MADAGASCAR POST-DISASTER DAMAGE ASSESSMENT:

Feasibility Study For a Training Program In Housing Repair

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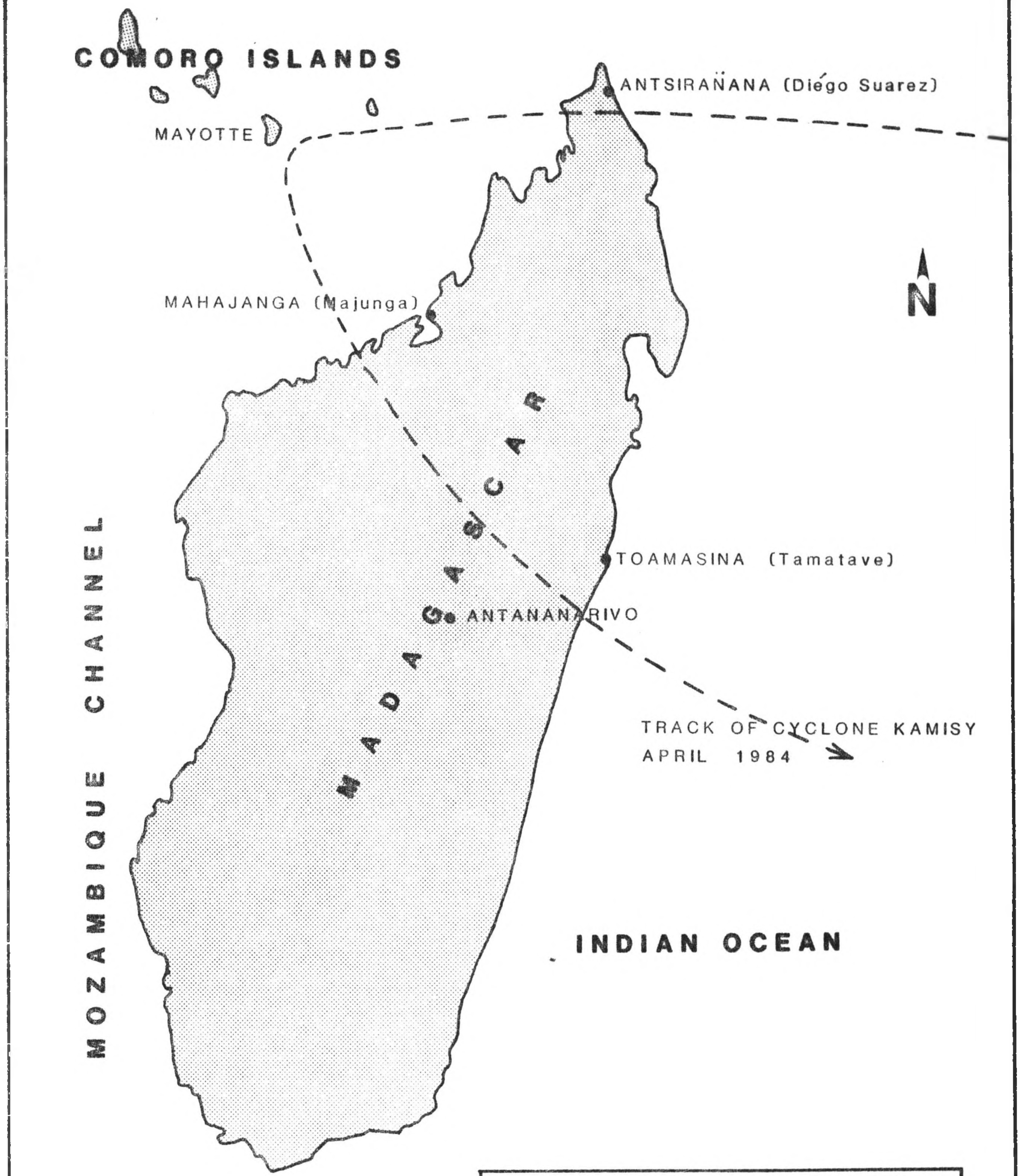
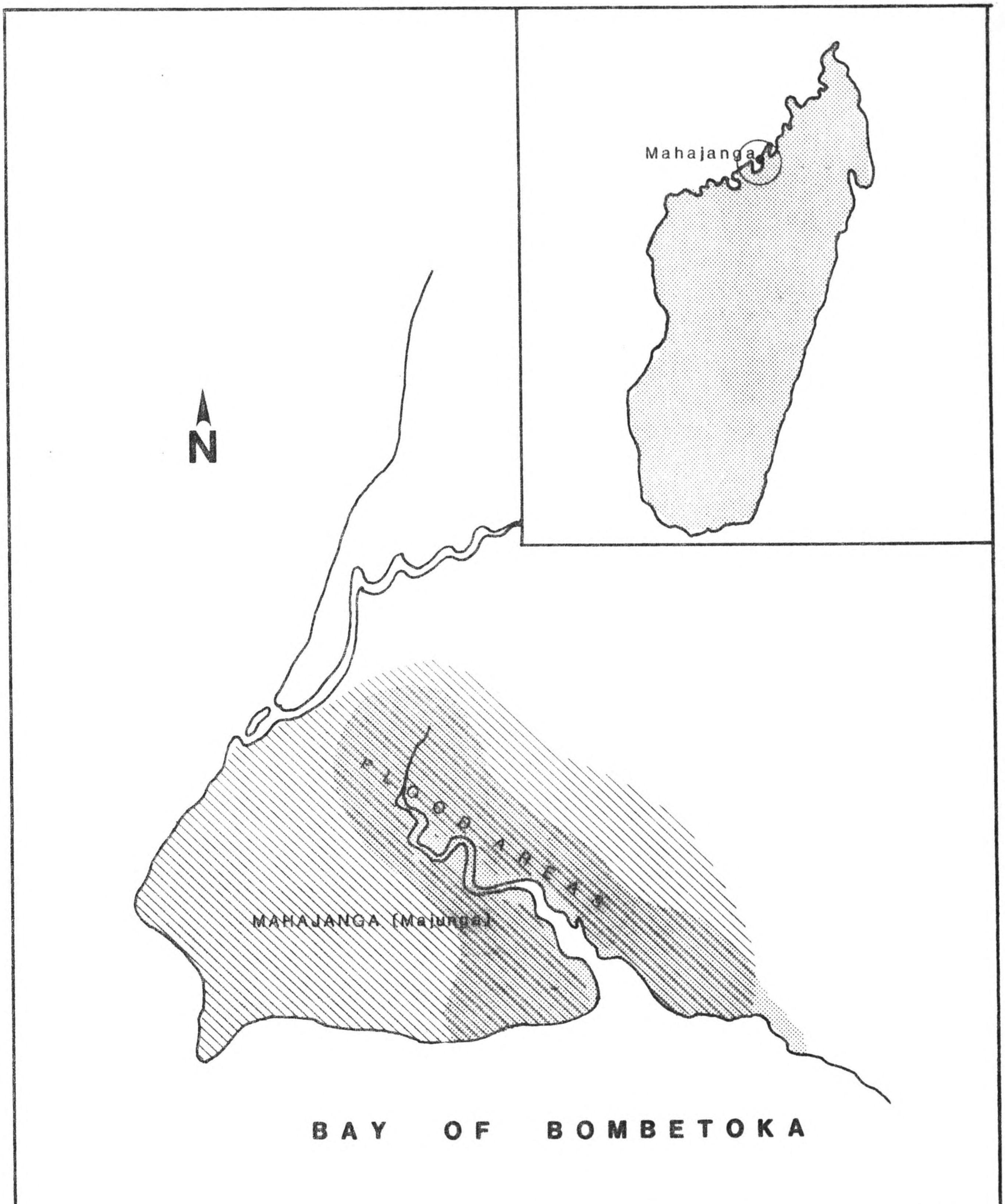
FIGURE 1



MADAGASCAR

INTERTECT, Dallas, Texas

FIGURE 2



AREAS OF MAHAJANGA
FLOODED BY CYCLONE KAMISY

INTERTECT, Dallas, Texas

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Feasibility Study for a
Training Program in Housing Repair

INTRODUCTION

This report describes an INTERTECT post-disaster assessment mission to Madagascar from May 15 - May 27, 1984, undertaken on behalf of the Office of U.S. Foreign Disaster Assistance, Agency for International Development..

