Wind Retrofit Guide for Residential Buildings

In Hurricane-Prone Regions

FEMA P-804

Second Edition

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FEMA

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Executive Summary

Every year, houses along the coast are subject to high winds that cause extensive damage and threaten the safety and security of coastal residents. Much of this wind-related damage can be reduced by improving the performance of the existing buildings through retrofits that strengthen the residential building's envelope and load path. Hurricane Ida demonstrated the damage a hurricane can inflict on the built environment when it made landfall as a major hurricane in Louisiana on August 29, 2021. Even though the storm was not a design-level event for wind loading on residential buildings, extensive damage was documented to the housing stock. In response to this storm, the Federal Emergency Management Agency (FEMA) decided to update FEMA P-804, *Wind Retrofit Guide for Residential Building*s (last published in 2010), with lessons learned from the last decades of storm observations and advances in wind engineering to help property owners retrofit their houses and apply for FEMA funding to do so. FEMA P-804 summarizes the technical information needed for selecting and implementing cost-effective FEMA-funded wind retrofit projects for existing one- and two-family dwellings in hurricane-prone regions of the United States and its territories. Although this Guide references guidance for one- and two-family dwellings in hurricane-prone regions, much of the guidance may also be applied to non-coastal areas subject to high winds.

This Guide presents mitigation measures in "Mitigation Packages." A Mitigation Package is a combined set of retrofit measures that must be implemented for a house to provide a defined level of protection. This Guide identifies three successive Mitigation Packages: Basic, Intermediate, and Advanced. Implementing the Mitigation Packages in this Guide on existing vulnerable houses within hurricane-prone regions of the United States and its territories will result in their improved performance in high-wind events. A change to the 2023 edition of FEMA P-804 is that the Mitigation Packages now correspond closely to the Insurance Institute for Business & Home Safety's (IBHS's) *2020 FORTIFIED Home Standard* FORTIFIED Home™ – Hurricane designations for existing homes. FEMA P-804 references the criteria for 2020 FORTIFIED Hurricane Home designations (referred also as the "Basis of Requirements") for existing homes with some exceptions, which are more conservative and designated as "FEMA Grant Requirements." FEMA Grant Requirements must be implemented to receive FEMA funds for retrofit projects. While this publication outlines minimum technical and performance-based grant requirements related to residential wind retrofits, refer to the latest edition of FEMA's Hazard Mitigation Assistance Program and Policy Guide (HMA Guide) for the most current FEMA policy on residential wind retrofit and HMA grants implementation requirements.

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Acronyms and Abbreviations

AFPA	American Forest and Paper Association
AISI	American Iron and Steel Institute
ASCE	American Society of Civil Engineers
ATC	Applied Technology Council
BCA	benefit-cost analysis
BCAT	Building Code Adoption Tracking
BCR	benefit-cost ratio
BRIC	Building Resilient Infrastructure and Communities
BRV	building replacement value
DP	Design Pressure
FBC	Florida Building Code
FEMA	Federal Emergency Management Agency
FY	fiscal year
Hazus-MH	Hazards U.S. Multi-Hazard
HMA	Hazard Mitigation Assistance
HMGP	Hazard Mitigation Grant Program
IBC	International Building Code
IBHS	Insurance Institute for Business & Home Safety
ICC	International Code Council
IEBC	International Existing Building Code
IRC	International Residential Code
MAT	Mitigation Assessment Team
MEMA	Mississippi Emergency Management Agency

MH	manufactured housing
mph	miles per hour
m/s	meters per second
N/A	Not Applicable
NFIP	National Flood Insurance Program
o.c.	on center
PG	Performance Grade
psf	pounds per square foot
RDP	registered design professional
SFBC	South Florida Building Code
SFHA	Special Flood Hazard Area
SHMO	State Hazard Mitigation Officer
SEI	Structural Engineering Institute
SI/SD	substantial improvement / substantial damage
SLOSH	Sea, Lake, and Overland Surge from Hurricanes
SPF	spray polyurethane foam
SSD	Substantial Structural Damage
StEER	Structural Extreme Events Reconnaissance

1. Introduction

Every year, houses along the coast are subject to high winds that cause extensive damage and threaten the safety and security of coastal residents. Much of this wind-related damage can be reduced by improving the performance of the existing buildings through retrofits that strengthen the residential building's envelope and load path. The building envelope is the shell of the house, including the doors, roof covering, windows, and wall coverings. Load paths are chains of connections throughout a building used to transfer loads from the point where a load is applied to the foundation.

1.1. Purpose and Basic Scope of FEMA P-804

The purpose of this Guide is to provide guidance on how to improve the wind resistance of existing one- and two-family dwellings in hurricane-prone regions of the United States and its territories. This Guide is not applicable to manufactured housing (MH) units or townhouse units. Although the guidance is primarily intended to be applied in hurricane-prone regions as defined by the American Society of Civil Engineers (ASCE)/Structural Engineering Institute (SEI) 7-22, *Minimum Design Loads and Associated Criteria for Buildings and Other Structures* (herein referred to as ASCE 7-22), it may also be applied to non-coastal areas subject to high winds. The Federal Emergency Management Agency (FEMA) has also published many other guidance documents on coastal construction. For circumstances not addressed in this Guide, such as specific material types, building layouts, and other customizable factors, the property owner should contact a registered design professional (RDP).[1] For questions regarding this document or other FEMA Building Science publications or guidance, contact the FEMA Building Science Helpline (at FEMA-BuildingScienceHelp@fema.dhs.gov or 1-866-927-2104).

This Guide presents mitigation measures in "Mitigation Packages." A Mitigation Package is a combined set of retrofit measures that must be implemented for a house to provide a defined level of protection. This Guide identifies three successive Mitigation Packages: Basic, Intermediate, and Advanced. These correspond closely to the Insurance Institute for Business & Home Safety's (IBHS's) *2020 FORTIFIED Home Standard,* FORTIFIED Home™. FORTIFIED Home™ has three Hurricane designation[2] levels for existing homes: FORTIFIED Roof™, FORTIFIED Silver™, and FORTIFIED Gold™, which correspond to this Guide's Basic, Intermediate, and Advanced Mitigation Packages, respectively. FEMA P-804 references the criteria for *2020 FORTIFIED Home Standard* Hurricane designations for existing homes with some exceptions, which are defined in Chapter 4 and designated as "FEMA Grant Requirements." These FEMA Grant Requirements represent more

[1] A registered design professional (RDP), for the purposes of this Guide, is defined as "an individual who is registered or licensed to practice engineering or architecture as defined by the statutory requirements of the professional registration laws of the state or jurisdiction in which the project is to be constructed."

