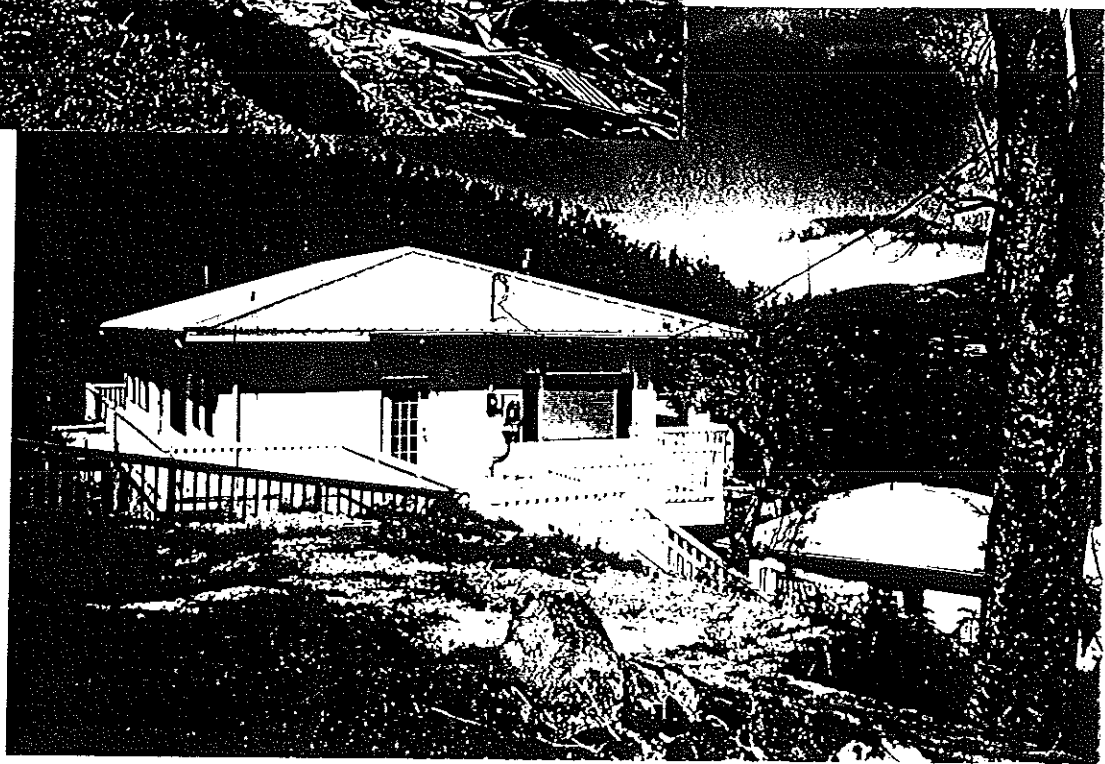
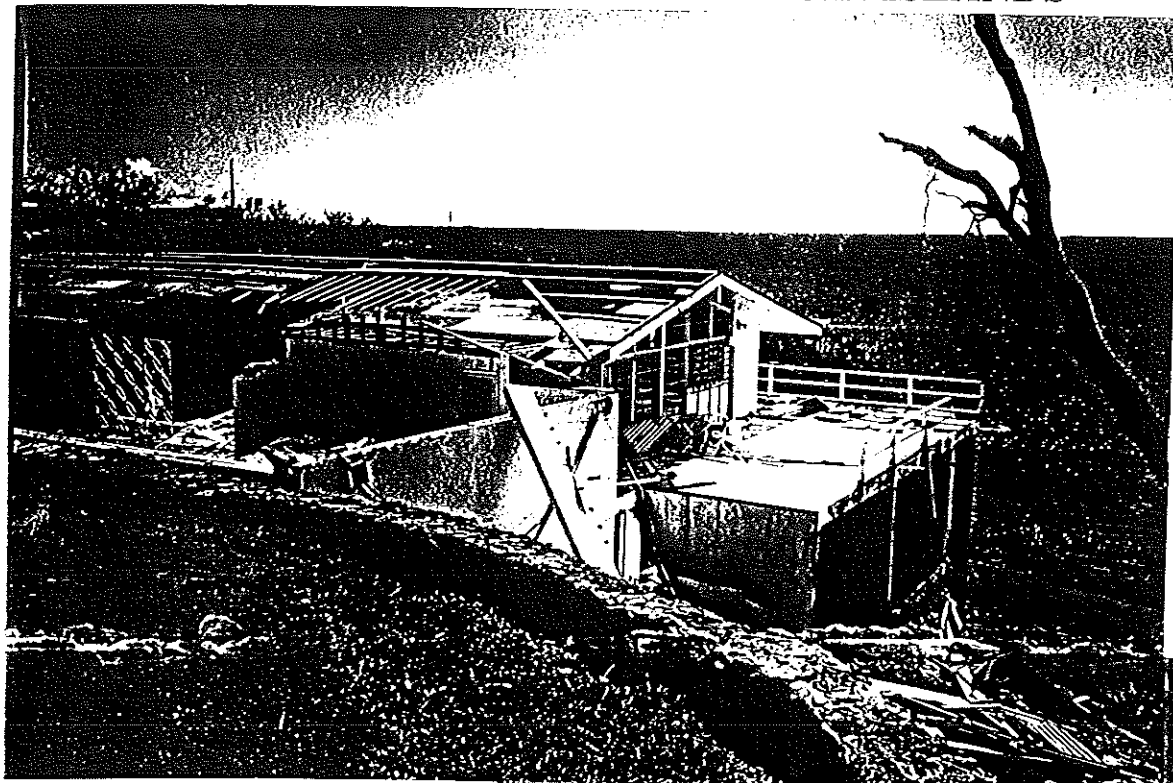


# BUILDING TO RESIST HURRICANES

A CONSTRUCTION GUIDE FOR HOMEOWNERS  
IN  
THE VIRGIN ISLANDS



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# Building to Resist Hurricanes

## Purpose

The purpose of this general fact sheet is to introduce a series of individual fact sheets produced by the Federal Emergency Management Agency that describe various "hurricane resistant" construction techniques. Individual fact sheets describe the basic procedures and concepts involved in building or repairing a house to withstand hurricane force winds.

