Minimum Building Standards and Environmental Guidelines for Housing

Safer Housing and Retrofit Program

St. Lucia National Research and Development Foundation

This document was originally prepared in May 1997
and substantially updated in May 2003

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Minimum Building Standards

Introduction

Providing comfortable and safe shelter for the family is perhaps the single most important aspiration of heads of household anywhere in the world. In St. Lucia, a safe home must be able to stand up to tropical storm winds, rains and hurricanes, which all too often visit the region. When a house suffers damage, family members' lives are disrupted, belongings are lost, and sacrifices need to be made to reconstruct and replace what was lost.

Low and modest income families are particularly vulnerable to the effects of natural hazards. The bulk of these families' financial worth is tied up in their house belongings. Their houses are likely to be constructed without due regard to building standards and quality of materials; they may be located in hazardous areas and are unlikely to be insured.

Each year tens of thousands of people die and billions of dollars of property damages result from disasters related to natural hazards. The risks from natural hazards change and increase as the Caribbean region grows and develops. Economic losses from these disasters will continue to increase and economic development will be retarded, unless serious attention is paid to mitigating the effects of these hazards.

Preface

This document has been compiled to provide guidelines to local builders and agencies in St. Lucia involved in safer housing/retrofitting work, so as to ensure that such work is carried out in the most effective manner. This document highlights the basic minimum standards for retrofitting and quality control tips for both new and existing wooden houses. Its purpose is to inform homeowners of the proper design and construction of safe housing and to serve as a reference for builders, artisans and inspectors. Inspectors play an important role, as frequent and informed inspections are necessary to ensure that structures are being built correctly and safely.

This document is not intended to be a detailed construction manual, but presents a summary of the recommendations of the writers' experience, observations and research over the years. It is intended to be used as a reference/guide for artisans, builders and homeowners in St. Lucia. Specific solutions are not offered, but the document details a number of options that the homeowner can use in building a home.

St. Lucia has developed a national Building Code and the accompanying Building Guidelines for Small Structures. The guidelines in this document are not intended to replace any National Code or Housing Manual in existence, but recommends, in some cases, techniques that may be stronger than the ones required in the code.

Acknowledgements

Under the USAID-sponsored Caribbean Disaster Mitigation Project (CDMP, 1993-99), the Organization of American States helped the St. Lucia national Research and Development Foundation (NRDF) with the establishment of a Hurricane Resistant Home Improvement Program. After seven years of operation, a thorough review was called for to update the procedures and revitalize the program. Principal funding for this review project was provided by the World Bank and the Government of the Netherlands, through the Bank-Netherlands Partnership Program. The World Bank established a cooperation agreement with the Organization of American States (OAS) for the implementation of this project. The Government of Brazil provided the OAS with seed funding as counterpart to the Word Bank funds.

Arnaud Guinard of the Latin America and the Caribbean Regional Group of the World Bank served as project manager for this activity and provided significant guidance throughout its implementation.

Assistance was also provided by Alcira Kreimer and Margaret Arnold of the World Bank's Disaster Management Facility. The support of Orsalia Kalantzopolous, Caroline Anstey and Tova Solo is also appreciated.

Jan Vermeiren of the Unit for Sustainable Development and the Environment of the OAS provided oversight through field visits to St. Lucia and review of the documentation. Steven Stichter served as the project manager for this activity and was responsible for the review and editing of the final documents.

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The *Environmental Siting* section of this document was prepared by Peter Norville. Peter Norville is a Registered Professional Engineer based in St. Lucia. He has over twenty years of experience in the areas of soil and water engineering, environmental engineering, agricultural engineering, environmental planning and management, rural development and project management. He has held several professional and managerial positions within the St. Lucia Public Service. He has also worked with the Organisation of Eastern Caribbean States. Mr. Norville currently operates as a Consultant Engineer, practicing in St. Lucia and in several other Eastern Caribbean States. Mr. Norville wishes to express his thanks to the following persons who provided assistance during the writing of this document: Mr. Bryan Walcott (NRDF), Ms. Joan Cools (NRDF), Mr. Roland Charles (NRDF), Mr. George Dujon (Sir Arthur Lewis Community College), Mr. Wenn Gabriel (Ministry of Health) and Mr. Joseph Medard (Ministry of Health).

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Hurricanes

Before one can seriously appreciate and be committed to the importance of safer housing construction or retrofitting, one needs first to understand hurricanes and how their destructive wind forces affect or destroy buildings and homes, especially those built of timber.

How are they formed?

The word Hurricane comes from the Spanish word 'hucan', which originates from the arrival of the Spaniards to the Caribbean. It comes from the Taino word 'Juracan' that means 'Evil Spirit', according to the Indians who lived in the Antilles at the time.

A hurricane can be described as a low-pressure area into which the hot and humid tropical air enters and tends to rise. This process acts as the motive force of the storm. The rotation of the earth causes the wind to turn in a counter clockwise, spiral path. A hurricane has several distinctive structural features, shown in Figure 1.

Eye: In the Northern Hemisphere, hurricane winds spiral counter clockwise around an eye, which is a low pressure area in which wind speeds are only 10 to 20 m.p.h. The area in the eye is characterized by a marked reduction in wind speed, a ceasing of heavy rain, and a partial clearing of the sky. In the most spectacular cases, the wind speed drops to nearly calm over an appreciable area, and all clouds disappear. The eye is usually circular in shape, the size of which can vary 10 – 100 miles in diameter.

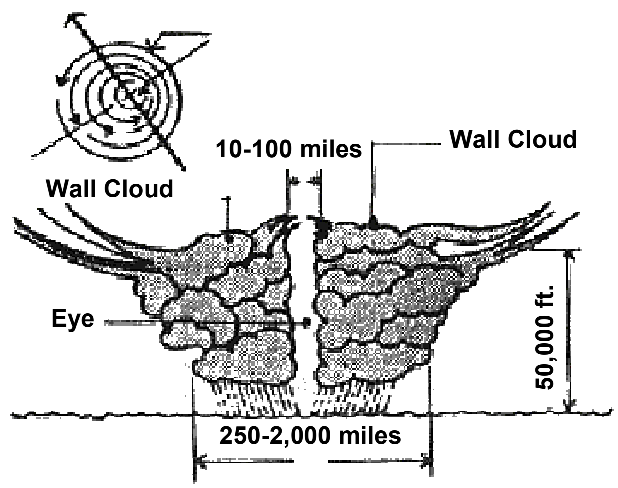


Figure 1 Structure of a Hurricane

Wall Cloud: Surrounding the eye of the hurricane is the so-called wall cloud. In the best-developed cases, this cloud structure completely encircles the eye and extends from the earth's surface to above 50,000 feet. The strongest wind speeds are usually found in the wall cloud, normally in the upper right quadrant, because the forward movement of the storm is added to the wind speeds in the storm. It is in this area that the pressure gradient is strongest and the rainfall is heaviest.

Storms are classified by the U.S. National Hurricane Centre using the Saffir/Simpson Scale, which is based on wind velocity and barometric pressure. The scale establishes five categories, of which Category 1 is a minimal hurricane and Category 5 the worst case. See the table below.

Category	Wind speed (m.p.h.)	Storm surge height	Barometric pressure (in.)
1	74 - 95	4 - 5 ft. above normal	greater than 28.94"
2	96 - 110	6 - 8 ft above normal	28.50 - 28.91"
3	111 - 130	9 - 12 ft above normal	27.91 - 28.47"
4	131 - 155	13 - 18 ft above normal	27.17 - 27.88"
5	Greater than 155	greater than 18ft	less than 27.17"

How do they affect/destroy buildings?

As the eye of a hurricane approaches a site, the winds increase gradually to a peak before the eye passes over the site. On the backside of the eye, winds increase again to another, lower peak. The winds on the backside blow in an opposite direction to those on the forward side as a result of the circular wind pattern in the hurricane. Since buildings may be subject to winds from several different directions as the storm approaches and passes, buildings must be designed to resist wind from all directions.

Wind damage is caused by the wrenching and bending forces imposed by gusting winds and the rapid increase in wind force as the wind speed increases. Wind force increases with the square of the wind speed, which means that when the wind speed doubles, the force of the wind on the structure increases four times.

Wind striking a building produces pressure, which pushes against the building on the windward side, and suction, which pulls the leeward side of the building and the roof (Figure 2). If no air leaves the building, then the pressure inside pushes against the walls and the roof.

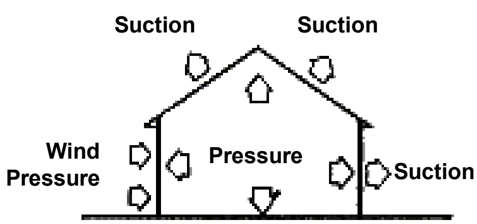


Figure 2

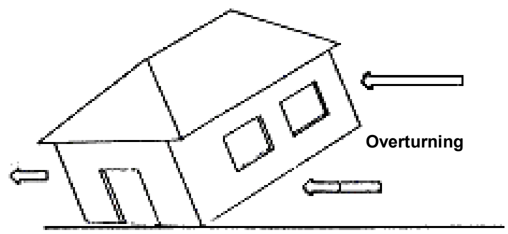


Figure 3

Failure may occur when the external pressure and suction on the wall combine to push and pull the building off its foundation. Overturning can occur particularly if the structure is lightweight and its weight is insufficient to resist the tendency of the building to be blown over (Figure 3).

Wind penetrating an opening on the windward side of a building during a hurricane will increase the pressure on the internal surfaces. This pressure, in combination with the external suction, may be sufficient to cause the roof to be blown off and the walls to explode (Figure 4).

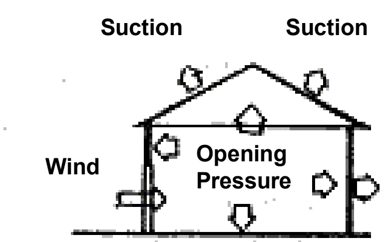


Figure 4

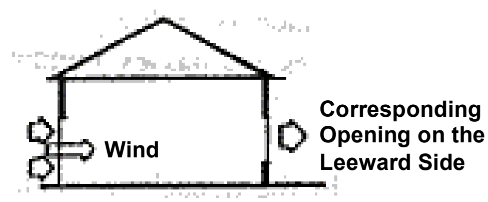


Figure 5

During a hurricane an opening may suddenly occur on the windward side of the building. The internal pressure that builds up as a result may be relieved by providing a corresponding opening on the leeward side (Figure 5).

Another mode of failure occurs when then windward side of the house collapses under the pressure of the wind (Figure 6).

If the building is not securely tied to its foundation and the walls cannot resist the push/pull forces they are subjected to, the structure tends to collapse, starting at the roof, with the building leaning in the direction of the wind (Figure 7).

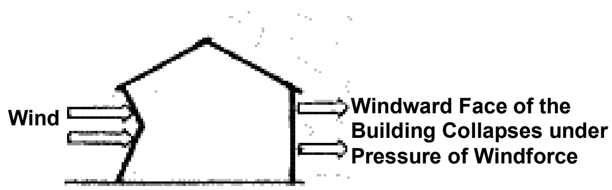


Figure 6

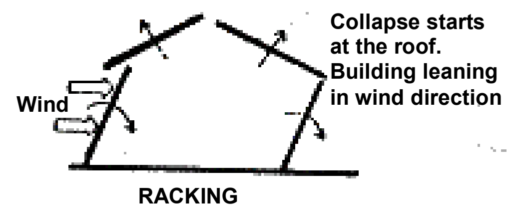


Figure 7

All modes of failure can be avoided or mitigated by providing adequate bracing, clamping and anchoring of framing components in timber construction, and by the use of good quality concrete and concrete elements with adequate steel reinforcement, particularly in foundations.

Basic Minimum Standards and Quality Control Tips for Builders, Artisans and Homeowners

The following areas will be given attention in this document since they are the areas that cause the most concern during a storm or hurricane. They are:

- Building Shape
- Foundations
- Framing (external walls and cladding)
- Roofs
- Floors
- Porches
- Shutters, Doors and Windows
- Connections between all components
- Location

Building Shape

It is reasonable to say that low-income house owners typically pay much more attention to size than design when building their homes. The shape of the house, however, is an important factor to be considered when thinking of resistance to high winds. The shape should be as simple as possible, preferably rectangular or square. Avoid 'T' or 'L' shaped houses; because they channel the wind into the junction between the two wings, they are especially vulnerable to high winds. The increase in wind pressure in the junction may lead to failure of the structure. When building rectangular houses, the length to width ratio should be 3:1 or less.

Figure 8 shows four building configurations, in order of increasing vulnerability to wind forces. The L-shaped houses are particularly vulnerable to hurricane-force winds at the interior corner where the winds develop higher forces.

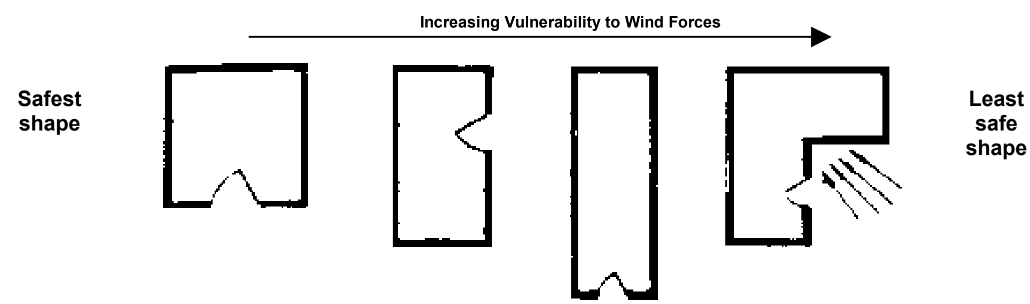


Figure 8

Recommendations—Building Shape

- Ensure that the house is rectangular or square in shape. Avoid irregular shaped houses (i.e. L- or T-shaped). If the need for extensions or additions to an existing house requires such shapes, it is safer to separate the two units by a corridor or walkway, which is itself a separate, self-supporting structure.

Foundations

The foundation anchors the house and transfers the weight of the structure to the ground. The practice of simply laying a structure on large stones, loose concrete blocks or wooden pillars is not recommended.

A safer practice is the use of concrete columns or concrete block walls, reinforced with ½” mild steel bars. The use of mild steel is encouraged since it is easier to bend than is high tensile steel. These bars must be continuous and project beyond the foundation by at least 12" to 14" (300mm to 350mm) to facilitate the securing of the structure to the foundation (Figure 9).

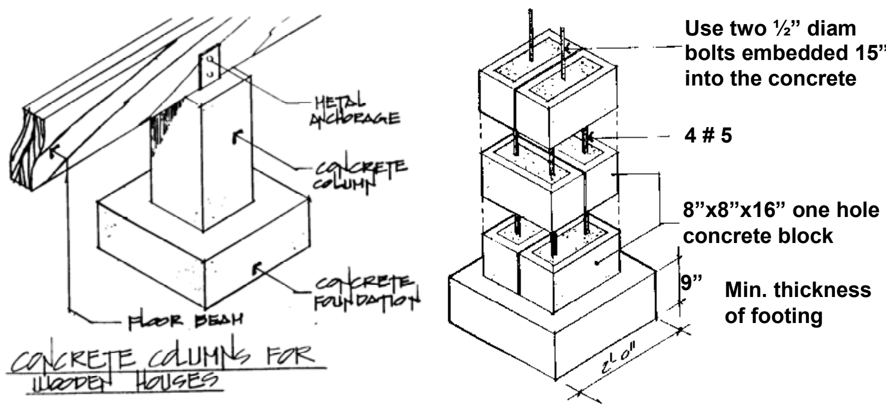


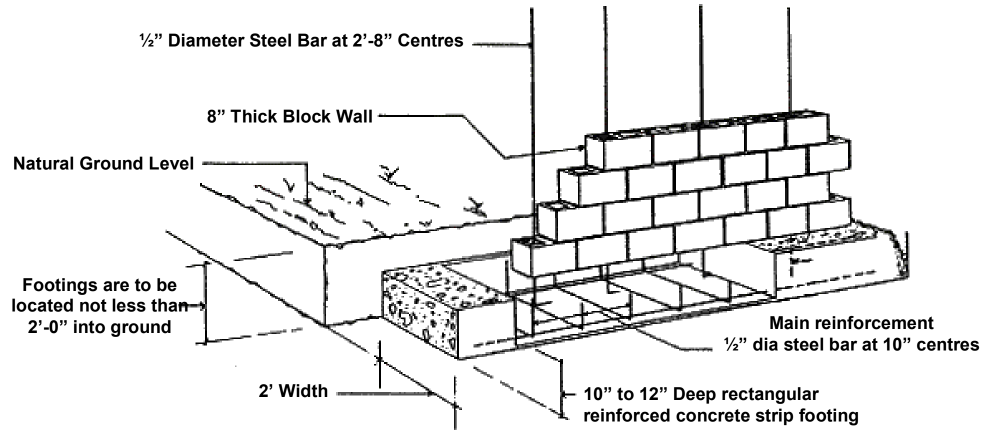
Figure 9 Concrete Columns for Wooden Houses

The footing of the foundation should be on firm soil, 2’-0” (600mm) wide by 10”-12” deep (200mm – 300mm) with 6” or 8” concrete blocks (Figure 10). When concrete columns are used, column that are up to 3 ft above ground should be a minimum of 9”x9”. The length of column below ground should be roughly equivalent to the length of column above ground. With every increase of 1 ft in the height of the columns, the width should be increased by 1 inch in each dimension.

Height (up to)	Minimum Column Width
3 ft	9” x 9”
4 ft	10” x 10”
5 ft	11” x 11” (etc)

When wood posts are used instead of a concrete block or column foundation, the posts should be treated with preservative and then buried in concrete four to eight feet (4'-0" to 8'-0") into the ground. The posts should have a minimum dimension of six by six inches (6" x 6") (Figure 11). The minimum diameter for round posts should be eight inches (8"). The hole in which the post is placed should be larger than the post itself to accommodate the backfill. Existing houses that do not meet the above recommendation should be improved by building proper pillars and securing the structure to them.

Existing houses with wooden pillars can be strengthened by excavating around the pillar, casting them in the ground with quality strength concrete (Figure 12) and bracing the pillars to provide lateral support to resist wind action (Figure 13). It is important that very strong pillars be used. Green heart, Capeche, Glory Cedar, Coconut trunks or Balata are a few examples of appropriate choices for pillars. For all types of pillars, the depth of pillar below ground should be similar to its height above ground to the underside of the floor.



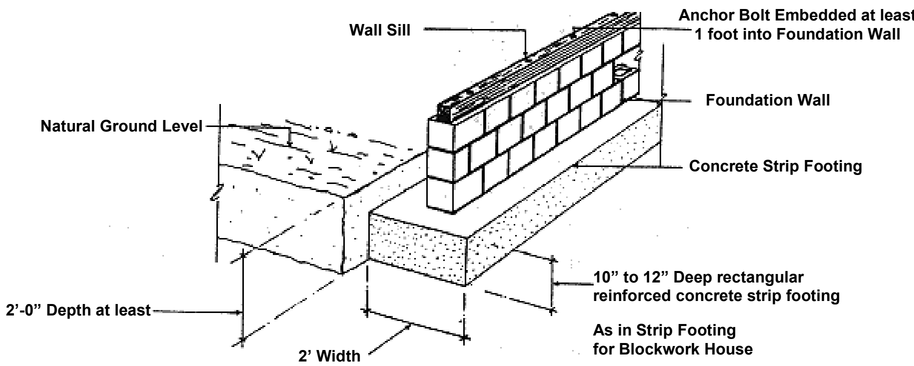
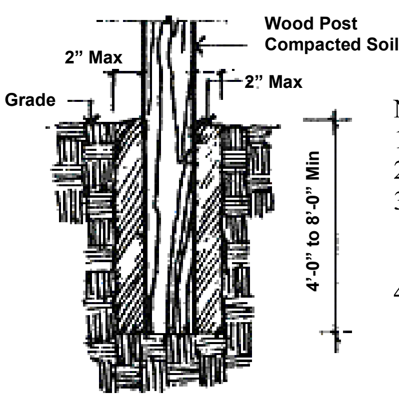


Figure 10 Strip Footing for Wooden Houses



Notes:
1. Minimum size of posts: 6”x6” or 8” diameter when round.
2. Backfill: well-compacted materials that will provide drainage.
3. Soil cement is made by mixing 5 parts each of crushed rock and sand and 1 part of cement plus water. All particles larger than one inch and all organic matter should be removed from the earth.
4. Steel bars in the concrete pier should be covered with at least 3” of concrete.

Figure 11

Many existing houses on reinforced concrete block pillars do not have any projecting steel bars left to secure the structure to the foundation. To correct this serious problem, a metal strap can be fastened to the pillars, which is then nailed to the bottom plate of the structure, to offer some resistance (Figure 14).

Foundations of buildings located in areas potentially subjected to erosion, including flood plains and along coastal areas, must be designed to withstand dynamic water force and battering action from floating debris, and the effects of erosion due to scouring.