The purpose of the assessment was to conduct an "overview" survey of the disaster-affected zone, identify the various building types, and make general assessments of the type and level of damage to the various types of structures. The consultant also met with national and local officials and with potential donors to determine current reconstruction activities and policies, to identify priorities and problem areas of reconstruction, and to determine the levels of assistance from non-U.S. sources. Discussions were held on what measures could be taken to safely rebuild houses and to repair damaged structures and on the feasibility of conducting a training program on how to repair and strengthen buildings.

ACKNOWLEDGEMENTS

The consultants would like to express their sincere appreciation to the staff of the U.S. Embassy, Antananarivo, especially Mr. Scott DeLisi, the Disaster Officer, and his staff, for their help and advice throughout the mission. We also gratefully acknowledge the kind assistance of our colleagues in the Ministry of Interior, Ministry of Public Works, and the Conseil Nacional de Secours (CNS) of the Government of the Democratic Republic of Madagascar.

DESCRIPTION OF THE AFFECTED AREAS

On April 9, 1984, Cyclone Kamisy crossed the northern tip of Madagascar in the vicinity of Antsirañana (Diégo Suarez). After passing out to sea, the storm continued westward to the Comoro Islands, then reversed direction and turned southeast, striking Madagascar again on April 11, at the western port city of Mahajanga (see Figure 1). The cyclone caused massive damage to structures in the urban areas and extensive damage to rural housing and schools in the surrounding rural zones of both communities.

The city of Mahajanga (Majunga) is the capital of the Province of Mahajanga. It is sited on the western coastal plains at the mouth of the Betsiboka River. The city is one of the principal ports of Madagascar; most of the cotton and much of Madagascar's food and building materials pass through the port. At best, however, the port is only a third-class facility because the river continuously deposits large amounts of silt adjacent to the wharfs. Most cargo is carried by lighters between the wharfs and ships lying offshore.

A large cement factory (one of two in the country) is located approximately ten miles upstream from the city of Mahajanga and has its own port where processed cement is also lightered to ships that take it to other parts of the country.

Mahajanga is situated on a series of low-lying hills and bluffs adjacent to the river on the south side and the sea to the west and north of the city (see Figure 2). Several low-income neighborhoods are located on low-lying areas adjacent to marshes and are subject to periodic flooding. The other portions of the city, however, are above the flood level and the hills are not so constricted that funnel-effect wind damages could be expected.

Antsirañana (more commonly known by its previous name, Diégo Suarez) lies at the eastern side of the very northern tip of Madagascar. It is also a port city and its harbor is considered one of the finest natural harbors in the Indian Ocean. However, due to its northernmost location and its distance from the capital and the more densely populated central areas, it is more a regional than a national port.

Antsirañana is situated on a series of hills well above sea level. Flooding is not a problem in the area from either runoff or storm surge. The hills on which the city is located are gently rolling and are not of sufficient height to create funnel-effect wind problems.

OVERVIEW OF THE DAMAGE CAUSED BY CYCLONE KAMISY

Both cities have a long history of cyclones, although few have caused as much devastation as Kamisy. Both cities have experienced a great deal of growth during the last 20 years, a period when severe cyclone strikes were not frequent. Most of the growth has occurred in the low-income neighborhoods, and persons erecting structures in these zones have built flimsy buildings of corrugated iron (C.I.) sheets that are poorly suited to resisting cyclone pressures.

Mahajanga

Widespread damage occurred in virtually all sectors of the urban area. Particularly heavily hit were houses in the slum areas, schools, hospitals, churches and public buildings. The principal type of roofing used throughout the city is corregated galvanized iron sheets. Almost every building utilizing this material lost all or substantial portions of the roof. This includes not only low-rise buildings but also the vast majority of high-rise buildings in the downtown area. Many of the older structures, especially those built during the 1920s and '30s, are covered with interlocking clay tiles. Many people felt that these tiles would adequately resist a cyclone; however, because no cement was used to fix the tiles to the roofs, those structures covered by tiles suffered extensive damage. No areas of the city escaped wind damage, and numerous structures experienced not only typical roof losses but also damage from falling trees and from objects propelled through the air by the high winds.

Portions of Mahajanga lie adjacent to mud flats and tidal marshes on the eastern and southern portions of the city. Fairly large squatter settlements are situated in these areas, and they received extensive damage from both floods caused by the heavy rains swelling the river and possibly a localized surge propelled by the cyclone (see Figure 2). In these areas, damages are high and government officials are anxious to discourage reconstruction in these zones.

Some houses are made of low-quality concrete block with CI sheet roofing. Houses built in this manner suffered extensive damage because the blocks were not reinforced with metal rebar. In those houses where sufficient metal rebar was used, damages are primarily to the roofs.

The town of Boanamary is situated approximately 10 kilometers due south of Mahajanga and is the site of one of the two cement plants in the country. The majority of people living in Boanamary work at or are dependent on the cement plant. Many of the houses in the area are made of wattle-and-daub construction with either CI sheet or thatched roofs. All these structures suffered extensive damage and, in one of the small villages near Boanamary, 95% of the houses are totally demolished.

Throughout the Mahajanga region, replacement building materials are a problem. There are no nearby forests; therefore, wood is scarce and costly. Cement is also expensive, although less so than in other areas of the country because of the nearby plant. The CI sheet roofing material is either imported from other locations in Africa or shipped from a factory on the east coast at Toamasina. (A list of current building material costs is shown in the Appendix.)

Damages to the port of Mahajanga are fairly extensive, although many can be quickly repaired with minimal effort. Of most concern are erosion caused by the cyclone, undercutting of the wharfs caused by overtopping of the wharfs by the storm waves, and undercutting now due to the erosion caused by the river and the tides. Of most concern to port officials are the warehouses. Several are extensively damaged and several buildings will have to be totally demolished. Many of these buildings, however, were quite old, in poor shape prior to the cyclone, and would probably have been replaced within the next 10-year period even had the cyclone not occurred. Unfortunately the buildings were not insured. Operations at the port have resumed and, despite damages to some of the cranes and the need for repairs at several points along the dock, it is estimated that the unloading of building materials can proceed without undue delay.

Damages to schools and hospitals are also extensive. Some buildings are completely demolished, but most of the damage consists of the loss of the roof and water damage from the heavy rains. Hospital administrators reported heavy losses of supplies and equipment but actual losses had not yet been totalled at the time of the damage assessment.

Most of the damage to schools and hospitals occurred because of the poor quality of the roof construction. Most of the roofs have low pitches, they cover large spans with only minimal structures supporting the roof sheets, and few roof trusses are securely tied to the walls. In many cases the buildings are old and do not have ring beams to help support the walls or to provide proper anchorage for the roof trusses. Overhangs are large, and the CI sheets simply peeled off in the high winds. In some cases, walls are constructed of poor-quality, unreinforced concrete block, and extensive damages occurred when the gables collapsed.

