be done by the government (due to the economics, legal problems and political considerations) to resolve the issue satisfactorily under existing methods and programs. For disaster preparedness officials, vulnerability reduction efforts will be hampered unless an alternative approach is developed.

One possible alternative which could be used as an interim measure and would have benefits beyond vulnerability reduction is for the government to establish a national housing safety policy. As part of this policy, minimum safety standards would be developed for each type of vernacular housing, identifying specific methods and techniques or modifications for improving the level of safety in each building type. These standards would be specific but broad enough to allow improvement of the livability as well as the safety of the structures. Next the government would encourage lenders to establish small loans which could be given to persons with an established credit record or with a demonstrated ability to repay the loan, enabling them to obtain the money to undertake maintenance, repairs or modifications according to a "schedule" of approved modifications.

This proposal has several advantages. It removes land tenure as a major obstacle to modification. Because the amounts of the loans are less, the criteria for obtaining loans could also be lessened and could be based on past performance and credit history rather than on a lien against the structure. Many persons should be eligible for these loans because they have established a credit record on agricultural, furniture, and other small loans.

Because a traditional lien would not be used, it might be necessary for the government or other agencies to provide loan guarantees as an inducement to financial institutions to undertake this type of program.

Another major advantage of this program is that it would place a major portion of the burden of financing home maintenance and upgrading on the private sector rather than the government, allowing the government to focus on other parts of the housing sector.

IMPLICATIONS OF WIDESPREAD HOUSING DETERIORATION

Random surveys in conjunction with this study indicate that an estimated 20% of the vernacular housing is in need of minor repairs, 30% is in need of major structural repairs, and 15% is currently deteriorated beyond repair. In terms of disaster preparedness, this means that approximately 45% of vernacular housing is now vulnerable to earthquakes and/or hurricanes.

It would not be unreasonable to expect that a major disaster could destroy upwards of 100,000 housing units. (A hurricane striking Puerto Rico, an island of similar size and with comparable housing types, experienced such a loss in recent years.) This would increase the existing demand for housing by 1,100% in that year (assuming that 10,000 units are required each year) and would double the current estimated housing deficit.

At today's value (1981), the replacement cost of such a loss would exceed 1.5 billion dollars (based on an average replacement cost of $15,000). The predominant method of supplying housing used by the government conventional housing schemes would not be practical except for a very small percentage of the affected population.

The economic impact of this loss to the nation would be measured not only in terms of direct losses to property, but also in indirect losses from increased debt and foreign currency depletion, as well as the loss of opportunities for development in other sectors as a result of having to redirect large expenditures into the housing sector.

A large percentage of the deteriorating buildings in Jamaica are types such as wattle-and-daub and certain nog construction. The modes of failure of these buildings are such that they could not be safely repaired, even if only slightly damaged, thus increasing the need for replacement housing in the aftermath of a disaster. With repairs, modification and routine maintenance, however, these buildings could be upgraded to a point where vulnerability would be negligible. If undertaken on a regular basis as an expanded part of the government's efforts in the housing sector, relying principally upon existing financial institutions, the increased costs to the government over and above existing expenditures in the housing sector would be relatively minor.

Thus it is clear that a major priority should be the systematic upgrading and maintenance of the existing housing stock, and that resources (both financial and technical) should be allocated in the immediate future. The results will not only be a major reduction in vulnerability, but also should contribute to reduction of the non-disaster-related housing demand.

LACK OF A DESIGNATED AGENCY

At the present time, no agency or ministry is assigned responsibility for providing assistance in maintenance and/or upgrading of existing buildings. The Housing and Construction Ministry defines its function as providing support for the development of housing schemes. The Urban Development

Corporation defines its responsibility as development of new communities. The National Housing Trust provides funds and support for new construction and additions to existing buildings. Other programs such as Sites and Services and Urban Upgrading concentrate on the provision of services to new housing, or the support of self-help housing activities for new buildings. Even building inspectors in both the Kingston Corporation and the Ministry of Local Government are concerned more with new construction than with existing construction.