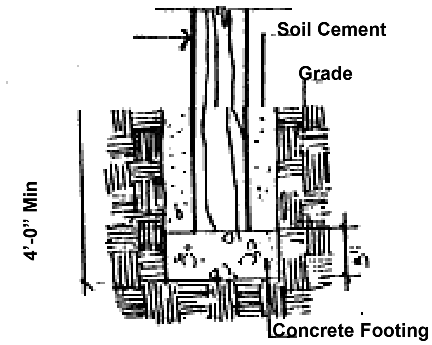
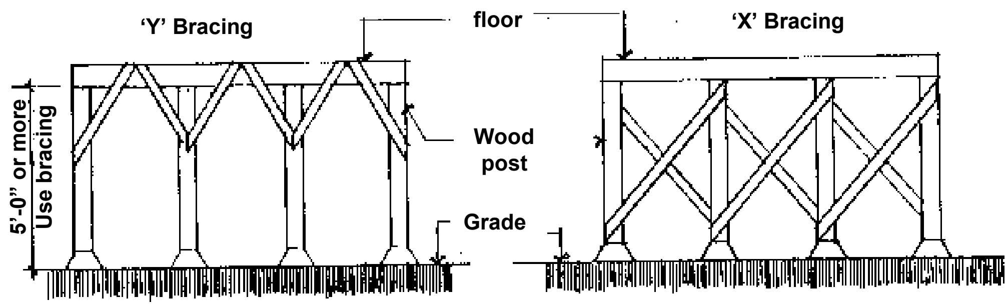
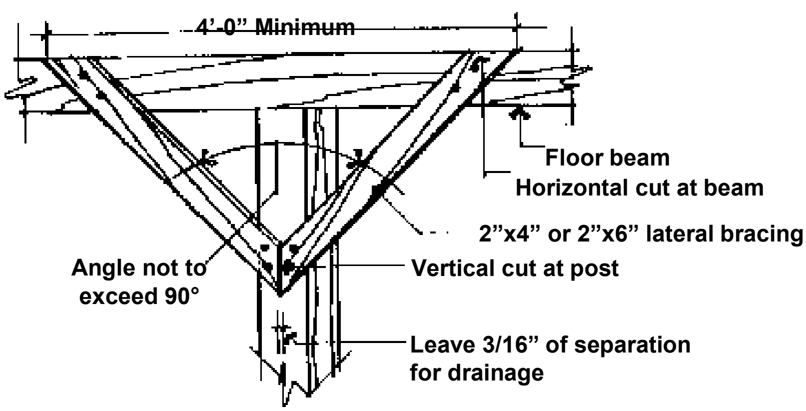


Figure 12





Notes:

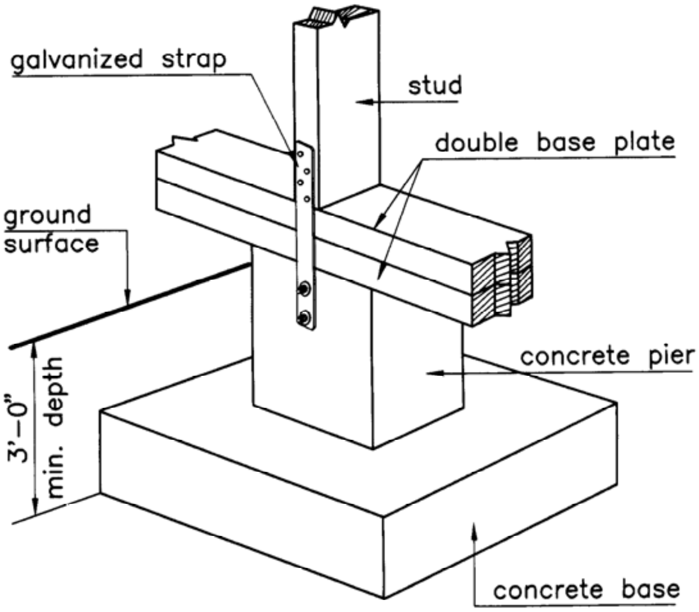
Use bolts or lag screws. Do not use nails.

During design, multi-hazards should be considered. Buildings on stilts, necessary construction in some flood-prone areas, are unstable during earthquakes and large open spaces under buildings encourage hurricane uplift. Consequently, height above ground should be limited.

Figure 13 Lateral Bracing for Wood Posts

Recommendations—Foundations

- Design and construct foundations using quality materials.
- Ensure that steel bars extend beyond the foundation walls to aid proper securing of the wooden structure to the foundation.
- If timber posts are used to support the building, make certain that they are adequately secured into the ground using concrete. To aid stability and to avoid isolated movement of the posts, diagonal braces can be used for reinforcement.
- Foundations of buildings located in flood plains must be designed to withstand dynamic water force, battering action from floating debris, and effects of erosion due to scouring.



Note:

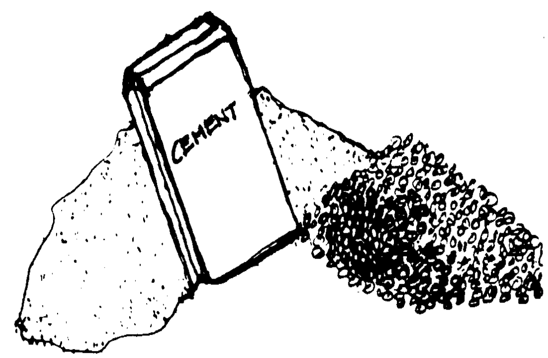
3"–4" nails should be put into double base plates at 12–18" centres to resist horizontal shear (stress along and between the plates). This nail lamination (whether with or without glue) will help resist possible separation of the plates.

In nail laminating, the nails must go completely through the thickness of the timbers and be staggered along the length of the plate.

Figure 14 Stud to foundation connection: Foundation anchorage

Concrete

Concrete is a mixture of cement, sand, gravel and water in correct proportions. A 1:2:4 mix, for example, consists of 1 part cement, 2 parts sand or fine aggregates and 4 parts crushed stones or course aggregates. Special attention must be given to the water/cement ratio, because if too much water is used when mixing, the potential strength will be reduced.



Concrete is inherently strong in compression but weak in tension. To handle tensile forces, it can encase and bond with steel reinforcement. It has different compressive strengths based on mix designs. Typical mixes range in strength between 2000 and 3500 pounds per square inch.

For thorough curing of the concrete, forms should be kept damp and left on for at least one week. The curing process is important as it prevents rapid drying of the concrete, which results in shrinkage. Shrinkage appears as cracks on the surface of the cured concrete. The curing process also keeps the hydration process (the chemical reaction between cement and water) going, which enables the concrete to develop its full strength more quickly. It must be noted that full compressive strength will develop within 28 days after placement; as a result, suspended floor slabs should remain supported for the full 28-day period

Floors

Wooden floors consist of joists laid on beams supported by wooden or concrete pillars and covered with plywood or tongue and groove boards (Figure 17). Another approach is to place the beams on top of a low wall of hollow concrete blocks along the perimeter of the house; the joists are placed on these beams and the floor covering is laid on the joists. Beams are the members supported directly by the pillars and make up the bottom plate. Joists are the members that are spaced on top of (and at right angles to) the beams; the floor covering is secured to the joists. Ground floor slabs made of concrete are typically laid directly on top of the hardcore and foundation walls.

Wooden floors should be a minimum of 18” above the ground level. There should be ventilation under the house and enough space for maintenance work to be carried out.

Materials used as floor joists should be two by six inches (2” x 6”) or greater while members used as beams should be four by ten inches (4” x 10”) to six by twelve inches (6” x 12”), depending upon the distance to be spanned (see table below). Seasoning of larger timber such as these, is more difficult than seasoning of smaller pieces. This can be addressed by combining members to achieve desired sizes measuring two by ten inches (2” x 10”) or two by twelve inches (2” x 12”).

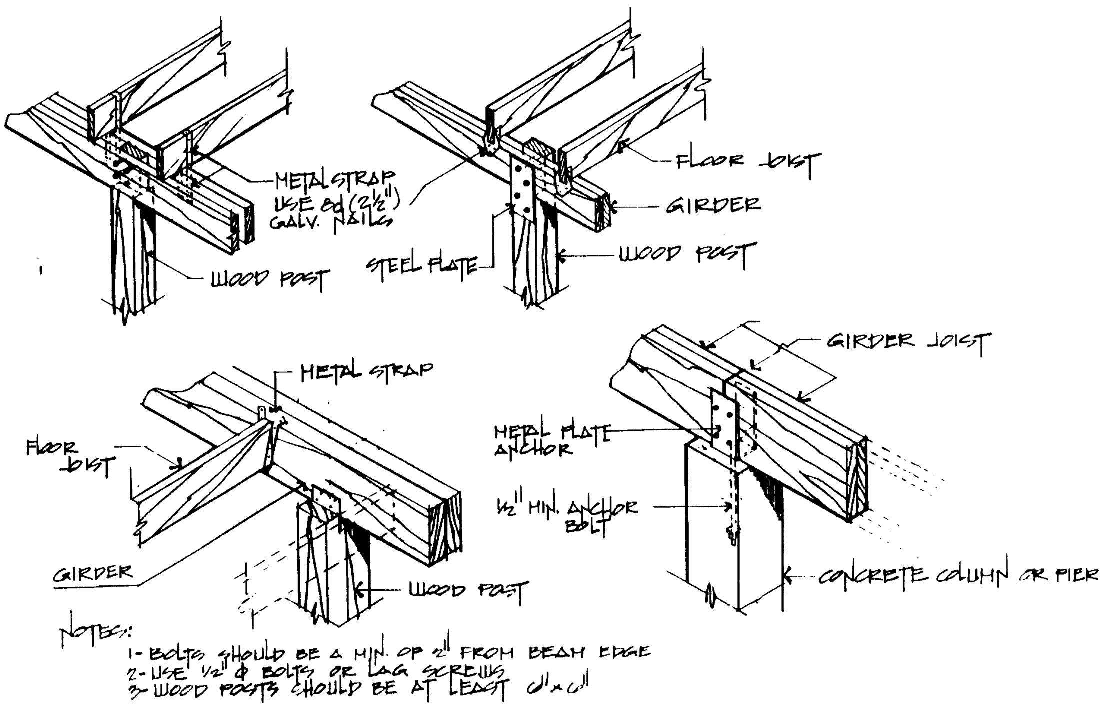
Inadequate sizing of floor joists results in excessive deflection (bending) of the members and floors, causing a springing or bouncing action when walked on. The common, but inadequate, practice of using four by four inch (4” x 4”) beams and two by four inch (2” x 4”) joists, spanning dimensions in excess of ten feet, often has this result. [Reference: *OECS Building Guidelines,* Section C, clauses 3.1(a), (b), (c)]

Recommended Minimum, Spans & Sizes for Pitch Pine Joists at 2 ft. centres

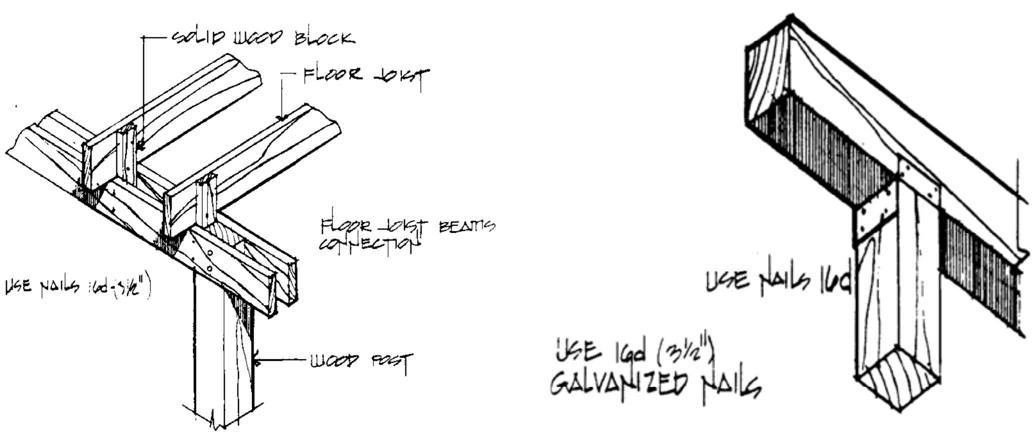
Span Range (feet)	Joist size (nominal inches)
6 – 8	2 x 6
8 – 10	2 x 8
10 – 12	2 x 8
12 – 15	3 x 8
15 – 20	3 x 12

Note: For more precise joist sizes and spans see St. Lucia Building Code, *Table C-1, Section 3.1.*

Wind or water forces could lift the wooden floor from the foundation if the connection between the two is not adequate. Figure 15 shows ideal details for the connection of floor framing members to ensure adequate resistance against separation during high winds.



Beam to Floor Joist Connection



Girder to Wood Post Connection

Figure 15 Connections

When flooring members must be spliced, ensure that splices conform to dimensions shown (Figure 16) and make certain that splices are constructed over a support. The length of the splice should be at least three times the depth of the joint on either side of the juncture.

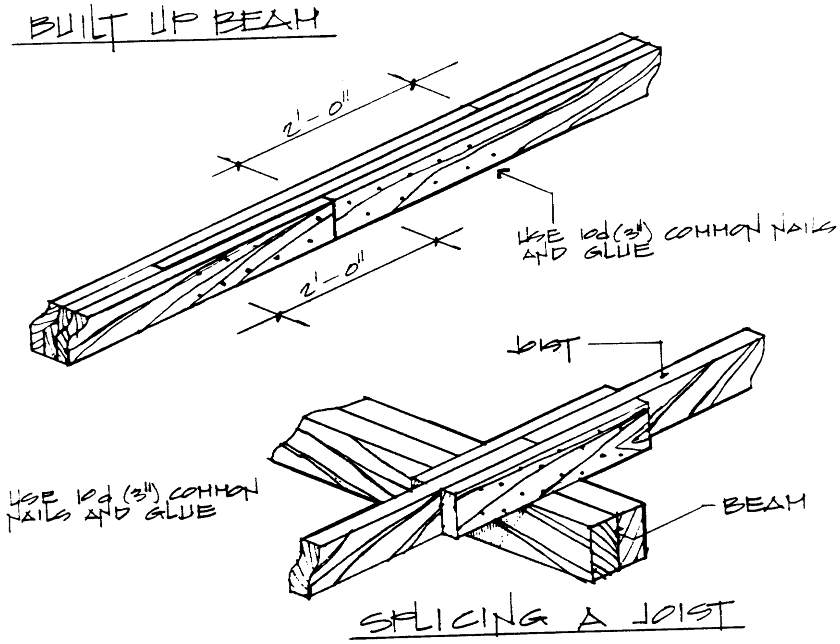


Figure 16 Splicing a joist

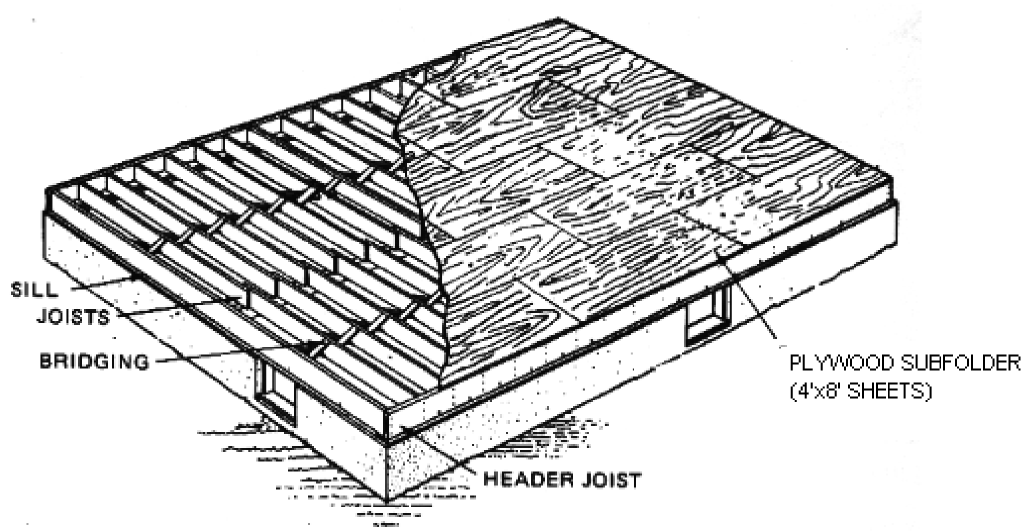
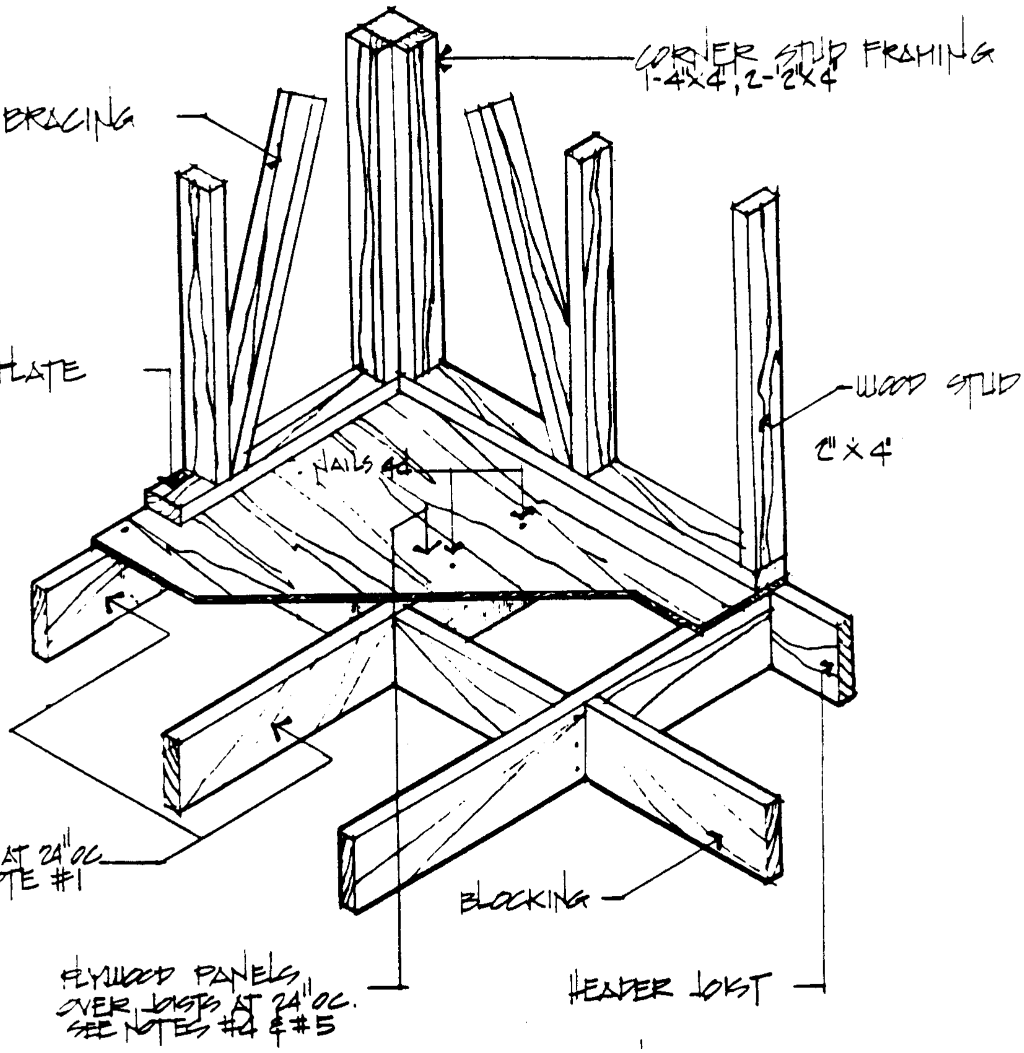


Figure 17 Sub-flooring installation

When spacing the joists for flooring, it is important that they are exactly on 12", 16" or 24" centres. Incorrectly spaced joists will not accommodate standard 4'-0" and 8'-0" sheets, which then must be cut to fit. With properly spaced joists, there is no need for cutting and, as a result, the job is completed much faster. When laying flooring, the initial flooring sheet should be placed such that the square or grooved edge of the sheet is flush with the outer edge of the beam and ends of the sheets rest on the joists.

The thickness of the plywood used for the floor covering depends on the spacing of the joists. The most common thickness is 5/8", which can be placed on joists spaced at 16" centres. The sheets must be laid with the surface grain of the plywood at right angles to the joist. They should be fastened down with 2" galvanized nails at 6" intervals along the edges of the sheet and 12" intervals along intermediate supports. The end joints of the sheets should be staggered so that no two joints are adjacent on the same joist.

When square-edged plywood is used as sub-flooring, 2" x 4" bridging must be nailed between the joists to support the edges of the sheets. If tongue and groove plywood sheets are used, this is not necessary as the edges of these sheets are self-supporting. Figure 17 shows proper installation procedures for installing plywood flooring. Figure 18 provides further details for correct installation of flooring components.



Notes:

1. Use 2"x 4" joist for a distance of 6'-0" between supports; 2"x 6" joist for a distance of 13'0" between supports; or 2"x12" joist for a distance of 15'-0" between supports.
2. Metal connectors or straps should be used.
3. Joist and stud spacing should be the same for structural efficiency and economy of material.
4. Floor panels should be nailed on all edges with 4d (1 ½") nails at 6" intervals and at 12" on the center of the panels.
5. Use ring-shank or screw-shank nails.

Figure 18 Floor details

Exterior Wall Framing and Cladding

The walls of the house should withstand the lateral forces produced by hurricane winds. The external walls should also sustain the load of the roof. [Reference: *OECS Building Guidelines,* Section C, clauses (a) to (d).] In timber wall framing, rigidity is critical. Rigidity can be achieved by closer spacing of studs, bracing studs with diagonal bracing and horizontal noggins and cladding the stud wall frame with rigid board materials.

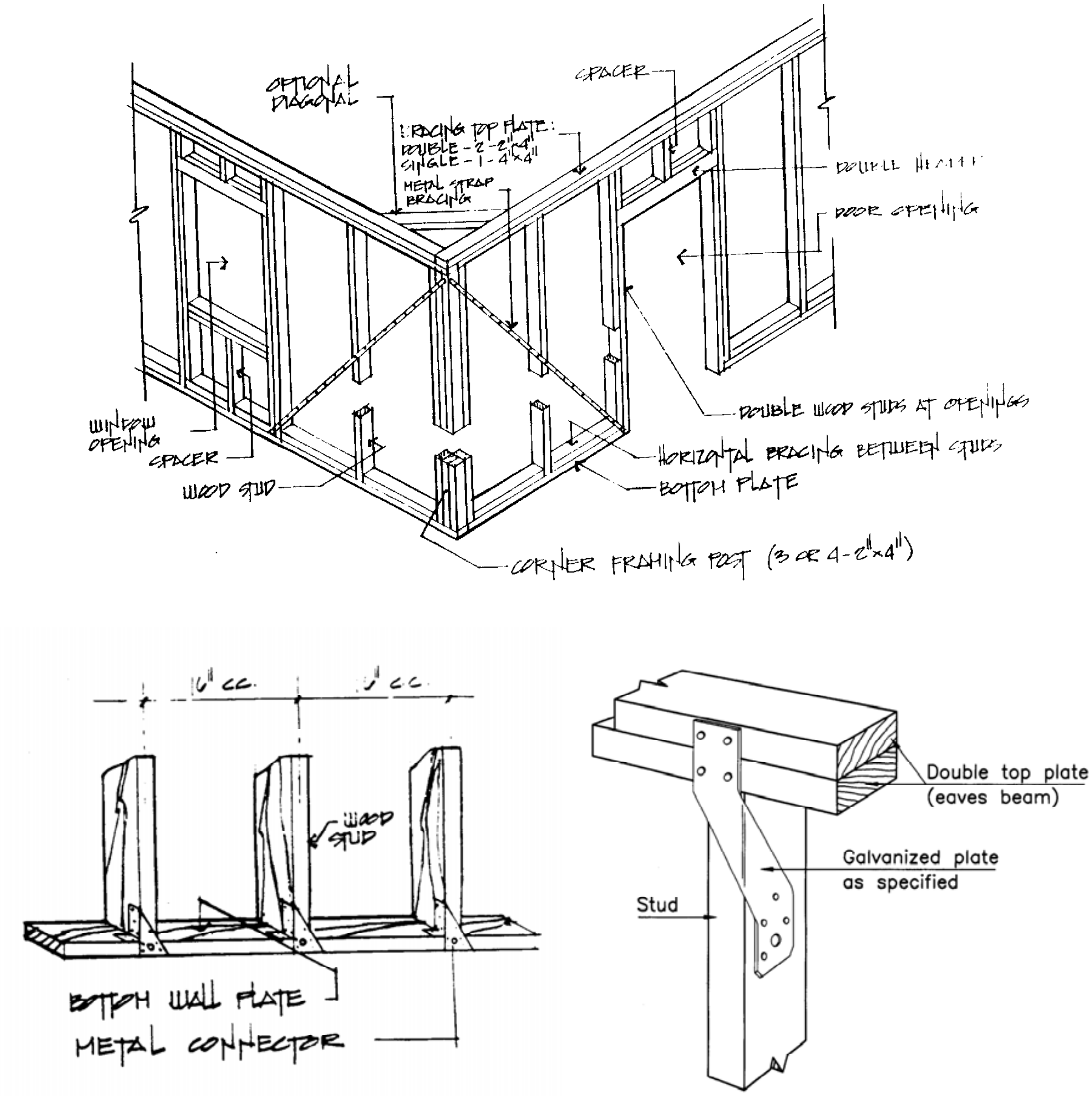


Figure 19 Wall framing

Walls are usually constructed to an average height of eight feet (8 ft), measured from foundation to top plate. They should be built with two by four inch (2” x 4”) studs placed at two feet (2 ft) on centres. For increased rigidity and to fit 48” width board cladding, studs may also be placed at 16” centres. Noggins of the same size material should be used to further strengthen the structure. Noggins are short horizontal wooden members in claddings or partitions that are secured in position by nailing through the studs. They are used to stiffen the studs and to provide extra support. [Reference: *OECS Building Guidelines,* Section A, clauses 2.2(a) to (g).]