Some of the rural schools and schools in the outlying areas of the city are made of wood, but most are built of poor-quality concrete block masonry. These buildings experienced extensive damage and several were totally demolished. Schools are of major interest to the government because children often come in from outlying villages and live at the schools; therefore, the loss of the school buildings and dormitories contributes to the housing shortage.

Antsirañana (Diégo Suarez)

Housing damage in Antsirañana is also extensive, especially in low-income neighborhoods. As in Mahajanga, the majority of the low-income housing is constructed entirely of thin, low-quality CI sheets, and many houses experienced total collapse. In the central portions of the city (i.e., those around the port), many houses are built of more permanent materials such as concrete block, stone and brick. Most of those houses are covered with CI sheets, and extensive roof losses occurred in the cyclone.

In the rural areas, the majority of the houses are made of wood and raffia -- a palm-like, light wood that is used for siding and sometimes for roofs. These houses experienced extensive damage because the type of construction permits air to freely enter through the walls and underneath the eaves. In some villages where all the houses are made of raffia, 100% of the houses collapsed, especially villages that consist of 30 houses or less. It should be pointed out, however, that raffia houses are usually replaced every 3 to 5 years. Therefore anywhere from 15-20% of the houses would probably be replaced during the course of the year anyway.

In the larger villages, damages are also severe. Many of the houses use a combination of wood and raffia walls with a CI sheet roof. Losses to this type of building are also heavy, although a few buildings survived because they are on the lee side of more substantial buildings or are protected by trees.

Other housing types in the villages included all metal structures like those found in the cities and a few unreinforced cement block buildings with CI sheet roofs. Both of these types experienced heavy damages and, in several communities, all unreinforced masonry buildings were destroyed.

In the rural areas, the quality of construction is extremely poor. What few good building techniques are used in the city have not been carried over into construction practices in rural areas.

In the housing sector, building materials are extremely scarce in both the urban and rural areas. No CI sheets are yet available on the market, cement is generally unavailable throughout the community, and wood is extremely scarce. In the rural areas, the government is permitting persons to salvage trees that have been felled by the cyclone and, in some cases, has provided trucks to enable families to gather the wood and transport it to rural villages. Most of this timber comes from reforestation schemes that were due to reach maturity in the next 10-15 years; therefore, the sizes of wood are relatively small.

In the urban areas, wood is also scarce, although some people are also managing to obtain trees from the reforestation scheme. There are two sawmills in the city, but one is currently not in operation and the second is able to produce only about 100 boards per day. Therefore, most of the materials that are being produced are small-diameter, uncut wood poles salvaged from the reforestation scheme.

Schools and medical facilities also experienced extensive damage in Antsirañana. Most of the damage is a result of loss of roofs due to poor design, large spans without proper reinforcing, and poor anchorage of roof trusses to the building frame. In the rural areas, the overall construction of the school buildings is poor; therefore, losses include not only roofs but often the entire building.

Damages to the port at Antsirañana are less severe than at Mahajanga. Most of the damage occurred at the naval port and is not of immediate concern to humanitarian relief efforts. However, some damages also occurred at the civil port, although they are not sufficient to pose problems in the unloading of building materials.

A large number of marine workshops and shipyard facilities are located at the port. These facilities have the capability of producing many of the components that would be used in a housing repair program such as building straps, hurricane fasteners, etc. Discussions with the government have indicated that they would be willing to instruct these workshops to prepare the necessary fasteners, if they are requested to do so and if the materials can be provided.

HOUSE TYPES AND DAMAGE PATTERNS

A. CI SHEET BUILDINGS

The vast majority of housing in both Antsirañana and Mahajanga prior to the cyclone was constructed entirely of corrugated, galvanized iron sheets. Metal sheets were used not only for roofs but also for exterior walls, interior partitions and, in most cases, for outbuildings such as cooking sheds and latrines. The use of CI sheets for housing is a relatively recent phenomenon and is indicative of both the poor economic status of the majority of residents of the cities and a lack of suitable alternative building materials in these areas.

Construction

There is surprisingly little variation in building design among the houses using CI sheets, although the sizes vary to some extent. Figures 3-5 illustrate the most popular designs.

Frame

A wood frame, usually made of unsawn wood poles of approximately two inches (5.08 cm) in diameter (or sometimes rough-cut or hand-hewn wooden boards approximately 2x2 inches (5x5 cm) square), is erected with the principal columns placed approximately 12-18 inches (30-46 cm) in the ground. In most cases, especially in urban areas, the columns are secured in place by laying a concrete floor that helps anchor the columns. No diagonal bracing is used in the frame to provide lateral resistance, and there are usually insufficient members to provide rigidity to the walls or to prevent vibration of the CI sheets during high winds (see Figures 6-12).

Roof

The most popular configuration is a two-sided gabled roof, although occasionally shed roofs are seen. The roof frame is also made of small wooden poles. Even if a family has been able to use sawn timbers for the columns, it will almost always use round, thin poles for the roof frame and rafters. In most cases, fairly long CI sheets are used; therefore, much of the load of the roof is supported by the roof sheets rather than by the roof frame.

Fastening

Crude wood joints are used throughout the frame. Wood pegs or nails are used to fasten the frame together. Where small-diameter poles are used, the nails split the wood, thereby offering little resistance to extraction in high winds. When larger posts are used, the number of nails is insufficient (see Figure 10).

Since the cyclone, many families are using bindings such as wire or metal straps to help strengthen the joints. Unfortunately, many of these are not done correctly (see Figure 8).

Size

Sizes of houses vary from 3x5 meters to 5x10 meters. The number of CI sheets necessary to cover the exterior portions of CI sheet houses varies between 60-82 sheets per structure.

Vulnerability

The most common damage caused by the cyclone was explosion damage. As high winds moved around the buildings, the materials vibrated due to a lack of rigidity and strength in the frame. The vibration caused the metal to fatigue, especially at the nails, and either the roof sheets peeled off the exterior portions of the building or, in some cases, gust-loading caused explosive damage which demolished the entire structure. In most cases, the number of buildings that were totally demolished exceeded the number that were partially damaged.

Specific Weak Points

Typical weak points of metal houses are the connections between the roof sheets and the roof frame (due to both a lack of nails and excessive spans and/or the lack of sufficient use of purlins to provide additional connections); weak connections between the roof trusses and the walls; lack of rigidity in the building frame, especially the failure to use sufficient wood in the frame to permit adequate fastening; and the use of small-head nails rather than nails and washers to improve the connection between the CI sheets and the frame.

Modifications for Wind Resistance

It is extremely difficult to modify these buildings to improve their structural performance in high winds. This is especially true if the CI sheets are thin and of poor quality as is the case in Madagascar. Most of the CI sheets used are 32, 36, and 38 gauge. The recommended material for high wind areas is 24, 26, or 28 gauge.

Another problem with using corrugated metal sheets is that it is extremely difficult to provide airtight seals at critical points in the building, especially under the eaves of the roof and at the roof line. The corrugation of the material makes the woodwork needed for the eave enclosures very difficult to construct, and there would probably be much resistance from the occupants to sealing the buildings on a permanent basis because heat would build up during the day, making the buildings almost unbearable to live in. While it is possible to design metal buildings that are climatically suitable, the cost and sophistication required would make it extemely difficult to achieve in Madagascar and it is probably not worth the effort.

Overall improvement of the buildings is also made difficult by the small sizes of wood. In other countries such as Fiji where CI sheet houses are used extensively, survivability is improved through use of wood columns that are approximately 8-10 inches (20-25 cm) in diameter. The wood frames of those buildings are fairly intricate and well-constructed. In order to stabilize the buildings in Madagascar, building frames using four-by-fours for principal columns and two-by-fours for other spans would have to be introduced.