[2] "IBHS 2020 FORTIFIED Home™ – Hurricane designations" is referred to herein as "2020 FORTIFIED Home Hurricane designations."

conservative criteria than *2020 FORTIFIED Home Standard* and must be implemented to receive FEMA funds for retrofit projects.

In addition to defining Mitigation Packages, FEMA P-804 summarizes the technical information needed for selecting and implementing cost-effective wind retrofit projects for existing one- and two-family dwellings in hurricane-prone regions of the United States and its territories. Many of the prescriptive solutions included in the Mitigation Packages are limited to a maximum Basic Wind[3] Speed of 130 mph and Exposure Category C, while others have higher limits or are applicable to any wind speed and exposure category. Where site conditions exceed the limitations for any construction requirement in this Guide, an engineered solution by a Registered Design Professional (RDP) is required. Refer to the text box and Table 2 in Section 2.1 of this Guide for a summary of Mitigation Package limitations and minimum wind design criteria. Implementing the Mitigation Packages in this Guide on existing vulnerable houses within the hurricane-prone regions of the United States and its territories will result in their improved performance in high-wind events.

FEMA P-804 (2023) UPDATE

FEMA P-804 (2023) features clarified and updated guidance based on post-damage assessments and lessons learned following hurricanes over the past 12 years, as well as research in the ever-growing field of wind engineering.

FEMA P-804 uses *2020 FORTIFIED Home Standard* criteria (also referred to in Chapter 4 as the "Basis of Requirements") for its Mitigation Packages. Where FEMA P-804 includes more conservative criteria than *2020 FORTIFIED Home Standard*, the criteria are referred to as "FEMA Grant Requirements," as they are required to receive FEMA funds. "FEMA Grant Requirements" are identified in Chapter 4 of this Guide.

This Guide is intended for multiple audiences, including homeowners, contractors, evaluators, and RDPs. Homeowners should always be involved in the process of their wind retrofit project; they must understand the benefits and costs of each potential decision. Using this Guide, homeowners should work with an evaluator, contractor, and an RDP (if necessary) to determine which Mitigation Package of wind retrofit activities is most appropriate for their house.

[3] The term "basic wind speed" in ASCE 7-22 is equivalent to the term "ultimate wind speed" in the *2020 FORTIFIED Home Standard*.

FEMA GRANT REQUIREMENTS

If wind retrofits for one- and two-family dwellings are completed with FEMA funds, the design must comply with the "FEMA Grant Requirements" described in Chapter 4 of this Guide, in addition to the *2020 FORTIFIED Home Standard* criteria (also referred to as the "Basis of Requirements" in Chapter 4). FEMA Grant Requirements were developed to incorporate best practices learned through decades of post-storm observations. For a comparison of the eligibility and minimum requirements identified in Chapter 2 of the 2020 *FORTIFIED Home Standard* and the corresponding FEMA Grant Requirements, refer to Table 1 of this Guide.

Should a property owner wish to use FEMA funding for a wind Mitigation Package in FEMA P-804, as well as take advantage of an insurance reduction in qualifying states for obtaining a 2020 FORTIFIED Home Hurricane designation, additional FORTIFIED programmatic requirements may need to be met. Visit https://fortifiedhome.org/ for more information on the FORTIFIED Programs and potential insurance reduction benefits.

While this publication outlines minimum technical and performance based grant requirements for wind retrofits, refer to the latest edition of FEMA's *Hazard Mitigation Assistance Program and Policy Guide (HMA Guide)* for the most current FEMA policy statement on residential wind retrofit and HMA grants implementation requirements. See: https://www.fema.gov/grants/mitigation/hazard-mitigation-assistance-guidance.

To learn more about how to apply for FEMA funding, visit https://www.fema.gov/grants/mitigation/applying.

State, local, tribal, territorial governments and entities who have mitigation programs in hurricane-prone regions will also benefit from this Guide by using the information to pursue, develop, and deliver technical assistance to the public on successful wind retrofit mitigation projects for residential buildings.

EVALUATOR

When implementing a wind retrofit project, homeowners and authorities having jurisdiction will need to work with an evaluator, who will evaluate the existing condition of the house. The evaluation will also help determine how a house can be retrofitted for the Mitigation Packages outlined in this Guide.

Evaluators must possess sufficient knowledge of the design and construction of residential buildings to perform these evaluations, but they need not be an RDP. However, the evaluator should have knowledge of and familiarity with the wind retrofit Mitigation Packages, their intent as described in this Guide, and any limitations due to existing conditions. An RDP would be needed when the retrofit solution is outside of the prescriptive solutions presented in this Guide.

Should a homeowner wish to qualify for a 2020 FORTIFIED Home Hurricane designation, an assessment conducted by a "Certified FORTIFIED Evaluator" is required. The evaluator will collect the necessary documentation and provide the report to IBHS for review. IBHS then determines whether to award the designation. Refer to Chapter 3 of this Guide and the *2020 FORTIFIED Home Standard* for more information on evaluations.

1.2. Need for Technical Guidance

FEMA P-804 (2010b) was originally developed in response to Hurricane Katrina. The Mississippi Emergency Management Agency's (MEMA's) Mitigation Section, in coordination with the Mississippi Department of Finance and Administration, applied for a Hazard Mitigation Grant Program (HMGP) grant under presidentially declared disaster number DR-1604 (Hurricane Katrina in Mississippi) to fund wind retrofit projects for homeowners in Mississippi. The program funded up to 75 percent of eligible costs of retrofits such as improving roof deck attachments, adding or improving roof-to-wall connections, and adding opening protection. FEMA P-804 (2010b) was developed to provide the technical guidance needed to facilitate the development of the FEMA-funded retrofit projects for residential buildings. FEMA P-804 (2010b) included engineering-based prescriptive construction solutions, implementation guidance, and wind-damage function data to support user-identified damage curves for performing the related benefit-cost analysis (BCA) that is required when seeking FEMA grant funds. Hundreds of successful residential retrofits were funded by FEMA, and implemented through MEMA, following FEMA P-804 (2010b) solutions.