## Discussion

### Hurricane Resistant Homes

Don't be a victim twice! Building or repairing your house to withstand hurricane force winds can prevent much of the damage to your home the next time the winds begin to blow.

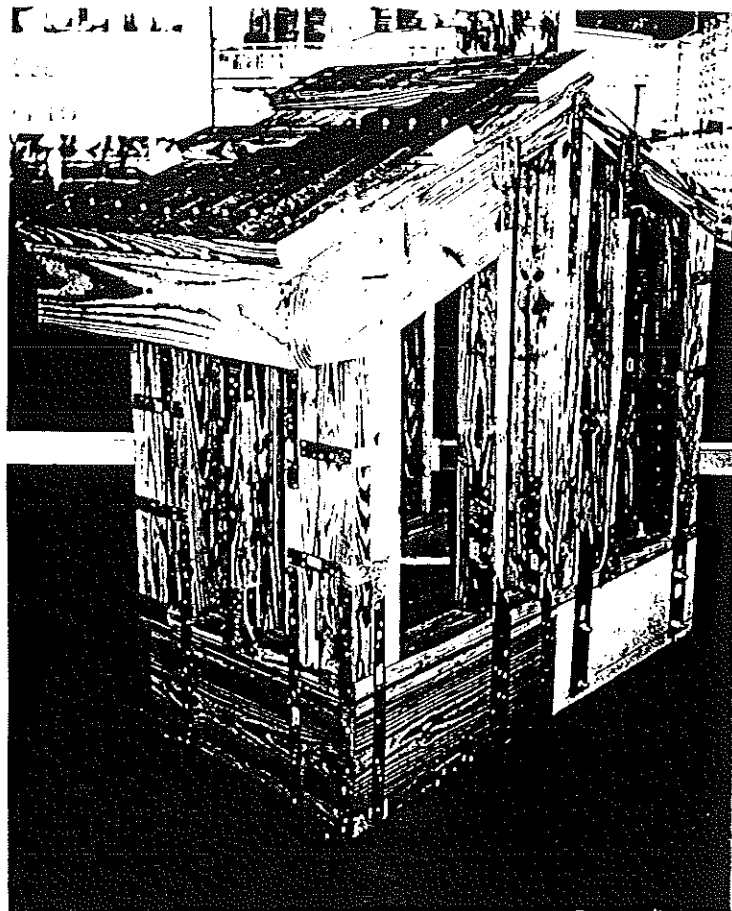
Building to resist hurricanes means using construction practices, techniques, and materials that are stronger than would normally be used. Special connectors tie the major components together so the house is strong from the foundation all the way to the roof.

Some of the following techniques can be used by homeowners with basic homebuilding skills. Others require the expertise of skilled tradesmen. The following techniques include the use of bolts, metal straps, screws and specially designed metal hurricane connectors to make your house much stronger. Strengthening your home now is one of the most important steps you can take to protect your family and your property.

### What about Earthquakes?

The Virgin Islands are located in a high seismic hazard area. Structures on the islands are at risk from damage caused by an earthquake. Seismologists tell us that the Virgin Islands are overdue for a large earthquake.

There are measures that homeowners can take now which would greatly lessen the impact from earthquakes on their property. Many of the same principles used in tying all the parts of the house together which are described in this fact sheet series, are also directly applicable to earthquake safety construction techniques.



### Building Permitting

The Virgin Islands Department of Planning and Natural Resources (DPNR) requires that a building permit be issued for all construction. Specific building code requirements must be met before construction can begin. This is to provide protection for you, the homeowner, against sub-standard construction practices.

The information in the Hazard Mitigation Fact Sheet series does not constitute a full description of the DPNR building permitting requirements. Please contact DPNR for further information regarding permits and safe construction practices.

## Key Connections

The most important technique to use in making your house wind resistant is to tie it together by constructing and reinforcing the connections to resist wind forces from all directions. This concept, known as "continuous load path", means transferring the wind forces from one part of the house to another until they are transferred to the ground. Any weak connection will cause the house to fail at that point.

Ways to tie your house together include:

- Secure the roofing materials to the purlins using screws.
- Secure the purlins to the roof sheathing (such as plywood) using screws.
- Secure the roof sheathing to roof rafters using screws.
- Anchor the roof ridge together using metal connectors.
- Secure the roof rafters to the walls using hurricane connectors.
- Strengthen wood walls with exterior sheathing or approved bracing.
- Reinforce both masonry or concrete walls.
- Properly fasten the sheathing to the wall studs.
- Secure the wall to the foundation.

## Strong Construction

Strong construction techniques used to build hurricane resistant housing are basically the same ones that are done during normal construction, except that stronger or extra materials are used. Cost-effective prevention techniques include:

- Center studs at 16" in wood frame construction.
- Wood walls need to have horizontal or diagonal bracing. Use exterior sheathing properly fastened to studs to provide needed strength.

- Use high grade concrete mixed to required specifications.
- Concrete block walls, when used, need to be filled with grout and reinforced with steel rebar. Reinforcing needs to be placed horizontally as well as vertically.
- Use adequately pressure-treated wood for construction. Check with DPNR for proper applications.
- Foundations should be correctly constructed and adequately reinforced to provide a sufficient base for the house. Some foundations, such as those on hillsides, need special design by a professional engineer.

