Code-Based Wind-Resistant Roofing for Homes: Reducing Wind Damage in the Commonwealth of the Northern Mariana Islands

This Recovery Advisory provides guidance to homeowners for design, repairs, and maintenance of their homes in the Commonwealth of the Northern Mariana Islands (CNMI. These guidelines are helpful for all homes, regardless of whether they were damaged by Super Typhoon Yutu in October 2018. It offers tips to homeowners about evaluating, repairing, and maintaining single-family homes. This guidance comes from observations made and lessons learned by FEMA's Super Typhoon Yutu Mitigation Assessment Team and from past hurricane building performance assessments.

The first step to repair or retrofit a home is to inspect all parts of the building that are exposed to high winds. This is important for all buildings, even if they were not damaged. If undamaged elements are found to be vulnerable, they should be mitigated as part of the repair work to help minimize future damage. Regular inspection, maintenance and repair of building elements are key to avoiding disaster damage.

This Recovery Advisory focuses on residential roof construction and materials, and roof-to-wall connections. It also details a seven-step process for enhancing your safety by improving the performance of your home during high winds.

Key Issues Addressed by this Recovery Advisory

- The environment in the CNMI creates unusually high winds with high-velocity wind-borne debris and harsh conditions that lead to decay and deterioration.
- Resisting these extreme conditions requires special materials and attention to construction details.
- Understanding the condition of the home and having a management plan is an important part of homeownership, repair, and maintenance. Failing to plan is planning to fail. Maintenance and repair are essential homeownership practices in the CNMI.
- Specific guidelines about design and materials for home repairs for roofs, connectors, and fasteners should be followed.
- Island environments require special design and construction practices. Resources and references are provided to assist homeowners with these procedures.

Design Wind Speeds: Exposure and Topographic Effects

The CNMI adopted and started using the 2018 International Building Code and International Residential Code (IBC and IRC) in 2019. The IBC and IRC govern the design and construction of one- and two-family dwellings. The code requires homes to be designed to resist design wind speeds.

Design wind speeds specified by the IBC and IRC are used to calculate the wind loads exerted on a building during a wind event. Design wind speeds are established for a certain physical setting and must be adjusted for site-specific effects, including building exposure, and topographic effects of sloping terrain, which may be different for each site.

Homes that have less protection from the direct wind path will experience higher winds. Thus, homes that are closer to the coast are more exposed to greater wind speeds from open water.

Higher wind speeds also can be caused by changes in topography or the shape of the land, such as hills, ridges, and escarpments. As shown in Figure 1, the effects of terrain on wind speed for design in Saipan includes topographic effects. Homes located on the upper half of these hills, ridges and escarpments should be designed to withstand increased wind speeds. Homes located on ridge lines will experience higher wind speeds than homes on lower, flat terrain (see Figure 2). The topographic speed-up increases in wind speed results in extremely high wind loads. Wind forces do not increase linearly, so a doubling in wind speed has a fourfold increase in wind loads. Including these effects during design helps improve building performance.