Although many advances in building code resilience, adoption, and enforcement were made in Louisiana and nationally between Hurricane Katrina and Hurricane Ida's landfall 16 years later, Hurricane Ida caused damage and catastrophic failures to residential buildings of all ages. Hurricane Ida made landfall as a major hurricane in Louisiana on August 29, 2021. Following a virtual and field deployment, the National Science Foundation–funded Structural Extreme Events Reconnaissance (StEER) team determined:

> The most catastrophic damage to many single-family residences was preventable or could be mitigated by cost-effective retrofits. Interior damage appears widespread due to failures of roof covering (asphalt shingle and discontinuous metal roofing systems) that resulted in extensive water leaks and interior damage. Structural failures were observed as light-framed wood metal plate trusses were lifted off exterior walls and enabled gable end walls to collapse. Many elevated houses failed as the connection of the superstructure to the piles appeared to fail as the superstructure was blown apart (StEER, 2021).

Because Hurricane Ida was not a design wind event for residential buildings (StEER, 2021) and because of the observed damage, the need for wind retrofits to help minimize future damage of residential houses in hurricane-prone regions has been clearly demonstrated. Therefore, additional technical guidance, through the update of FEMA P-804, is needed to facilitate the development of retrofit projects for residential buildings.

FEMA P-804 has been updated with lessons learned from the last decades of storm observations and advances in wind engineering, including IBHS' *2020 FORTIFIED Home Standard* (IBHS, 2020). The BCA precalculated benefits for retrofits using FEMA P-804 have also been revised to reflect the updated FEMA Mitigation Package contents and economic conditions.

REFERENCED CRITERIA

FEMA P-804 Mitigation Package requirements meet or exceed the criteria of the respective 2020 FORTIFIED Home Hurricane designations (Figure 1). Chapters 1 and 4 discuss the relationship between 2020 FORTIFIED and FEMA P-804. Additional eligibility or administrative documentation may be required to achieve a FORTIFIED designation, which may qualify property owners for insurance benefits in participating states.

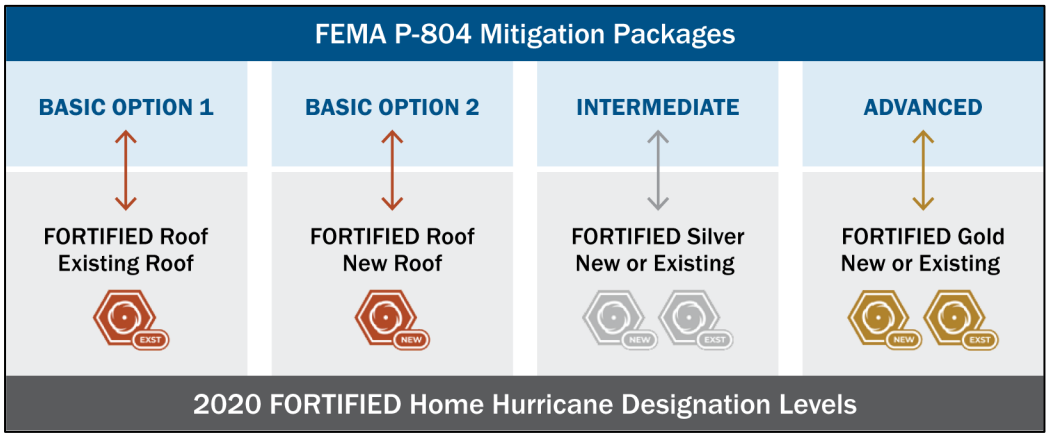


Figure 1: FEMA P-804 Mitigation Package requirements meet or exceed the criteria of the respective 2020 FORTIFIED Home Hurricane designations shown

1.3. Wind Retrofit Projects

The purpose of a residential wind retrofit project is to reduce the vulnerability of and damage to houses from wind and wind-driven rain intrusion during a long duration, high-wind event, such as a hurricane. According to recent FEMA Mitigation Assessment Team (MAT) deployments following hurricanes, three areas of the house are typically most vulnerable to failure due to high winds:

- Roof and wall coverings
- Openings (e.g., windows, doors)
- Load path connections

In recent years, there has been evidence that despite better structural performance for new construction built to more modern building codes, wind-driven rain has consistently caused extensive and costly water intrusion damage when it enters through wind-damaged envelope components (roof coverings, wall coverings, roof ventilation components, soffits, and windows and doors). The Mitigation Packages in FEMA P-804 provide techniques to mitigate against wind-driven rain, while also strengthening the structural integrity of the house. The Advanced Mitigation Package focuses on creating a strong, continuous load path from the roof to the foundation.

MATs have also continually demonstrated that properly designing and constructing a building to locally adopted building codes provides the minimum level of protection for the wind hazard at a

particular site for new construction. However, because of improvements to the model building code, houses that comply with today's codes are typically less vulnerable to wind and wind-driven rain damage than older houses. This Guide describes retrofits for those older buildings and for newer structures that were not designed or constructed to comply with modern hazard-resistant building codes.

FEMA MITIGATION ASSESSMENT TEAMS

FEMA carries out many actions in response to a natural disaster. When a Presidential Disaster Declaration is made and a state, tribe, or territory requests an investigation, FEMA may deploy a MAT to the location impacted by the natural disaster. A MAT conducts performance assessments of buildings and related infrastructure to determine both the causes of damage and performance of past mitigation efforts and projects. The MAT then recommends actions that federal, state, and local governments; building officials; floodplain administrators and regulators; the design and construction industry; building code and standard organizations; academia; emergency managers; building owners and operators; or other stakeholders can take to mitigate damage from future natural hazard events. Furthermore, the recommendations resulting from a MAT help FEMA coordinate with agencies and organizations to assess the hazard-resistance provisions of building codes and standards. Long-term strategies can then be developed to help reduce future damage and impacts from a variety of natural hazard events and improve community resilience.