In order for housing improvement and vulnerability reduction efforts to be effective, a ministry must be tasked with this responsibility.

VII. VULNERABILITY REDUCTION STRATEGIES

Vulnerability reduction activities can be divided into three classifications according to the time period during which the activities should be conducted. These are short-term, intermediate, and long-term activities.

SHORT-TERM ACTIVITIES

The overall objective of short-term or emergency activities is to provide comprehensive protection from an immediate danger such as a hurricane. Short-term measures would include immediate action to ensure the safety of persons within a house.

Short-term activities are a preparedness function, and thorough planning and preparation are required in order to effectively disseminate the required information when a disaster is imminent. Preparedness planning in the housing sector should be accomplished in conjunction with a comprehensive strategy including housing, evacuation and, if necessary, emergency shelter.

The requirements for comprehensive emergency activities are:

A. Thorough preparedness planning: This includes a review of the actions required, the organizations that will participate, the tools and equipment necessary, and the formulation of a comprehensive plan to structure response.

B. Identification of public information requirements: A variety of media is required in order to disseminate the information thoroughly, including leaflets, posters, pre-recorded announcements (both audio and video), newspaper inserts and supplements. These must be designed to show how to protect a house, reduce damage from blowing debris, and reduce injury in case a building fails. Information should also be available to enable homeowners to determine flood or storm surge threat, and whether they should evacuate. For those who will evacuate, an evacuation plan is required, and maps showing evacuation routes must be prepared and disseminated to appropriate organizations and news media. In addition, route markings and equipment for personnel must be prepared and prepositioned. In some cases, hurricane shelters may be required, and they must be designated and strengthened in advance.

C. Training and technical assistance for local emergency relief officials and organizations: Not only must information on how to protect houses be distributed in advance, but also a sufficient number of people acquainted with how to use the techniques should be trained and available to help the public in each parish.

D. Information dissemination mechanisms: The most effective means of communicating information on protection of buildings is through visual media. To a limited extent, newspapers and television can be helpful in disseminating this information. More comprehensive information, however, will require highly illustrated booklets and leaflets. A mechanism for distributing this information must be developed in advance, and the materials for distribution must be prepositioned for distribution to these outlets prior to the occurrence of a disaster.

Overall responsibility for implementation of short-term activities is assigned to the Office of Disaster Preparedness & Emergency Relief Coordination (ODIPERC). The other agencies that should be involved are the Ministry of Local Government, the Kingston-St. Andrew Corporation, and the Agency for Public Information (API).

INTERMEDIATE ACTIVITIES

The overall objective of intermediate activities is to strengthen existing housing and to upgrade the majority of structures so that they can withstand a hurricane or earthquake. They are basically activities which can be carried out by the homeowner with minimal financial and technical assistance, and do not require extensive reconstruction or modification of the existing building.

Upgrading should be carried out in a manner that will contribute to the reduction of the demand for replacement housing. Therefore, the types of activities that are carried out should be broad enough to include upgrading of the buildings to improve livability and to reduce costs of maintenance and operation.

In order to carry out intermediate vulnerability reduction activities, the government should first make a policy decision that such activities are in the interest of the government and should develop an appropriate framework to encourage these activities. In addition, the government must designate an agency or agencies to serve as coordinator for housing improvement activities.

A. Requirements: In order to encourage people to carry out housing upgrading and modification, the following are required:

1. Building Performance Standards. To provide a framework for determining which actions are appropriate and supportable in the upgrading of a structure, minimum building standards based on building performance and emphasizing the safety of occupants should be developed by the government for all types of vernacular housing. These are necessary to provide a base upon which financial institutions can determine which improvements can be funded by loans, and the standards will help to identify the critical components and features of a disaster resistant building for each housing type.

2. Financial Assistance or Other Incentives. Upgrading of housing that is deteriorated will require some families to seek financial assistance. The government should act to expand existing loan programs to accomodate the demand. Special plans will be required to handle requests from families without clear registered title to their lands.