## Hurricane Mitigation Fact Sheets

Because of the various building types in the Virgin Islands several different fact sheets have been prepared. Each of these deals with a particular key connection. By selecting the correct fact sheets, you can learn how to tie together all of the components of your house.

The fact sheets used in this series each discuss recommended details for connections. Methods of anchoring that have worked in both the Virgin Islands and other areas that experience high winds are described.

The following fact sheets are currently available from the Federal Emergency Management Agency and the Virgin Islands Department of Planning and Natural Resources.

1. Building to Resist Hurricanes
2. Building Construction Checklist
3. Building the Roof
4. Connecting the Roof to a Wood Wall
5. Connecting the Roof to a Masonry Wall
6. Shutters and Hurricane Panels
7. Building Strong Walls
8. Connecting the Walls to the Foundation
9. Building the Foundation



# Building Construction Checklist

This checklist is designed to help you through the construction process. The path that you take from assessing your damage, to designing your repair, to obtaining a permit, to actual construction, can be complicated, and it is important that each step is carefully considered. Please use this checklist to guide you through the construction and/or repair process.

## PLANNING YOUR CONSTRUCTION

- Have three sets of drawings been submitted to DPNR and a building permit been obtained?
- Have electrical and/or plumbing permits been obtained from DPNR?
- Have you hired a reputable contractor, and obtained a written estimate?
- Do you need to obtain flood insurance?
- Do you need a permit from Coastal Zone Management?

## FOUNDATION CONSTRUCTION

- If the house is located in a difficult area, such as on a hillside, is the foundation designed by a professional engineer?
- Is the foundation correctly designed with proper strength concrete and steel reinforcing?
- If the building is in a floodplain, is it properly elevated and reinforced?

## WOOD FRAME CONSTRUCTION

- Are the walls securely attached to the foundation and to the bottom and top plates with metal connectors and anchor bolts?
- Is exterior grade structural sheathing (such as plywood) fastened to the wall studs to strengthen the walls?
- Are the roof rafters securely fastened to the wall framing with hurricane connectors?
- Are connecting walls securely fastened and braced at the corners?

## CONCRETE OR CONCRETE BLOCK CONSTRUCTION

- Are walls securely fastened to the foundation by means of reinforcing bars in grouted cells?

- Is vertical and horizontal reinforcing steel provided at corners and around openings?
- Is there steel reinforcing placed horizontally in the walls?
- Are ring (bond) beams securely attached to the walls with reinforcing bars?
- Are top plates securely attached to the walls with anchor bolts?

## ROOF CONSTRUCTION

- Are rafters securely attached to the top of the wall frame and tied together at the ridge with hurricane connectors?
- Is exterior grade sheathing fastened to the rafters with the proper screws?
- Are purlins fastened to the sheathing and rafters with the proper screws?
- For metal roofing, is the metal fastened to the purlins using screws which are adequately spaced and of sufficient strength?