FEMA's most recent hurricane MAT report at the time of publication, FEMA P-2077, *Mitigation Assessment Team Report: Hurricane Michael in FL* (FEMA, 2020) (Figure 2) includes best practices pertaining to wind-driven rain, which were incorporated into this Guide.

For more information on FEMA's MAT and to access MAT publications, visit https://www.fema.gov/mitigation-assessment-team-program.

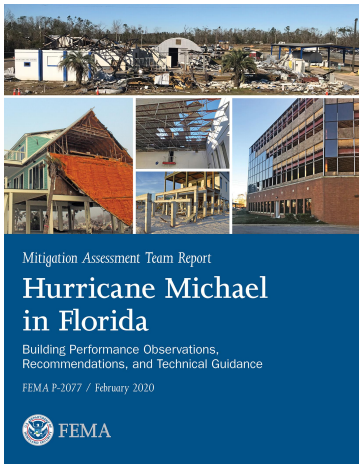


Figure 2: Hurricane Michael MAT Report

While complete property protection from high winds may be difficult and costly to achieve, many types of wind retrofit projects can be effective and cost-beneficial in reducing damage from high-wind

events, FEMA has updated this Guide to continue to encourage wind mitigation of existing residential buildings with updated engineering and guidance. The Mitigation Packages in this Guide are only applicable to one- and two-family residential dwellings with three or fewer stories above grade. They are not applicable to townhouse units or MH units. For wind retrofit measures applicable to townhouses and MH units, refer to *2020 FORTIFIED Home Standard* Section 2.2 in which these building types are "Qualifying Dwelling Types" (IBHS, 2020). For a comparison of the eligibility and minimum requirements identified in Chapter 2 of *2020 FORTIFIED Home Standard* and the corresponding FEMA Grant Requirements, refer to Table 1. For more comprehensive guidance on FEMA funding for residential wind retrofit projects, see Chapter 5 of this Guide.

Table 1: Comparison of Eligibility and Minimum Requirements from IBHS 2020 *FORTIFIED Home* Standard and FEMA Grant Requirements

2020 *FORTIFIED Home* Standard SECTION / TITLE	2020 *FORTIFIED Home* ELIGIBILITY AND MINIMUM REQUIREMENT*	FEMA P-804 (2023) GRANT ELIGIBILITY AND MINIMUM REQUIREMENT
2.1: Applicable Regions	Includes designations for hurricane (within hurricane-prone regions), high wind and hail (outside of hurricane-prone regions). 2020 FORTIFIED Home Hurricane designations are applicable where the ultimate design wind speed (V_{ult}) is greater than 115 mph as specified in ASCE 7-10 through ASCE 7-16 or the nominal design wind speed (V_{asd}) is greater than 90 mph as specified in ASCE 7-98 through ASCE 7-05.	There are no absolute geographical restrictions for grant eligibility; however, for areas where the ASCE 7-22 Basic Wind Speed for Risk Category II buildings is 115 mph or less, FEMA recommends the FORTIFIED Home High Wind & Hail designation be considered (vs the FORTIFIED Home Hurricane designation). Note, in order to receive FEMA funding for residential wind retrofits, subapplicants must meet the requirements of this publication. In addition, the use of the precalculated benefits (in Table C-2) only applies to dwellings located in hurricane-prone regions where the ASCE 7-22 Basic Wind Speed for Risk Category II buildings is 120 mph or greater. Refer to Section 2.1 in this Guide for more information on hurricane-prone regions and how to determine your site-specific ASCE 7-22 Basic Wind Speed.
2.2: Qualifying Dwelling Types	▪ Single-family detached houses with three or fewer stories above grade ▪ Two-family dwelling units (duplex) with three or fewer stories above grade ▪ HUD MH units ▪ Townhouses	▪ Single-family detached houses with three or fewer stories above grade ▪ Two-family dwelling units (duplexes) with three or fewer stories above grade

2020 *FORTIFIED Home* Standard SECTION / TITLE	2020 *FORTIFIED Home* ELIGIBILITY AND MINIMUM REQUIREMENT*	FEMA P-804 (2023) GRANT ELIGIBILITY AND MINIMUM REQUIREMENT
2.3: Ineligible Foundation Types	Dry-stack foundation with provision for retrofitted engineered foundation to comply with HUD-code MH unit requirements	N/A per Qualifying Dwelling Types requirement
2.4: Qualifying Foundation Types	▪ Slab on ground ▪ Elevated-floor house-to-foundation with connections ▪ HUD-code MH unit foundations	▪ Slab on ground ▪ Elevated-floor house-to-foundation with connections
2.5: Qualifying Roof Structural Members	Refer to 2020 FORTIFIED Section 2.5 for details	No changes to 2020 FORTIFIED requirements; see Section 3.2 in this Guide for more information
2.6: Qualifying Ring-Shank Nails	Refer to 2020 FORTIFIED Section 2.6 for details	No changes to 2020 FORTIFIED requirements for qualifying nail types; refer to individual Chapter 4 retrofit requirements in this Guide for any modifications to nail size
2.7: Acceptable Debris Impact Ratings	Refer to 2020 FORTIFIED Section 2.7 for details	No changes to 2020 FORTIFIED requirements
2.8: Acceptable DP Ratings	Refer to 2020 FORTIFIED Section 2.8 for details	No changes to 2020 FORTIFIED requirements
2.9: Referenced Codes and Standards	Latest edition OR locally adopted building code with referenced edition of ASCE 7 (back to 2000 IRC/ASCE 7-98)	ASCE 7-22 where wind loads are required to be determined; where 2020 FORTIFIED prescriptive solutions are referenced, use ASCE 7-16 option
2.10: Ultimate vs. Nominal Wind Speed	Refer to 2020 FORTIFIED Section 2.10 for details	N/A per Referenced Codes and Standards (i.e., all FEMA-required codes and standards use “ultimate wind speeds” only)
2.11: Corrosion Protection	Refer to 2020 FORTIFIED Section 2.11 for details	No changes to 2020 FORTIFIED requirements. See Section 4.1.2 in this Guide for more information.
2.12: Documentation Requirements	Refer to 2020 FORTIFIED Section 2.12 for details	Check with FEMA HMA for current guidance regarding documentation requirements