Even if modifications could be carried out, the ability for this type of structure to resist high winds would still be low-to-moderate.

CI SHEET HOUSE

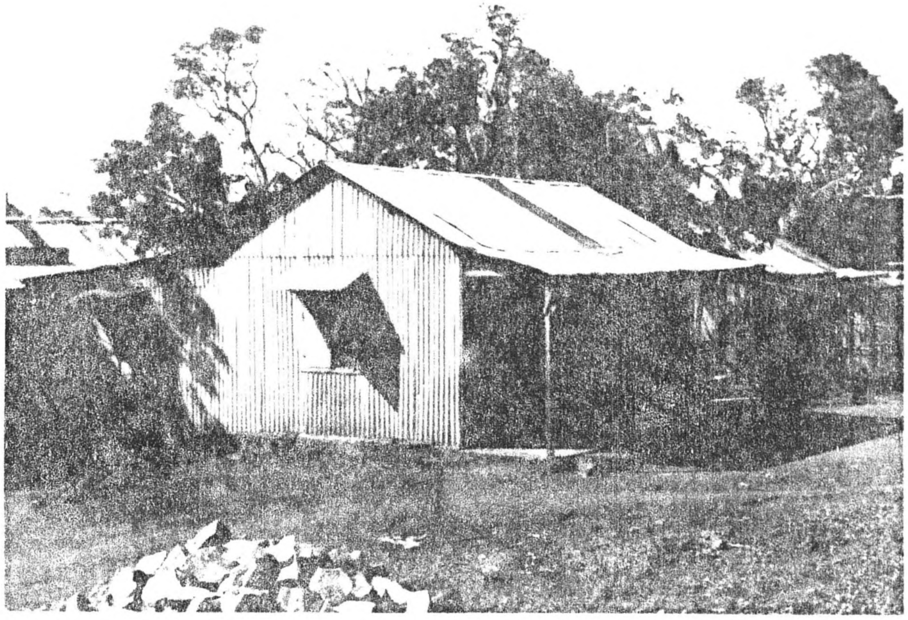
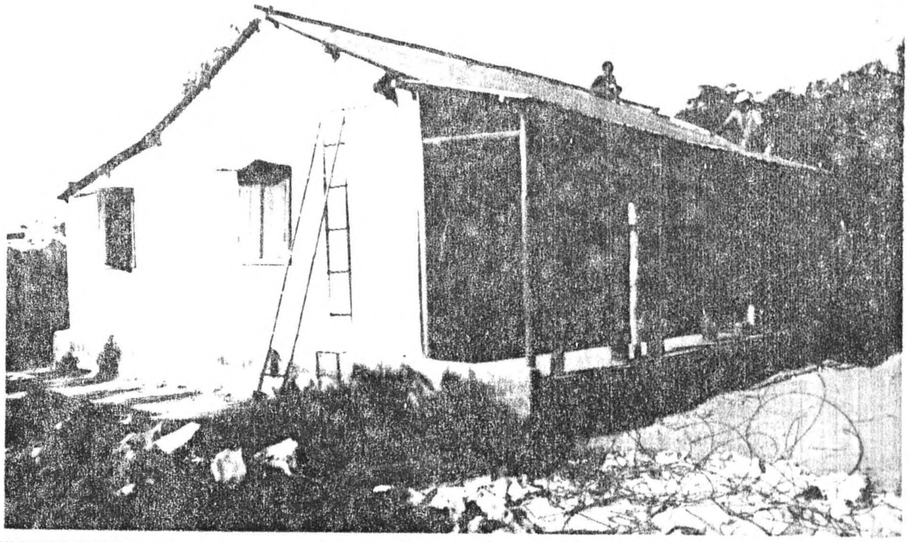