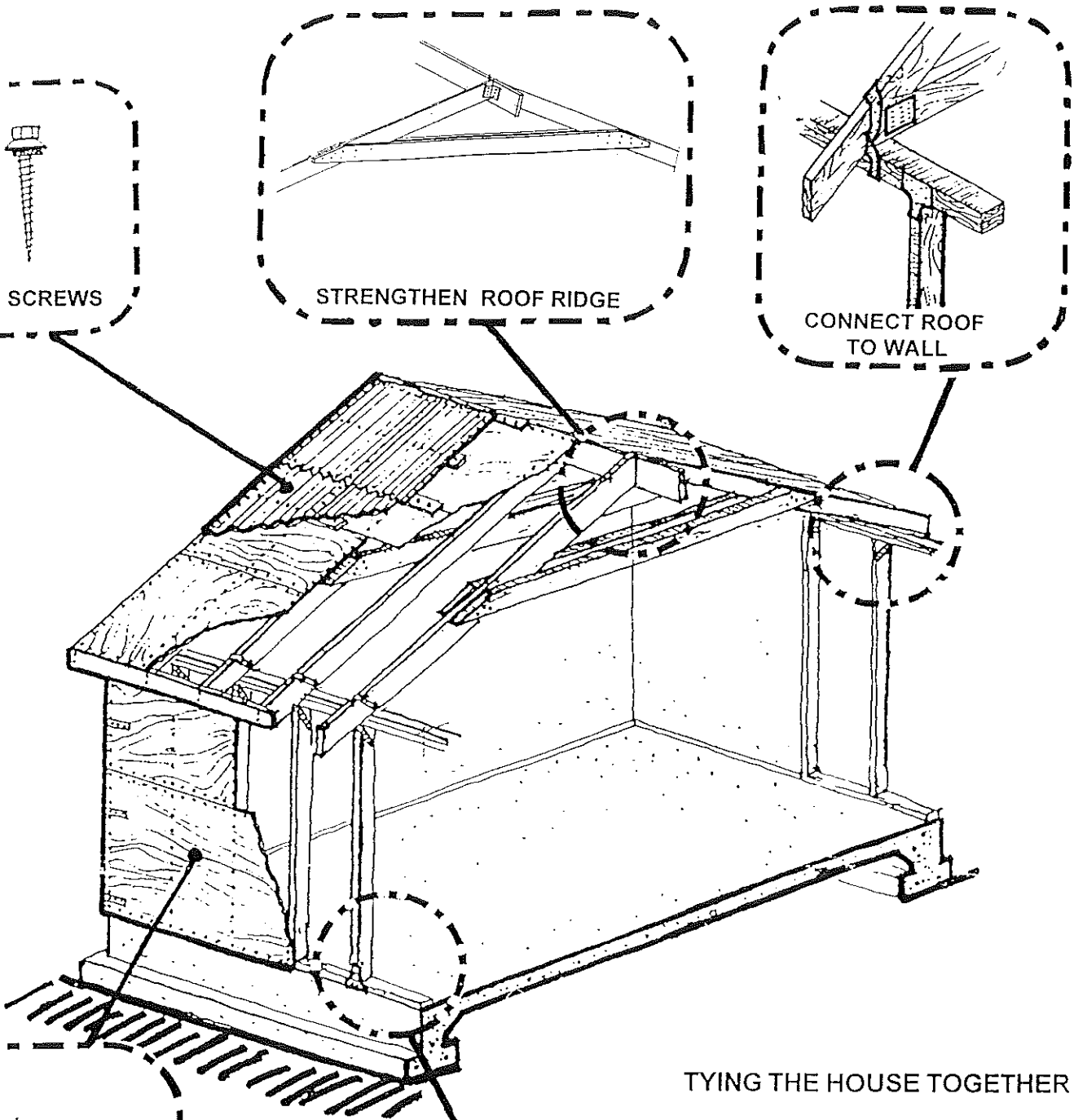
## SHUTTERS

- Are hurricane shutters provided for all glass openings or other openings which may need protection from high winds?
- Are shutters fastened securely with adequate screws?
- In lieu of permanent shutters, can temporary pre-cut plywood window coverings be easily installed prior to a storm?

## UTILITIES

- For damaged buildings, has a licensed electrician checked the weather-head and electrical systems?
- Has DPNR issued an electrical and/or plumbing permit?
- Has the cistern been checked for damage and contamination?

# TYING THE HOUSE TOGETHER

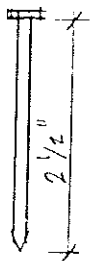


USE SCREWS

STRENGTHEN ROOF RIDGE

CONNECT ROOF TO WALL

Use exterior grade sheathing and attach with 8d nails @ 4" oc at edges, 8" oc at intermediate studs.



STRENGTHEN WALLS

BOLT WALL TO FOUNDATION

## TYING THE HOUSE TOGETHER

means that the individual parts of the house are well-connected to each other. This ensures that your house acts as a single unit attached to the ground. Individual parts of the house will not blow away.



# Building the Roof

## Purpose

The purpose of this fact sheet is to discuss methods to strengthen your roof framing, and to describe the attachment of the roofing materials to the roof frame.

## Discussion

The areas most prone to failure during the high winds of a hurricane are the attached roofing materials and the roof framing. In wood frame roof construction, extra care must be taken to strengthen the roof framing as well as to strengthen the attachment of the roofing materials to the roof frame. Two types of wood roofs are commonly found on the Virgin Islands: These are gable roofs and hip roofs (Figure 1). Hip roofs are less susceptible to the negative pressure lifting forces created by high winds driven across the roof. Gable roofs can be strengthened to perform satisfactorily under high wind loading.

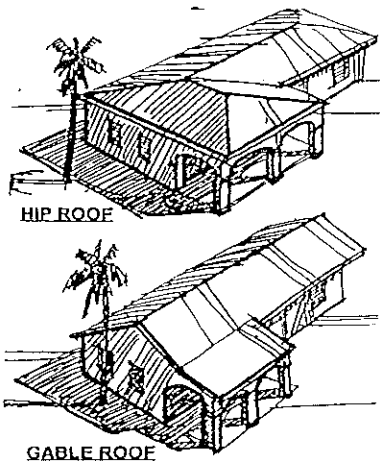


Figure 1. Roof types.

## Procedure

The basic frame of the roof can be strengthened by using metal connectors at the ridge-rafter connection along with metal strapping across the top of each rafter-ridge-rafter connection. For hip roofs, extra reinforcing should be placed at the ridge-ridge connections. For gable roofs, a collar tie can be added between the rafters to increase the roof framing stability (Figure 2).

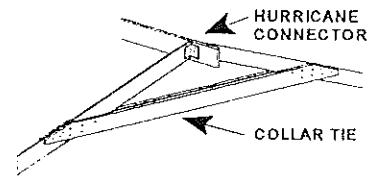
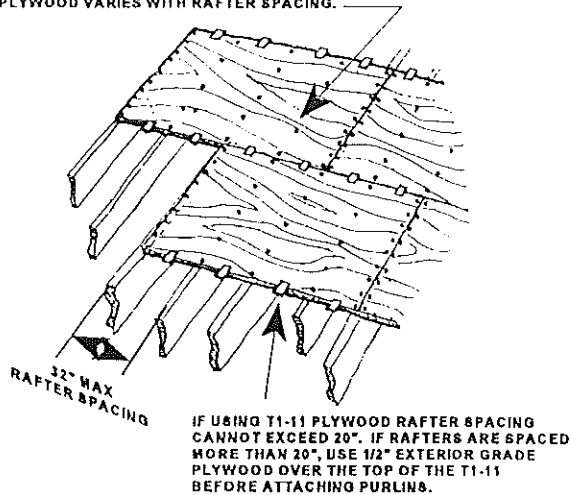


Figure 2. Gable roof collar tie to strengthen roof.

Gable ends should be braced to the roof framing and masonry gable ends should be reinforced to adequately resist the wind loads.

Roofs should be reinforced by attaching exterior grade sheathing (such as plywood) over the entire roof area. The sheathing should be screwed to the rafters every six inches at the edges and every 12" at the intermediate supports. Plywood connectors should be used between plywood sheets halfway between each rafter (Figure 3).

ATTACH 5/8" EXTERIOR GRADE PLYWOOD OR OTHER SHEATHING WITH #14 X 2-1/2" SCREWS SPACED AS REQUIRED. THICKNESS OF PLYWOOD VARIES WITH RAFTER SPACING.



\*STRONGER SHEATHING ALTERNATIVE: USE 3/4" TONGUE & GROOVE PLYWOOD

Figure 3. Roof sheathing.