2020 *FORTIFIED Home* Standard SECTION / TITLE	2020 *FORTIFIED Home* ELIGIBILITY AND MINIMUM REQUIREMENT*	FEMA P-804 (2023) GRANT ELIGIBILITY AND MINIMUM REQUIREMENT
2.13: Recommendation for Flood Mitigation	Not a requirement, but recommends elevating lowest floor (or lowest horizontal structural member) 3 feet above the base flood elevation or to the 500-year flood elevation	FEMA supports 2020 FORTIFIED's elevation recommendation. As with all design and construction matters, please work with the local building department and all other authorities having jurisdiction to ensure that ALL state and local requirements are being met, even when using FEMA publication and guidance recommendations.
2.14: Appropriate Use of FORTIFIED	FORTIFIED Home requirements are minimum requirements and do not take the place of structural design or supersede more restrictive requirements from the structural design, locally adopted building code(s), or product manufacturer's specifications. The FORTIFIED Home Standard is to be applied in conjunction with federal, state, and local codes, ordinances and regulations in addition to the structural design which is by others. In case of a conflict between provisions, use whichever is more stringent.	Be advised that state and local jurisdictions may have requirements that are more stringent than FEMA's guidance and recommendations. As with all design and construction matters, please work with the local building department and all other authorities having jurisdiction to ensure that ALL state and local requirements are being met, even when using FEMA publication and guidance recommendations.

* Table entries include a summary of *2020 FORTIFIED Home Standard* requirements; please refer to table-identified sections in *2020 FORTIFIED Home Standard* for details.

ASCE = American Society of Civil Engineers
DP = Design Pressure
HMA = Hazard Mitigation Assistance
HUD = U.S. Department of Housing and Urban Development
IRC = International Residential Code
MH = manufactured housing
N/A = Not applicable

Through its Hazard Mitigation Assistance (HMA) grant programs, FEMA administers two grant programs that fund wind retrofit projects: the HMGP and the Building Resilient Infrastructure and Communities (BRIC) grant program. The HMA process cycles through five stages starting with mitigation planning and ending with successful execution of a project (Figure 3). Chapter 5 provides more information on the HMA process and the roles and responsibilities of stakeholders at each stage of the process. Homeowners, business operators, and nonprofit organizations cannot apply directly to FEMA. However, they can be included in a subapplication submitted by an eligible subapplicant. To learn more about how to apply for FEMA funding, visit https://www.fema.gov/grants/mitigation/applying.

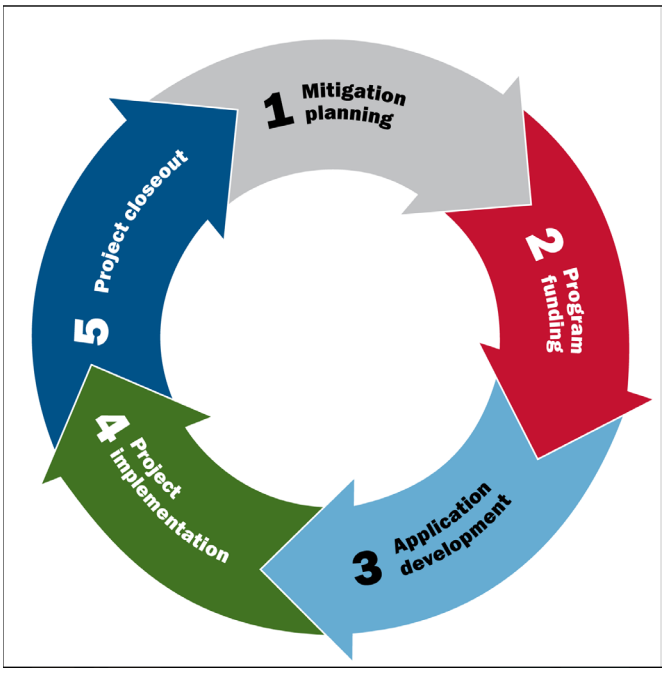


Figure 3: HMA grant process

1.4. Using This Guide

FEMA recommends that users review this Guide in its entirety before pursuing the development of a wind retrofit mitigation project. The Guide consists of five chapters and four appendices, as follows:

- Chapter 1. Introduction provides an overview of the Guide, summarizing its purpose and contents.
- Chapter 2. Identifying the Risks and Desired Level of Protection describes wind hazards, how to identify wind risks for a particular site or area, and how the wind hazard is addressed through building codes and best practices.
- Chapter 3. Evaluating Existing Houses explains how to assess houses to determine their vulnerabilities and what type of mitigation measures would be most appropriate and feasible.
- Chapter 4. Technical Design and Construction Methods provides details and specific measures for each of the three Mitigation Packages: Basic, Intermediate, and Advanced.
- Chapter 5. Implementing Mitigation Projects describes how to move a project forward, important issues and challenges that should be considered, and details about potential sources of assistance.
- Appendix A. FORTIFIED Home™ – Hurricane for Existing Houses summarizes the Hurricane designations of the IBHS's *2020 FORTIFIED Home Standard* FORTIFIED Home™ program. Mitigation projects that meet the criteria for FEMA P-804 should also meet or exceed the criteria for the corresponding 2020 FORTIFIED Home™ Hurricane designation. However, additional eligibility or administrative documentation may be required to achieve a 2020

FORTIFIED Home Hurricane designation, which may qualify property owners for insurance benefits in participating states.

- Appendix B. Evaluation Guidance provides guidance on conducting an evaluation of a house that is being considered for a wind retrofit project; this appendix supplements the information in Chapter 3.
- Appendix C. Using the FEMA BCA Toolkit Hurricane Wind Module for Determining Cost-Effectiveness of Retrofit Projects contains information that can be used with the FEMA BCA Tool (Version 6.0) to model the post-mitigation cost-effectiveness of the projects detailed in Chapter 4. A BCA must be performed as part of a FEMA mitigation grant application.
- Appendix D. Acknowledgements provides a list of those who helped with the review and direction of this Guide.