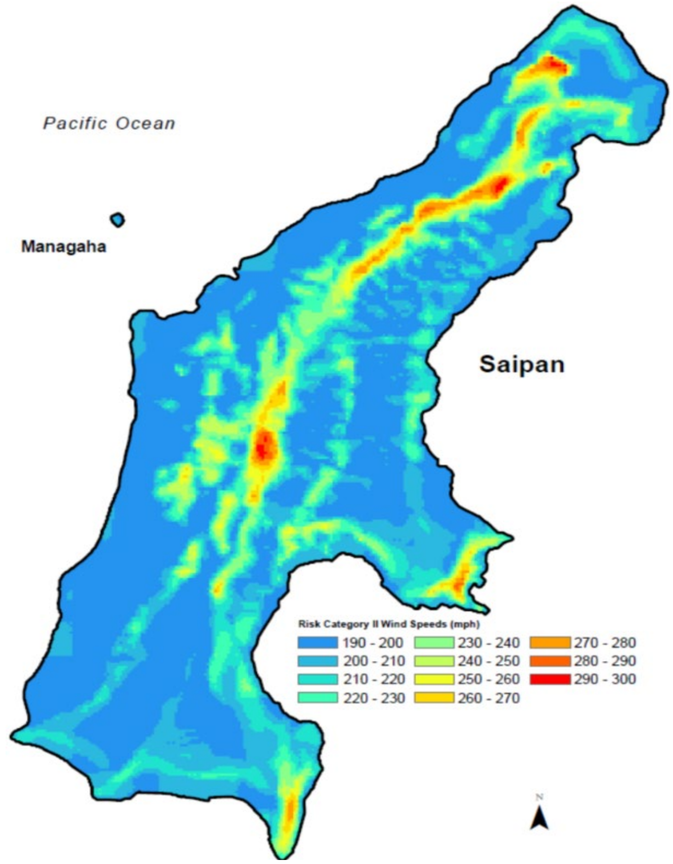

Figure 1: Colorized Wind Speeds for Saipan showing the effect of topography. [Image Source: Special Wind Region (SWR) Maps for the Commonwealth of the Northern Mariana Islands (CNMI) FEMA Handout]

Figure 2: Homes located on a ridgeline, like these in Saipan (indicated by red arrows), typically experience higher wind speeds than homes on lower, flat terrain. See map in Figure 1 also.

Architects and engineers who design homes can visit The Applied Technology Council (ATC) website for hazard identification: https://hazards.atcouncil.org/. The site is available to anyone who wants to learn more about the hazards of a location.

Roofing System: Construction Materials and Details

The extreme winds and harsh environment in the CNMI require architects, engineers, designers, and builders to choose strong and durable materials and products. Design wind speeds for homes in the CNMI can range from 190 mph to more than 290 mph in some locations. For comparison, buildings in the interior mainland United States have residential design wind speeds of about 110 mph. Designs that suit those mainland U.S. areas are not appropriate for the CNMI.

The most successful materials for framed roofs in the CNMI are metal roofing installed over strong, pressure-treated roof decking or sheathing. Roof systems that do not have structural decks are not sturdy enough to transfer loads that are required to protect life and property (see Figure 3).

Figure 3: Corrugated metal roofing typical for the CNMI. Note the absence of roof decking or sheathing under the metal roofing as is required for load transfer. This is not good practice.

Roof Sheathing and Decking

The use of roof sheathing or decking provides needed strength, while the metal roof panels provide weather resistance. Wood framing for roofs must be pressure treated, extremely strong, well connected, and closely spaced (2 feet or less). Determining the size of wood members should be done by a licensed design professional, either an architect or engineer, using the appropriate wind loads specified in the building code. The American Wood Council (AWC) has reference materials and online tools available to help with these decisions. Concepts and guidance for the design and construction process in the CNMI are available in FEMA reports and Recovery Advisories for similar events, such as the U.S. Virgin Islands and Puerto Rico from hurricanes Irma and Maria in 2017.

The use of roof sheathing or decking is required when corrugated metal roofing will be installed over roof framing. This is because the corrugated metal roofing, by itself, cannot effectively transfer the wind-induced loads to the framing and beyond. The corrugated metal acts as a weather barrier, but it is not effective in transferring wind loads. Therefore, metal roofs in the high-wind regions that comprise all of the CNMI require the use of 3/4-inch, 7/8-inch, or thicker roof decking to manage the very high loads. Multiple layers of thinner material could be used to reach the needed thickness. In addition to adding strength, roof decking allows the use of a secondary membrane for greatly improved water prevention performance. Figure 4 illustrates construction details for roof coverings and sheathing to strengthen roofs.