To strengthen the attachment of the metal roofing to the roof, first attach 2" x 4" purlins spaced 24" to the plywood sheathing using screws. Corrugated, galvanized metal roofing material should be attached to the purlins using roof screws (Figure 4).

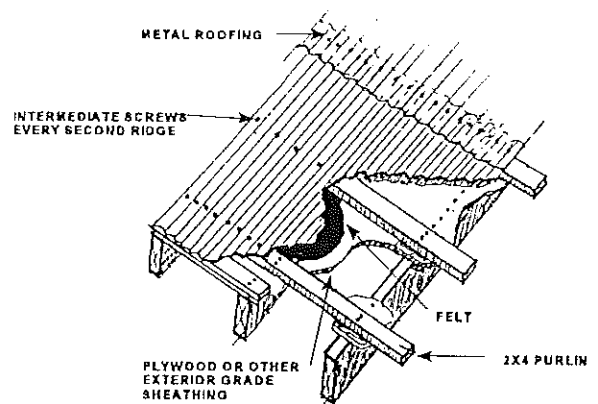


Figure 4. Securely attach roofing materials.

Overlap the galvanized metal by six inches (two corrugations) and screw overlapped sections together with screws (Figure 5).

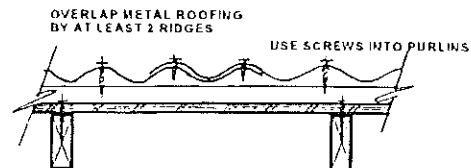


Figure 5. Overlap corrugated metal roof and secure with screws.



# Connecting a Roof to a Wood Wall

## Purpose

The purpose of this fact sheet is to describe various methods that can be used to connect roof framing to a wood frame wall. The procedures described can be used with a wood frame wall with plywood sheathing.

## Discussion

A very important connection is that between the roof framing and the walls, because the roof is subject to very strong uplift forces from hurricane winds. Wood frame roof systems covered with corrugated, galvanized metal sheets are very common in the Virgin Islands. Unfortunately, they are one of the first parts of the house to fail during a hurricane.

The strongly constructed roof that is not well-connected to the walls will likely fail at the wall connections. The commonly used method of toenailing roof rafters to the walls will not resist hurricane force winds. A strong roof to wall connection can be established by using the techniques recommended in this fact sheet.

The best source of information is the Department of Planning and Natural Resources (DPNR) and the local building codes. In some cases, you may want to use even stronger construction than what is indicated by the code.

## Procedures

### Connecting rafters or trusses to wall plates.

Rafters and trusses can be tied to the wall top plate in two ways. The first is to use specially designed metal connectors to attach the roof to wall plates *that are already well-connected to the wall studs* (Figure 1). The other method is to use metal strapping or connectors that tie the roof

rafters to the wall top plate and the wall stud (Figure 2).

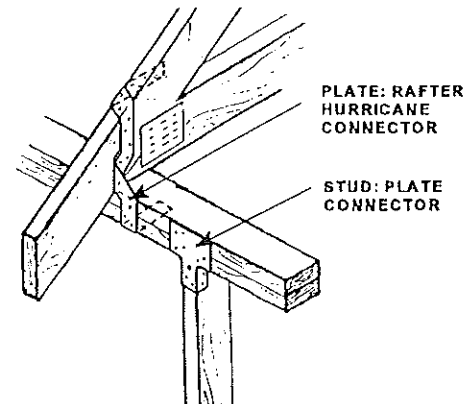


Figure 1. Connect the rafters or trusses to the top plate and to the wall studs using specially designed metal connectors.

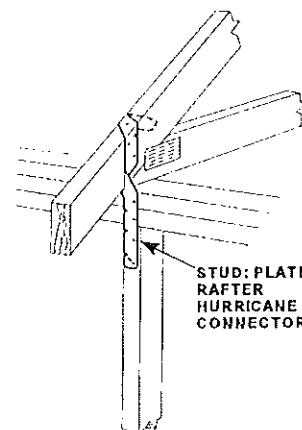


Figure 2. Connect the rafters or trusses to both the top plate and wall studs using specially designed connectors.

In choosing the appropriate connectors for your walls, refer to the manufactures tables for specially designed hurricane connectors, and the Building Department for code specifications.





# Connecting a Roof to a Masonry Wall

## Purpose

The purpose of this fact sheet is to describe various methods that can be used to connect a roof to a masonry wall. The procedures described in this fact sheet can be used with a poured concrete wall or one that has been made from concrete blocks.

## Discussion

Wooden roofs that are attached to masonry walls are very common in the Virgin Islands. These roofs are subject to very strong uplift forces from hurricane winds. Because of this, one of the more important connections are those between the roof and the walls. Unfortunately, they are one of the first parts of the house to fail during a hurricane.

A strong roof must be well-attached to the masonry walls that support it, or the roof will fail at the roof/wall connection. The roof rafters should be tied into the masonry construction by connecting the roof to an anchored top plate or by attaching the rafters directly to the ring (bond) beam.

As with any construction, it is required by law to obtain a building permit from the Department of Planning and Natural Resources to ensure that your building is in compliance with the Virgin Island Building Codes. The building code describes minimum building standards. In some cases you may want to strengthen construction beyond what the code requires.

## Procedures

**Key connections.** The following modified Virgin Island construction techniques will meet or exceed code: 1) connecting a top plate to the masonry wall and attaching hurricane connectors,

2) embedding roof connectors into the bond beam or, for retrofitting existing structures, 3) attaching hurricane connectors to existing bond beams, and pouring new concrete.