2. Identifying the Risks and Desired Level of Protection

To better understand the wind-related risk to a house from hurricanes, it is important to know how wind hazards are defined. Further, to understand the level of protection provided by a house before and after implementing a retrofit project, homeowners should identify the building code and local regulatory requirements to which their house was constructed, and the methods and materials used during construction. Homeowners can contact their local authority having jurisdiction to inquire about governing building codes, appropriate construction methods, and allowable construction materials.

This chapter discusses wind hazards in coastal regions and summarizes how and when building codes and standards started to address these hazards. The chapter also addresses the level of protection provided by houses and the level of protection or performance that is reasonable to expect after implementing a wind mitigation project.

2.1. Wind Hazards in Hurricane-Prone Regions

High-wind natural hazards affecting hurricane-prone regions include hurricanes, tropical storms, typhoons, nor'easters, and tornadoes. The retrofits outlined in this Guide provide guidance to protect existing houses from hurricane damage in hurricane-prone regions defined by the ASCE 7-22. ASCE 7-22 defines hurricane-prone regions as the U.S. Atlantic Ocean and Gulf of Mexico coasts where the basic (design) wind speed for Risk Category II buildings (includes one- and two-family dwellings) is greater than 115 miles per hour (mph), as well as Hawaii, Puerto Rico, Guam, U.S. Virgin Islands, Northern Mariana Islands, and American Samoa. Although most common in coastal areas, the damaging effects of hurricane-force winds are not limited to coastal counties. Furthermore, although the guidance is primarily intended to be applied in hurricane-prone regions as defined by ASCE 7-22, it may also be applied to non-coastal areas subject to high winds.

Figure 4 shows the hurricane-prone regions of the United States, as defined in the 2022 edition of ASCE 7. ASCE 7-22 defines the windborne debris region as areas within 1 mile of the mean high-water line where an Exposure D condition (coastal or open terrain; flat unobstructed areas and water surfaces) exists upwind of the water line and the basic wind speed is equal to or greater than 130 mph (and in Hawaii), or in areas where the basic wind speed is equal to or greater than 140 mph.

ASCE 7 EDITION FOR FEMA P-804

Unless otherwise stated, all wind speeds in this edition of FEMA P-804 correspond to the ASCE 7-22, 3-second gust, basic wind speeds for Risk Category II buildings. At the time of printing this Guide, the 2024 International Residential Code (IRC) is not yet published but, based on the voting outcomes from the code hearings, ASCE 7-22 will be referenced in the 2024 edition of the IRC.

ASCE 7 HAZARD TOOL FOR DETERMINING WIND SPEED FOR A PROPERTY

Products that help determine the site-specific wind speed for a given location can provide a valuable service. One such product is the ASCE 7 Hazard Tool (https://asce7hazardtool.online). The basic wind speed for a one- or two-family dwelling (Risk Category II) from ASCE 7-16 and ASCE 7-22 can be found by entering the property address into the tool.

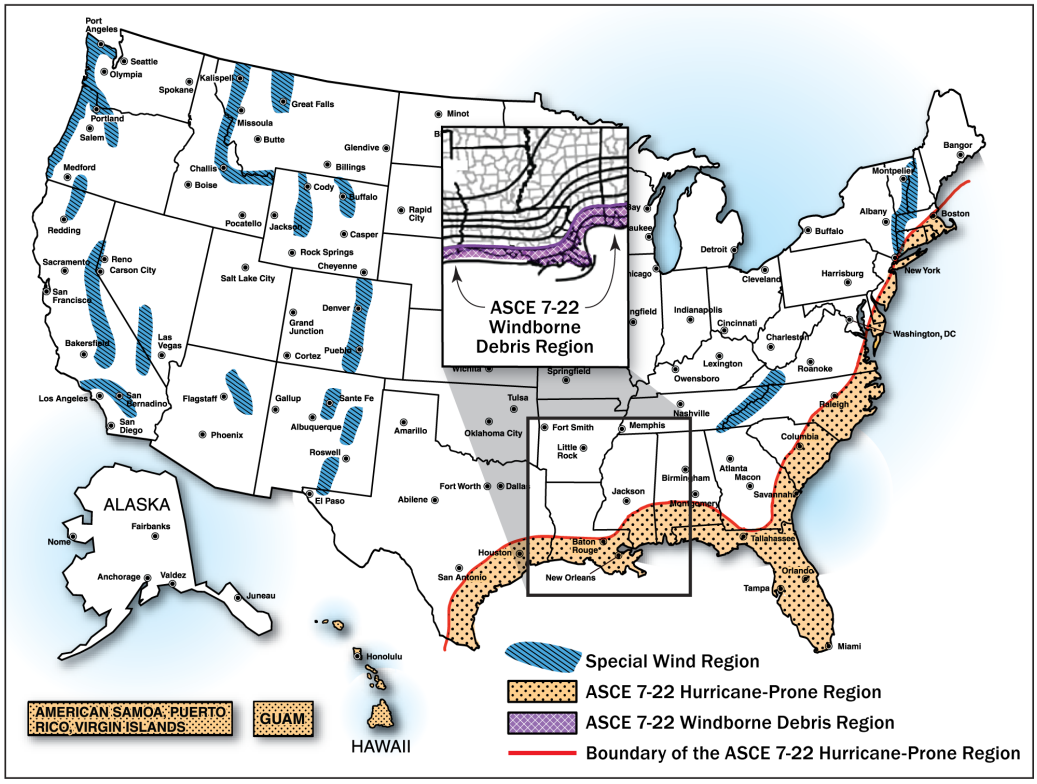


Figure 4: Illustration of hurricane-prone regions of the United States adapted from ASCE 7-22 (with permission from ASCE). Note that the map is for illustration purposes only and should not be used to determine (basic) design wind speed. Inset shows the ASCE 7-22 Windborne Debris Region in purple checkered shading along a portion of the Gulf Coast.