Figure 3

Figure 4



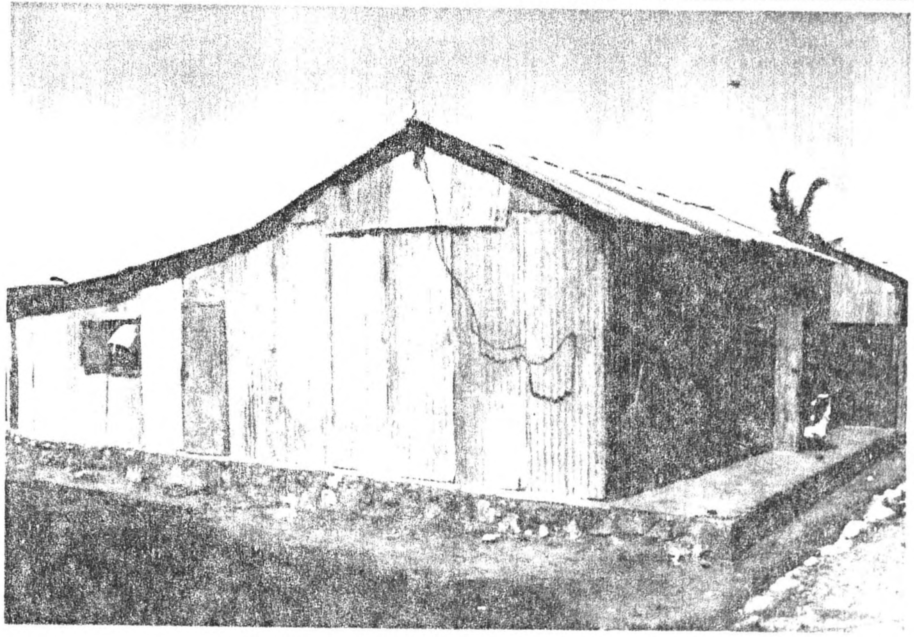


Figure 5

FRAMES OF METAL BUILDINGS

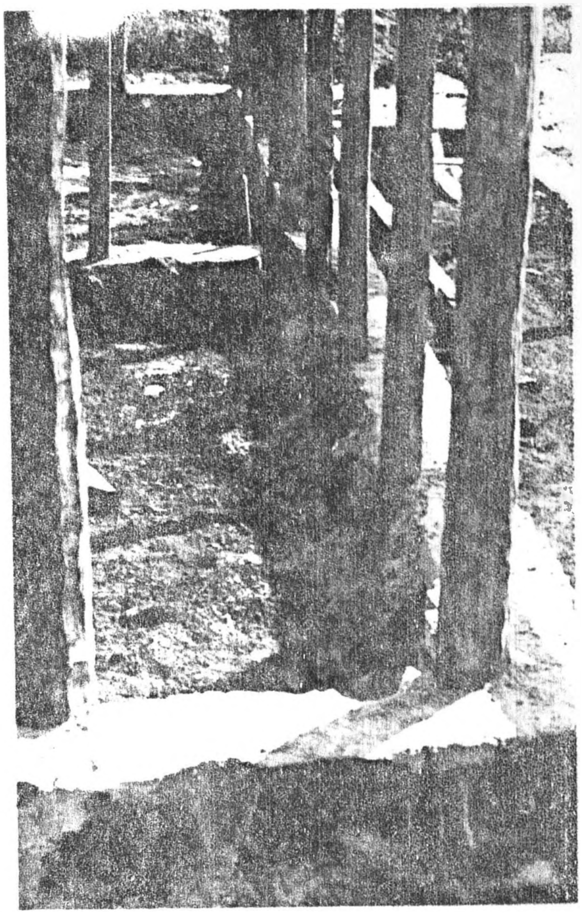


Figure 6 - Posts Cemented to Foundation

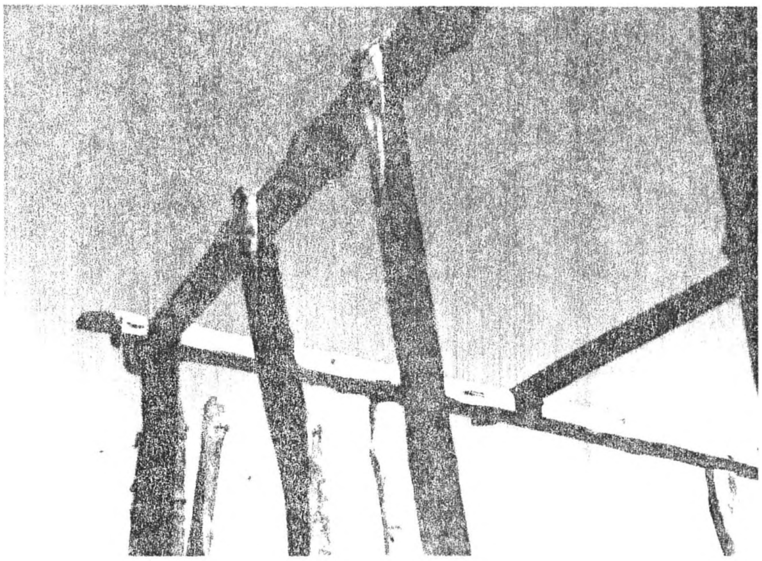


Figure 7 - Posts and Beam Showing Weak Connections

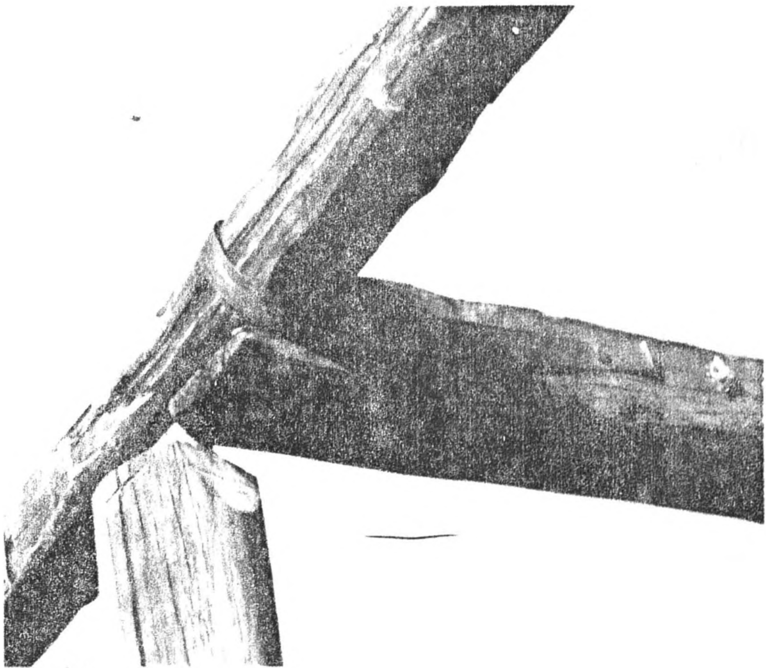


Figure 8 - Improper Use of Strap

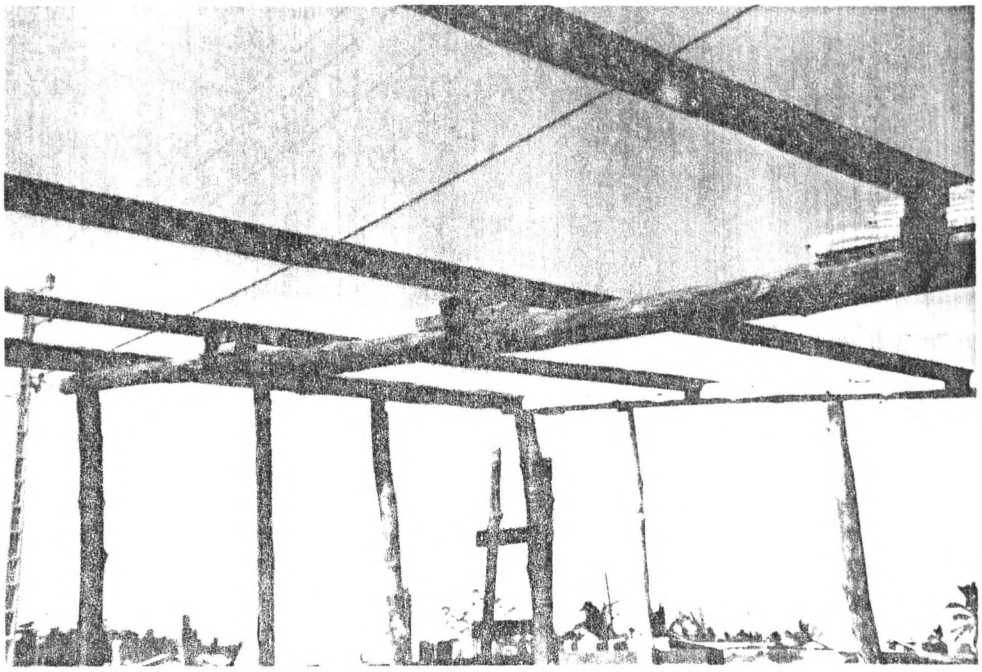


Figure 9 - Detail of Weak Roof to Wall Connections

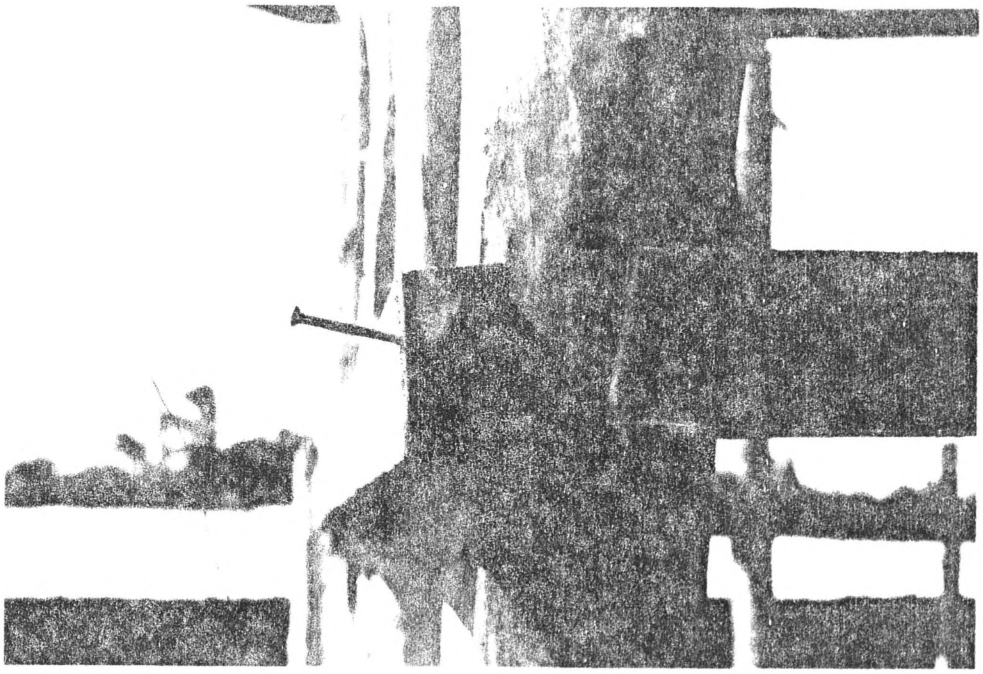


Figure 10 - Poor Use of Nails

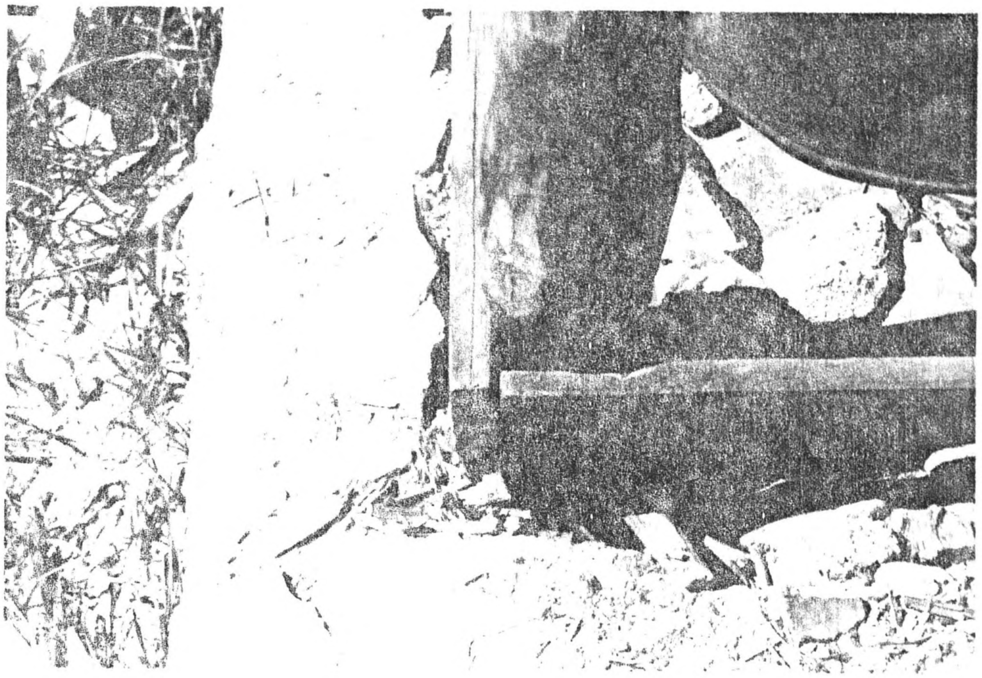


Figure 11 - Boards Used for Attaching CI Sheets at Bottom of Wall (Note Small Size of Board and Only One Nail)

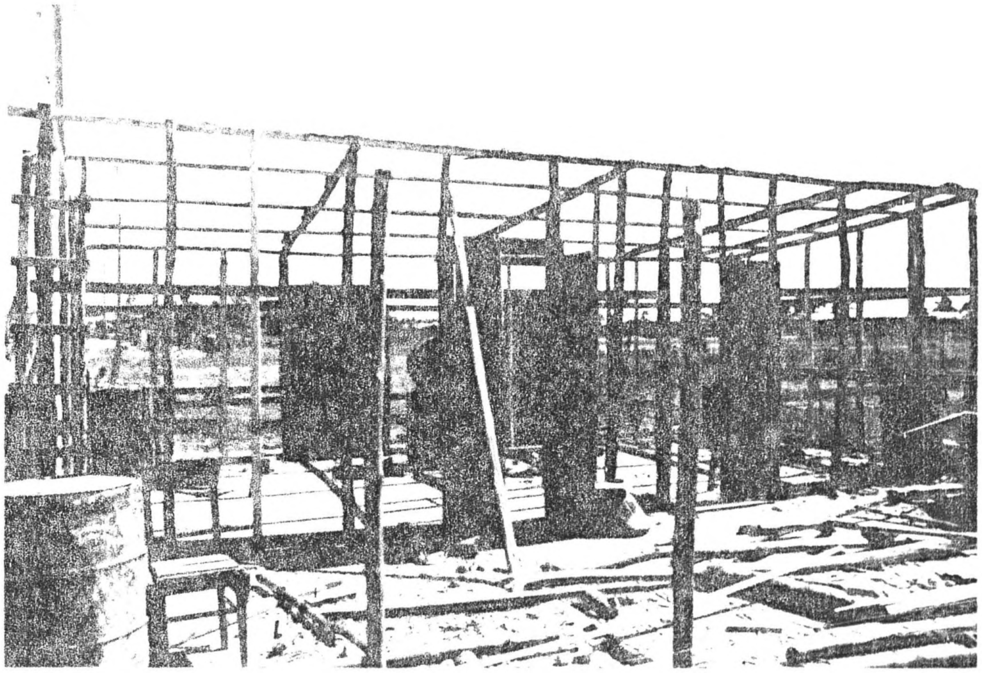


Figure 12 - Building Frame Near Completion (Note Small Size of All Members)

B. WOOD FRAME AND RAFFIA HOUSES

Wood and raffia houses are found in large numbers throughout the rural areas near Antsirañana. This type of construction is particularly well-adapted to the rural climate and environment, although the houses only last for a fairly short period of time. They are inexpensive to build but are very difficult to maintain, and few last longer than 3-5 years. As a general rule, these houses are found in the poorest of the rural areas and are often built by persons without land. The houses take only a matter of days to erect and, therefore, many of those houses that were destroyed were replaced within a month after the cyclone.

Construction

In the usual wood and raffia structures, strong wooden corner posts are set in the ground and a frame consisting of round wooden poles approximately 2-3 inches (5 to 7.5 cm) in diameter is fastened to the columns. Raffia panels are made by cutting the raffia material into the proper length and then connecting the post together with wooden pegs to form a panel. The panel is then attached with wooden pegs to the building frame. Sometimes construction wire is used to tie the structure together, but in most houses natural materials such as vines or locally-made ropes are used. In some cases the building frame is nailed together, but normally wooden pegs are preferred.