**Connecting a top plate to the ring (bond) beam - new construction.** The top plate is the wood that is connected to the top of the masonry wall to create an anchoring surface for the roof rafters. This wood serves as the anchor surface for the roof and it is critical that it be firmly connected to the concrete or block. This can be done with bolts, straps or connectors that are embedded in the concrete ring beam, as shown in Figures 1, 2 and 3. Connect the rafter to the top plate using specially designed connectors. Connecting the roof directly to the ring (bond) beam new construction. You can anchor the rafters directly to the bond beam by embedding metal straps into the concrete bond beam, and then attaching these straps directly to the rafters.

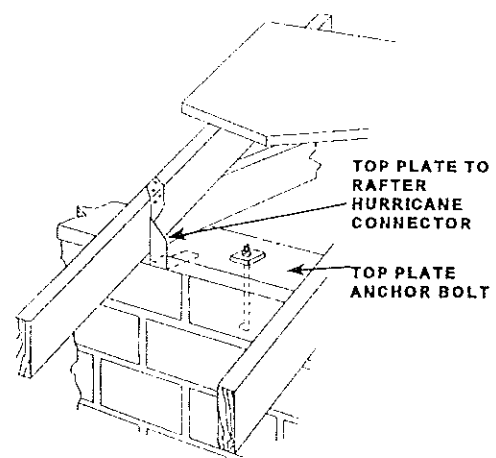


Figure 1. Connecting the top plate to the wall and the rafters to the top plate.

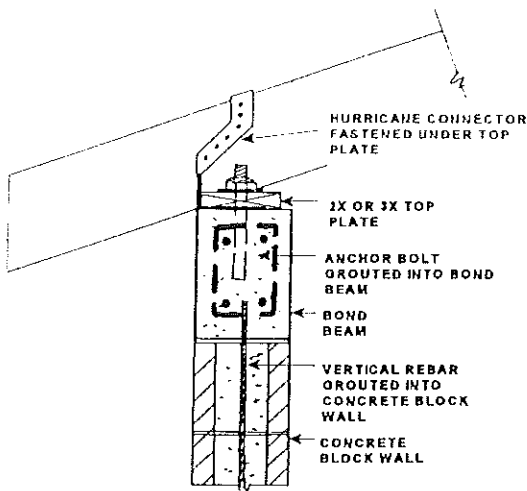


Figure 2. Attaching the rafter to the top plate and the top plate to the ring beam.

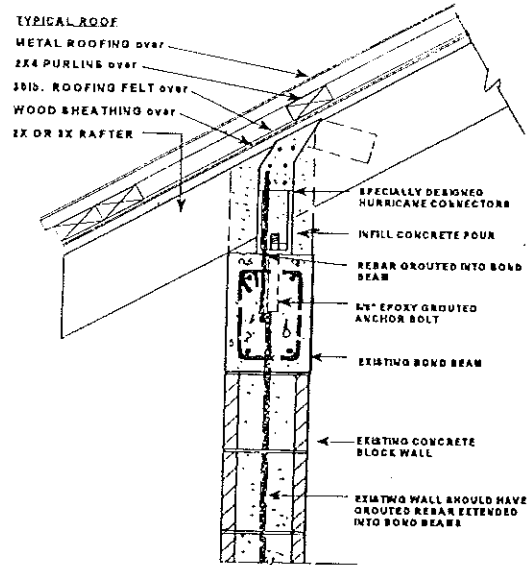


Figure 4. Recommended retrofit procedure - Connector top-mounted to existing masonry and then infill with concrete.

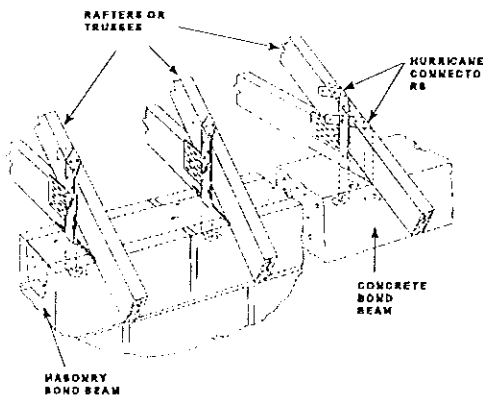


Figure 3. Attaching the rafters to the top of a masonry wall using embedded hurricane connectors.

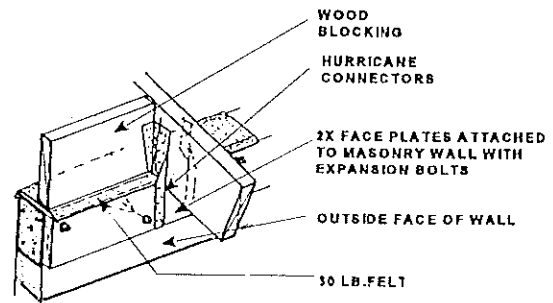


Figure 5. Retrofit procedure - Connector attached to face-mounted plate.

### Connecting the roof to the ring (bond) beam - retrofitting or repairing existing construction.

To retrofit existing construction there are several methods. One involves pouring and anchoring new concrete infill above an existing bond beam after metal connectors have been fastened to the existing rafters and the existing bond beam (Figure 4). Another method is to add a wood plate to the face of the bond beam using expansion bolts and then attach this plate to a properly blocked rafter using either metal straps or hurricane connectors (Figure 5).

One common repair involves replacing an existing top plate, anchoring the new top plate to the existing wall, and fastening the properly blocked rafters using metal straps or hurricane connectors (Figures 6 and 7).

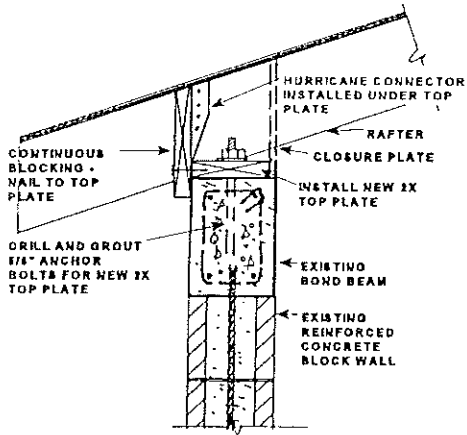


Figure 6. Retrofit procedure - Connector under the top plate.