Metal straps ('T's) plus corner braces must be added to secure studs at top and bottom plates and at corners of the structure (Figure 19). Metal connectors allow nails/screws to work in shear, which is the most efficient way for them to perform.

Materials used for cladding must possess good strength. For example, 5/8" exterior plywood and shiplap pitch pine boards are appropriate cladding materials.

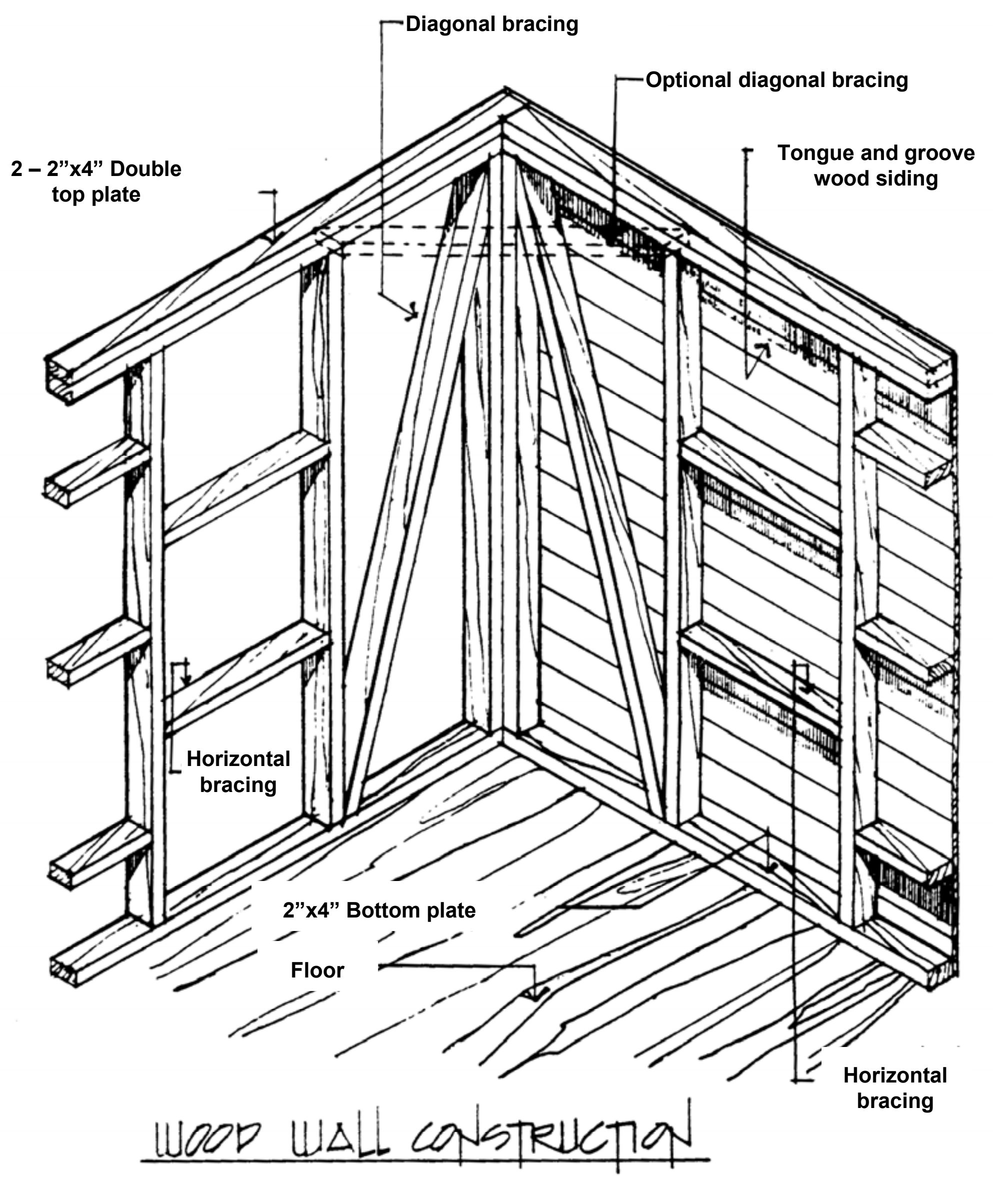


Figure 20 Wood wall construction

Stud spacing should be kept to a maximum of two feet (2 ft) (Figure 20), to ensure that both the centre and edges of the sheet of plywood are supported, which increases wind resistance. The common practice of using very large stud spacing (4'- 0") without noggins should be discontinued. Sound materials, such as pitch or yellow pine, should be used for studs. Studs must be doubled around all openings (doors and windows), as openings tend to weaken a wooden structure.

External cladding should be so constructed such that no gap is left between the top of the wall plate and the underside of the roof-covering material. Such gaps afford wind intrusion with potentially catastrophic results (Figure 21).

When plywood is used as external cladding, maintenance costs can be quite high, especially when the exterior is left unpainted or guttering is not provided. Lath and plaster is a sound protective method, which can be applied to external walls (especially the weather side) to reduce maintenance costs and preserve the integrity of the building. [Reference: *OECS Building Guidelines,* Section 2-3, clauses (a), (b), (c) and (d).]

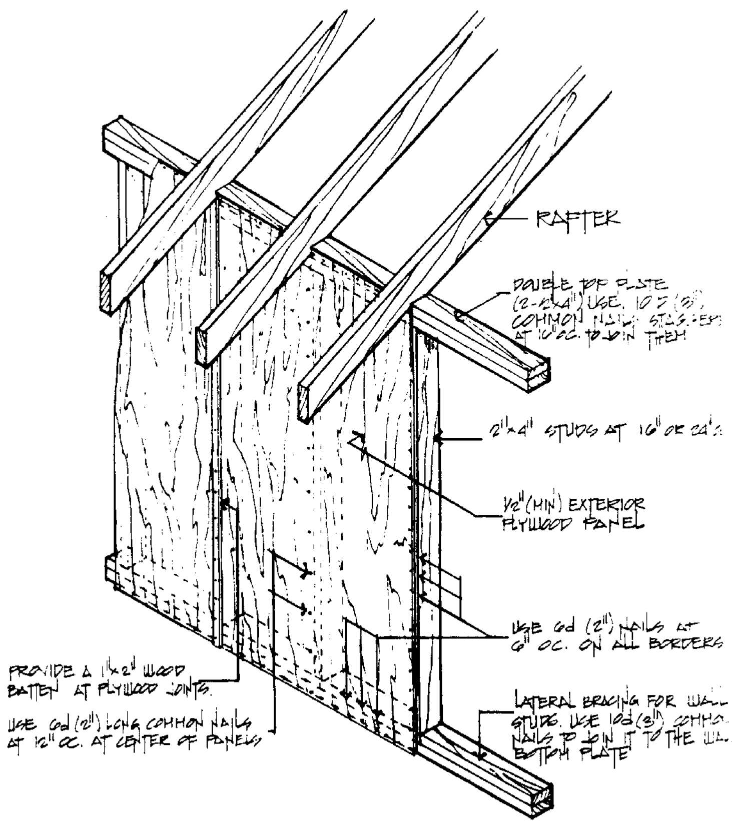


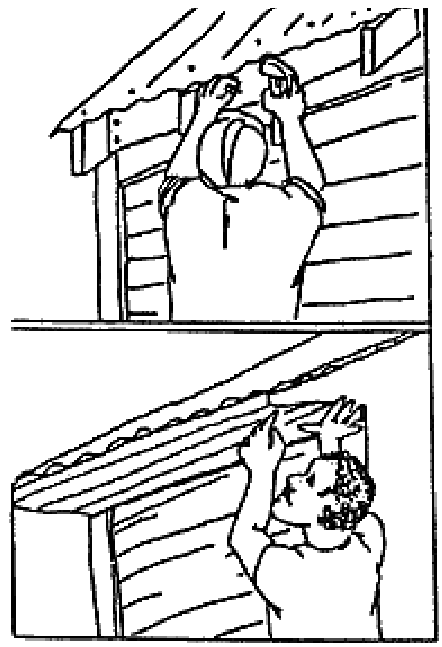
Figure 21 Plywood panel siding installation

In existing houses, a number of options are available for strengthening existing walls. Additional studding and noggins can easily be added, as can additional 'T's and corner bracing. 'T's should be used to connect the studs to the bottom and top plates of the skeletal frame of the building.

Wall plates should be of dimension two by four inch (2''x 4") or two by six inch (2" x 6") and top plates should be of the identical size but doubled. Joints in successive layers of the wall plate should be staggered.

Do not leave too much space between the roof and the walls!

Close up the space and leave smaller spaces to ventilate the roof!



Or, even better, leave ventilation spaces in gable ends!

Recommendations—Framing and Cladding

- Ensure that cladding material used provides sufficient strength and that adequate bracing has been provided to withstand high winds.
- Studs spacing should be 2'-0" on centres.
- Studs are doubled around openings
- Diagonal bracing is provided at corners.
- Metal straps are used to connect components.
- Use lath and plaster on external walls on weather side to protect plywood siding from the elements.

Roofs

Roofs are the most vulnerable part of a building during a hurricane. Therefore, they must be strong and resistant to high winds. Research has proven that, because of their design, hip roofs are most resistant to hurricane strength winds. If the hip roof can be afforded, it should be given priority over the other types (Figure 22). Additionally, steeper roof slopes can significantly decrease the uplift forces imposed upon it. Roofs with slopes of 30° or more are recommended.

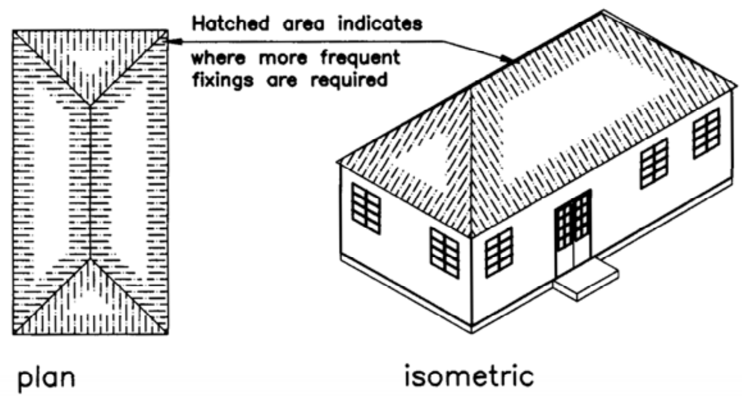


Figure 22 Hip roofs

The gable roof is most frequently used roof type (Figure 23). With gable roofs, it is important to ensure that the roof members are strong. Materials used as rafters should be 2”x 4” (rough lumber) at 24” centres, or 2”x 6” (dressed lumber) also at 24” centres. The use of dressed lumber, which is treated, is preferred over rough lumber, which is not treated. Hurricane clamps should be used to secure the rafters and laths to counter the effects of high winds. [Reference: *St. Lucia Building Code,* Section 4.3, clauses (a), (b) and (c).]

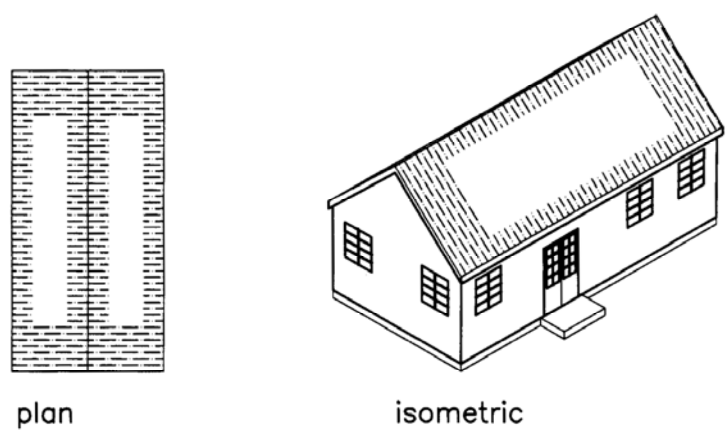


Figure 23 Gable roofs

The connection of the roof covering must be given serious attention. In St Lucia, corrugated galvanized sheet is the most commonly used roof covering. Proper selection and fastening of these roofing materials is critical to maintain the stability of the roof. [Reference: *St. Lucia Building Code,* Section C, clauses 4.1 to 4.5.]

For galvanized roofs, the use of 24 gauge galvanized sheet metal is recommended. 26 gauge galvanized can be used, but extra attention must be paid to proper fastening of edges and overhangs. Gauges thinner than 26 (i.e. 28 and higher) are not acceptable, as they can easily be torn loose by strong winds. The galvanized sheets are anchored to purlins or laths. Purlins are 2” think wooden strips, which are laid on edge, while laths are up to 1” thick and are laid flat. Purlins should be preferably 2" x 2" or 2" x 3" rough. 1" x 3" purlins are inadequate; their use should be discontinued. Spacing should not be more than 2' - 0" apart (Figure 24).

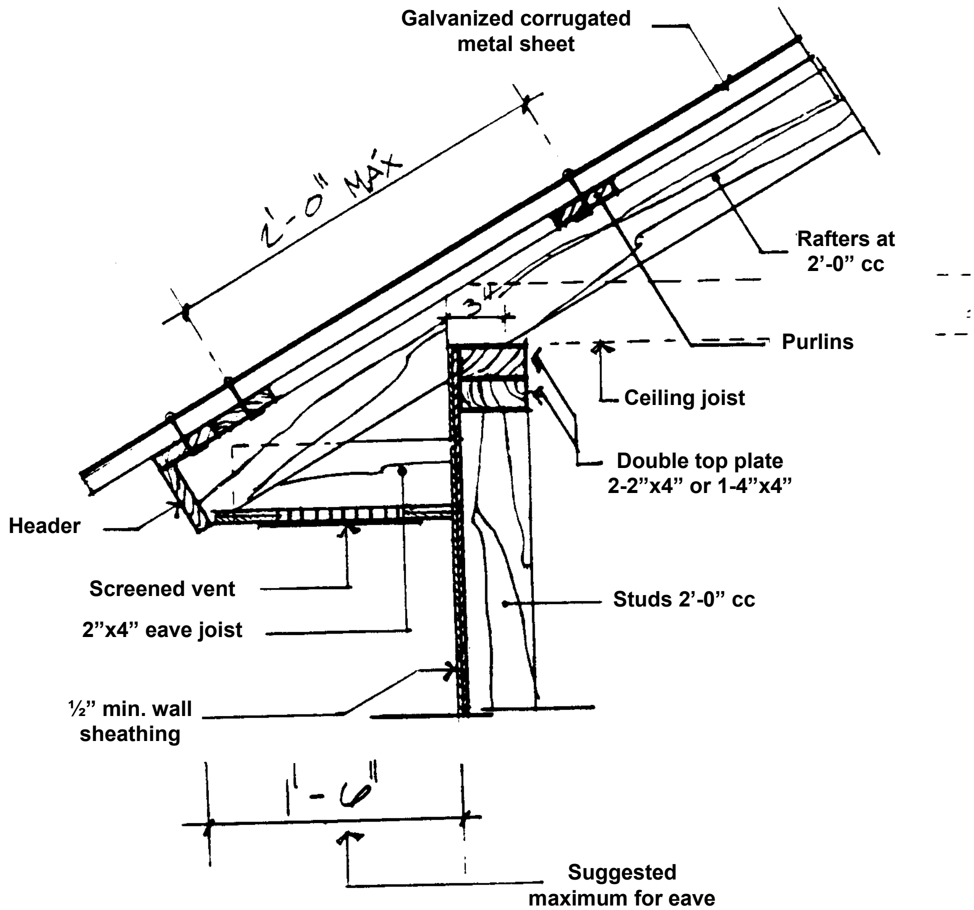


Figure 24 Eave section

Once the laths have been properly placed, it is important to nail each galvanized sheet carefully to the laths. If one of the sheets becomes separated, it could form a chain reaction pulling the others with it, leaving the exterior of the house exposed, thus risking the safety of the occupants and causing damage to personal property (Figure 25).

The following should be adhered to when installing galvanized sheet metal roofing, to minimize the effect of high winds on the roof covering:

1. At the ridge and eaves of the roof, nails should be placed at each corrugation, as the eave are where the lift is greatest and where nails and screws are most likely to tear through the sheets. For the rows in between the ridge and the eaves, one nail should be placed at every other corrugation (Figure 26). Corrugated roof sheeting should always be nailed through the crown of the corrugation, not through the trough (Figure 28).
2. The galvanized sheet and ridge cap should be made to overlap the barge board by about 2” to 2 ½”, so that they can be bent over the barge board and secured with 1” nails. This helps prevent the sheet from lifting at that point (Figure 27). Ridge capping must extend at least 4 inches (4”) beyond the lower edge of the purlin/lath. Fascia boards must be installed, and whenever possible

the eave should be boxed. Ventilation should be provided to boxed eaves to remove humidity and to equalize the interior and exterior pressures. These vents should be placed in the attic and in overhangs.

3. The length of the eaves must be as short as possible. A shorter eave offers less surface area and hence reduces the upward thrust acting on them by the action of hurricane strength winds. Eaves should be no longer than 8” unboxed or up to 18” when boxed.

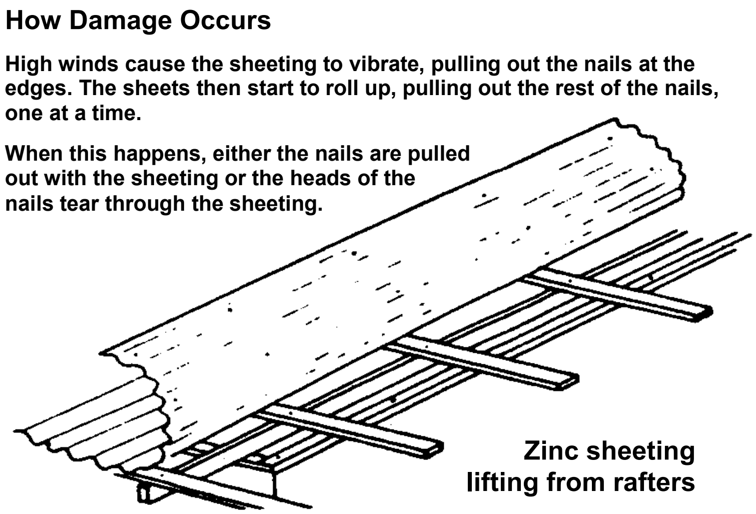


Figure 25 Sheeting lifting from rafters

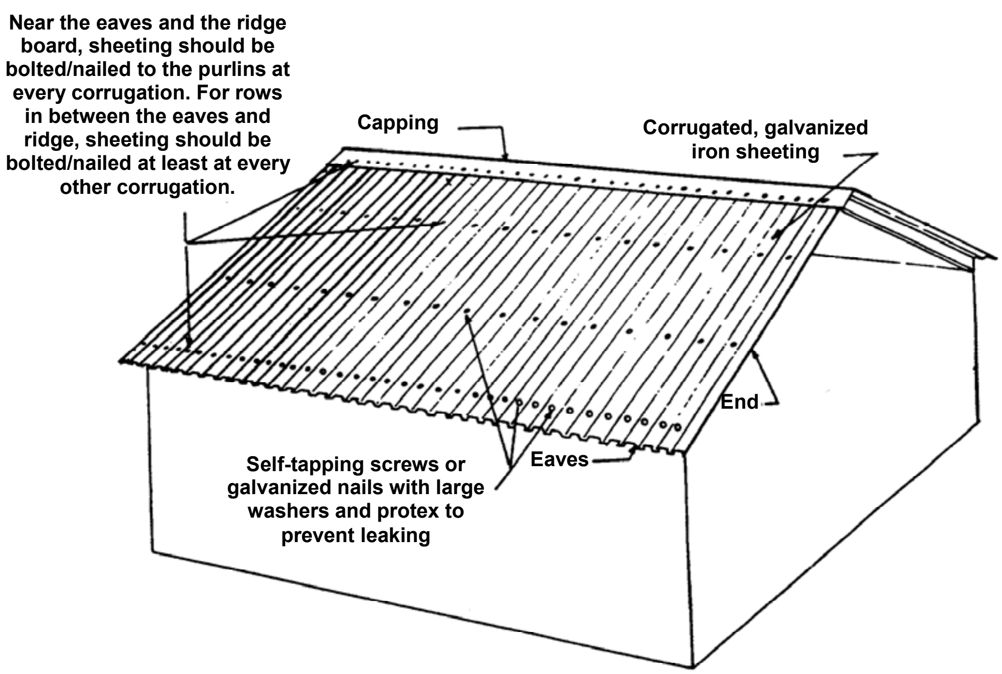


Figure 26 Nailing

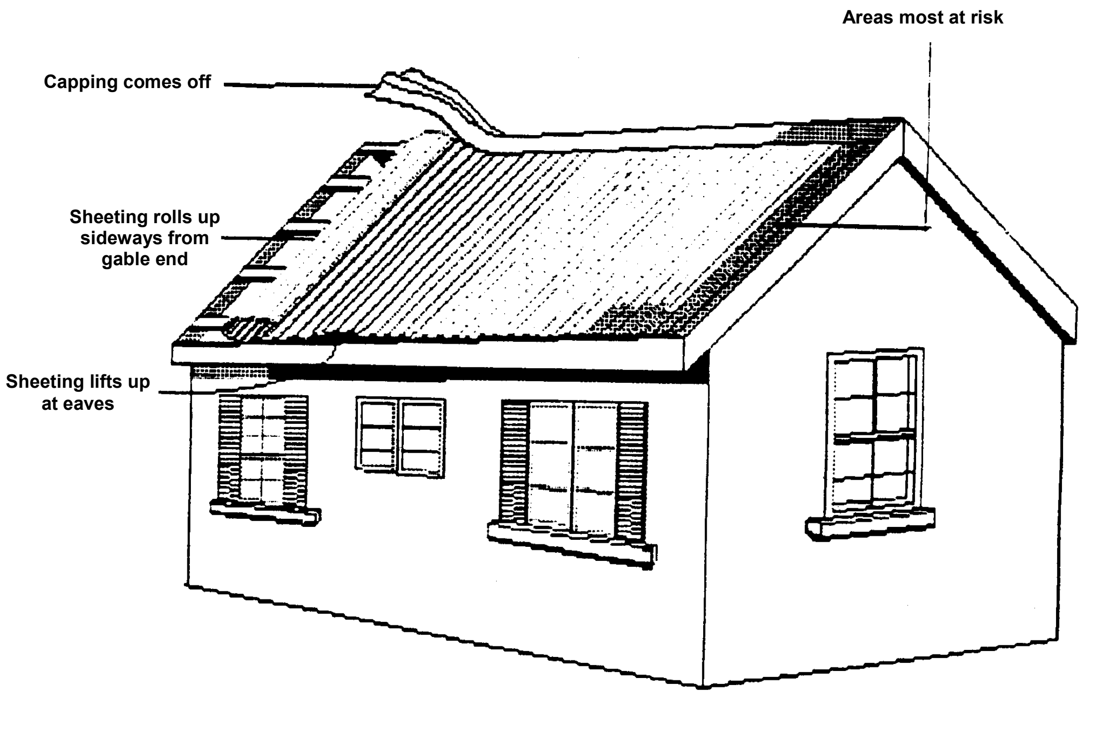


Figure 27 Roof areas most at risk to sheeting loss

There is the tendency to bend the roofing nails into the lath on the underside of the roof, however, this is not good practice. Bending may cause the large head of the nail to become loose, which will cause leaks and release the grip of the nail head on the corrugation of the sheets. Bending of nails can also dent the corrugations, creating a gap between the nail and the roof sheet, which can cause leakage (Figure 28 and Figure 29).