Roof

Raffia houses normally have thatched roofs made of palm leaves or grass. In the larger villages, thatched roofs have been replaced by CI sheets.

Size

Raffia houses vary between 3x5 meters to 5x10 meters.

Vulnerability

Most raffia houses are extremely weak because the raffia panels themselves are not strong, the wood frames quickly rot, there is very little lateral resistance, and wind can easily penetrate the structure. When damaged, raffia houses are difficult to repair and most families usually choose to rebuild an entirely new structure. However, even the total collapse of a raffia building is rarely life-threatening. The roof usually blows off the structure, then the panels blow out, leaving the exposed frame. Many people in the rural areas indicate that they would prefer to experience a hurricane in a raffia building rather than a metal one, for fear that flying metal might cut them as it peels off the structure.

Modification for Wind Resistance

It is doubtful that extensive improvements to the raffia houses could be made at a cost that would make the houses desireable or affordable to the people now living in this type of building. Structural performance could be improved by strengthening the building frame and by using stronger types of wood for the posts and beams or by treating the poles now used. However, the cost of these additional improvements would increase-the cost of houses by approximately 40% and, since the houses are normally considered to be of short duration anyway, it is doubtful that people would be willing to invest time or money in making these improvements.

C. WATTLE-AND-DAUB HOUSES

A small number of wattle-and-daub structures are found in the rural areas and villages near Mahajanga. Most of these houses have a fairly short lifespan of between 5-10 years. This type of house is not favored, however, because the wood deteriorates rapidly and the mud walls are considered to be unclean and difficult to maintain.