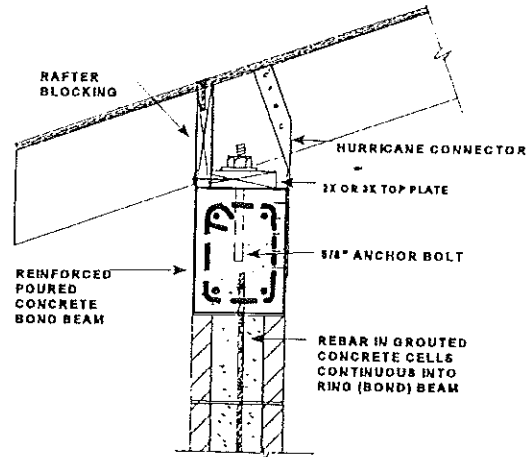
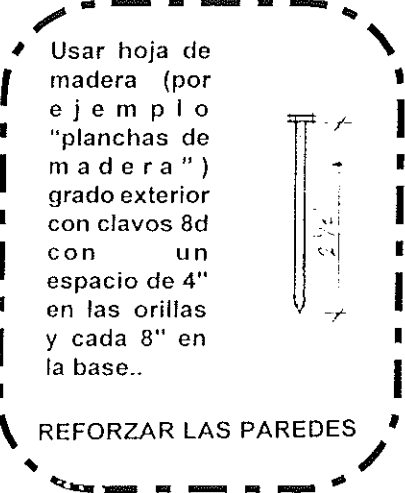
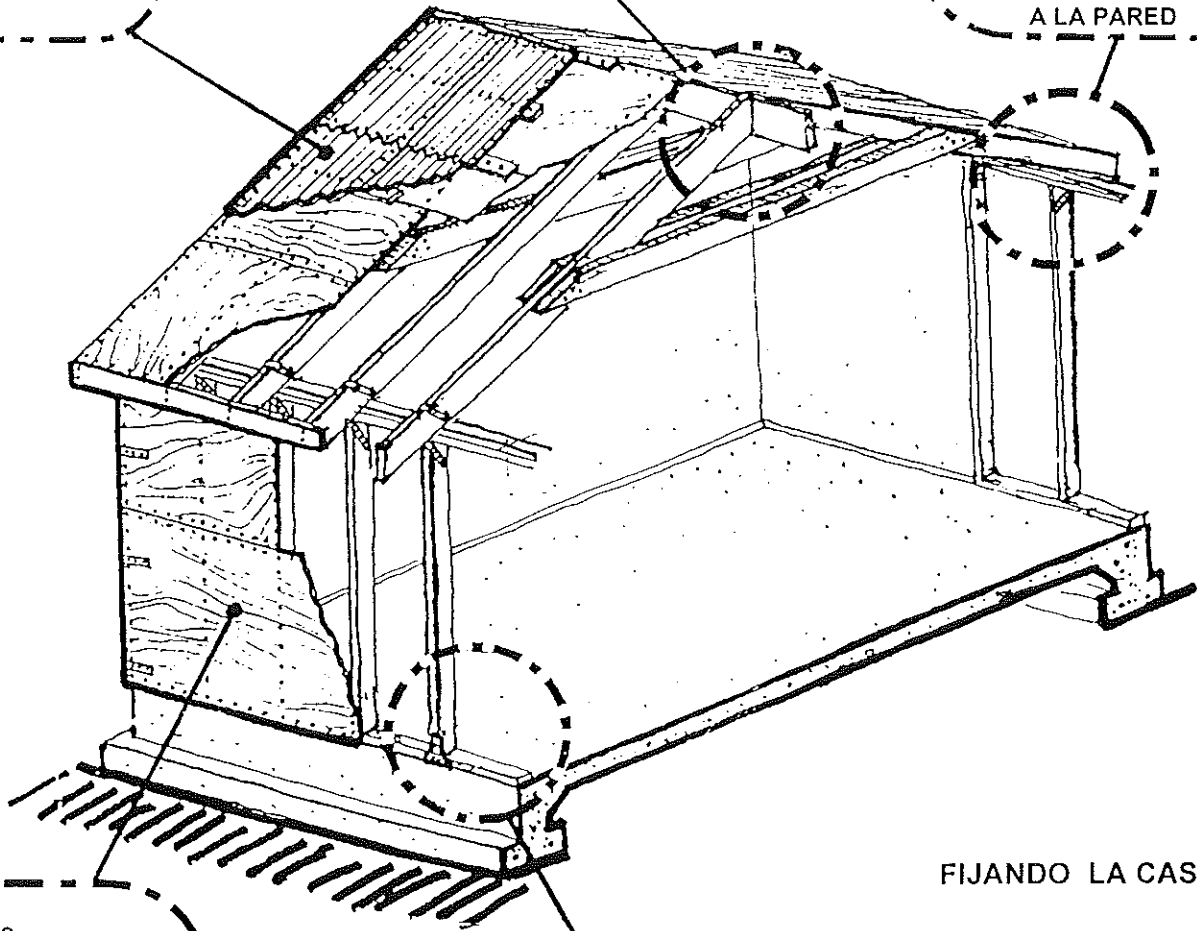
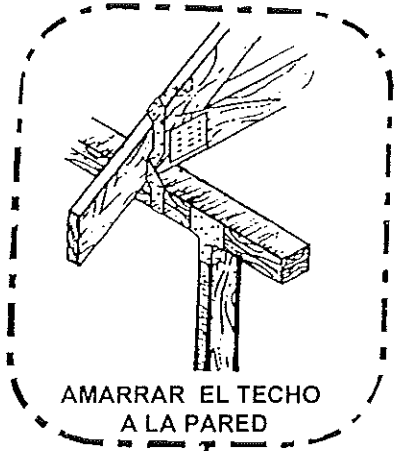
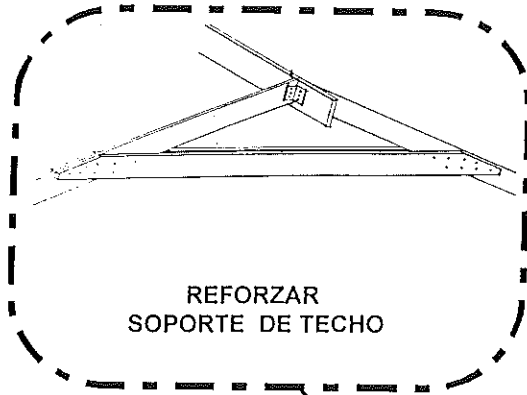
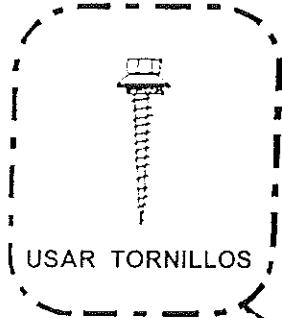