In addition to the wind speed and location within hurricane-prone regions, the exposure category is also an important component in identifying a building's vulnerability to wind-related damage. ASCE 7-22 also defines exposure categories in a way that reflects the upwind terrain roughness for the building site (see "Exposure Categories from ASCE 7-22" text box). If comparing identical storms over different terrain, as the terrain becomes flatter with fewer obstructions there are less obstacles for the wind to strike and consequently higher wind speeds. Conversely, areas that have dense ground obstructions such as suburban and wood areas, will have slower wind speeds due to the roughness of the terrain.

EXPOSURE CATEGORIES FROM ASCE 7-22

B: Urban and suburban areas, wooded areas, or other terrain with numerous, closely spaced obstructions that have the size of single-family dwellings or larger.
C: Open terrain with scattered obstructions that have heights generally less than 30 feet. This category includes flat, open country and grasslands.
D: Flat, unobstructed areas and water surfaces. This category includes smooth mud flats, salt flats, and unbroken ice.

Houses in hurricane-prone regions can be damaged by high wind pressures and wind-driven rain, as well as windborne debris. Wind-driven rain requires special attention in the hurricane-prone region. High winds can produce large amounts of debris that may become windborne and perforate the building envelope and openings. Once a building envelope is perforated, wind-driven rain can enter the building, causing water damage to the interior and contents. A broken window or glass door may also allow wind pressures to increase within the house, leading to structural damage. As such, building codes require new houses in windborne debris regions be constructed to protect glazing (windows and glass doors) against damage and impacts from windborne debris. Homeowners should consider adding protection to the openings in their existing house to mitigate this risk. The inset of Figure 4 illustrates the windborne debris region for several Gulf Coast states.

PRESCRIPTIVE SOLUTIONS LIMITATIONS AND WIND DESIGN CRITERIA OR TESTING REQUIREMENTS

Prescriptive Solutions Limitations

Many of the prescriptive solutions specified to meet the Mitigation Packages are limited to a maximum **Basic Wind Speed of 130 mph** and **Exposure Category C**. This limitation is specified, as applicable, for each prescriptive solution in the *2020 FORTIFIED Home Standard*. Some of the Mitigation Package requirements, such as Sealing the Roof Deck in Section 4.1.2 of this Guide, are applicable to any wind speed and exposure category. **It is important for users of this Guide to carefully read all of the requirements and limitations specified in Chapter 4 of this Guide and the *2020 FORTIFIED Home Standard* for each retrofit being considered**. Where a prescriptive method limitation or minimum design requirement applies, a text box is provided for each specified retrofit identifying the prescriptive solution limitations and/or minimum design requirement. **Where site conditions exceed the limitations of the prescriptive solutions in this Guide, an engineered solution by an RDP in accordance with ASCE 7-22 is required.** Prescriptive high wind standards such as the *2024 AWC Wood Frame Construction Manual* are permitted to be used if they are based on ASCE 7-22.

Prescriptive solutions in the *2020 FORTIFIED Home Standard* are provided for ASCE 7-10 and ASCE 7-16. The Mitigation Packages in the Guide require the use of the prescriptive solutions specified for ASCE 7-16 in the *2020 FORTIFIED Home Standard*.

Minimum Wind Design Criteria or Testing Requirements

Where this Guide requires systems and components to be designed or tested to meet the applicable wind loads, they must be determined in accordance with ASCE 7-22 for site-specific conditions, but not less than the following:

- Basic Wind Speed, $V \geq 130$ mph
- Exposure Category C

Where permitted in this Guide, the simplified wind loads from Table R301.2.1(1) of the 2024 IRC can be used to determine wind loads for the minimum conditions specified above.

Table 2 provides a summary of the prescriptive solutions limitations for the Mitigation Packages detailed in Chapter 4. Where site conditions exceed the limitations of any given prescriptive solution, Table 3 provides the minimum wind design criteria needed to develop an engineered solution. Additionally, Table 3 includes product testing requirements where applicable to the corresponding retrofit criteria.

Table 2: Summary of Prescriptive Solutions Limitations

Mitigation Package	*Retrofit Criteria*	*P-804 Section*	*Prescriptive Solutions Limitations*
Basic – Option 1	Qualifying roof structural members and roof covering	4.1.1	Minimum qualifications apply to all locations
	Sealing and strengthening the roof deck	4.1.1	Prescriptive solutions apply to all locations within hurricane-prone regions of the US as defined by ASCE 7
	Attic vents and covers	4.1.1	Prescriptive solutions apply to all locations within hurricane-prone regions of the US as defined by ASCE 7
Basic – Option 2	Roof decking minimum thickness	4.1.2	Maximum Basic Wind Speed 130 mph and Exposure Category C
	Roof deck attachment	4.1.2	Maximum Basic Wind Speed 130 mph and Exposure Category C
	Sealing the roof deck	4.1.2	Prescriptive solutions apply to all locations within hurricane-prone regions of the US as defined by ASCE 7
	Roof coverings	4.1.2	N/A – see Testing Requirements in Table 3

Mitigation Package	*Retrofit Criteria*	*P-804 Section*	*Prescriptive Solutions Limitations*
Basic – Option 2 (cont.)	Attic vents and covers	4.1.2	Prescriptive solutions apply to all locations within hurricane-prone regions of the US as defined by ASCE 7
	Corrosion protection	4.1.2	Prescriptive solutions are unlimited and independent of wind design or testing requirements
Intermediate	Impact protection for windows and skylights	4.2.2	N/A– see Testing Requirements in Table 3
	Impact protection for entry doors	4.2.2	N/A– see Testing Requirements in Table 3
	Impact protection of Garage doors with glazed openings (garage doors with glazed openings)	4.2.2	N/A– see Testing Requirements in Table 3
	Design wind pressure rating of garage doors	4.2.2	N/A– see Testing Requirements in Table 3
	Gable end wall sheathing	4.2.3	Maximum Basic Wind Speed 130 mph and Exposure Category C.
	Gable end wall bracing	4.2.3	Maximum Basic Wind Speed 180 mph and Exposure Category C Other Limitations: See FEMA Grant Requirements for Gable End Wall Bracing
	Gable end overhangs	4.2.3	Maximum Basic Wind Speed 180 mph and Exposure Category D
	Soffits	4.2.4	Wood structural panel prescriptive soffit installation limited to a maximum design pressure of 90 psf
	Chimneys	4.2.5	Prescriptive solutions apply to all locations within hurricane-prone regions of the US as defined by ASCE 7 provided existing chimney conditions are met Other limitations: See Section 4.2.5