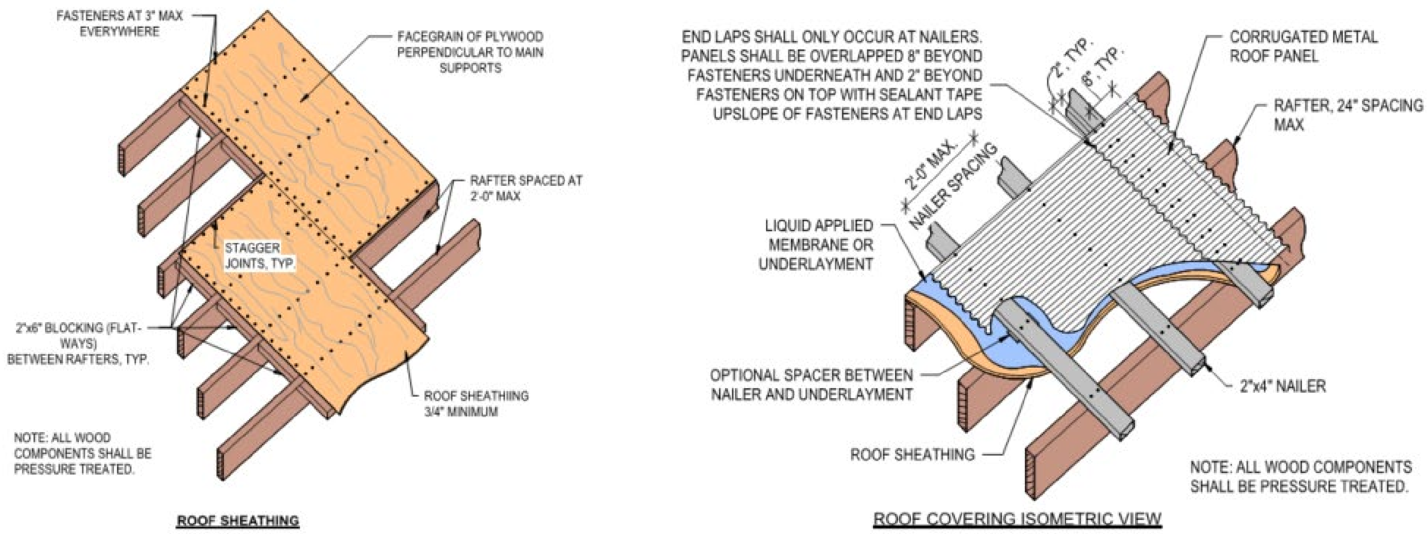

Figure 4: Construction detailing for strengthening roofs in the CNMI.

Roof Fastener Spacing and Material

Strengthening the roof is an important step in making a home safer. Homes with strong roofs are able to weather storms more successfully. Increasing the thickness of the roof deck and the number of fasteners is a key method to strengthening the roof. Figure 5 is an illustration from the U.S. Virgin Islands Department of Natural Resources document *Construction Information for a Stronger Home, 4th Edition,* which shows the need for better fasteners for roof decking. It is important to pay attention to the edges of the roof and the edges of the plywood sheathing. Figure 5 also shows the extra fasteners at the roof edge. Where a secondary membrane is used, it is to be placed on top of the wood deck and under the nailers under the metal roof.

Metal roofing should be installed with corrosion-resistant screws (as opposed to nails). Stainless steel and hot-dipped galvanized metal offer corrosion resistance, with stainless steel fasteners recommended as a far-superior option requiring less maintenance and replacement over time.