The overlap for ridge caps should be 6" - 8" to prevent leaks caused by driving rain. Roof sheets should preferably extend continuously from the ridge to eaves to eliminate intermediate overlaps. Where overlaps are unavoidable, they should be a minimum of nine inches (9").

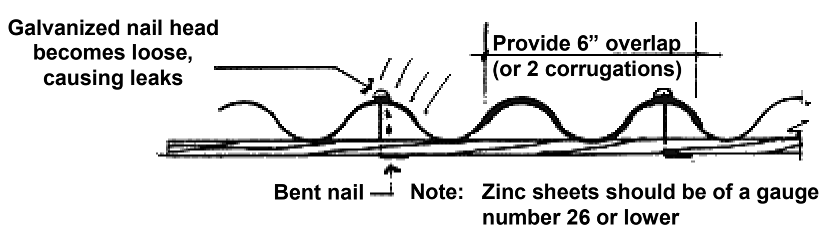


Figure 28 Section detail

Proper connection between rafters and top plate is of paramount importance as uplift created around building fixtures as well as pressure and suction gradients inside and outside the building walls contribute to roofs being blown off during a storm. All rafters must be toe -nailed on both sides of the rafter to ensure that load is transferred vertically into the external walls. If seat cuts are made in the rafters, the depth of the seat cut should not exceed 1/3 of depth of the material used for the rafter. This cut must be accurately executed, as any cut greater than the prescribed depth will seriously weaken the rafter.

It is recommended that each rafter be provided with a pair of hurricane clamps fastened to the side of the rafter and wall plate. It is recommended that screws be used to fasten hurricane clamps It is common practice to use one clamp per rafter, probably because of financial constraints. However, as it has been previously stressed, it makes no economic sense to compromise the quality and structural integrity of any structure.

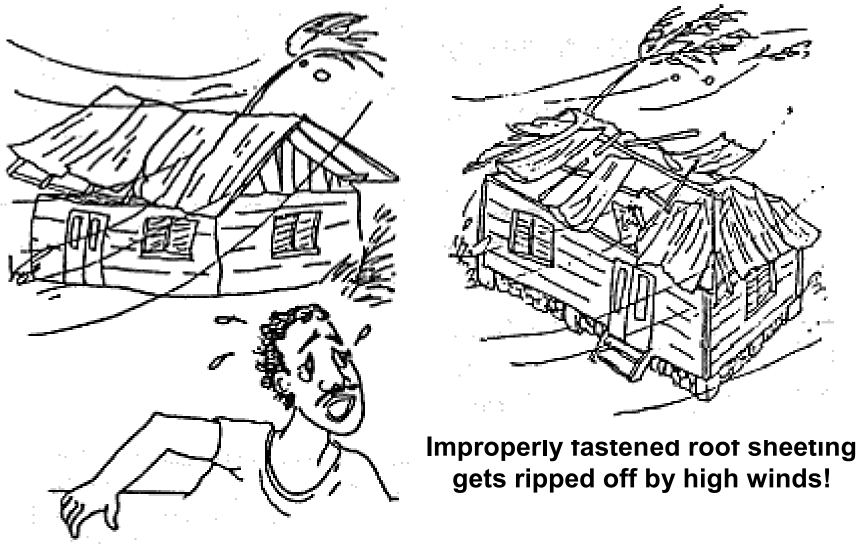


Figure 29 Wind can remove roof sheeting

Before and after a hurricane, roofs should be inspected to ensure that the sheeting is well secured. If they are not, additional nails should be added and damaged sheets should be replaced.

In existing houses, if the recommended nailing patterns have not been employed, additional nails can be installed, as needed. Additionally, clamps can easily be installed to help secure the laths to the rafters.

To further strengthen the roof, collars or ties can be incorporated in the roof structure. Collar ties offer increased rigidity to the roof structure, as they strengthen connections between rafters. Such ties should be nailed to the side of the rafters. Ties nailed to the face of the rafters will pull out more easily.

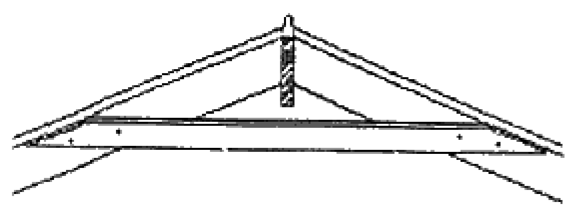
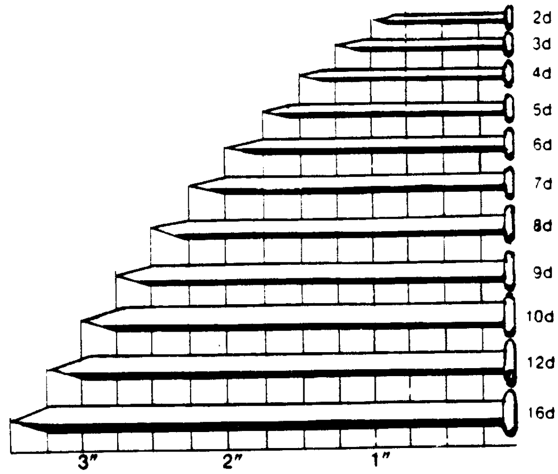


Figure 30 Collar Ties

Recommendations—Roof

- If galvanized sheets are used, ensure that they are of appropriate gauge (24 gauge) and are properly secured to the laths so as to ensure adequate resistance in high winds.
- Allow sufficient overlaps to ensure that the edges of the sheets can be bent over to prevent lift in high winds
- Roofing nails should be galvanized, with large steel washers at their heads (Figure 31).

Nails



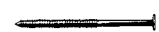
A number of materials are used in to manufacture nails, including steel, aluminum, copper, bronze, zinc, stainless steel and galvanized steel. Heat-treated, high carbon steel nails are used for greater strength in masonry applications. The type of metal used should be checked for compatibility with the materials being secured to avoid corrosion and the loss of holding power and to prevent staining.

The following recommendations should be taken when using nails:

1. Use a nail that is three times (3) longer than the thickness of the board to be nailed. Standard nail lengths range from one to six inches (1"- 6"); the most common lengths are 1", 1 ½", 2", 2 ½", 3", 3 ½", 4", and 6".
2. Sharp pointed nails have greater holding strength but may split the wood. Flatten the point with hammer before driving into easily split wood.
3. Thinner nails are used for hardwood or finish work.
4. For roofing, use twisted galvanized nails with a large cap/washer (Figure 31).
5. When nailing corrugated roofing, always nail through a wooden fillet fitted between the crown of the corrugation and the purlin/lath.
6. Gauge: Use gauge of 26 or less.

- **Common Nail:** Used for general construction work.

- **Ring-Shank Nail:** Has more gripping strength than common nails. For plywood of any thickness used in floors and roofs.



- **Double-headed nail:** Most common for scaffold, bracing or any temporary fastening that must be later removed.

Roofing nails. Several types are available to secure specific roofing material.

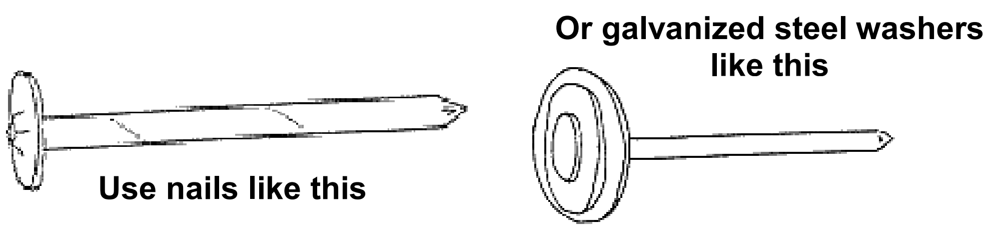


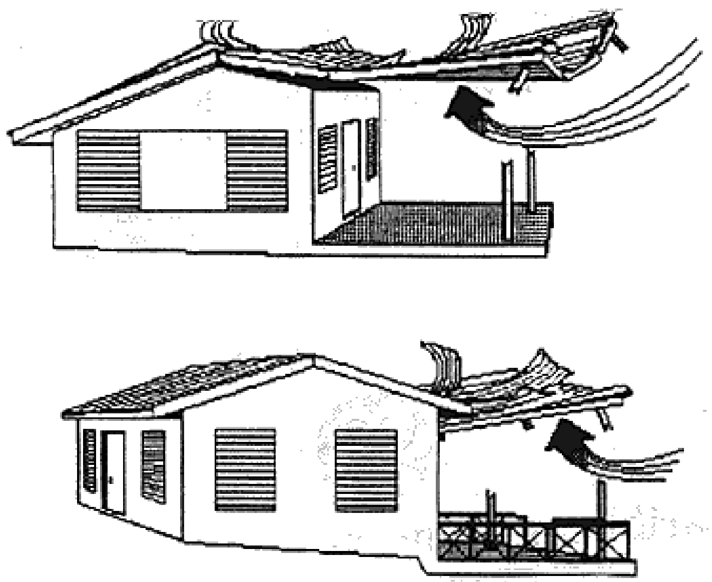
Figure 31 Roofing nails

Porches

Because of high humidity and intense sun normally experienced during the summer, most persons will include a porch in the design of their homes. If not properly designed, however, porches can prove problematic in a hurricane. Porches and verandas should be kept structurally separate from the main building, but firmly anchored to it.

Half porches should be avoided, because wind trapped underneath an open or half porch will increase uplift on the roof, which may be sufficient to cause failure of the roof structure. If a house has a half porch, a strengthened ceiling should be provided.

The roof of a full porch should be separated from the rest of the house so that, during a hurricane, failure of the exposed porch roof will not endanger the main structure (Figure 32).



Design to Avoid

Recommended Design

Build verandahs and patios as separate structures rather than extensions of the main building, so that, if they are blown away, they will not damage the rest of the structure.

Figure 32 Improperly built verandas jeopardize the entire roof

Shutters, Doors and Windows

Glass doors and windows offer very little resistance to high winds. The loss of a glass door or window will increase the pressure inside of the house and this pressure will cause failure of the roof structure. Permanent or temporary shutters can provide important protection for door and window openings. Due to their vulnerability to breakage from flying objects and pressure and suction forces, glass windows in particular need the reinforcement provided by external protection measures, such as shutters.

While shutters have traditionally been part of housing design in the Caribbean, their use has declined dramatically in recent years. Shutters are now considered to be an unattractive feature by many and are not an apparent priority to homeowners. This is unfortunate, as shutters provide important protection from high winds, particularly in a region where hurricanes are a common occurrence.

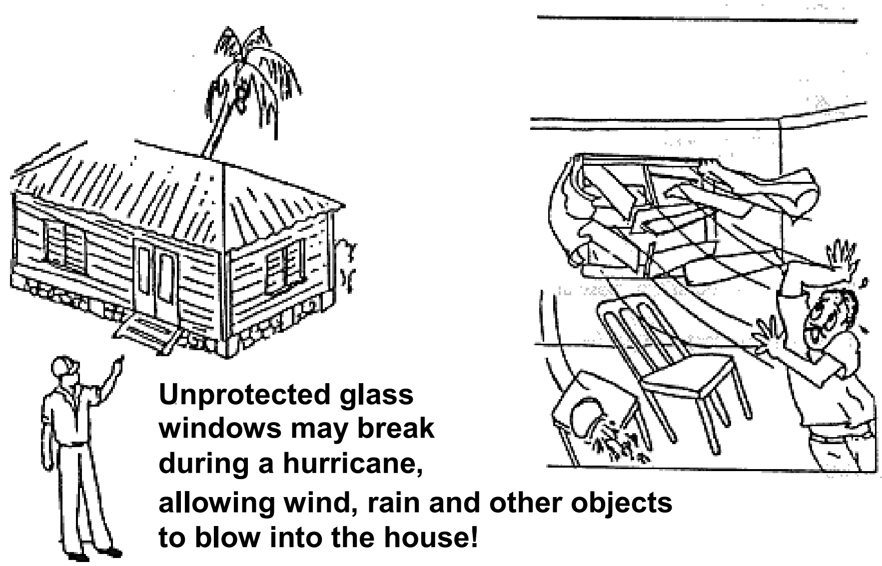


Figure 33 Dangers of unprotected windows

If permanent shutters are not installed, the use of temporary shutters is a viable option (Figure 34 and Figure 35). Temporary shutters, however, can create a storage problem when they are not in use. Bearing this is mind, both new and existing houses should have permanent shutters installed or provision for temporary ones should be made.

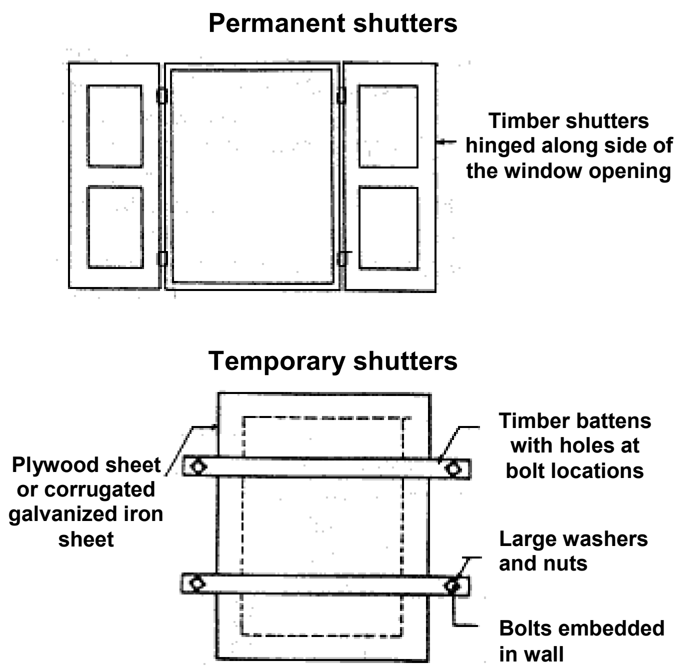


Figure 34 Permanent and removable shutters

Corrugated metal sheets or fitted plywood could be rapidly mounted over door and window openings. Permanent manual and mechanical systems are also available (Figure 35).

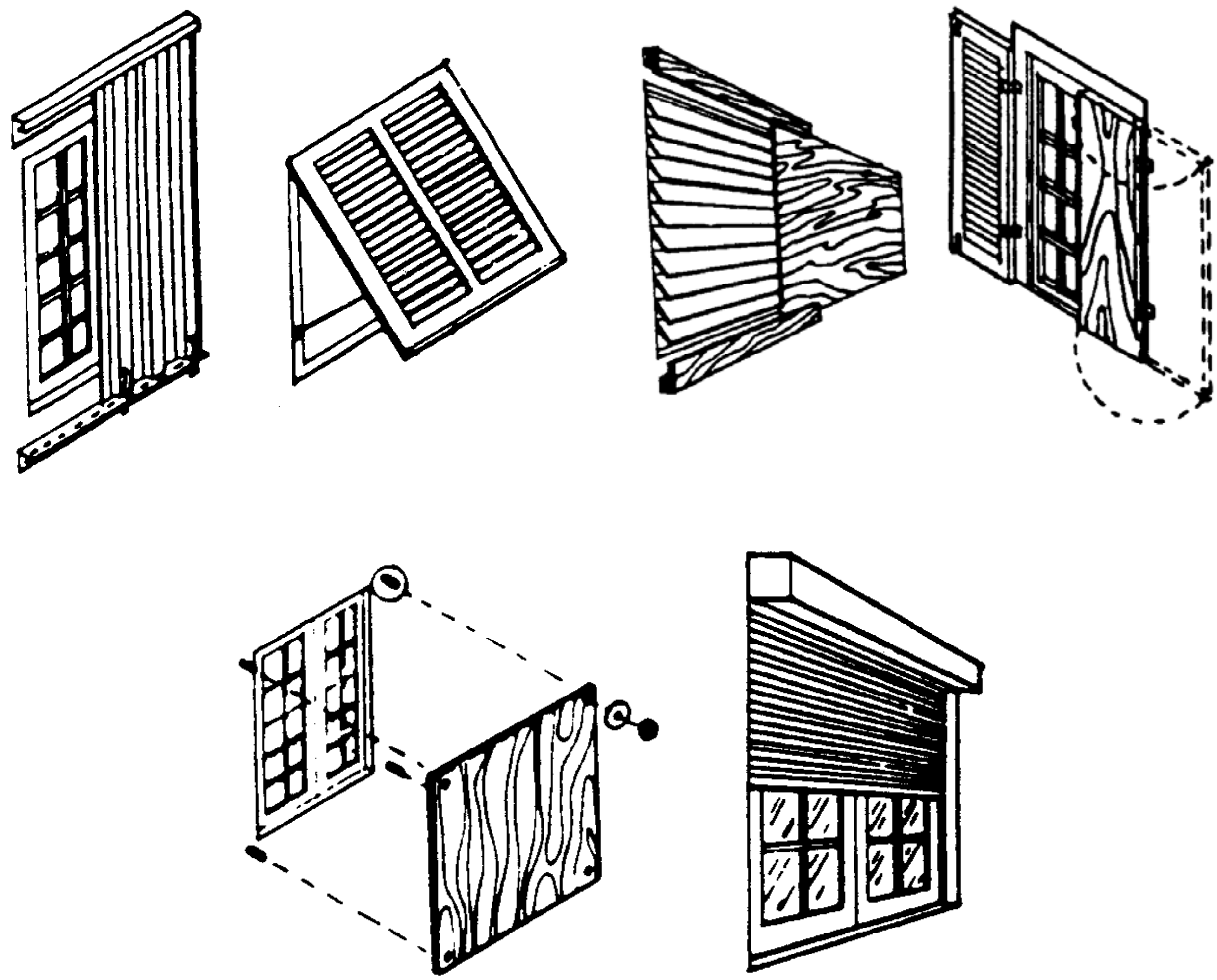


Figure 35 Types of window shutters

A door lock may not be sufficient to hold the pressure of the wind. Bolts should be added as necessary (Figure 36). Bars placed on some types of doors and windows can offer good resistance against the wind and boards can be used on the tracks of sliding doors to keep them from opening.

For windows and doors without temporary or permanent shutters, boards can be nailed over the opening prior to a storm (Figure 37). If it is too late to install protectors you may use tape (duct tape is best) on the glass windows. This will add strength to the glass and, if the glass breaks, the number of projectiles will be minimized. Remember that some prevention is better than no prevention at all.

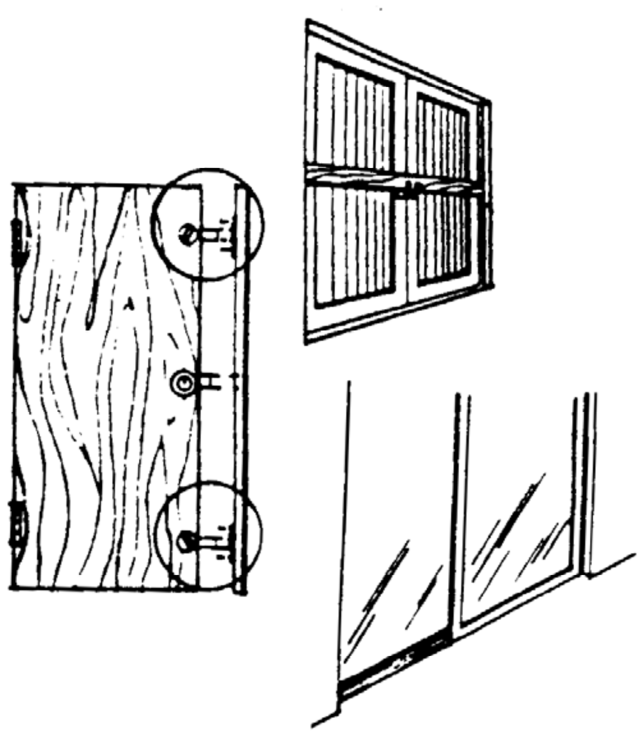


Figure 36 Door protection measures

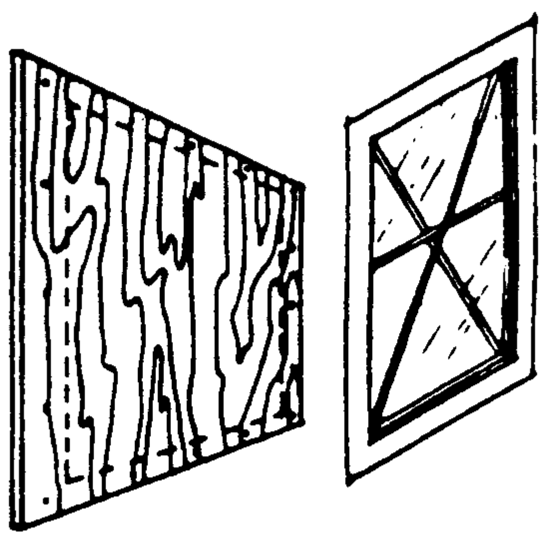


Figure 37 Protection for openings without shutters

Recommendations—Shutters

- Shutters should be provided for all glass openings and any other opening that may require protection from strong winds. If shutters are of the removable type, be certain that they can be installed quickly and easily.