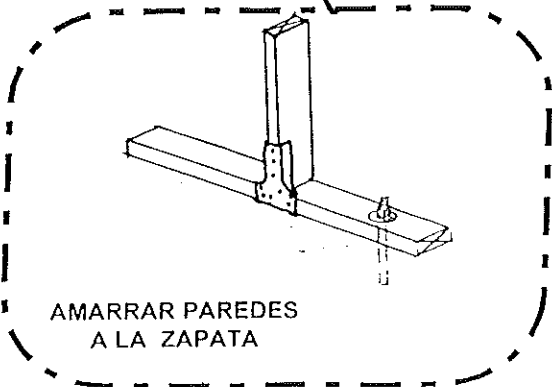
Figure 7. Retrofit procedure - Connector face mounted to masonry.

Other connection designs may be more appropriate for your home. A professional architect or engineer can design a system that will meet the requirements of the new building code and also work for you.

# FIJANDO LA CASA



Usar hoja de madera (por ejemplo "planchas de madera") grado exterior con clavos 8d con un espacio de 4" en las orillas y cada 8" en la base..



## FIJANDO LA CASA

quiere decir que las partes individuales de la casa esten bien conectadas entre si. Esto asegura que su casa actúe como una unidad sola atada al suelo. Partes individuales de la casa no serán derribadas.

# Listado Para la Construcción de Edificios

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Este listado ha sido diseñado para ayudarle a través del proceso de construcción. Los pasos que tomes para evaluar los daños, diseñar sus reparaciones, obtener un permiso, hasta la construcción, puede ser complicado, y es importante que cada paso sea cuidadosamente considerado. Por favor, use este listado para guiarle a través del proceso de construcción y/o reparación.

## PLANIFICANDO SU CONSTRUCCION

- ¿Sometió tres planos a DPNR y obtuvo un permiso de construcción?
- ¿Ha obtenido permisos de DPNR para la electricidad y/o plomería?
- ¿Empleó a un contratista acreditado y obtuvo un estimado por escrito?
- ¿Necesita obtener seguro de inundación?
- ¿Necesita obtener un permiso de la Administración de la Zona Costera?

## CONSTRUCCION DEL CIMIENTO

- Si la casa está localizada en un lugar difícil, tal como en una loma, ¿ha sido el cimiento diseñado por un ingeniero licenciado?
- ¿Están los cimientos correctamente construidos con fuerza adecuada de concreto y reforzado con hierro?
- Si la estructura esta en un área de inundación, ¿ha sido elevada y reforzada adecuadamente?

## CONSTRUCCION DEL ARMAZON DE MADERA

- ¿Están las paredes conectadas al cimiento y a las placas de base y superiores con conectores de metal y tornillos de ancla?
- ¿Se han puesto planchas de madera (~~grado exterior~~) para reforzar las paredes?
- ¿Están las viguetas del techo firmemente conectadas al armazón de la pared con cintas de metal?
- ¿Están las paredes firmemente sujetadas con abrazaderas en las esquinas?

## CONSTRUCCION CON BLOQUES DE CEMENTO

- ¿Están las paredes firmemente fijadas al cimiento por medio de barras de refuerzo?
- ¿Se ha instalado acero vertical y horizontal reforzado en las

esquinas y aberturas? -

- ¿Están las vigas firmemente fijadas a las paredes de mampostería por medio de barras de refuerzo?
- ¿Están las placas superiores firmemente fijadas a la pared con amarres de metal de anclaje?

## CONSTRUCCION DEL TECHO

- ¿Están las viguetas fijadas a la parte superior de la pared y amarradas al techo cresta con conectores de metal?
- ¿Se han atado planchas de madera grado exterior a las viguetas del techo con tornillos?
- ¿Se han atado alfajías a las planchas de madera con tornillos?
- Si usa techo de metal, ¿está sujetado a las alfajías con tornillos separados y adecuados?

## TORMENTERAS

- ¿Se han provisto tormenteras para toda abertura con cristales u otras que necesiten protección de los vientos fuertes?
- ¿Están las cubiertas protectoras firmemente fijadas con tornillos?
- Donde no existan tormenteras permanentes, ¿se pueden instalar planchas de madera fácilmente antes de una tormenta?

## SERVICIOS PUBLICOS

- En los edificios dañados, ¿fueron revisados los sistemas eléctricos y medidos por un electricista licenciado?
- ¿Existe permiso de electricidad o plomería de DPNR?
- ¿Ha verificado la cisterna por daño y contaminación?