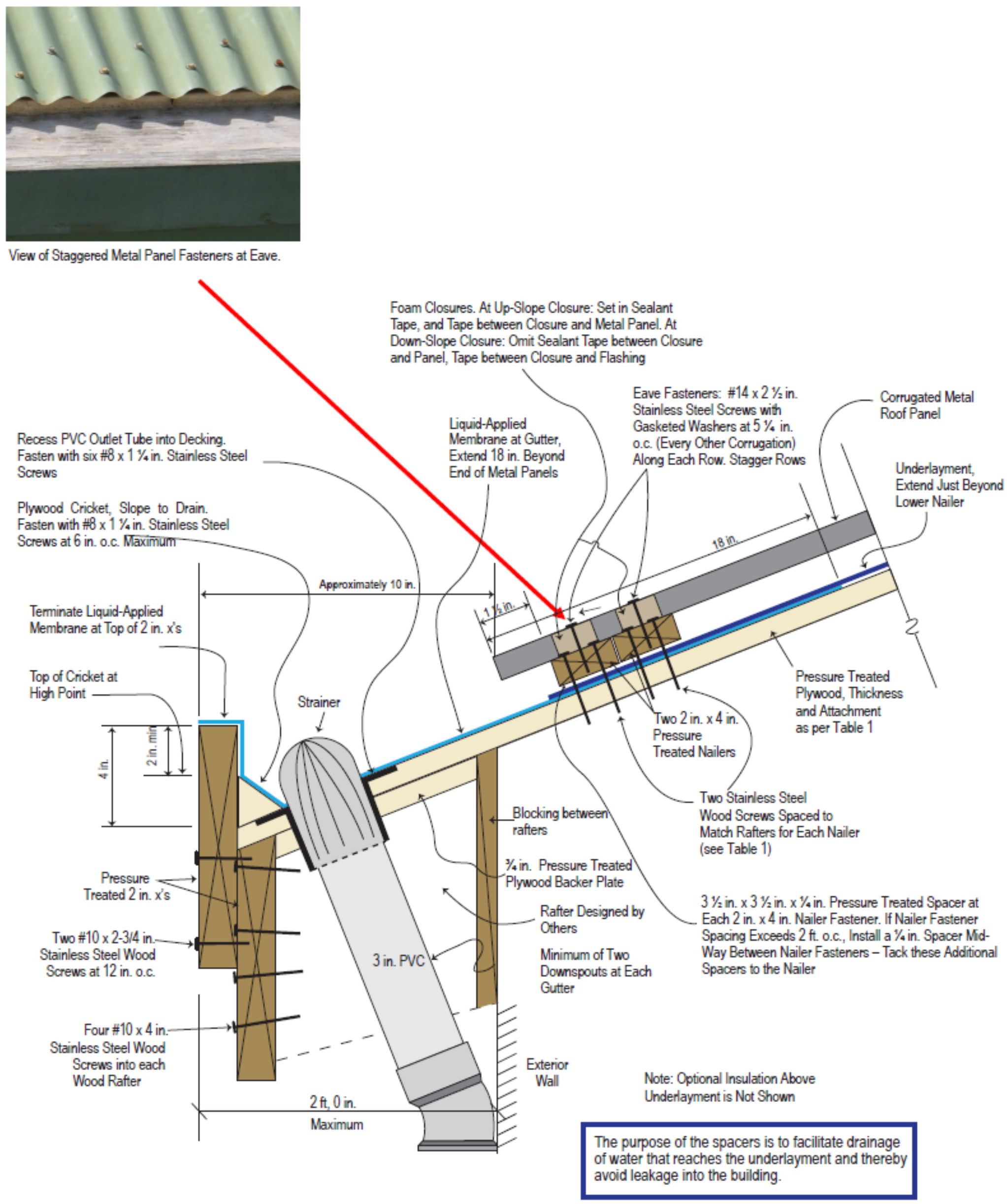

Figure 5: Roof edge detail showing extra fasteners and fastener arrangement at roof edge.

There are some examples of roofs on homes in the CNMI using additional fasteners around the edge of roofs. Some homeowners in a neighborhood in Koblerville, Saipan were aware of these important details at the roof edge and were observed installing corrugated metal using more closely spaced fasteners than observed on nearby homes. This is good practice, but more fasteners are still needed to comply with the building code (see Figure 6). Increased fastener patterns also can be seen in homes built and repaired under the FEMA Individual Assistance Permanent Housing Construction (PHC) program. The program's houses used a different type of metal roof (Figure 6, right image) than the corrugated metal (left image). The image on the right shows the houses also used closely spaced fasteners at the edge of the roof and at the edge flashing.

Figure 6: Left—Homeowner construction of corrugated roofing in Koblerville showing better attention to fastener patterns. The perimeter fasteners should have been doubled, but this is a good start. Right—Roof showing good attention to increased fasteners at the edges.