Good and Poor Building Practices in the HRHIP

Good Building Practices

Intermediate support provided where spans are too great. This will help reduce deflection of floor joists and subsequently add rigidity to the flooring system. Runners are tied with ½ inch mild steel rods. This anchors the structure to the foundation. Solid bridging is used to support to the edge of the plywood floor covering. Lateral movement can be further resisted by embedding into the concrete ¼"x3"x9" steel plates on either side of the joist, which are then screwed into the joist. See picture below.

The runner is secured to the foundation by a steel plate fastened with nut and bolt. This method securely anchors this element to the foundation.

'T' strap used to connect the stud to top plate.

Hurricane clamps connects rafter to top plate. This assist in resisting uplift during high winds. 'T' straps used to connect studs to top plate.

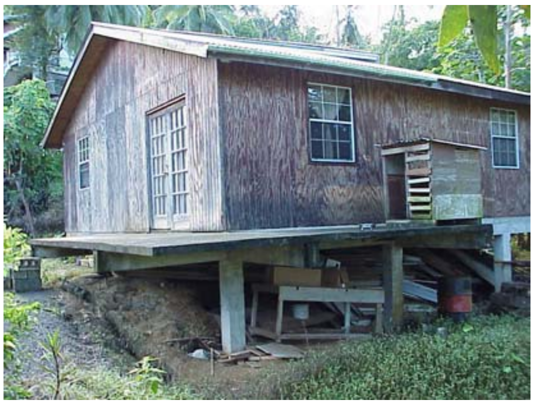
Poor Building Practices

Load bearing elements should be placed over the centre of supports (not to the edge). Loading should not be off centre as shown, as only a limited section of the concrete column is being relied upon to carry the load. This practice could lead to failure of that section of the column where load is applied.

Breaking and cracking of the support column results when tensile column reinforcement is used to secure bearers to foundation. Instead, one of the following measures should be used to provide adequate fixing to receive bearers: 1) use mild steel rebars (mild steel is more pliable) or 2) cast mild steel ‘U’ clamps or steel plates into concrete column.

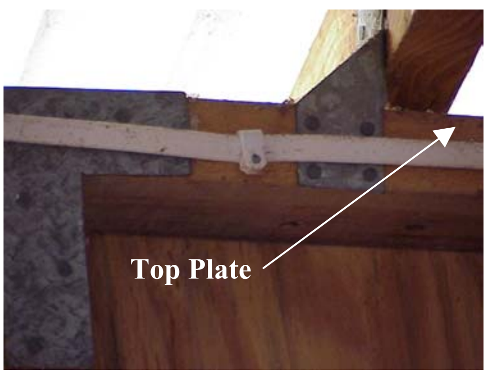
This picture shows an example of a poor concrete mix. Honey-combing is the result of 1) ungraded coarse aggregates, 2) insufficient fine aggregates, 3) the use of too much water in the mix and 4) possibly poorly constructed formwork, which allows the sand/cement paste to escape.

This structure is of composite timber and masonry construction. The lack of knowledge of reinforced concrete construction and the absence of professional input has jeopardized the structural integrity of the finished construction shown. The next picture shows deflection of the floor.



Concrete floor slab showing sign of deflection. The absence of guttering is causing serious damage to the exterior cladding. Guttering should be provided at eaves to limit the continuous saturation of the plywood cladding, which results in unsightly discolouration and eventual degradation of the material.

A gable roof is used here instead of a hip roof in an area where the degree of exposure to strong winds is high. Also the glass windows and doors are not protected against high winds. Hurricane shutters should have been installed. They are no longer fashionable but they are important.



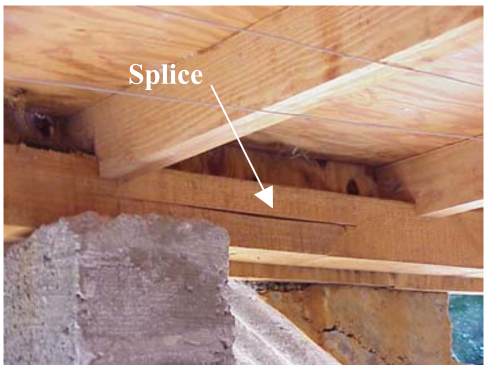
This picture shows good practices but there are areas to be given attention here. Example the top plate should be doubled because it carries the weight of the entire roof. The gap left open at junction with the top plate and the underside of the roof covering is vulnerable during high winds; it should be closed to avoid winds from entering the structure. Finally, no seat cut is provided on the rafter at its intersection with the top plate.

Joists that cross large spans will deflect if they do not have the require depth to span the opening without intermediate supports. The floor will spring as a result.

In this picture it can be seen that intermediate support had to be installed as a corrective measure. A simple formula can be applied to determine the depth of the joist require to span an opening unsupported: depth of joist = 1/25 of span + 2” [or + 50mm if calculated in metric]

Joist should not be notched at intersection with bearers (or sill plate) as shown. This practice reduces the property of the section in shear (which is greater at the supports) and reduces the effective depth of the section with regards to deflection. In general this practice reduces the load-bearing capacity of the member.

Notching of rafters is to be avoided at all costs.



Splices in floor joists and bearers must occur directly over a support. Failure to apply this practice will increase deflection in the respective member, resulting in a bouncing floor and possibly eventual failure if dead and live loads are increased on the floor. All joints especially in floors must occur directly over a support. If not they are likely to fail.

Building Design and Construction

The design and construction of buildings should be a carefully supervised and coordinated process involving as much professional input as is possible at all phases, not only because of the financial input involved but, more importantly, the risk of loss of human life when natural hazards threaten. In the context of light frame (timber) residential buildings, which this document addresses, it is even more imperative—though contrary to popular opinion—that all aspects of design and construction be given careful consideration. These structures are some of the most vulnerable when exposed to the intense lateral, twisting and bending forces produced by a storm or hurricane.

Square or rectangle buildings are the most desirable building shapes, as they do not interrupt wind flow or create zones that restrict free wind flow around the building. Such interruptions and wind flow restrictions cause wind pressure to build up, which could cause failure of structural components, such as walls and roofs. Building orientation should take into account solar radiation, temperature and wind flow considerations.[1]

The importance of creating a sound load path to be evenly transmitted into the ground cannot be over emphasized. In addition, and just as important, is to ensure that all building components (from roof to foundation) are securely fastened to each other using metal straps and clamps, and that the building's foundation is firmly anchored into the ground.

Trenches for foundations (regardless of the foundation system used) must be excavated to a point below ground firm enough to sustain and distribute the building loads. Foundations must be constructed of adequately sized elements and properly reinforced. In the event that timber members are used, they must be of adequate cross sectional dimension, properly preserved and firmly anchored into the ground. Provision must be made to have framing anchors for the foundation elements (including foundation walls, piers, columns) to firmly secure floor beams to the foundation.

All floor joists must be firmly secured to beams, and materials of adequate cross-sectional strength must be used. Twisted metal straps should be used for securing these elements to each other. Appropriate joist spacing relative to beam sizes and spans is specified previously in this manual and in the National Building Code. Materials used for floor boarding must be securely fastened to floor joist using nailing patterns prescribed in the *Minimum Standards* manual, as the underside of a large number of homes in St. Lucia are exposed to winds which can create uplift. This is particularly true for homes built on hillsides.

The connections between exterior wall framing and flooring system must be sound. Bottom plates must be secured to the header or floor joists using appropriate metal straps and all studs must be connected at joints with wall plate and double top plates using T-shaped metal straps. Rafters must be securely fastened to wall plates with approved hurricane straps and built with the appropriate seat cut to ensure good vertical load distribution into the external walls and rafters. Framing around all opening must be doubled as openings create weak planes in a structure, and all corners of the building must be diagonally braced in the approved manner. Materials used as lath to receive the roof covering must toenailed into the rafters and twisted straps should be provided to adequately secure them to the rafters. Roof covering materials can finally be nailed to the laths in the approved manner.

During the design stage of a structure, which will be required to withstand high winds, the focus must be on the correct connections and where they are to be made. The areas that must be given most attention are the foundation, cladding, roof and roof covering.

[1] See Victor Olgay (1963) *Design with Climate* and Mazria (1979).

During construction, builders must be knowledgeable and well informed as to the importance of making appropriate and solid connections between all parts of the structure and must ensure that the best level of construction and construction practices are maintained. The following building tips and recommendation will serve as a guide.

Recommendations—Design and Construction

- Have all parts of the building (including doors, roofs and cladding) designed to withstand high wind pressure, including suction.
- Obtain the necessary permits for building from the local Authority.
- Have detailed drawings and specifications, which cover all aspects of construction.
- Ensure that persons involved in the construction are sufficiently experienced and qualified in hurricane- and flood-resistant construction.
- Secure all plates to foundation by means of bolts, straps, wood bracing or by using other special connectors to resist wind or water pressures.
- Secure all studs to sill plates and top plates with metal connectors or straps.
- Ensure that metal straps or connectors have been used to make a positive connection from the foundation through to the structural members of the roof.
- Make certain that all material used and techniques employed provide adequate strength for withstanding potential hazards.
- Use framing anchors where possible, as these anchors put shear stress on nails and screws, which is the highest efficiency connection. Toe-nailing must be avoided, unless the cladding is braced ad is of very rigid continuous sheeting (e.g. plywood).

Building Maintenance

The long-term durability of a structure is heavily dependent on the level of maintenance work that is carried out to prevent deterioration of the structure. Periodic checks and preventative maintenance can help prevent rot, termite infestation and uplift of roof covering during high winds. The recommendations given below should be used as a guide.

Recommendations—Building Maintenance

- Carry out regular maintenance work to ensure that the house is fit to offer resistance to high winds.
- The most important areas for regular checks in a house are:
    a. Roof covering: for rusty or damaged corrugated sheets and missing nails or screws.
    b. Rafters and laths: to ensure that they are sound.
    c. All joints in the structure: for signs of weakness or movement.
    d. Pillars, both concrete and wood: for sign of cracks, rot, movements or disconnection.
    e. Pillars, wooden: for any sign of termites; if termites are present, preservative should be applied immediately.

New Construction Methods for Low-Income Housing

Low-income housing in St. Lucia is predominantly timber frame construction on concrete pillars, with gable roofs covered with corrugated zinc sheets and claded with ½" T1-11 exterior grade plywood sheets.

The construction methods used are generally acceptable. In an effort to economize, however, low-income earners typically seek help from relatives and friends (who possess few or no building skills) during the construction process. This decision can seriously affect the quality of the finished product. Structural members used for flooring and roofing systems are usually undersized, which also compromises the structural integrity of the housing. New construction methods are available, however, which are both structurally sound and cost-effective.

Built-up Plywood Joists and Beams

The building up of members (e.g. joists and beams) using plywood is an emerging trend. The advantages of plywood beams include their strength and rigidity, the ease with which they can be built, their light weight and their relative economy. The use of joist hangers could also be employed, which can speed up the construction work. Roofing systems could be strengthened by using trusses. This method is economical, as smaller members can be used for their fabrication.

The building up of members and the employment of roof trusses in low-income housing will ensure that:

- strength is not compromised in an effort to economize
- members can span larger openings with fewer intermediate supports
- they can be spaced further apart thus reducing the number of joist or rafters needed.
- the structure would be erected much faster (speed of erection is a factor in low-income housing)

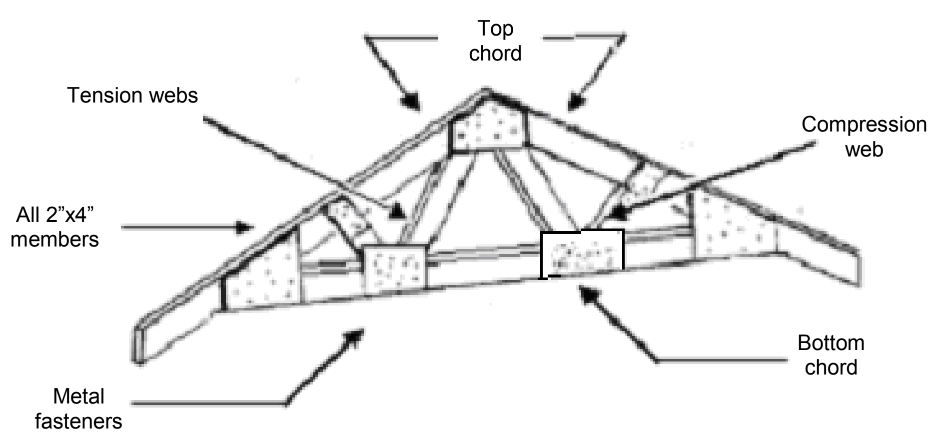
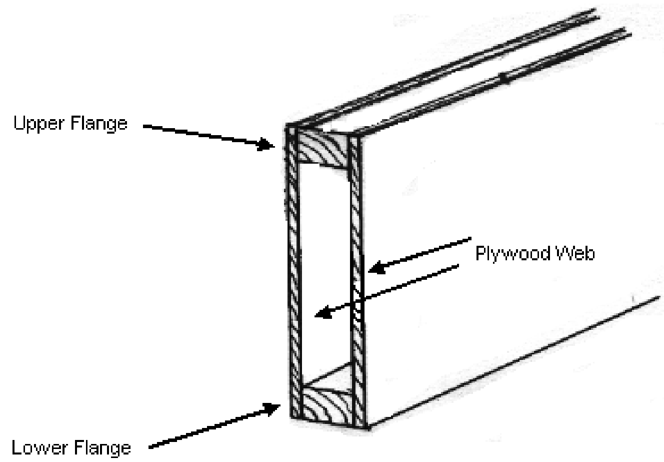


Figure 38 Roof Truss

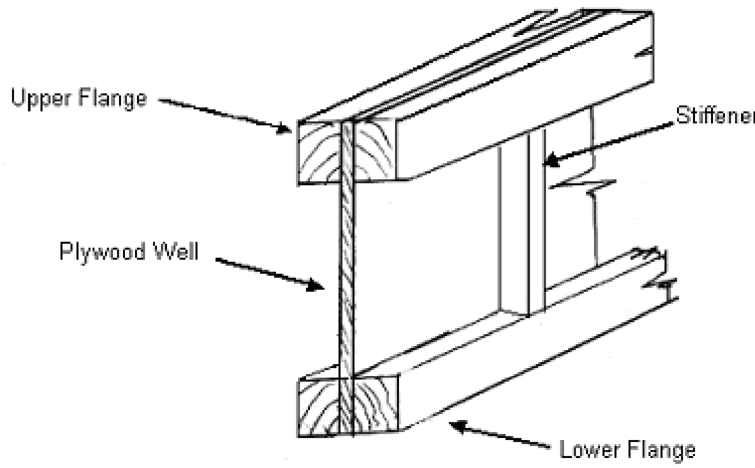
The employment of built-up members and roof trusses in the low-income housing sector means that the tradition of allowing relatives and friends exclusively to erect structures will have to change. A qualified carpenter must carry out the fabrication of these members. If this is not done, the structural integrity of the fabricated work cannot be guaranteed.

Cladding Protection

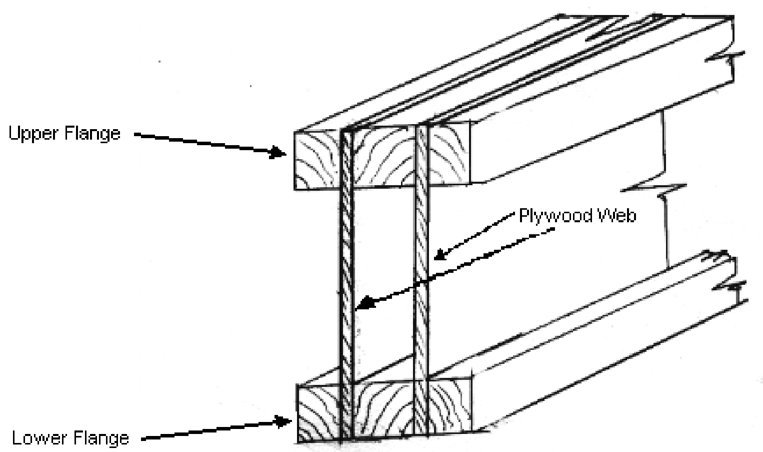
The exposure of external cladding materials to the elements in Caribbean conditions lead to severe deterioration of the materials (especially timber). Protection of exposed timber facades must be given a high priority, as it can significantly reduce replacement cost in the long term. [Reference: *St. Lucia Building Code,* Section 2.3, clauses (a) to (d).]



Box Beam



I-Beam



Double I-Beam

Figure 39 Examples of Plywood Box Beams

Lath and plaster, also known as cement render or stucco, could be applied to those facades of the building exposed to the weather (Eastern and Southern facades). Lath and plaster consist of bituminous roll felt, which is tacked on to the plywood cladding. Expanded metal sheets are fastened over the cladding, with two coats of sand/cement plaster (1:3 mix) ½" thick (each coat) applied as finished surface. Another option is the use of 'sand dash', which is the spraying of paint mixed with fine sand or powdered marl onto the wooden cladding.

Users Guide for Hurricane Straps and Other Framing Anchors

Hurricane Straps

Hurricane straps are galvanized metal angle plates drilled to allow them to be fixed with nails. There are two types available, left hand and right hand, which allows hurricane straps to fit either on the left or right side of the rafter. They are used to take shear, compressive and tension stresses. This offers resistance against up-lift of roofs at the eave during a hurricane.

The straps shown in Figure 40 and Figure 41can be manufactured very easily using 18-gauge zinc-coated sheets steel, a snip to cut out the strap and a hammer to aid in the bending of the strap. Note the dimensions are very important and must be measured accurately[2]. The holes should be well spaced and not too close to the edge and should be about 1/8 inch in diameter.

When manufacturing or using hurricane straps, it is essential that the two flat parts of the straps are exactly at right angles to each other. This ensures that the two faces are flush with the timbers, so that the nails (or preferably screws) are stressed in shear, where they are most efficient. If these two faces are not flat, uplift forces will dominate.

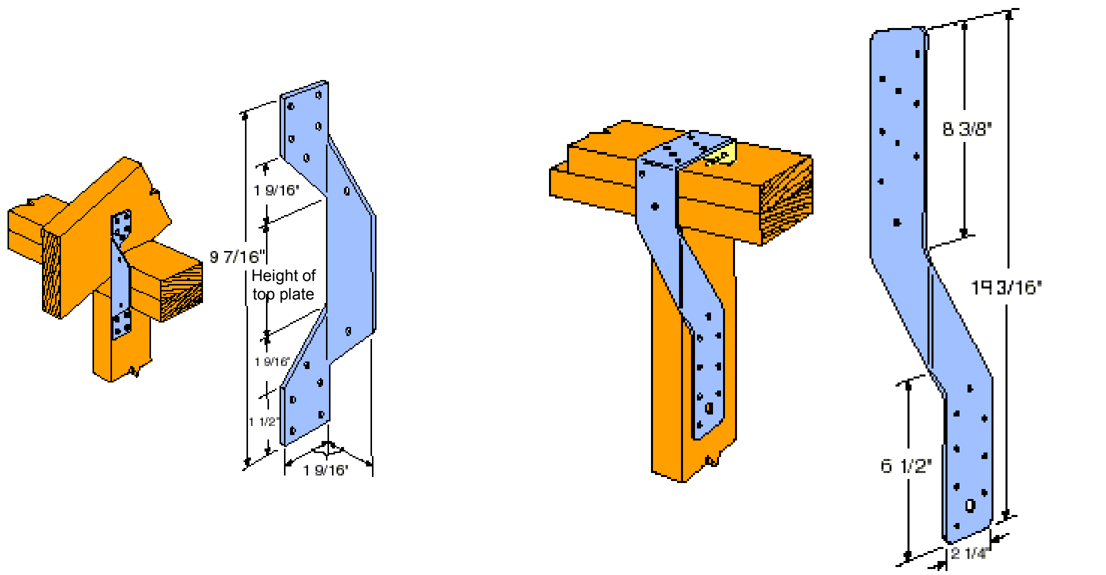


Image source: http://www.stormsurvival.homestead.com/Hurricane_Straps.html

Figure 40

The strap shown in Figure 42 is the example of a different design that can be just as effective as the ones shown in Figure 40.

Triple-L-Grip anchors are made in three basic types, A, B, and C, with left and right hand bends. One advantage of using hurricane straps over right angle L straps is that the nails are always loaded laterally, which makes the strongest connection. Note: Nails must be placed in all the holes of the strap; 1” nails are sufficient.

[2] Note: the height of the middle section of the clamp depicted on the left is a function of the thickness of the top plate to which this clamp is attached.