3. Information. In order to both encourage and guide housing improvement activities, a variety of information should be prepared, including:

   a. Information about how to decide what modifications are required and practical;

   b. Information on where to obtain assistance;

   c. A variety of media, especially films and highly illustrated booklets, to provide detailed "how to do it" information;

   To help homeowners determine whether they need to upgrade their homes, and what techniques would be practical, a simple "home test" should be devised and disseminated. This test would use a numerical grading system to help determine how safe the building is and would show the homeowner how vulnerability could be reduced through the addition of certain components or features.

4. Technical Assistance. A large number of people upgrading their houses would do so on a self-help basis. To ensure that upgrading is carried out in a correct manner, technical assistance in the form of advice and demonstrations should be readily available in all parishes.

5. Development of Local Skills. Some housing improvements will require the services of contractors. It is important that the government provide training to existing building contractors in order to enable them to participate in housing improvement activities. A certification program for local contractors would be a means of improving the skill level, as well as ensuring that an adequate reservoir of talent is developed.

B. Coordination and Implementation: Overall responsibility for the implementation of the upgrading of existing buildings should be assigned to the Ministry of Local Government. This Ministry currently has the best infrastructure for dealing with such activities and can provide technical assistance to homeowners through strengthening of the office of the Building Inspector. ODIPERC, the Ministry of Housing, API, CAST and the Vocational Training Development Institute should provide assistance to this program in both the planning and implementation phases.

C. Financial Assistance: New approaches should be developed for the provision of financial assistance to homeowners for the upgrading of their houses. The primary emphasis for financial assistance remains with existing institutions. To enable a greater number of people to be served, the criteria for making small loans should be expanded. This may require loan guarantees from the government or other institutions. Loans would be provided only for those improvements specified in the building standards. For persons unable to obtain loans, alternative programs where they can obtain easy access to materials or cash should be developed. An example would be a community service work program wherein people could obtain credits toward purchase of materials at discount or subsidized prices. As a general principle, the provision of direct cash grants should be avoided.

D. Technical Assistance in the Parishes: The focal point for technical assistance should be the Office of Building Inspector in each parish. This office should be strengthened and personnel trained to help people improve their houses. The Building Inspector/Instructor would not only provide advice to those upgrading their homes, but would also work with local contractors to train and encourage them to participate. The Inspector/Instructor would maintain a list of certified contractors and help homeowners determine what improvements are necessary or practical, as well as helping them to obtain the appropriate financial and technical assistance required.

E. Technical Information Resources: At the present time, there is no single repository for information regarding vernacular housing or the techniques and skills required to maintain and upgrade these buildings. In addition, there is no organization currently involved in building research which emphasizes the use of indigenous building materials and skills. Several proposals have been forwarded regarding a building institute, but no such organization has yet been established. The government should establish a "national center for building and construction" which would include:

1. A housing information center with library and public information materials on all types of building construction found in Jamaica, including both engineered and non-engineered structures and building techniques.

2. A national housing reference library that would be useful to architects, engineers, planners, builders, public officials, material suppliers, or anyone interested in any aspect of building construction and human settlements in Jamaica. It is especially important that data be developed concerning historic and vernacular construction.

3. A building and materials research component, structured to enable it to carry out a variety of research activities including socio-economic as well as architectural and engineering research. Particularly important is the development of a program to investigate indigenous materials and non-engineered structures. Emphasis must also be placed on the development of local approaches to disaster mitigation.

LONG-TERM ACTIVITIES

The overall objective of long-term activities is to ensure the safety of new housing, by encouraging builders to incorporate disaster resistant features in buildings as they are erected. This requires creating an awareness of the need to add these features and the development of a reservoir of talent and public information on how to build safely.

Long-term activities will require a variety of commitments and adjustments on the part of the government. The first is a national housing policy which recognizes the role of non-engineered buildings and supports activities designed to improve this class of housing. This in turn may require new directions in land development and urbanization policies/approaches.

The tools required are essentially the same as for intermediate activities, although the emphasis is on new construction rather than existing buildings, and specific programs will have to be modified as appropriate.