Roof-to-Wall Connection: Concrete Masonry Units and Wood Details

A continuous load path is an important part of a home's ability to resist wind-related damage. The continuous load path makes sure that loads are transferred from any part of the home to the foundation and the ground. The roof-to-wall connection helps create a continuous load path through the building. Figure 7 shows the concept of a continuous load path for a home. It is important to have strong, positive connections between all the structural frame and non-structural components as well.

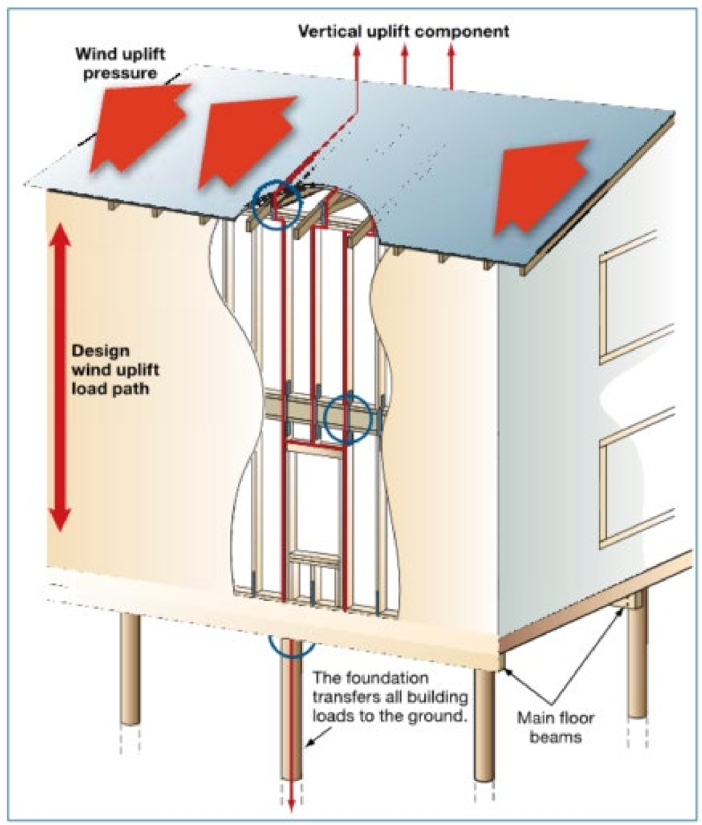

Figure 7: Image showing load path continuity from roof to foundation. [FEMA P-804 Page 3-5]

Framing Connectors

The connections between building elements are very important and must be designed for high winds and be corrosion resistant. Wind load connectors typically are steel fabrications that have been designed and tested for use in high wind areas. The use of metal connectors is common and has been shown to help create a load path for high wind loads. There are connectors for almost every type of framing situation. An Internet search for "wood connectors and hangers" will show information and manufacturers for these various applications. Figure 8 shows connections for wood-framed homes.

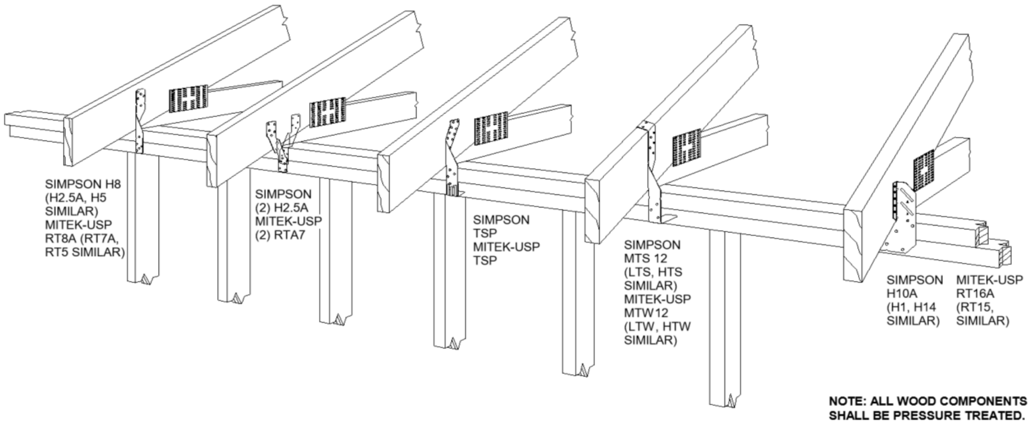

Figure 8: Illustration of the wood roof framing to wood-framed wall connections.