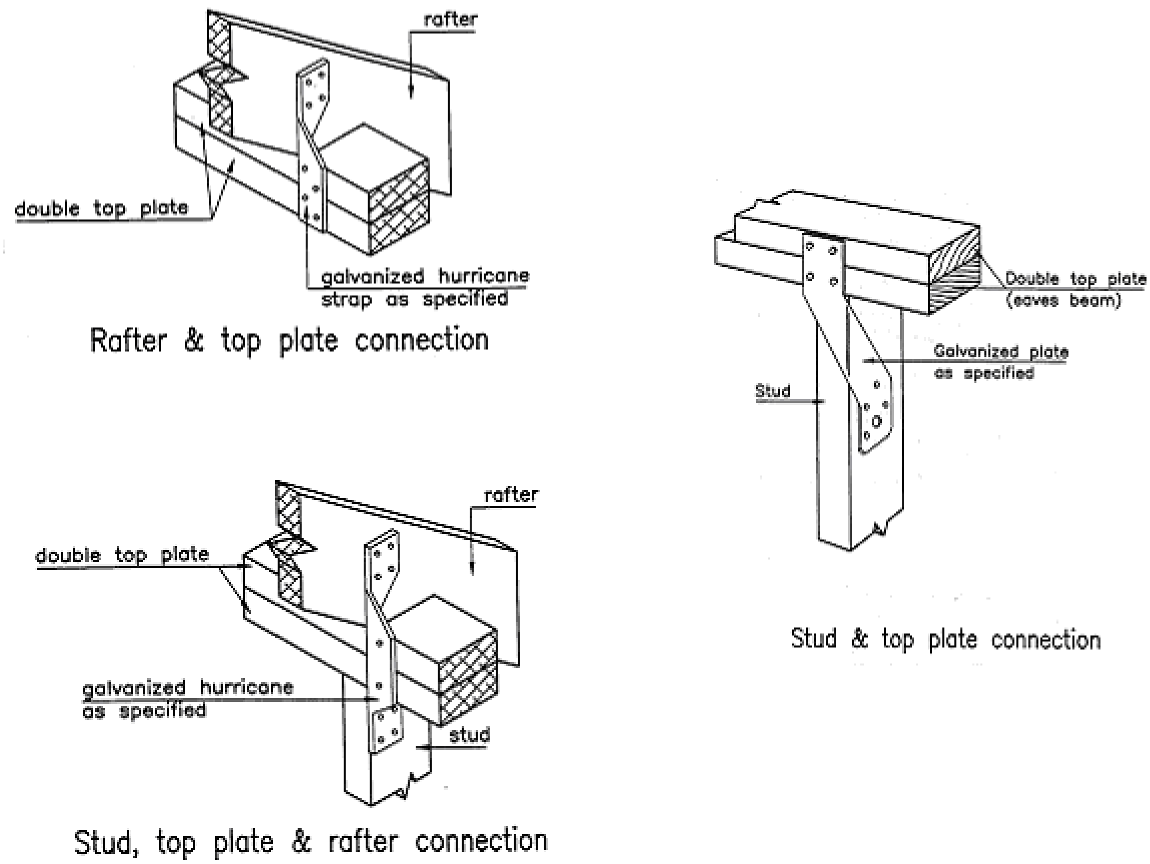


Figure 41 Examples of the Use of Straps shown in Figure 40

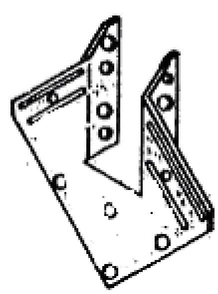


Figure 42

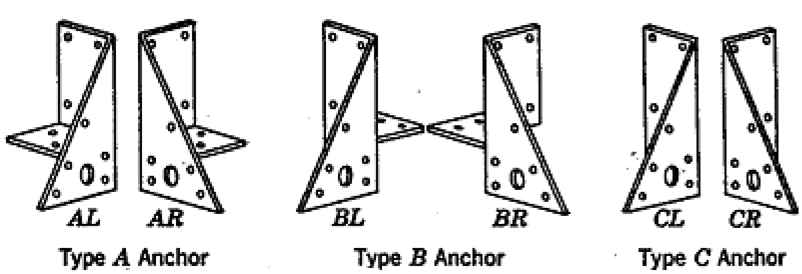


Figure 43 Trip-L-Grip Anchors

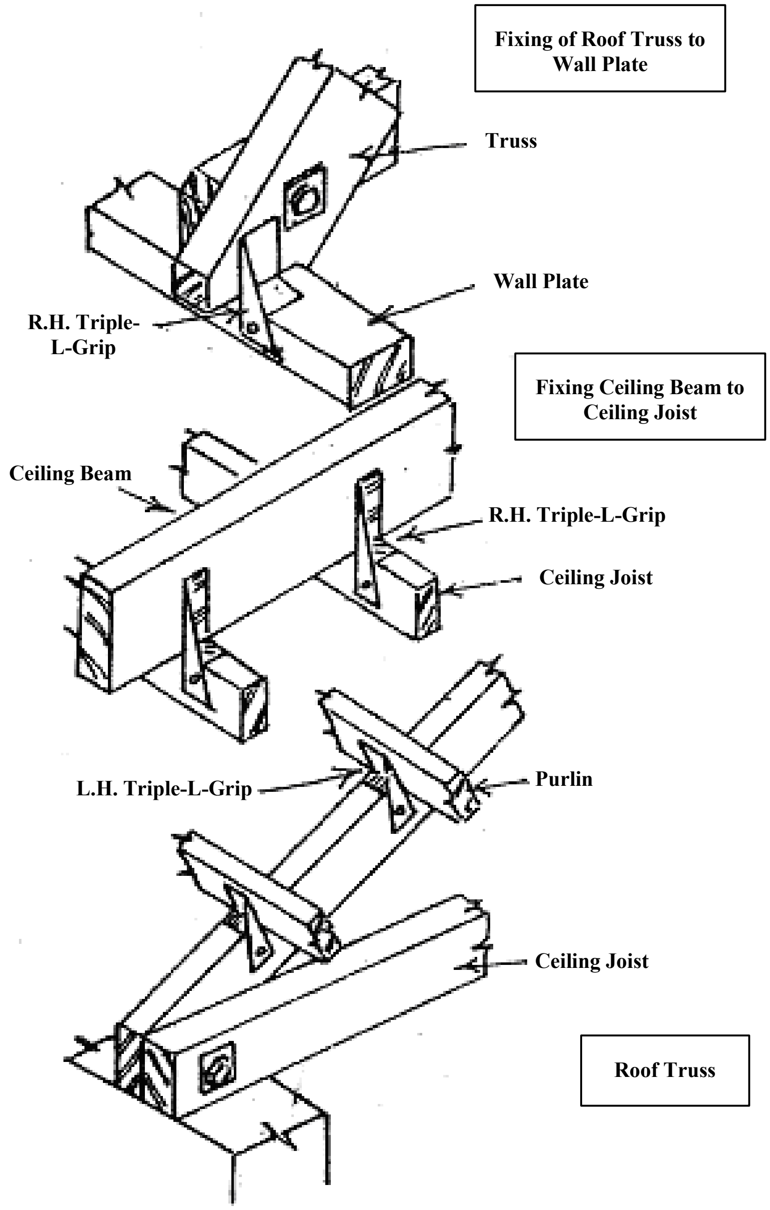
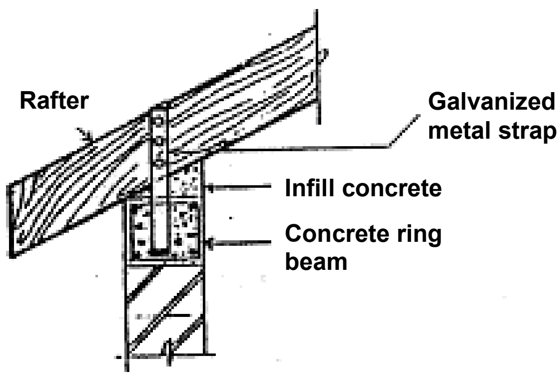


Figure 44 Use of Triple-L-Grip Anchors

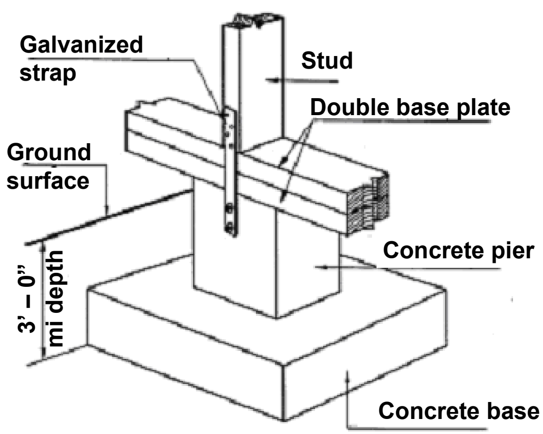
Securing the Load Path

Proper connections must be made between all parts of the structure, including the foundation and bottom plate, bottom plate and studs, studs and top plate, top plate and rafters, rafters and battens/lathes or purlin and roof covering and battens/lathes or purlin. Proper connections between all parts of the building, from foundation to roof, will make the difference between survival or loss of a structure.

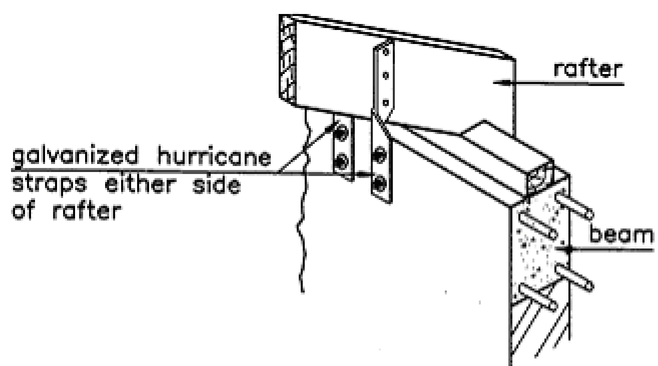
Once this has been achieved the structure's ability to withstand hurricane force winds would be improved significantly. Framing anchors and Hurricane straps when used as demonstrated in the sketches below to make the connections between the various members will afford homeowner better security during a hurricane.



Note: Ties or ceiling joists must be used in the cases depicted in these diagrams to counteract the effects of lateral forces on the external walls.



Stud to foundation connection
Foundation anchorage



Timber rafter connection to concrete

Figure 45

Health and Safety

Building sites can be very dangerous, both to the workmen and passers-by, especially when the following activities are being undertaken:

- Demolition works
- Working at heights
- Lifting or carrying heavy objects
- Operating electrical powered tools

Accidents on a building site can be reduced by workers' awareness of the root causes and adoption of safer working habits that can avoid endangering themselves and others. It must be noted that two of the most common factors which cause accidents on a work site (or elsewhere) are the attitude of individuals and the ignorance of the correct way machinery/ equipment work or are operated. The following are examples of dangerous attitudes:

- An inclination to take risk and behave recklessly.
- Believing that safety precautions are a waste of time.
- Thinking that if accidents are going occur, there is little anyone can do to stop them.

If workers change their attitudes and develop safer working habits, this would go a long way towards reducing accidents.

The second factor, the ignorance of persons as to the correct way machinery/equipment works or are operated, can be corrected by persons ensuring that they are knowledgeable and skilled in the safe use of machinery/equipment before attempting to use them. In the same manner, persons must be skilled in Carpentry or general building works before attempting to erect structures, because when the structure fails lives may be lost.

The following safety tips, if observed, can help reduce accidence and save the lives of workers and other people as well.

Safety on the Building Site

1. Keep work area clean. Clean up as you go, especially during demolition work.
2. Pull nails from boards at once. It is the odd piece of material with protruding nails that can cause serious injuries.
3. Wear thick-soled shoes with toe protection to protect your feet from protruding nails and heavy objects that may fall on your toes.
4. Use hard hats whenever you are working with persons above you or when you are below ground level (e.g. if you are digging a pit for a septic tank.)
5. Wear a respirator with changeable filters whenever you are working in a dusty environment
6. Do not operate machinery or sharp edged tools or climb ladders or scaffolds when under the influence of alcohol or other drugs that may impair your judgment.
7. When carrying out demolition/renovation work, make sure there are no children or other persons in the way before knocking out damage cladding.
8. Wear safety goggles whenever there is a chance that your eye would be endangered.

Electrical Safety

9. Always cut the power and check electrical outlets with a voltage tester.
10. When working in areas that you may cut into or otherwise disturb, keep in mind that there may be electric wires and pipes behind finished surfaces.
11. Power tools are commonly used; make sure, you know how to operate them. If it is raining, work should be stopped immediately as there is a chance that you will suffer an electric shock that could be fatal.
12. Check the electric cord of power tools to make sure that there are no cuts.

Scaffolding Safety

13. All supports for scaffolding must be solidly footed. Make sure they are checked every morning before you start work.
14. Platforms for scaffolding should be without twist or major cracks and they should be cleated (nailed) together.
15. Platform ends must not overhang more than l'-0" beyond their supports.

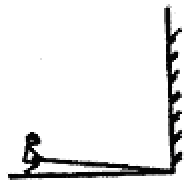
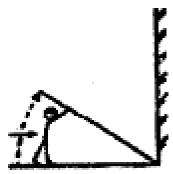
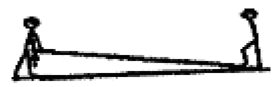
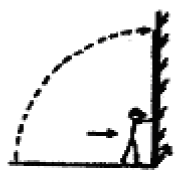
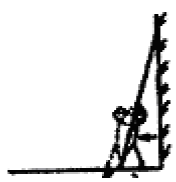
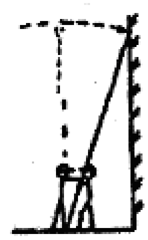
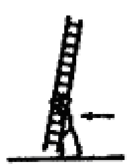
Safety while Working at Heights

16. Scaffolds that are higher than 3'-0" should have guard rails to protect workers from falling, and toe boards to stop objects from being accidentally kicked off the scaffold.
17. Working with ladders and scaffolds are dangerous as workers can fall from a height and injure themselves and persons below. They must be strongly built and well braced, as they have to carry heavy loads of persons and materials.
18. When working on a roof, erect scaffold up to the lower level of the roof to save anyone who slips down a roof slope.
19. Use roof ladders or crawl board to spread the load of the worker's weight when moving up and down the roof slope.
20. Roofs with zinc-corrugated sheets are not meant to support a person's weight between the timber frames. Walking on this type of roof covering requires extreme care because you need to move along the line of the nails or screws fixed to the battens/purling.
21. Do not use tools or do jobs requiring two hands while standing on a ladder.
22. Do not drop materials from a ladder.
23. Do not straddle from the ladder to a nearby foothold.
24. Do not allow more than one person up a ladder at a time.
25. Do not carry sheets of material, especially if it is windy.
26. Do not overreach.

Safety while Lifting or Moving Heavy or Awkward Objects

27. Protect your back muscles when lifting heavy objects. Get someone to help you. Lift with your arm and leg muscles, not your back.
28. Get help when carrying long boards or ladders, even if they are not heavy.

Manipulating and Maneuvering Ladders

Short Ladders	Long Ladders
Stage 1: Lift, bend knees and keep back straight 	Stage 1: Shoulder carrying 
Stage 2: Move forward and raise ladder 	Stage 2: Lifting – Assistant footing base of ladder 
Stage 3: Stand ladder up against a wall 	Stage 3: Move forward to raise ladder, assistant stationary 
Stage 4: Move out from wall 	Stage 4: Lean ladder against wall 
Stage 5: Carrying ladder 	

Note: When erecting and moving ladders over short distances, be aware of overhead cables and other obstacles. Metal ladders must not be used in areas where electric cables are present.

Ladder Safety

Ladders must be used correctly, if not, serious injury can result. The tips below should be a useful guide.

1. Do not erect on sloping ground.
2. Do not erect on movable objects.
3. Do not erect in front of a door that may be opened.
4. Do not erect against a slippery surface.
5. Do not erect at a shallow angle.
6. Do not erect horizontally as a plank or bridge.
7. Do not erect at too steep an angle.
8. Do not use a ladder that is too short.
9. Do not use a defective ladder.
10. Do not use a makeshift or 'home-made' ladder.
11. Do not overload a ladder or support it with a rung bearing on a board.
12. Do not slide down a ladder.
13. Do not carry a ladder while riding a bicycle.
14. Do not use an alloy or wet ladder near electrical conductors.
15. Always place a ladder on a firm level base.
16. Always set at an angle near to 75° from the horizontal (i.e. 4 in l).
17. Always tie the ladder in position, if possible at both the top and the bottom. (See pictures above.) If that is not possible, a worker should stand with one foot on the bottom rung holding the stiles to steady the ladder.
18. Always make sure the ladder projects above the climbing off level.

Relationship between the Minimum Standards Guide and the Building Guidelines

The St. Lucia Building Code was developed to ensure that homes and buildings constructed in St. Lucia are safe and sound. This Building Code was adapted from the OECS Model Building Code.

Building Code

The Building Code does not make a direct reference to hurricane resistant construction. Hazard-resistant building techniques are integral to the standards set forth in these documents. Section 14 of the Building Code (timber construction), for example, addresses quality, uses and sizes of structural timber and design parameters (e.g. allowable stresses) for various timber elements. Subsection 1406.1 provides timber construction details and reference information for material sizes required to span various distances.

The Building Code document is designed for use by Designers and Engineers. This information was re-presented in this document in a more accessible manner.

Building Guidelines

The information contained in the National Building Guidelines is based primarily on reports of the Construction Industry in the OECS and generally follows the customs and tradition in the design and construction practices. The Building Guidelines make use of the building traditions that lead to “safe” construction and introduced construction methods required for the proper use of contemporary materials. The Building Guidelines are to be used for design and construction of simple buildings such as private dwellings and small retail shops in St. Lucia of less than 2500 square feet gross area, and includes diagram and sketches of firm holding down mechanisms especially for light timber frame building, many of which are overturned or destroyed in high winds.

The Minimum Standards document addresses the same concerns of the Building Guidelines relative to light timber construction, but presents the information in a more graphic manner, and uses simpler terms and phrases which could be easily interpreted by untrained artisans and lay persons who are involved in the construction of dwellings in the vicinity of 1200 square feet or less.

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Environmental Guidelines for Housing

This section of the document was prepared by Peter Norville, Consulting Engineer.

1.0 Background

This section of the *Manual* outlines the main environmental management issues relating to the establishment and construction of low-cost housing units, and presents guidelines to minimize the negative environmental impacts of decisions and activities related to the establishment and construction of low-cost housing units. These guidelines are presented in a user-friendly format, for use by housing programme managers and homeowners.

In attempting to obtain documentation on the subject of environmental management in relation to low-income housing, it was found that such documentation was sparse. Further, few local regulations and technical guidelines relating to environmental management exist, and those which do exist, are of little relevance to low-income housing. Consequently, this material is based primarily on the knowledge and experience of the author.

2.0 Introduction

Funding provided under the housing programme by the NRDF largely relates to the construction or expansion of wooden houses and the expansion of masonry houses. The houses are, for the most part, located outside of the larger urban areas, usually on family lands, or on rented “house spots”, and not within planned residential developments. The houses are usually located on relatively flat or moderately sloping lands, away from public paved roads and they are often serviced by footpaths or narrow unpaved roads. In the majority of cases, formal planning approval is not sought for the construction or location of the houses. It should be noted however that formal planning approval is not required in St. Lucia for expansion of residential developments when the area of the expansion amounts to less than one-third of the area of the original development.

It is commonly thought that because of the relatively small scale of the activities involved in low-income housing, particularly when undertaken on one house at a time, the environmental problems associated with an individual low-income housing venture are generally insignificant and of limited impact. However, within any given area, a series of minor environmental problems can combine to produce significant negative impacts. For example, the indiscriminate disposal of waste into a ravine or river course by several households will cumulatively lead to the pollution of that watercourse. Also, an improper practice associated with one household can over time lead to a major environmental problem with impacts on an entire community. For example, the improper construction of drains on one house lot on a hillside may over time lead to the formation of a gully, which can cause the loss of large amounts of soil or inundation of properties located downhill. Therefore, as simple or insignificant as activities related to low-income housing may appear to be, they may contribute to significant environmental problems unless certain measures are adhered to. Some of these measures may be quite simple and relatively cheap. However some low-income homeowners may be unable to afford to implement some of these measures, at least not at the same time as they are seeking to address expenses directly related to the main housing unit.

The typical environmental problems associated with low-income housing ventures in St. Lucia are for the most part related to the Location and Placement of houses, Site Preparation, Drainage and Waste Disposal. Descriptions of these problems, and the guidelines on the measures which should be implemented to address these problems, are provided in the following sections.

3.0 The Location and Placement of Houses

3.1 Problems associated with the Location and Placement of Houses

Indiscriminate and uniformed placement of houses creates both environmental hazards and danger to the occupants of these houses.

A large number of the houses established through low-income housing programmes are located within unplanned developments. The houses funded through the NRDF housing programme are, in most cases, located on family lands which have not been formally partitioned, or on rented "house spots" which have not been surveyed. In such cases, the houses are often located away from public roads and the houses are not directly serviced by paved roads, although tracks and pathways may be found, and infrastructure such as water supply pipelines and electricity poles are not laid out in an organized manner. In such instances, there are no rules to govern the placement or location of houses, and homeowners and builders often determine the placement and location of houses based on their own judgments and preferences. Very often, no consideration is given to the future development of the surrounding lands, and, as such, the orderly future development of the area may be compromised. Invariably, after some time, the landowners would seek to rationalise and formalize the development and this process may become quite complicated because of the absence of any kind of planning during the time when houses were being located or placed. Houses are often placed so close together that it may be difficult to establish a proper road network. Plot sizes may be so small that it may be impossible for individual houses to be attached to septic tanks, even if they are upgraded and the homeowners are able to afford septic tanks.

In considering the placement and location of houses, attention should also be paid to flood risk. Houses may be located in watercourses or gullies, causing flooding of the house or nearby areas. Whereas flooding may not be a consequence of any activities undertaken by the builder or homeowner, the improper placement and location of houses in flood prone areas may result in considerable discomfort, loss of property, injury and even loss of life.

Since St. Lucia is a small island, issues related to the establishment of developments within or near coastal areas are often encountered. Among the most significant of these issues in relation to housing developments are the risks associated with property damage and injury to residents, as a result of storm surges. Storm surges are essentially walls of water created by a tropical cyclone (topical wave, tropical storm or hurricane) out at sea. They can reach the shore at destructive, well above normal sea levels. When storm surges hit the shoreline and coastal areas, they can cause significant damage to property located within these areas, and of course they can result in the injury of residents and even death.

There are a number other important environmental management issues associated with housing developments in St. Lucia's coastal areas. These relate to public access to beaches, the natural erosion and accretion of beaches, pollution of nearshore waters as a result of land-based activities, and aesthetics. Public access is a sensitive issue, and several public statements have been made about the commitment of Government to ensuring that the public has free access to St. Lucia's beaches. In addition, beaches undergo natural processes of erosion and accretion, and it is desirable that these processes be allowed to take place as freely as possible, in order to maintain the natural balance of coastal ecosystems. Further, whenever waste is generated through land-based activities close to the shore, there are pollution risks associated with the disposal of such wastes into the nearshore waters, and particular measures need to be put in place to minimize or eliminate these risks. The visual impact of developments in coastal areas are also important as the attractive coastal views are important to St. Lucia's overall image as a tourist destination.

3.2 Guidelines on the Placement and Location of Houses

3.2.1Placement and Location of Houses in Unplanned Developments

In deciding upon the location of houses, particularly within large parcels of land for which subdivision plans have not been prepared or implemented, consideration must be given to the future development of the area. The main issues to be considered are:

Lot sizes: lots should not be less than 3000 square feet in area. Control of lot sizes and proper layout (sub-division) is paramount. This is the minimum lot size approved by the Development Control Authority in residential developments. It should also be borne in mind that the Ministry of Health does not normally approve septic tanks on lots below 3000 square feet. Even if septic tanks are not an immediate priority of the homeowner, consideration should be given to the possible future upgrading of the house to include a septic tank. This not only allows proper disposal of sewage on site using septic tanks, but also proper access to individual sites by cesspool trucks for removal of sewage.