Responsibility for effecting improvements in new construction of non-engineered housing should be assigned to the Ministry of Local Government, again with assistance from the Ministry of Housing, ODIPERC, API, CAST and the Vocational Training Development Institute.

The most effective ways to achieve an impact on new building construction are through financial assistance to the homeowner and through training of building contractors. To accomplish the former, the government must recognize the need to provide financial assistance to those building outside the formal construction process and develop appropriate means of providing limited funds in this sector. Eligibility would be dependent upon the use of disaster resistant construction techniques.

A more comprehensive range of technical assistance and information would be required to effect improvement in new construction, but the number of building types involved is much smaller. Initial emphasis should focus on block and steel construction. Provision of technical assistance at the local level should again be assigned to the Office of Building Inspector/Instructor and local certified contractors. Simplified plans and drawings should be developed for families to enable them to build minimal safe structures of block and steel or wood.

The office of Building Inspector/Instructor should also be assigned the tasks of reviewing all plans for industrialized building systems to ensure that adequate disaster resistant construction techniques are incorporated in the design and checking construction to ensure that the contractors install the components correctly.

VIII. RECOMMENDATIONS FOR A COMPREHENSIVE PROGRAM OF VULNERABILITY REDUCTION

The following is a suggested plan for a comprehensive program designed to upgrade non-engineered housing in Jamaica. The activities are planned to encourage safer construction techniques and to establish better building methods as part of the normal building practice.

In order to initiate these actions, a pilot or demonstration project should be scheduled for the purpose of developing and testing:

--- administrative procedures

--- technical information resources and dissemination techniques

--- financial incentives and assistance packages

--- other aspects of the program as deemed appropriate and necessary

During this project, the government would determine a suitable agency to serve as "lead agency" for housing improvement and vulnerability reduction efforts, develop a framework for coordination between the lead agency and other ministries or offices, train appropriate staff, and develop support in the private sector.

The quality of vernacular housing can be upgraded. Interest is high throughout the country and Hurricane Allen has demonstrated the need. Thus a comprehensive program of vulnerability reduction can have substantial impact.

OBJECTIVES

The overall objectives of a vulnerability reduction program for housing are:

A. General Objectives:

1. To increase the level of safety of non-engineered buildings which are vulnerable to hurricanes and earthquakes;

2. To reduce the effective housing demand for new or replacement housing through upgrading and maintenance of a significant portion of the existing housing stock.

B. Specific Objectives:

1. To introduce (or in some cases to re-introduce) and establish safer building methods affordable to the majority of homeowners living in non-engineered buildings;

2. To develop a balanced program of upgrading and maintenance which can be carried out by the government and private resources without undue additional expenditures on the part of the government;

3. To improve non-engineered housing in such a manner that the overall cost of housing to the homeowner can be reduced;

4. To establish a focal point for coordination of housing improvement activities;

5. To establish a repository of technical information and other resources that can provide ongoing assistance to builders and homeowners engaged in housing improvement and vulnerability reduction activities.

GOALS

The overall goal of a vulnerability reduction program is to reduce the level of vulnerability and the number of homes specifically vulnerable to different types of disaster to a measurable extent.

The initial pilot project should demonstrate achievement of the following specific goals within a five-year period in the project area:

A. Modification to a safe minimum standard of 10% of the new housing built during the project;

B. Retrofitting and upgrading of 20% of the existing housing;

C. Training and orientation on disaster resistant construction techniques of a majority of the building contractors.

WORK PLAN

The following is a recommended task sequence for a pilot vulnerability reduction program:

A. Designate a lead agency. It is recommended that the Ministry of Local Government be selected as lead agency.

B. Establish an intergovernmental coordinating committee to coordinate technical assistance and other inputs from the different government agencies. Members should include the Ministry of Housing, ODIPERC, Agency for Public Information, and the Urban Development Corporation.

C. Establish a program advisory committee. This committee should be made up of representatives of each non-government organization participating in the program. The role of the committee is to advise and help coordinate activities (not to administer or govern the program).