Fabricated metal connectors are available to make wood roof framing to wood-framed wall connections (Figure 8). These connectors have been tested and have proven to be effective. They are reasonably priced and readily available because the parts are mass produced. There can be unexpected results when informal site-fabricated connectors are used. Therefore, it is strongly recommended that commercial connectors be used instead of improvised or site-fabricated connectors.

Figure 9 shows how the connection for a roof truss to a concrete masonry unit (CMU) wall is made. More illustrations can be seen in the U.S. Virgin Islands Department of Natural Resources, *Construction Information for a Stronger Home, 4th Edition* (2018).

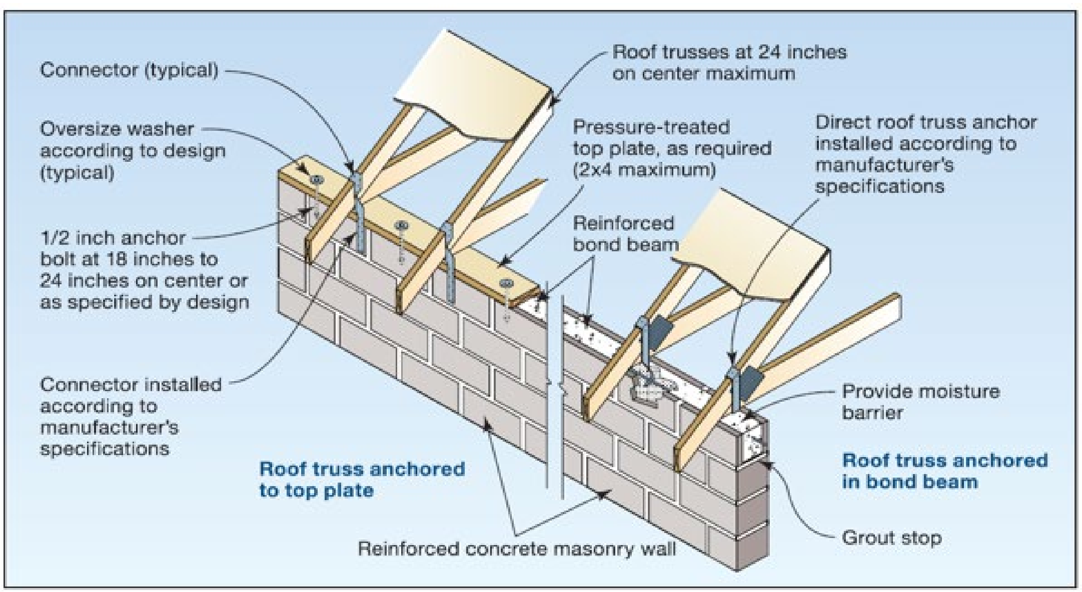

Figure 9: Illustration of the wood roof framing to CMU wall connections. [FEMA 55 Figure 9-10]

Metal roof fasteners should be corrosion resistant for all construction on the islands because all the islands' surfaces are close to the effects of the sea and salt-laden air. Stainless steel and hot-dipped galvanized steel connectors are recommended. Stainless steel will likely provide better long-term performance with less maintenance because zinc galvanizing wears off over time as it is consumed during the life of the fastener. It is possible to paint or apply spray-on galvanizing or “cold galvanizing” to extend the life of metals as the factory-applied galvanizing is exhausted.

A proper connector provides a firm and snug connection between the roof and walls. This reduces damaging vibrations and fluttering from loose roof framing during very high winds. Figure 10 shows what happens when the roof-to-wall connection is inadequate. This building on Tinian used informal roof-to-wall connectors.

Figure 10: Home on Tinian that used informal roof-to-wall connections. The residential building lost the roof framing during high winds. The roof-to-wall connectors failed to secure the roof framing to the top of the wall.