Roads or footpaths: provision should be made for the future construction of roads. The minimum road width normally required in residential developments is 20 feet. At any rate, whenever plans are made to construct roads, a provision of 10 feet should be made for footpaths. Apart from the provision of adequate width for future roads and footpaths, consideration should be given to the appropriate alignment of these in a manner that will optimize the use of the available land area, as well as the provision of adequate linkages to established public roadways. In addition, any established rights-of-way through the property to adjacent parcels of land must be recognized and maintained.

3.2.2 Soil stability and land slippage

In areas with unstable soils or steep slopes, the improper placement of houses can add to soil instability and contribute to land slippage. In instances where a sections of a hillside is to be levelled off to accommodate a house, placement of the house too close to a slope break can cause land slippage, if the increased load on the soil exceeds its capacity. This would most likely occur during rainfall events when the weight of water in the soil would be added to the loading created by the house to cause land slippage. It should be borne in mind also that slope failure or land slippage caused by placement or location of a house too close to the slope break may lead to loss of the house, and even the loss of life. The house should therefore be placed well away from the slope break so as not to contribute to slope failure. The required distance between the house and the slope break may vary according to the soil types, slope, size and type of house. However, as a general rule, the foundation of the house should not be located less than 20 feet from the top or bottom of a slope break (Figure 46).

In instances where houses are to be constructed at the foot of a slope, there is a risk that the slope may fail and move towards the house to partially or completely cover it. Such a scenario has been experienced on several occasions, in certain cases resulting in damage to or complete the loss of the house, and even loss of life of the occupants of the house. Slope failure and land slippage in such cases often occur during or after heavy rainfall. In order to avoid or minimize the risks associated with the location or placement of houses at the foot of a slope, efforts should be made to stabilize the slope by applying the techniques and methods described in Section 4.2 below. In addition, the house should be placed well away from the foot of the slope. The distance from the slope would vary depending on the height of the slope, the soil type, the types of activities undertaken on or above the slope, the level of protection given to the slope (vegetation, retaining wall) and the height of the house. However as a general rule, a minimum clearance of 30 feet from the foot of the slope should be maintained in situations where the slope height exceeds the height of the house. This distance can be reduced according to the height of the slope relative to the height of the house.

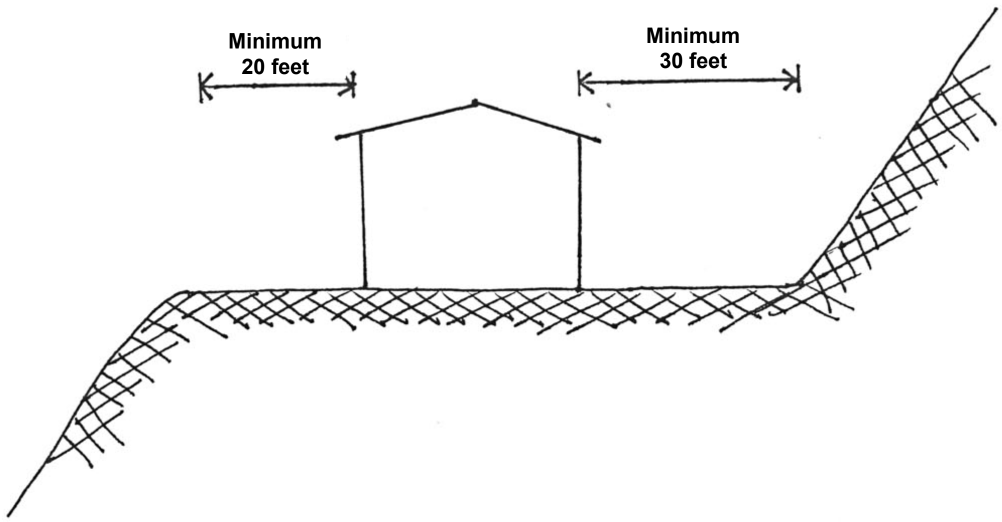

Figure 46 Location of Houses on Slope

3.2.3 Flood Risks

Homeowners planning to move into an area with which they are not familiar should seek to obtain information on the risks of flooding in the area, particularly if the area is relatively flat or near a large ravine or a river. Scientifically developed flood risk information is not immediately available in St. Lucia and so homeowners should seek to obtain information on such matters as the frequency of flooding and the flooding patterns. Such information can be obtained by speaking to persons living in or familiar with the area. On the basis of information received, appropriate measures could be taken in relation to the placement and location of the house. In particular, the location selected for the house should be at a safe elevation above standard flood heights, and/or the construction of appropriately sized drains around the house (Section 5).

3.2.4 Setbacks for Coastal Developments

In general, most of the negative environmental impacts associated with developments in coastal areas can be addressed through the application of appropriate setbacks.

Coastal development setbacks have several functions:

- They provide buffer zones between the ocean and coastal infrastructure, within which the beach zone may expand or contract naturally, without the need for seawalls and other structures, which may imperil an entire beach system. Thus in this sense, they may actually reduce beach erosion.
- They reduce damage to beachfront properties during high wave events and storm surges.
- They provide improved vistas and access along the beach.
- They provide privacy for the occupiers of coastal property and also for persons enjoying the beach as a recreational resource.

The Development Control Authority (DCA) has developed guidelines for developments within coastal areas, which are laid out in the *Manual For Developers—Volume 1* of February 1988. The manual states, "Any subdivision along the coast of St. Lucia, which is not specifically designated as a harbour or industrial site, must be set back from the high water mark. The distance required for setback will depend on the slope/gradient of the area, the nature of the sub-strata, and prevailing oceanographic conditions". Figure 47, which illustrates the guidelines for setbacks in coastal areas, is adapted from diagrams provided in the *Manual For Developers—Volume 1*.

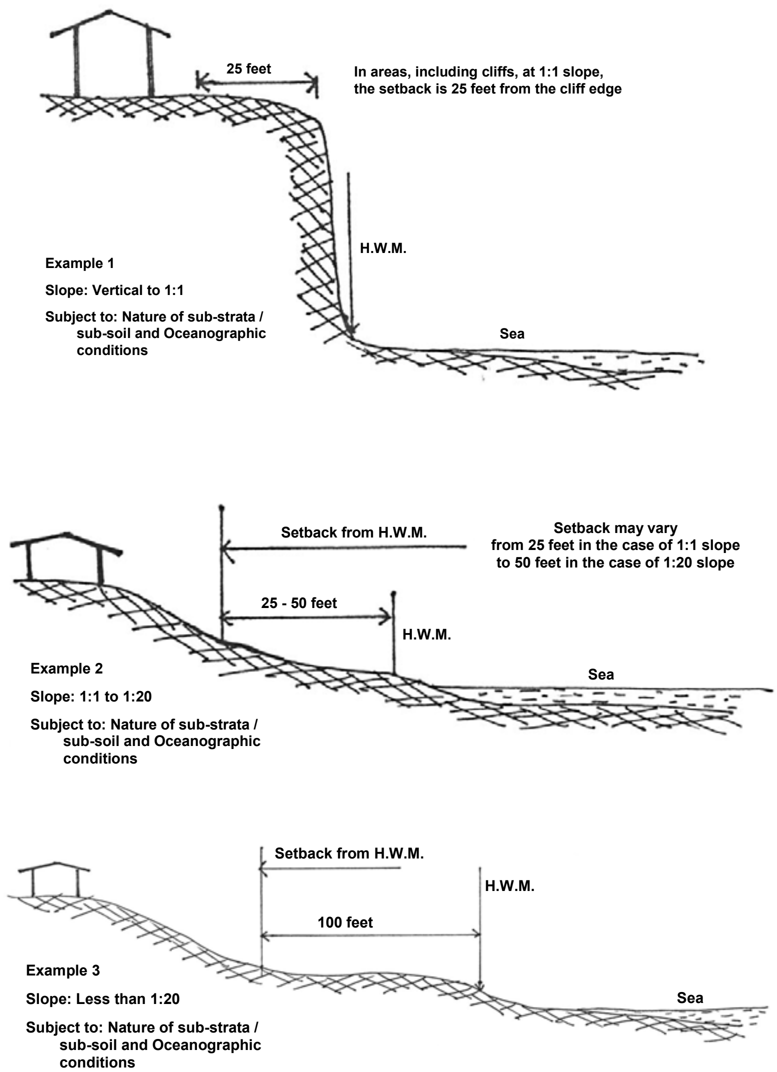

Figure 47 Setback Requirements for Developments in Coastal Areas
(Adopted from DCA Manual for Developers)

In considering developments within coastal areas, it should be noted that St. Lucia is in a unique position, since the land adjacent to the beach (within 186 feet of the high water mark) is known as the "Queen's Chain". The Queens Chain is owned by the Government and it generally extends around the coast except along the waterfront areas of the cities, towns and villages. Land within the Queen's Chain cannot be purchased, only leased, and the persons wishing to develop land within the Queen's Chain would normally have to own the land behind (landward of) the Queen's Chain. The *Manual For Developers—Volume 1* lays out guidelines for developments within the Queen's Chain. The first guideline listed states that "Development shall be of low density with a minimum plot size of 10,000 square feet". The minimum plot size stipulated in this guideline suggests immediately that low-income housing developments are not to be encouraged within Queen's Chain.

4.0 Site Preparation

4.1 Problems associated with Site Preparation

The preparation of the site is one of the more important preliminary activities in the process of construction or establishment of the house. At this stage of the process, certain basic procedures and guidelines should be adhered to, in order to avoid complications and difficulties in the future stages. Some of these difficulties may be associated with environmental problems such as soil erosion and land slippage. These problems are often in turn related to the clearing of vegetation, the removal of soil and the cutting of slopes.

4.1.1 Clearing of Vegetation

It has been well established that vegetation plays a significant role in maintaining soil stability and reducing soil erosion. Generally, the root systems of vegetation serve to bind the soil and decrease its susceptibility to erosion and slippage. Also, vegetative cover protects the soil from the direct impact of rainfall, thereby reducing the extent of soil erosion. The clearing of vegetation, particularly when widespread, renders the soil unstable and facilitates soil erosion which lead to sedimentation of rivers, increased flood risks in low lying areas, and pollution of rivers and coastal areas. Vegetation, therefore, should only be removed in from areas where the actual building will be erected. Trees should only be removed if they obstruct the construction process or are likely to be a danger to the house. After completion of construction, vegetation must be replanted to help prevent soil erosion and to improve soil stability.

4.1.2 Removal of Soil and Cutting of Slopes

In the preparation of a site for construction or establishment of a house on a hillside, it is often necessary to remove soil or to cut into the hillside to obtain the required conditions to establish the footing or to construct the foundation. Topsoil may have to be removed to expose the more compact and stable underlying soil layers or bedrock, which are required for the construction of strong footings or foundations. If the removal of soil or the cutting of slopes are not properly undertaken, the area can be rendered unstable and this can in turn lead to excessive erosion or land slippage. It is therefore necessary to pay special attention to these matters to avoid future difficulties.

4.2 Guidelines on Site Preparation

Excessive excavation should be avoided. The depth and width of such excavations should only be the minimum required. This reduces the possible instability of earthworks and the need for backfilling and consolidation.

The removal of soil should be limited to only those areas where it is necessary for the proper construction of the footing or foundation of the house. Also, it should be limited only to the necessary depth. Further, the soil that is removed should be safely placed in another location. If the amount of soil is not substantial, it can be spread over surrounding areas if they are relatively flat and if the chances of washout by rainfall are minimal. Also, some topsoil may be retained for use in the potting of plants.

In instances where it may not be convenient to the use the soil on the same site, the soil should be disposed of at another location. In that case, the builder and homeowner should ensure that disposal is undertaken in a responsible manner, either at an approved site for backfilling or disposal of soil or at another location but with the approval of the land-owners or their agents, and in a manner which reduces the risks of the deposited soil being easily washed away.

When the cutting of slopes is undertaken to accommodate a house, attention should be paid to the stabilization of the cut slopes to prevent soil erosion and land slippage. Steep slopes are one of the principal conditions favouring landslides and soil instability and so care should be taken to ensure that any slopes created in preparation for the construction or establishment of houses are at least at the most stable angle for the particular type of soil, the angle of repose. The table below provides guidelines on the recommended slopes for the most common soil types.

Recommended Slopes for Common Soil Types

Soil Type	Recommended Slope
Clays and Loams	1:2; 65° or 200%
Silts	1:1; 45° or 100%
Sands	2:1; 30° or 50%

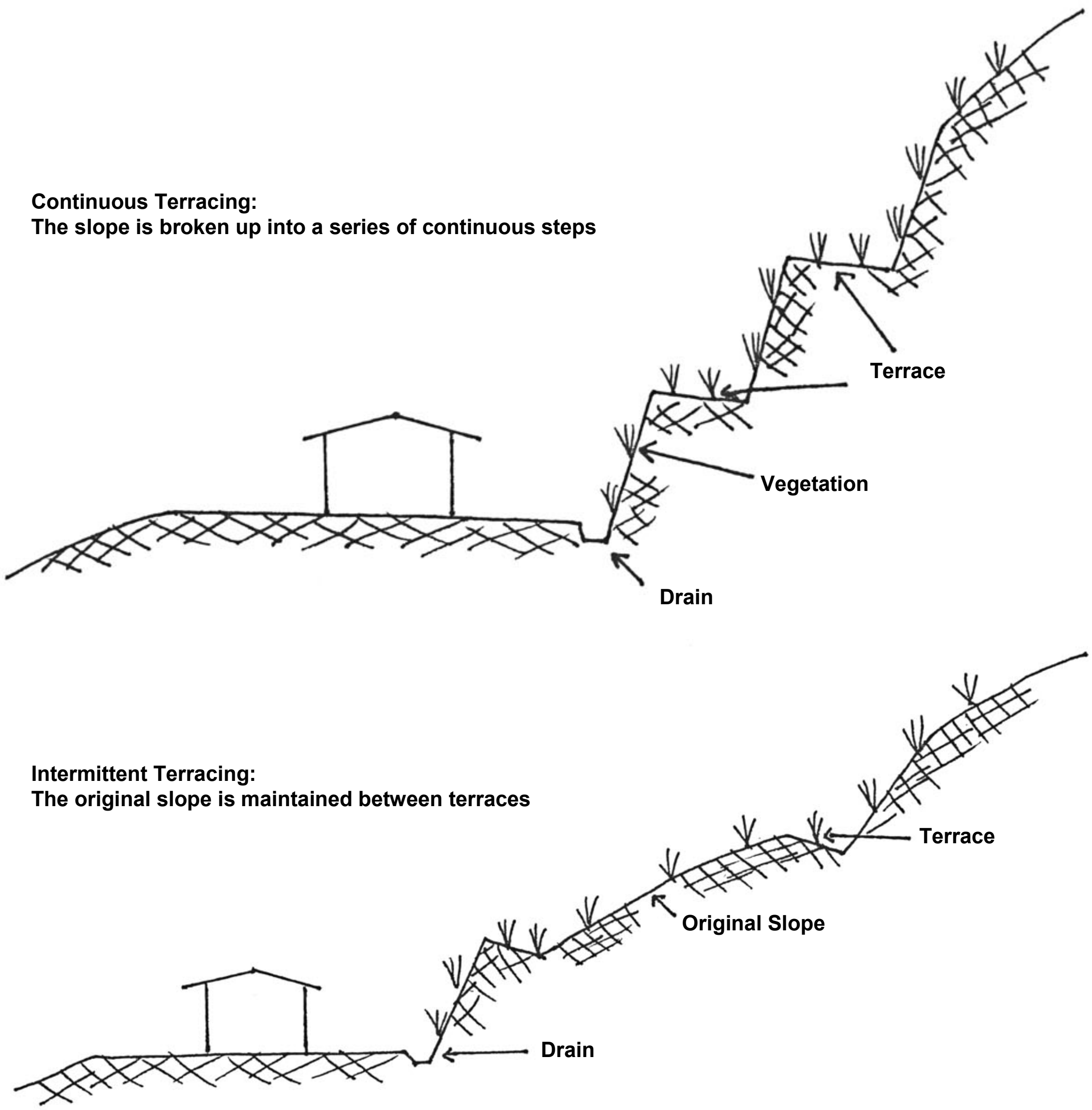

Figure 48 Reduction of Slope Height through Terracing

In addition to ensuring that slopes are cut at the right angle, it is also advisable to establish vegetation on the cut slopes to further reduce the risks of soil erosion and land slippage. Vegetation influences slope conditions in two main ways. Hydrologically, it influences the rate and volume of water entering the soil by promoting infiltration and thereby reducing overland flow which contributes to soil erosion; and mechanically, it binds soil particles together, thereby increasing the strength of the soil and contributing to its overall stability.

Vegetation increases the resistance of the soil to shear, that is the tendency for adjacent soil layers to shift in relation to each other, because the roots of he vegetation serve to bind the soil layers together. Vegetation also protects the surface of the soil from erosion by overland flow and traps soil particles that may be moving down slope. Vegetation, which is selected for the particular condition of the site, well established and to a sufficient density, can provide effective surface slope protection. One of the most common grass species associated with slope stabilization in St. Lucia is Vetiver Grass, also called Khus Khus Grass *(Vetiveri zizaniodes).*

It should be noted that, in addition to steep slopes, the other main physical factors that contribute to landslides are weak underlying bedrock and heavy rainfall conditions. These factors in combination are almost certain to result in landslides. Additionally attention should be paid to the overall height of the slope. It is advisable to limit slope heights. Where the slope height exceeds 6 feet, the slope should be cut into terraces, each 6 feet or less in height. See Figure 48.

5.0 Drainage

5.1 Problems associated with Inadequate Drainage

Uncontrolled drainage may undermine housing foundations and alter water courses, leading to flooding and generally affecting the quality of the environment. Such conditions may include ponding of water, which may lead to mosquito breeding, and indiscriminate flow of runoff, which may contribute to soil erosion and the formation of gullies or land slippage. In addition, the movement of vehicular and pedestrian traffic may be made difficult as a result of poor ground conditions due to inadequate drainage, particularly during the rainy season. It is therefore important that adequate attention be paid to drainage when considering the construction or placement of houses.

5.2 Guidelines on Drainage

Ideally, drainage associated with residential developments should be considered within the context of an overall system. That is, an overall drainage plan should be developed for a residential area, with such a plan taking into consideration the layout of the lots, the existence of established natural drainage channels and the drainage inflows and outflows of relevance to the development. However, in the context of low-income housing in St. Lucia, since houses are more often constructed or established on an individual basis, the consideration of drainage issues and the work to be undertaken by the homeowner is limited in scope.

The drainage considerations related to a single house may be generally classified into two main aspects: (i) the handling of runoff from the roof; and (ii) the handling of surface runoff.

Ideally, runoff from the roof of the house should be collected through a system of guttering, and safely conveyed through a down-pipe to a stable drain. However, in most low-income housing ventures, the installation of guttering is not undertaken because of the expense involved. At any rate, the absence of guttering contributes to indiscriminate flow of runoff around the house which may lead to poor ground conditions and soil erosion, and which may even adversely affect the stability of the footing or foundation of the house. It is therefore highly advisable that efforts be made to install a guttering system at least along sections of the roof where it would be most desirable.

Uncontrolled upland runoff onto the site is a significant problem that must be addressed. Where this is a problem, cutoff drains should be constructed to intercept and divert overland flows. The construction of surface drains in an appropriate manner around the house is also highly desirable. Such drains facilitate the orderly and efficient removal of runoff from areas around the house, thereby improving ground conditions after rainfall events and controlling overland flow in a manner that minimises soil erosion. These drains may also allow footpaths and roadways to remain firm and stable during the rainy season.

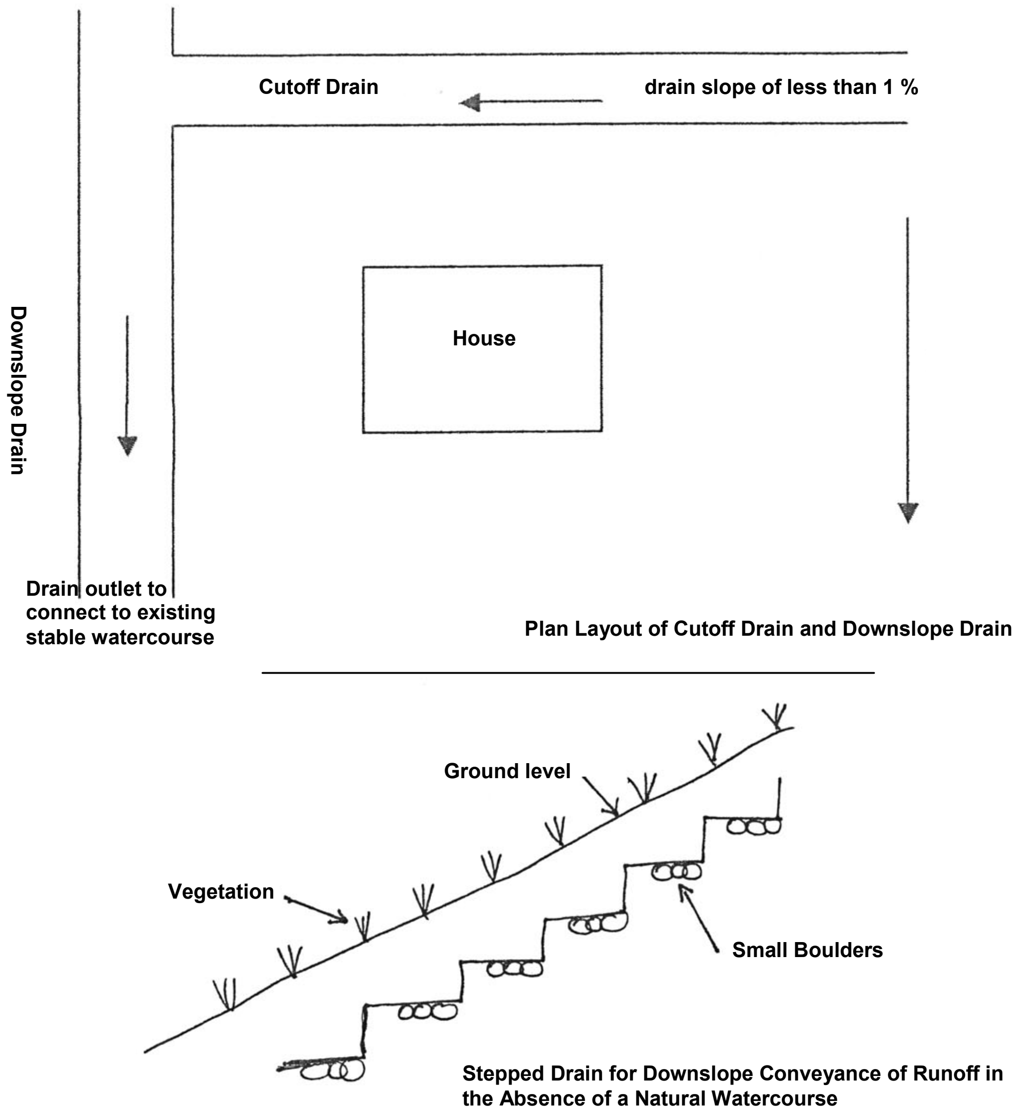

Figure 49 Cutoff Drain and Downslope Drain

Surface drains in residential areas should ideally be constructed of concrete, as they are generally easier to maintain. Because of the costs associated with construction of such drains, they are often not used in low-income housing areas, and earthen drain are used instead.