D. Conduct a feasibility study to determine the interest in the program, what level of participation could be expected, and what financial assistance will be required.

E. Prepare minimum performance standards for all types of non-engineered and vernacular construction.

F. Convene a workshop for assisting institutions, especially the financial institutions, to present the concept of the program and discuss the goals and objectives. Guidelines for participation in the project should be presented. Building standards should also be presented and discussed.

G. Prepare the materials necessary to train parish staff (a list of these materials is provided in Appendix I).

H. Prepare the instructional materials required to train local contractors (a list of these materials is provided in Appendix I).

I. Conduct a training workshop for project personnel in the parishes. Training should stress use of the modification techniques, how to train contractors in these methods, and how to promote adoption of the methods by the general public.

J. Conduct a workshop for financial institutions and associations to acquaint them with the financial aspects of the program and to further encourage their participation.

K. Initiate implementation activities. During this stage, all training and promotional efforts are begun, and the various financial approaches are monitored to determine if modifications are required.

L. Review the program. The lead agency should conduct periodic workshops to review the progress of the overall program. At a minimum, these workshops should be held on an annual basis.

DURATION OF THE PROGRAM

It is recommended that the pilot program last approximately five years. Two years after commencement of implementation activities, a mid-point evaluation should be conducted to determine:

A. The workability of the overall approach;

B. Adjustments and changes to the financial and promotional aspects of the program;

C. Whether enough experience has been gathered to expand the program to other parishes.

TARGET GROUPS

Public information activities should focus on those groups within the general population that are most likely to be receptive. In general these groups are:

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

B. Building tradesmen. Emphasis should be placed on improving the skills of the contractors. Without their participation in the program, it is unlikely that the ideas will be perpetuated.

C. Persons living in urban fringe areas. The majority of new construction occurs in settlements in the urban areas. Efforts to affect these houses should be carried out in cooperation with other programs to assist squatter settlements and the newly developing areas.

D. Persons living in transitional housing. Many families currently reside in marginal buildings whose purpose is to secure land tenure or to provide an interim building until more resources are obtained for construction of a more formal structure. Educational materials on how to upgrade these buildings and/or how to build small core structures that can be gradually enlarged in a safe manner should be provided to these families.

E. Homeowners living in deteriorated older-period buildings. There are now many homeowners living in older buildings that could be brought up to standard. It is important to focus on homeowners rather than renters as they are most likely to make investments in their buildings.

COST REDUCTION STRATEGIES

In order to make housing improvements more desirable, and thereby increase participation in the program, a number of cost reduction strategies and incentives should be explored, including:

A. Cost Reductions: In order to enable some families to participate, the cost of materials may have to be reduced. Program implementers should identify those materials that are critical and require a decrease in cost. The lead agency should then identify methods that can be used to reduce material costs. Methods may include:

1. Payment of transportation costs;

2. Local production of components;

3. Subsidies.

B. Multiple Financial Approaches: Financial assistance will be required to ensure that every group of people can participate. A balanced program with several different approaches is necessary. Possible programs include loan guarantees, subsidized loans, soft loans, and revolving loans.

C. Cooperative Activities: One of the best means of lowering the cost of housing is for families to work cooperatively. One method is the formation of a group of four or five families to help each other build or repair. The families collectively pay for the services of a certified contractor to supervise their work. Construction occurs simultaneously, thereby lessening the possibility that one family would fail to assist the others once their house has been finished. Other forms of cooperative action should be explored.

INCENTIVES FOR HOME OWNERS

Incentives help to popularize innovations and stimulate participation. Among the possible incentives are:

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

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

C. The designation and awarding of municipal prizes to those communities attaining certain levels of housing safety;

D. Tax reduction incentives to those houses meeting a basic minimum standard.

INCENTIVES FOR CONTRACTORS

It is unrealistic to expect contractors and other building tradesmen to participate in a long training period without strong financial incentive. Experience has shown the best incentives are:

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

B. Honoraria or salaries for the time spent in classroom instruction or payment for helping to build demonstration houses.