Construction

For most of the wattle-and-daub houses, a wooden frame is erected with the principal columns sunk into the ground approximately 12-18 inches (30-46 cm). A wood or reed frame is then woven between the columns and covered with mud. The total thickness of the wall is fairly thin, usually no more than 4-6 inches (10-15 cm), and offers very little rigidity. Thus the mud often cracks when animals or people lean or brush against the walls. Usually the houses are bound together with ropes made from local fibers or other natural materials, but in some cases construction wire has been used and, in some of the newer houses, nails have replaced the bindings.

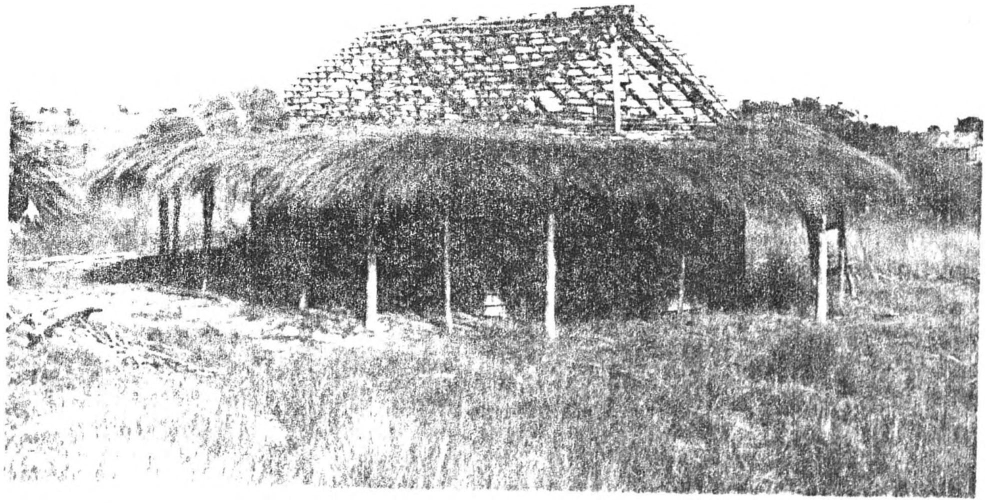


Figure 13 - Wattle-and-Daub House Under Contruction

Roofs

Wattle-and-daub houses normally have thatched roofs made from grasses (or, in a few cases, palm leaves) or a roof covered with CI sheets. Both gabled and hipped configurations are used although, if CI sheets are used, a gabled roof is almost always built.

Size

Wattle-and-daub houses vary in size between 3x5 meters and 5x10 meters.

Vulnerability

Most wattle-and-daub houses are fairly weak due to the small sizes used for the columns in the building frame and the lack of rigidity of the frame. The newer structures that use nails are very vulnerable to cyclones because the nails have insufficient friction and strength to resist the pressure on the joints caused by high winds.

When damaged, wattle-and-daub houses are difficult to repair; most occupants usually rebuild a new structure. However, even the total collapse of a wattle-and-daub house is rarely life-threatening. In most cases, the roof blows off and then the walls tilt over.

Modifications for Wind Resistance

Wattle-and-daub houses can be modified to improve wind resistance, and the type of frame and building construction in Madagascar lends itself to some degree of improvement. However, structural improvements will be difficult unless a good supply of wood is assured and wood treatment can be made available at a reasonable cost.

The primary means of improving resistance would be to build thicker walls. As earthen material is the lowest-cost material in the structure, this should not be too difficult. The use of stabilized earth or stablized earth coverings would further improve the houses.

Additional attention should also be paid to improving the quality of the roof. Thatched roofs can be made stronger by improving the weave of the thatch, and the roof frames can be improved by using better wood material. As in the case of other types of structures, however, wood is in short supply and improvments to the roof may require providing wood that is not currently available.

Improvements to wattle-and-daub houses must be viewed in light of the social and economic context. The majority of people residing in these structures are poor, rural families who are unlikely to be willing to spend much to improve their houses. In many cases, the houses are probably situated on land where tenure is not secure; therefore, families may be unwilling to make much of an investment in the structures.

D. CONCRETE BLOCK CONSTRUCTION

If properly built, concrete block houses can withstand the forces of windstorms and are a safe form of construction. If improperly-built and -reinforced, however, this type of construction is extremely dangerous because the collapse of heavy walls can injure the occupants.

Concrete block houses are fairly rare in low-income sectors of both Mahajanga and Antsirañana. This is due to the fact that concrete blocks are relatively costly in comparison with CI sheets. When concrete block houses are built, they are rarely reinforced properly; therefore, they often experience extreme damage.

Construction

Most concrete block houses in both Mahajanga and Antsirañana are constructed using handmade concrete blocks (i.e., blocks made in hand molds). The blocks are usually laid on top of stone foundations, although in a few cases the first course of blocks is laid several inches below ground level. Little cement mortar is used between the blocks; therefore, the bond is very weak. In many cases, tie beams are omitted at both the ground level and at the top of the wall, and in no cases were any tie beams evident in the middle sections of walls. If iron rebar is used at all, it is normally in the corner, and usually only one or two pins are used to provide the connection.

CI sheets are used to roof concrete block houses. The sheets are attached to wood purlins which are fastened to trusses held in the walls in one of two ways. In the first, the wooden truss is imbedded in the wall and cement mortar is poured over the top of the wood to hold it in place. In the second, iron rebar is placed in the top layer of blocks and cemented into place, then bent over the wooden truss to hold it to the wall. (It should be noted that a complete ring beam is not used; the rebar is simply cemented into one or two of the blocks at the top of the wall.) Roofs normally have a gabled configuration, although a few hipped roofs were also noted. Most gabled roofs are fairly flat, thus increasing the suction as the air passes over the top. Most of the roofs also have large overhangs which permit high winds to be deflected upward, peeling the roof sheets off the frame.

Most of the purlins are spaced in such a way that it is not possible to provide adequate fastening of the sheets to the roof frame.

Size

Most cement block houses vary in size between 3x6 meters and 5x10 meters.

Vulnerability

The principal damage to reinforced cement block houses was loss of roofs due to poor connection of the roof frame to the walls. The principal damage to unreinforced cement block houses was loss of roofs and, in many cases, total collapse of the exterior walls, especially if interior walls were made of a lightweight material such as CI sheets or wood. A large number of "explosions" were noted, indicating that the walls were poorly constructed and that there was not adequate bonding between the blocks.

Modifications for Wind Resistance

If properly built, concrete block houses are among the safest types of structure and can adequately resist the forces of cyclones. The key to improving the strength of block houses is improving the quality of the blocks themselves, improving the masonry work, especially increasing the use of mortar between the blocks, and useing proper reinforcement. Improvements to the design of the roof frame would also substantially improve the survivability of block buildings in high winds.

Given the lack of other suitable building materials and the availability of cement, high priority should be given to the introduction of better building techniques for concrete block houses. Incentives should be offered to encourage people now residing in metal houses and other types of poor-quality construction to consider concrete block structures. This must be done carefully, however, because poorly-built concrete block houses will be more dangerous than the types of building now used in the affected areas.

REPAIR AND REHABILITATION PROBLEMS

Several problems have surfaced in the aftermath of the cyclone that impede repair and rehabilitation of housing. First and foremost is the lack of building materials. If existing buildings are to be rehabilitated and repaired, massive amounts of CI sheeting need to be imported, as well as purchased locally from the rolling mill at Toamasina. Of equal importance, however, is the lack of wood; it is unlikely that the buildings can be repaired safely without the importation of large quantities of four-by-fours and two-by-fours.