Seven Steps to Improve Wind Resistance: Repairs, Upgrades, Retrofits, and Maintenance

Homes that experience less wind damage typically have been well maintained. Owners should follow seven steps to make sure their homes are better prepared for the next storm and can be reoccupied quickly afterward.

Home elements that are damaged or vulnerable should be identified. A plan to address areas of weakness or decay should be prepared. It is very important to understand the condition of a home to be able to identify and address any weaknesses. This information—and acting on it—is essential for homes to survive the very high winds that occur in the CNMI. Figure 11, below, outlines seven steps you can take to improve how your home can survive the next storm.

Step 1: Be proactive. Develop an ownership mindset. Make plans to stay ahead of maintenance. Create an annual maintenance schedule. Take pride in and care for your home.

Step 2: Know good practices. Educate yourself. Learn about good practices for materials and construction. Contact the local building officials for information. Find and learn from the references and resources noted at the end of this advisory. There is a lot of helpful information prepared after recent storms in the Caribbean that relates to the CNMI Super Typhoon Yutu recovery.

Step 3: Know the real condition of your home. Inspect and assess. Don't be surprised by unnoticed weak areas or decay. Look at, operate or touch everything at least once a year and following any high-wind event. Be mindful of fastener corrosion and wood decay from termites and moisture.

Step 4: Evaluate your options and make plans. When you know the condition of your home, you can decide whether to maintain, repair, or upgrade. Budgeting is an important part of the plan. Failing to plan is planning to fail. Set aside 2-3%of the value of your house each year for a repair fund. This is a typical recommendation for homeownership. In the CNMI, more savings might be necessary because of the strength of storms and harsh conditions. Saving 3-5%for repairs and maintenance each year is recommended.

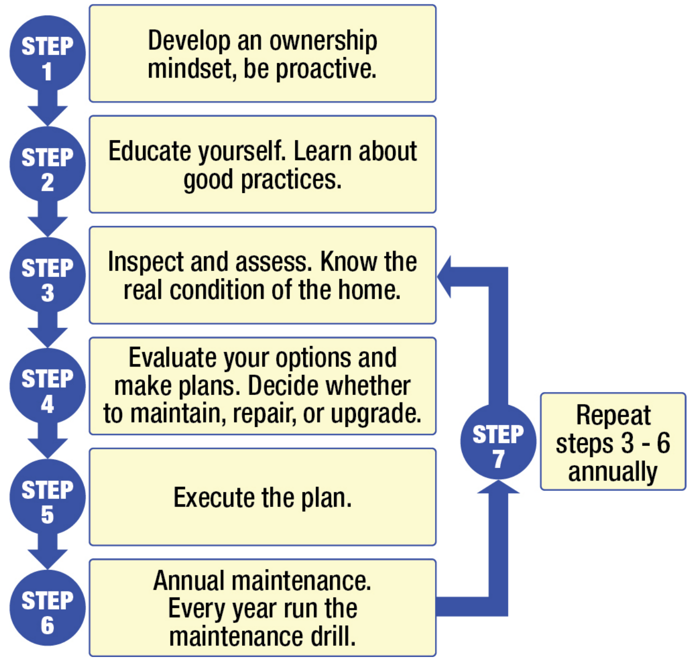

Figure 11: Seven-step process to improve building performance.

Step 5: Execute the plan. Follow through and start regular maintenance and improvement.

Step 6: Hold the line. Perform annual maintenance. Run the maintenance drill each year: fasten loose trim; tighten loose screws or add new screws; seal cracks, seams and holes; lubricate window hardware.

Step 7: Repeat Annually. Repeat Step 3 through Step 6 every year.

References and Resources

References

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Resources

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FEMA Hurricane Irma and Maria in the U.S. Virgin Islands, *Recovery Advisory 3: Installation of Corrugated Metal Roof Systems (March 2018).*

FEMA P-499. *Home Builders Guide to Coastal Construction (2010).*

FEMA P-804. *Wind Retrofit Guide for Residential Buildings (2010)*.

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