C. Guarantees that the government will use the builders' services in the comprehensive program or make them otherwise available for work generated by the program.

OTHER PARTICIPATING GROUPS AND AGENCIES

There are many organizations in Jamaica with experience in the building sector or with related experience or expertise which could be helpful in vulnerability reduction efforts. The lead agency should seek participation of these groups.

A. Technical Associations. Groups such as the Master Builders Association, the Jamaican Society of Architects, and similar associations should be asked to provide advisory services to the project.

B. Voluntary Agencies. Although a number of voluntary agencies work in Jamaica, few have experience in the housing sector. However, these agencies may have resources and skills beneficial to the project. Furthermore, larger groups such as CADEC and CRS have potential capabilities of providing direct assistance that could be developed independently as a part of overall vulnerability reduction activities.

C. Associations of Housing Finance or Lending Institutions. There are several housing finance associations including the Building Societies Association of Jamaica and the Savings & Loan Association. Other groups include private agencies or foundations, cooperatives, and other private institutions which finance housing.

RECOMMENDATIONS FOR THE INVOLVEMENT OF THE AGENCY FOR INTERNATIONAL DEVELOPMENT

Appropriate roles for the AID Mission are:

A. Provision of technical and financial assistance to the lead agency, and stimulation of interest in and support for the proposed activities;

B. Support for the preparation of training aids required for technology transfer and promotional activities;

C. Provision of technical assistance to help develop the financial component of the pilot project;

D. Provision of technical support to institutions participating in the pilot project;

E. Encouragement of financial institutions to participate in the pilot project by encouraging expanded loan programs. This could include providing loan guarantees;

F. Serving as a link to technical assistance resources outside the country;

G. Provision of financial support for a "national center for building and construction";

H. Provision of references and other information required for the library of the "national center for building and construction".

Another U.S. agency that could provide assistance to the program is the Peace Corps. 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 many excellent technical references and publications that could be used in support of the training programs.

APPENDIX I:

RECOMMENDED TRAINING AIDS AND PROMOTIONAL MATERIALS

Four separate sets of materials are required. Many of these materials are already available or can be quickly adapted from existing resources. Also many of the materials can be used interchangably between sets.

MATERIALS REQUIRED FOR TRAINING INSPECTOR/INSTRUCTORS

1. Program Description: A brief booklet outlining the goals and objectives of the program and describing the role of the Ministry and the Inspector/Instructors in accomplishing these tasks.

2. Instructor's Manual: A manual including sections on construction techniques, building details, instructional techniques and 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. Suggested course outlines and checklists for each class in a training program should be included.

3. Instructor's versions of all student training aids.

MATERIALS FOR PUBLIC AWARENESS AND PROMOTIONAL ACTIVITIES

4. Film: Disaster Resistant Construction: A 20-minute film explaining how the forces of hurricanes and earthquakes damage houses. This film would be used for both public information activities and portions of the instructional program. The film should be animated, showing how buildings collapse and illustrating how different building features and designs affect performance. The film should be prepared by API with technical assistance from ODIPERC.

5. Audio-cassettes for Radio Programs: A series of audio-cassettes for distribution to radio stations, describing methods for improving buildings, providing information about the pilot program, and announcing specific activities that are about to commence.

6. Posters: A variety of posters used to announce program activities and to stimulate interest in the program. Posters should describe where interested parties can obtain more information.

7. "How Safe is Your House?": Pamphlet to help families determine whether their houses need improvement or modification. The pamphlet should use a checklist and numerical grading

system to help homeowners determine the relative safety of a building, and it should help them determine the relative value of various options they may choose. (A simplified version of the checklist may be produced and printed in newspapers to help encourage people to determine safety at the beginning of each hurricane season.)

MATERIALS FOR TRAINING CONTRACTORS

Materials are needed to explain the construction techniques for new buildings and modification/retrofitting of existing buildings.