The second problem is that few disaster victims have been able to obtain financing for repair or rehabilitation. There are no lending institutions in the affected areas that provide funds for housing. This is a major problem since the cost of the few available materials has more than doubled due to demand. It is made even more severe by the fact that almost none of the larger commercial and government buildings were insured. Thus there is little of the normal building boom that normally occurs when insurance claims are paid and little of the spin-off construction activity that one would normally expect to find at this stage of the disaster.

A third problem is that many individuals have initiated the repair of their houses without adequate technical assistance and are rebuilding in an extremely poor fashion (see Figures 14-16). Rather than decreasing vulnerability to future disasters through safe repair, vulnerability is probably increasing.

The greatest concentration of problems is in low-income neighborhoods where most reconstruction consists of building small shelters out of salvaged CI sheets and wood poles. For all practical purposes, there is little difference between repair and rehabilitation of houses and reconstruction, since the houses that existed prior to the cyclone were so extensively damaged and the lack of building materials will necessitate that the shelters being erected now form the nucleus for an expanded house in the future, if no other type of building material is provided.

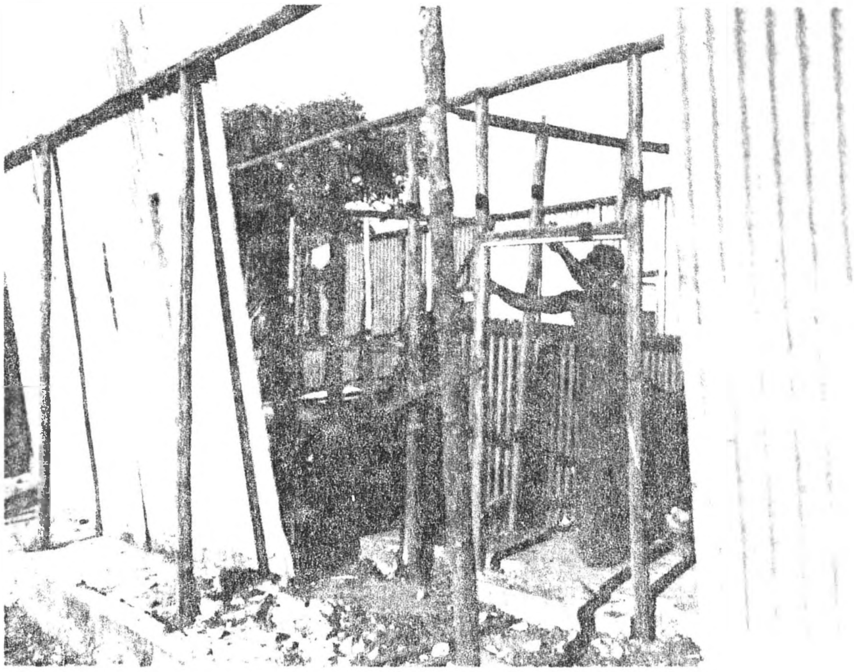


Figure 14

Figure 15

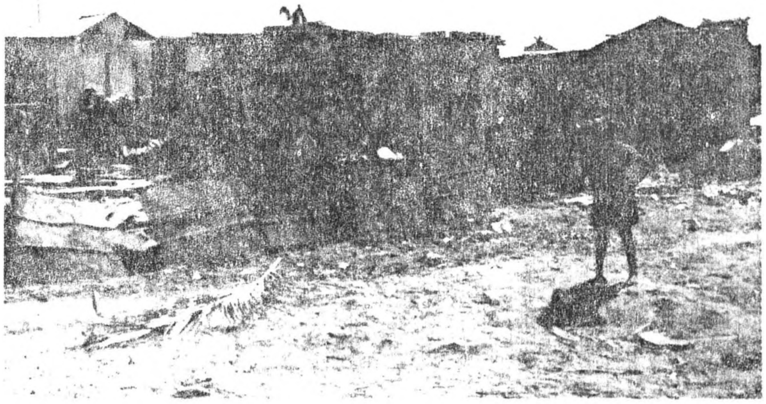


Figure 16

RECOMMENDATIONS

Based on the site visit and analysis of existing conditions in the affected areas, the following activities are recommended:

--- The level of support for the repair and rehabilitation effort should be increased from the $500,000.00 currently programmed to a level of $3.5 to $5 million dollars total assistance. The majority of these funds would be used to provide building materials at a subsidized cost through either (a) direct purchase of materials in Kenya and other nearby countries for importation to the affected areas; (b) direct purchase and shipment of materials available in Madagascar; or (c) stimulation of local production of building materials on site.

--- The Office of U.S. Foreign Disaster Assistance should support a training program to demonstrate methods for determining whether or not a building can be safely repaired and how to repair or reconstruct a building in a safe manner. This training should be coordinated with the materials distribution program in such a way that the materials can be used as an incentive to encourage safe construction.

--- The U.S. Government should capitalize on the experience of the cyclone to encourage further vulnerability reduction efforts in other portions of Madagascar. The Government of Madagascar is currently expressing high interest in disaster mitigation and may be receptive to technical assistance in this field.

PROGRAM IMPLEMENTATION

The following general procedure is recommended for implementation of a training program:

--- Technical advisors (TAs) should train personnel from the Ministry of Public Works at the central level. The training should consist of:

1. an overview of the physical nature of cyclones and how they affect small buildings;

2. the principles of cyclone resistant design and construction;

3. introduction to materials and methods of construction;

4. application of these principles to repair and strengthening of existing buildings, rehabilitation and reconstruction of existing buildings, and design and construction of replacement buildings.

--- The technical assistance team should then work with the national government and local authorities to develop and conduct a public awareness program designed to encourage persons to use the safe construction techniques being promoted. Emphasis should be placed on how families can assess the damage to their buildings and how to determine whether they can be safely repaired or need to be entirely reconstructed.

--- The technical assistance team should then help establish procedures for the subsidized sale of building materials to low-income families. A procedures manual for establishing the program and monitoring the sales activities should be prepared and used as the primary instrument of control for the program.

--- The proceeds from the sale of the materials should be used for four purposes:

1. To purchase additional materials on the local market for sale to the disaster victims.

2. To establish small, labor-intensive projects that can be reserved for low-income disaster victims to enable them to work either for building materials or for cash to purchase building materials (or other necessities). It is anticipated that there would be spin-off benefits to local markets by injecting this capital into the communities.

3. To establish small enterprises to produce building materials such as cement blocks and sawn timber. Several micro-enterprises could be very successful and could help further reduce the cost of construction.

4. To pay a core of building contractors from the private sector who would assist families in the safe repair and rehabilitation of their houses.

Once the training has been completed and the subsidized materials are available for sales, the Public Works instructors would commence extensive training and public awareness activities in areas designated as high priority rehabilitation areas (by the urban planning division of the Ministry).

A certification program of local builders, carpenters and masons would be carried out under the auspices of the Ministry of Public Works. Persons purchasing the subsidized building materials would be referred to certified contractors in their neighborhoods who would supervise the repair and rehabilitation of their buildings at no cost. Personnel from the Ministry of Public Works would periodically inspect the buildings under construction to ensure that they were being built according to specifications.

It is estimated that the entire program would take approximately six months to complete. The majority of the technical assistance portion would be completed in approximately two months.

APPENDIX:

Cost of Principal Building Materials

	Mahajanga	Antsirañana
Corrugated Iron Sheets:		
32-gauge	11-15,000 FMG	6-7,000 FMG
Wood Poles:		
Uncut (4m)	500	800
Rough-Hewn (4m)	7-800	4,800
Cement:		
(per 50 kg bag)	2,500	4-6,000
Iron Rebar:		
(per kilo)	600	600
Concrete Blocks:		
(20 x 20 x 40 cm)	550	1,000

Note: 560 FMG = $1.00 US in May 1984