The factors to be considered in the construction of drains around the house are:

Layout of drains: Layout and sizing of drains is important if drainage is to be successful. Run-off from houses and adjacent areas must flow freely to drains. This may necessitate the filling in of localized low spots on the lot to facilitate free flow to the drains and to prevent the ponding of water. Ponding not only prevents free flow, but also tends to undermine the stability of drain cuttings and embankments.

Consideration should also be given to conveyance of runoff from the roof. In cases where guttering is used, the down-pipe should be directed into a drain around the house. Consideration must also be given to the slope along the bottom of the drain. This slope should facilitate steady flow at a velocity which is not excessive. Excessive flow velocities can lead to erosion in the drain which can enlarge the drain and eventually create gullies. Generally, in order to avoid excessive velocities, the slope of the drain should not exceed 1%. See Figure 49.

The construction of open drains on hillsides can be a major issue. Cutoff or interceptor drains are required to intercept runoff originating from lands at higher elevations. These should be constructed along the contour, to a stable watercourse that can safely convey runoff downhill. Where such watercourses are not immediately accessible, a drain must be constructed to convey runoff downslope. Special measures must be undertaken to ensure that drains constructed to convey runoff downslope remain stable. Typical configurations of these drains are provided in Figure 49.

Finally, the layout should allow for safe conveyance of the runoff to an appropriate outlet such as an existing roadside drain, ravine or river. Homeowners should take responsibility for the safe disposal of runoff from drains that they have constructed, and in instances where they do not have direct access to outlets indicated above, they should seek agreement with persons in the surrounding areas to arrange for the safe conveyance and disposal of runoff from the drains around their house.

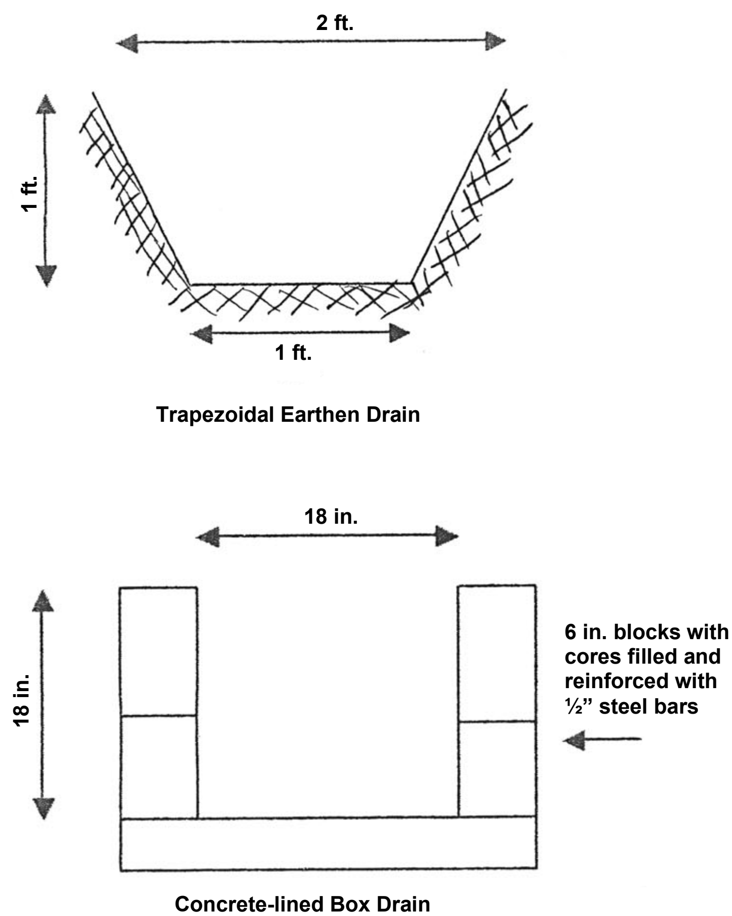

Figure 50 Typical Drains Outside of the House

Sizing of drains: The sizes of drain constructed in residential areas are normally a function of the volume of runoff to be conveyed by the drain. However, in most cases the drains constructed around houses are usually relatively small in size, unless they are required to intercept runoff from surrounding areas.

The smaller drains constructed around houses should be constructed with a side slope. Straight-sided earthen drains are not desirable as the sides of such drains are not as stable as those that are sloped, and there is an increased risk that soil may fall into the drain and create blockages that impede free flow. The typical cross sections and dimensions of drains constructed around houses are provided in Figure 50.

Drain sizing must increase from narrow to large in the direction of water flow and must be properly sized to accommodate flows.

6.0 Waste Disposal

6.1 Problems associated with Improper Waste Disposal

The disposal of solid and liquid waste has generally received little attention in the consideration of issues related to low-income housing. However, improper waste disposal at the household and community level can lead to problems such as fly and rodent infestation, pollution and obstruction of watercourses and offensive odours which affect human health, the environment and the overall quality of life.

6.1.1 Solid Waste Disposal

The proper disposal of solid waste generated during the construction or relocation of a house is a matter that is often overlooked. However, in certain instances, such as when the demolition of an old structure is part of the overall activity, solid waste disposal can be a significant matter which requires particular attention. Generally however, in the context of low-income housing, only small amounts of waste are generated during the construction or establishment of houses, principally because of the small-scale nature of the activity. At any rate the basic guidelines provided in Section 6.2 should be adhered to.

6.1.2 Liquid Waste Disposal

In the context of low-income housing, liquid waste disposal is generally related to wastewater generated from household activities such as dishwashing, laundering, bathing and cleaning as well as to sanitary wastewater associated with human waste.

Most residential areas are not served by municipal sewerage systems and so each household is required to be responsible for disposal and treatment of its sanitary wastewater.

In low-income housing, pit latrines are commonly used for disposal of human waste. This practice is still accepted by health authorities in St. Lucia. The use of septic tanks is encouraged, wherever these can be afforded. However, most persons in the low-income bracket are unable to afford a septic tank system and therefore the preference in relation to disposal of sanitary waste is for a pit latrine. At any rate, even when pit latrines are used, it is often the case that limited attention is paid to proper construction methods, resulting in foul odours and fly infestation problems.

6.2 Guidelines on Waste Disposal

6.2.1 Solid Waste Disposal

The following measures should be adhered to during construction or relocation of houses:

- Waste should be stored in containers and should not be allowed to accumulate on-site for extended periods of time;
- Only small amounts of waste should be placed at the roadside for collection under the regular household waste collection service;
- Large amounts of waste and bulky items should be transported to the landfill for disposal;
- Waste being transported must be covered to prevent dispersion or littering during transportation;
- The burning of waste on-site should be avoided;
- Waste should not be disposed of in drains, ravines, or rivers.

During normal occupation of a house, all households are required to properly store their solid waste and to place them in the designated storage containers in their neighbourhood or along the route of the garbage collection vehicles on the designated collection days. The St. Lucia Solid Waste Management authority had developed some basic guidelines which could be applied to households and which would contribute to the smooth running of the solid waste management system and the improvement of environmental conditions. The main guidelines that apply to households are as follows:

- Waste should be stored in containers with tight fitting lids;
- All household waste should be put out for collection in bags which are securely tied;
- Waste should be placed at the roadside along the collection route, only on the designated collection days;
- In areas where community bins are provided these used be used and waste should not be placed at the roadside;
- Waste should be protected from dogs, cats rats and other animals;
- Bulky waste such as discarded refrigerators and stoves should be put out for collection only on the days designated for bulky waste;
- Materials such as plastic bags, jars, packaging, and bottles should be reused as much as possible;
- Whenever possible, items should be purchased in reusable containers;
- Waste should not be disposed of in drains, ravines, or rivers.

6.2.2 Liquid Waste Disposal

It is currently a common practice for wastewater from common household activities to be disposed of into open drains, which are invariably also used for conveyance of surface runoff around the house. Such a practice may be continued in the absence of municipal sewage systems. The guidelines relating to these drains are presented in Section 5.2. Care should be taken not to use these drains to dispose of any hazardous chemicals. Such chemicals should be disposed of in accordance with guidelines provided by the manufactures or suppliers, and in instances where the homeowner is unable to undertake disposal, the assistance of the Environmental Health Department should be sought.

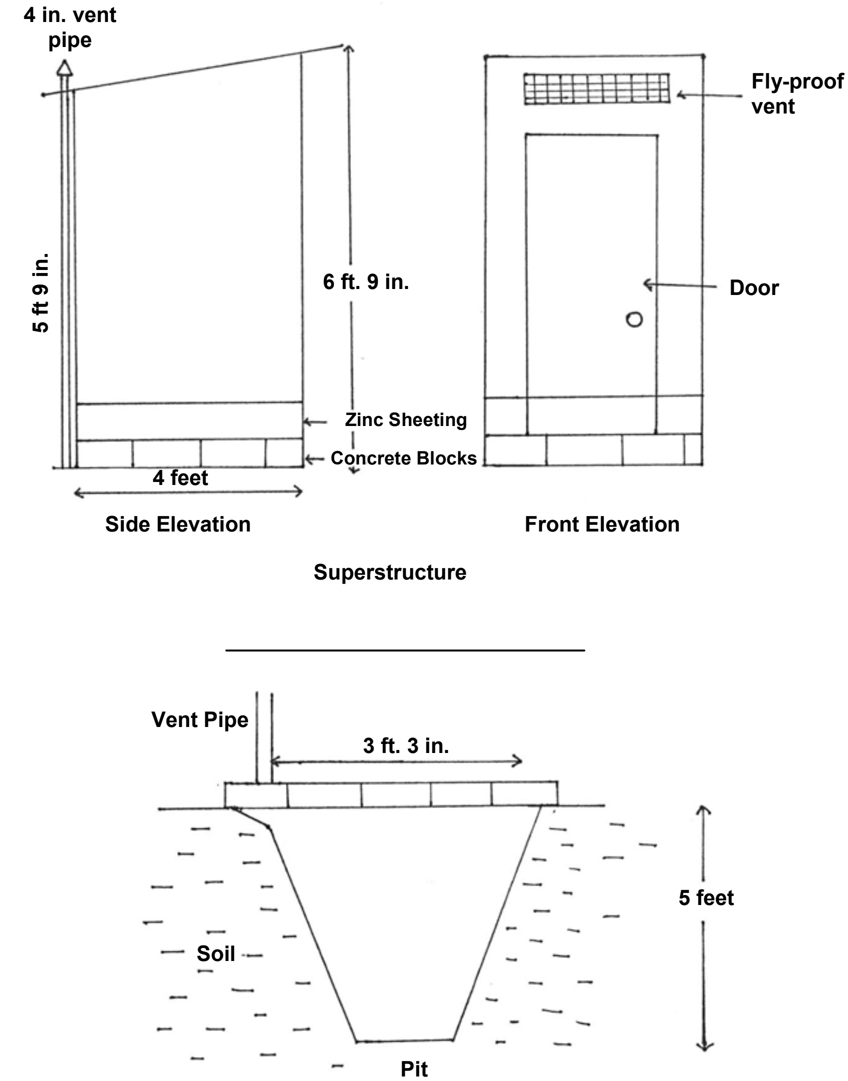

Figure 51 Ventilated Improved Pit Latrine

Over the past several years, the Ministry of Health, through its Environmental Health department, has encouraged the construction and use of Ventilated Improved Pits (VIP) Latrines by low-income households. VIP Latrines are pit latrines that incorporate use of a vent pipe to channel gases and odours into the air in such a manner as to prevent the odour nuisance normally associated with latrines. The VIP also makes provisions for the prevention of fly infestation by the use of screens or fly traps. The VIP is constructed in nearly the same way as the conventional pit latrine except that provision is made for additional features involving a vent pipe and fly screens. The advantages of such latrines are:

1. They minimize the nuisances of foul odour and fly infestation
2. They are relatively easy to construct and maintain;
3. They can be constructed at relatively low cost
4. Their have the potential to be upgraded to pour flush toilets
5. They involve minimal requirements for water
6. The superstructure is portable and reusable
7. They are no major health risks associated with their use

Contrary to popular belief that the latrine must be located well away from the house, the VIP latrine can be constructed close to the house, provided that the vent pipe can receive plenty of sunlight so that it can be heated to release offensive odours and gases into the atmosphere. These odours and gases are effectively released if the VIP latrines are properly constructed and sited, and so the nuisances that they pose are minimized.

The VIP is constructed in nearly the same way as the conventional type of pit latrine except that provision is made for certain additional features. Drawings of the VIP are provided in Figure 51. The main guidelines relating to construction of the VIP latrine are:

- The pit should be about 5 to 6 feet in depth, and approximately 3 feet in length and width.
- The pit must be dug to make allowance for the vent pipe on the side which will receive sunlight for most of the day (usually the south-west side).
- The slab must be placed on at least one row of blocks and not on the ground.
- The slab should be at least one foot longer and wider than the opening of the pit.
- The blocks can be placed by constructing a trench approximately 2-3 inches from the edge of the pit. The trench should be 4 inches wide and 2-3 inches deep. Some mortar should be placed in the trench and the blocks laid on the mortar.
- The slab should fit exactly on the blocks with only the allowance for the vent pipe being left exposed.
- All cracks and crevices within and between the blocks and the slab should be securely sealed.
- The superstructure should be of the same length and width as the slab.
- Before placing the superstructure over the slab, the bottom of the superstructure should be treated to repel ants and termites.
- The vent pipe must be placed outside of the superstructure and painted black so that it will heat the gases to promote their expulsion into the atmosphere.
- The vent pipe must be provided with a screen or fly trap at the top to prevent the escape of flies which may enter the pit.
- The superstructure should be protected for the first 2 feet off the ground with tin or zinc sheeting. This serves as a rodent guard as well as for protection from rain-splash, to prevent early rotting

7.0 Concluding Remarks

As simple or insignificant as activities related to low-income housing may appear to be, they may contribute to significant environmental problems unless certain measures are adhered to. Some of these measures may be quite simple and relatively cheap. However some low-income homeowners may be unable to afford to implement some of these measures.

In seeking to assist persons in the low-income bracket to own their own homes, development agencies and funding agencies should give consideration to the environmental impacts of their housing programmes and provision should be made within these programmes for assistance to be given to homeowners and relevant national agencies to enable them to address any negative impacts. Such assistance will contribute to the improvement of the overall quality of life of the beneficiaries of the low-income housing programme, and in turn, to the overall sustainable development of the nation.

There are very few policy and legal instruments or technical guidelines addressing matters relating to low-income housing. This is somewhat surprising, as over the past several years, low-income housing and the related programme area of poverty reduction have been identified as key components of Government's development agenda. Therefore, there appears to be a need to develop policies and relevant supporting legislation, regulations and guidelines, which provide the framework for effective and sustainable development of the low-income housing sector. In that regard, the Department of Housing should undertake the development of a National Housing Policy which will, among other things, address the underdeveloped framework for the promotion of low-income housing.

Further, the planning approval process in relation to low-income housing needs to be addressed. The current process does not account for the peculiar circumstances of low-income persons, with the result that a significant proportion of these persons who pursue establishment or construction of their homes do not seek planning approval. The process is generally too complex and expensive for these persons, and the technical requirements of the Development Control Authority (DCA) may further add to the construction costs, thereby making it more difficult to construct a house which satisfies the requirements of the Authority. Further, some funding agencies, including the NRDF, do not require planning approval as a pre-condition for lending. This is cause for concern, as they appear to be facilitating the establishment of developments without the approval of the DCA. The NRDF and other financing agencies involved in low-income housing should therefore be encouraged to enter into dialogue with the DCA and its technical arm, the Physical Planning Section of the Ministry of Physical Planning, Environment and Housing, with a view to implementing appropriate mechanisms and procedures to facilitate and promote the legal establishment of low-income housing developments.

References—Environmental Siting Guidelines

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Gumbs, F.A. *Soil and Water Conservation Methods for the Caribbean*. 1987. University of the West Indies, St. Augustine, Trinidad.

UNESCO, 1997. *Planning for coastline change-Guidelines for construction setbacks in the Eastern Caribbean islands*; CSI info4.

List of Principal Agencies to be Contacted on Matters Relating to Environmental Management and Low-Income Housing in St. Lucia

Agency	Address	Telephone/Fax/E-mail
Department of Housing Ministry of Physical Development, Environment and Housing	Greene's Building Sans Soucis Castries	Tel: (758)-468-4400 Fax: (758)-458-2330
Sustainable Development and Environment Unit Ministry of Physical Development, Environment and Housing	Greaham Louisy Administrative Bldg Waterfront Castries	Tel: (758)-468-4460 Fax: (758)-452-2506 sdestaff@planning.gov.lc
Physical Planning Section Ministry of Physical Development, Environment and Housing	Greaham Louisy Administrative Bldg Waterfront Castries	Tel: (758)-468-4438 Fax: (758)-452-2506 gisunit@hotmail.com
Environmental Health Department Ministry of Health, Human Services and Family Affairs	Chaussee Road Castries	Tel: (758)-452-2859 Fax: (758)-452-5655 e-mail: health@candw.lc

Minimum Standards Checklist for use by Builders

a. Foundation:

1. Solid cement/concrete pillars, minimum 9” x 9” in cross section, firmly embedded 18 inches in ground with ½” rebar extending 12 inches above foundation.

   OR

2. Wooden pillars (6" x 6" minimum or 8" diameter) of treated lumber, sunk at least 4 feet into the ground

Note: the height of foundation pillars should be controlled to prevent possible buckling or overturning. A maximum of 2’ between the ground and the underside of the building is recommended.

b. Walls:

1. Wall plate/sill attached to cement foundation/pillars by bolted rebar
2. Wall plate/sill attached to wooden pillars by straps and nails
3. Floor joists toe-nailed to wall plate
4. Wall uprights (studs) located at 2'-0" centres or 16” centres for increased rigidity.
5. Double studs around doors and windows and cross braces at corners

c. Roof:

1. Hip or gable shaped roofs with minimum 30 degree slopes
2. Overhang of approximately 8" or less horizontal, or maximum 18” when enclosed
3. Ventilation installed in gable ends
4. Rafters attached to wall plate with twisted metal straps
5. Rafters located at 2'-0" centers maximum
6. Every second set of rafters connected by collars or ties beneath the ridge board
7. Cross laths (purlins) located at 2'-0" centres
8. Galvanized sheets of no thinner than 26 gauge should be used (24 gauge is the recommended thickness.)
9. Galvanized sheets should overlap to at least one complete corrugation but preferably two complete corrugations
10. Galvanized sheeting should overlap at least 10" when they are joined lengthwise.
11. Galvanized sheets should be nailed at the top of every corrugation at eaves and the ridge board and every second corrugation on lath/purlins. Nailing should be done through the crown of the corrugation and a wooden fillet to the purlin/lath.
12. Ridge is capped and nailed at every corrugation.
13. Dome head galvanized nails or washered bolts used for roofing.
14. Porch/veranda roof is separate from house roof and can break away.

d. Windows/Doors:

1. Shutters made and attached for rapid closing OR Shutters pre-made and stored to be nailed in place before storm strikes
2. Family trained to keep all entrances closed throughout storm period and/or open entrance on opposite sides of house to neutralize air pressure.

Summary

Building meets all minimum hurricane resistance standards of the Safer Housing Programme:

___________________________________ ___________________________________

(Inspector's Signature) (Date)

Building fails to meet minimum hurricane resistance standards of the Safer Housing Programme. The following items must be completed in order to qualify for final loan disbursement.

1) ____

2) ____

3) ____

4) ____

5) etc ____

___________________________________ ___________________________________

(Inspector's Signature) (Date)

Easy Guide Checklist

Hurricane-resistant Home Improvement Checklist
for use by HRHIP Building Officer

Lower Income Families in the Caribbean

Premises

1) The families owning these properties have a modest income, desire to do home improvements and will need to be guided as to the value and importance of including hurricane resistance measures in their home improvement plans.
2) Any hurricane resistance measures included will need to be folded into the larger home improvements the family desires.
3) Families may have to do both their home improvement and hurricane resistance retrofitting in progressive stages, for they may not have enough funds to complete the entire project at one time.

Priorities

When a complete retrofitting project cannot be financed all at one time, then retrofitting measures should be undertaken in the following order of priority:

1. Strengthening and tying down the roof as much as possible, since heavy rains and damaging winds are perennial occurrences in the Caribbean. If the roof fails, whether in hurricane or regular storms, all the other home improvements will be damaged and possibly wasted.
   - replace any rotten roofing sheets and/or rafters
   - add extra nails with dome heads in corrugated sheeting
   - box eaves and/or cut off overhang in excess of 8 inches
   - insert extra lath/purlins and nail sheeting to the laths
   - strap roof rafters to wall plate and ridge beam using metal connectors
   - place collar ties on every second set of rafters
2. Establishing a firm footing/foundation and tying the house to this solid foundation. If a house shifts off of its footing during a storm there will be great water leakage and damage to other home improvements.
   - embed into the ground four or more concrete/wood pillars to strengthen footing
   - bolt/strap floor sill to new and existing footing/foundations
3. Strengthening the walls at the corners, around doors and windows and where they are attached to floor sill and wall plate.
   - strap wall studs to floor sill and wall plate using metal connectors
   - double studs around doors and windows and add cross braces in corners
   - add extra studs if currently installed further than 20 inches apart
4. Providing protection/shutters to doors and windows to withstand winds
   - teach family members how to completely close and/or leave open opposite entrances to neutralize air pressure in hurricane force winds.
   - construct pre-fit shutters that can be installed or nailed on when needed
5. Implement the remainder of the items on the minimum standard checklist and/or additional amounts of each of the above (i.e. six footing pillars instead of four, more metal straps, additional studs etc.)

All of the above skills can be taught to any family member who has a working knowledge of a hammer, saw, measuring tape and nails. Therefore, a family with severely limited resources can save costs by doing much of the work themselves under the watchful eye of a technical supervisor.

Each of these steps can be done progressively as and when the family has the funds to buy the necessary supplies. A family may choose to repair and strengthen the roof in the first year, and then construct a new kitchen (with some hurricane resistance included) in the second year. In subsequent years they can do the footings and strengthen the walls. Each step will make the house stronger and more hurricane resistant. The risk with this progressive approach, however, is that a strong hurricane will hit midway in the project and destroy the repairs made before the entire house is fully strengthened.