A. New Buildings:

8. Introduction to Wind Resistant Construction: A Guide for Agencies in the Caribbean: Booklet produced by INTERTECT for Catholic Relief Services and OXFAM, to be used to introduce the basic concepts of wind resistant construction to persons who can read.

9. "How to Build a Safe House": Pamphlet that should be prepared as a simplified version of the booklet above (#8) using drawings instead of text to convey the information about safe housing construction. It should be designed to use the same types and styles of drawings as those used in the film (#4) so that it can serve as a memory aid to the film.

10. "How to Build a Safe Wood Frame House": Pamphlet that should be prepared to serve as a guide for those building new wood frame houses.

11. "How to Build a Safe Concrete Nog House": Pamphlet that should be prepared to serve as a guide for those building with concrete nog.

12. "How to Build a Safe House of Block and Steel": Pamphlet that should be prepared to serve as a guide for those building with block and steel.

13. "Techniques of Concrete Construction": Pamphlet to demonstrate correct techniques for preparing and using cement and concrete (can be prepared from existing materials available from VITA and the Peace Corps).

14. Flipcharts: Training aids to amplify points made in the various booklets, for use by instructors in the classes. These charts should be prepared on cloth or plastic to make them more durable.

15. Scale Models of Each Housing Type: Models that should be prepared depicting the correct construction for each type of house. These would show the proper placement of braces and fasteners, and would demonstrate correct techniques

for joining and splicing wood and other materials.

B. Existing Buildings:

16. "How to Strengthen a Nog House": Pamphlet to guide owners of the different types of nog houses in how to correctly strengthen their buildings. The pamphlet should discuss the relative value of the different types of modifications and retrofitting measures possible, and provide guidance in how to determine the structural integrity of wooden components.

17. "How to Strengthen A Wattle-and-Daub House": Pamphlet to illustrate simple techniques for improving hurricane and earthquake resistance, to be developed for owners of wattle-and-daub structures. The limits on wattle-and-daub housing improvements should also be discussed.

18. "How to Strengthen Wood Frame Buildings": Pamphlet to illustrate retrofitting measures which can improve the strength of wooden buildings in hurricanes. Special emphasis should be placed on the problem of stilts and on correct siting.

19. "How to Strengthen Houses Made of Block and Steel": Pamphlet to guide homeowners in how to reduce vulnerability, placing special emphasis on the roof and building features such as verandas.

INSTRUCTIONAL MATERIALS FOR EMERGENCY PROTECTION OF EXISTING BUILDINGS

Many of the materials identified above can be used to provide homeowners with information on repairs, modifications or retrofits that can be carried out when a hurricane threatens. In addition, a special pamphlet entitled "How to Protect Your House in Hurricanes" (#20) should be developed. This would be a guide to simple improvements for all types of housing, and would provide information on how to protect the building and the site, and how to determine whether or not a family should evacuate to a safer area.

APPENDIX II:

PROPOSED CURRICULUM FOR INSTRUCTORS

In order to orient and provide basic training to instructors, the following two-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 program goals and objectives of the Pilot Vulnerability Reduction Program, identify and explain the programs of participating financial institutions, and explain the role of the instructor. The recommended training aid for this segment is the "Program Description" (#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 (#4).

   At the conclusion of the orientation, the pamphlet entitled "How to Build a Safe House" should be distributed (#9).

2. Introduction to Safe Construction:

   A classroom discussion on how to build a safe house would be conducted next. Detailed explanations of building techniques would be introduced. Recommended training aids are the instructor's version of "How to Build a Safe House" (#9) and the pamphlets on safe housing construction of particular building types (#10-12), to be distributed at the end of the class.

3. Introduction to Vernacular Buildings:

   Classes would be presented on different types of construction and how to build safely and/or retrofit each type of housing. Recommended training aids are the instructor's versions of the pamphlets on safe housing construction of particular building types (#10-12) and on the upgrading of existing buildings (#16-19).

   Field trips with walk-around discussions of specific types of buildings should be conducted. 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. The recommended training aid is "How Safe is Your House?" (#7).

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; and the techniques of monitoring the progress of students. The recommended training aid is the Instructor's Manual (#2).

7. Review:

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

APPENDIX III:

PROPOSED CURRICULUM FOR CONTRACTORS AND SELF-HELP BUILDERS

The following curriculum is recommended for the training of contractors and self-help builders. The course would include one week of theoretical training and demonstrations followed by the actual construction or upgrading 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.

FIRST WEEK: THEORY AND DEMONSTRATION

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. The recommended training aids are the film (#4) and posters (#6).

   At the end of the class, the pamphlets about how to build a safe house (#8-9) would be distributed for review prior to the next class.

2. Introduction to Safe Construction:

   The pamphlets about how to build a safe house (#8-9) 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 ensure that the basic principles are introduced and stressed. Recommended training aids are the flipcharts (#14), the instructor's version of "How to Build a Safe House" (#9), and model houses (#15).

   At the end of the class, the pamphlet, "How Safe is Your House?" (#7), 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 asked to critique the houses themselves. At the end of the field trip, the pamphlets on safe construction for specific types of housing (#10-12) 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 instruction would point out the specific improvements and the correct placement and construction of each. Recommended training aids are the instructor's version of the building guides (#10-12) and the model house (#15) for the particular building type being studied.

5. <u>Detailing (Part I)</u>:

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

a. Better wood joints;

b. Use and placement of braces;

c. Use and placement of fasteners.

Recommended training aids are the model houses (#15), model braces and wood joints, and an adequate supply of fasteners, tools and supplies for students to build practice models of the components.

6. <u>Detailing (Part II)</u>:

In this class, the proper techniques for preparing and using concrete would be presented. In those areas where students would be building concrete nog houses, correct techniques for mixing and reinforcing concrete would be demonstrated. Where cement block construction would be used, proper masonry techniques would be demonstrated. Where wooden houses would be built, proper techniques for building concrete footings would be demonstrated.

Recommended training aids are the pamphlets on safe construction (#10-12) and the pamphlet, "Techniques of Concrete Construction" (#13).

7. <u>Detailing (Part III)</u>:

Classes about specific building details and techniques would be held. Possible subjects include the use of plumbs and guidestrings for alignment of houses, wood preservation, carpentry techniques, etc.

SECOND WEEK: ACTUAL CONSTRUCTION PRACTICE

Students should participate in the actual construction or modification of a house using the new building methods.

APPENDIX IV:

TYPICAL BUILDING COSTS *

A. MATERIALS

1.	6" Concrete Block	\$80 per 100
2.	Zinc Roofing Sheets, 30-gauge	\$19 per sheet (8' length)
3.	Cement	\$9 per bag (100 wt.)
4.	Gravel ($\frac{5"}{8}$ and $\frac{3"}{8}$)	\$12 per cubic yard
5.	Sand	\$25 per cubic yard
6.	Steel Rebar ($\frac{1"}{2}$)	\$12.60 per 30'
7.	Steel Rebar ($\frac{3"}{8}$)	\$9 per 30'
8.	Wood Preservative (Atlas A)	\$5.60 per half-gallon
9.	Scantling (2" x 4")	\$155 per 100
10.	Siding Boards (8" x 16')	\$154.27 per 100
11.	Nails (ave.)	\$2 per pound
12.	Hurricane Straps	\$1.15 each

B. LABOR

1.	Mason	\$20 per day
2.	Carpenter	\$25 per day
3.	Assistants or Apprentices	\$10 - \$15 per day

C. AVERAGE COST OF VARIOUS TYPES OF HOUSES
(Basic house w/2 rooms, approx. 500 sq. ft., including labor)

1.	Block and Steel	\$15,000 - \$20,000
2.	Wood Frame	\$14,000 - \$18,000
3.	Concrete Nog	\$9,000 - \$11,000
4.	Stone Nog	\$7,000 - \$10,000
5.	Spanish Wall	\$6,000 - \$10,000

* All costs in Jamaican dollars.
\$1 Jamaican = \$.56 U.S. (May 1981)

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