Mitigation Package	*Retrofit Criteria*	*P-804 Section*	*Prescriptive Solutions Limitations*
Intermediate (cont.)	Attached structures	4.2.6	Maximum Basic Wind Speed 180 mph and Exposure Category D Other limitations: See Section 4.2.6
Advanced	Design wind pressure rating of openings (windows, skylights, glass block, doors, and garage doors)	4.3.2	N/A– see Testing Requirements in Table 3
	Exterior wall impact resistance	4.3.3	Prescriptive solution applies to all locations within hurricane-prone regions of the US as defined by ASCE 7
	Continuous load path	4.3.4	N/A

Note: It is important for users of this Table to carefully read all of the requirements and limitations specified in Chapter 4 of this Guide and the *2020 FORTIFIED Home Standard* for each retrofit being considered. This Table was developed to be used in conjunction with Chapter 4 of this Guide and the *2020 FORTIFIED Home Standard*.

Table 3: Summary of Minimum Wind Design Criteria for Engineered Solutions and Minimum Testing Requirements

Mitigation Package	*Retrofit Criteria*	*P-804 Section*	*Minimum Wind Design Criteria or Testing Requirements*
Basic – Option 1	Qualifying roof structural members and roof covering	4.1.1	N/A - Minimum qualifications apply to all locations
	Sealing and strengthening the roof deck	4.1.1	N/A – Prescriptive solutions apply to all locations within hurricane-prone regions of the US as defined by ASCE 7
	Attic vents and covers	4.1.1	N/A – Prescriptive solutions apply to all locations within hurricane-prone regions of the US as defined by ASCE 7
Basic – Option 2	Roof decking minimum thickness	4.1.2	Site-specific requirements corresponding to not less than 130 mph and Exposure Category C
	Roof deck attachment	4.1.2	Site-specific requirements corresponding to not less than 130 mph and Exposure Category C

Mitigation Package	*Retrofit Criteria*	*P-804 Section*	*Minimum Wind Design Criteria or Testing Requirements*
Basic – Option 2 (cont.)	Sealing the roof deck	4.1.2	N/A - Prescriptive solutions apply to all locations within hurricane-prone regions of the US as defined by ASCE 7
	Roof coverings	4.1.2	Site-specific requirements but for pressure-rated roof coverings, design pressures corresponding to not less than 130 mph and Exposure Category C
	Attic vents and covers	4.1.2	N/A - Prescriptive solutions apply to all locations within hurricane-prone regions of the US as defined by ASCE 7
	Corrosion protection	4.1.2	N/A – Prescriptive solutions are independent of wind design or testing requirements
Intermediate	Impact protection for windows and skylights	4.2.2	Minimum Large Missile D from ASTM E1886 and ASTM E1996 and AAMA 506; or Florida Building Code Testing Application Standards TAS 201 and 203
	Impact protection for entry doors	4.2.2	Minimum Large Missile D from ASTM E1886 and ASTM E1996 and AAMA 506; or Florida Building Code Testing Application Standards TAS 201 and 203
	Impact protection of Garage doors with glazed openings (garage doors with glazed openings)	4.2.2	Minimum Large Missile D from ASTM E1886 and ASTM E1996 and AAMA 506; or Florida Building Code Testing Application Standards TAS 201 and 203
	Design wind pressure rating of garage doors	4.2.2	Site-specific requirements with design pressures corresponding to not less than 130 mph and Exposure Category C
	Gable end wall sheathing	4.2.3	Site-specific requirements corresponding to not less than 130 mph and Exposure Category C
	Gable end wall bracing	4.2.3	Site-specific requirements corresponding to not less than 130 mph and Exposure Category C
	Gable end overhangs	4.2.3	Site-specific requirements corresponding to not less than 130 mph and Exposure Category C
	Soffits	4.2.4	Site-specific requirements with design pressures corresponding to not less than 130 mph and Exposure Category C.
	Chimneys	4.2.5	Site-specific requirements with design pressures corresponding to not less than 130 mph and Exposure Category C.

Mitigation Package	*Retrofit Criteria*	*P-804 Section*	*Minimum Wind Design Criteria or Testing Requirements*
Intermediate (cont.)	Attached structures	4.2.6	Site-specific requirements with design pressures corresponding to not less than 130 mph and Exposure Category C.
Advanced	Design wind pressure rating of openings (windows, skylights, glass block, doors, and garage doors)	4.3.2	Site-specific requirements with design pressures corresponding to not less than 130 mph and Exposure Category C.
	Exterior wall impact resistance	4.3.3	N/A - Prescriptive solution applies to all locations within hurricane-prone regions of the US as defined by ASCE 7
	Continuous load path	4.3.4	Site-specific requirements with design pressures corresponding to not less than 130 mph and Exposure Category C.

Note: It is important for users of this Table to carefully read all of the requirements and limitations specified in Chapter 4 of this Guide and the *2020 FORTIFIED Home Standard* for each retrofit being considered. This Table was developed to be used in conjunction with Chapter 4 of this Guide and the *2020 FORTIFIED Home Standard*.

2.2. Levels of Protection

Over the past few decades, building codes have progressed toward addressing design and construction practices that will result in buildings that are more resistant to high winds. However, much of the existing building stock in hurricane-prone regions was designed and constructed to codes and standards that required far less than current codes to mitigate wind damage—or was constructed to no code at all. It is important for homeowners to be aware of the limits of the building code used to construct their house, the existing level of risk, and how and to what extent the risks can be mitigated.

Homeowners can obtain information about both the effectiveness and limitations of the building code used to construct their house by contacting their State Hazard Mitigation Officer (SHMO). Contact information for SHMOs can be found online at https://www.fema.gov/grants/mitigation/state-contacts. The FEMA Building Science Helpline can provide additional information regarding building science, substantial damage, high winds, floods, and building codes. The helpline can be reached by email at FEMA-BuildingScienceHelp@fema.dhs.gov and by phone at 866-927-2104. The National Building Code Adoption Tracking (BCAT) Portal can also be used to determine the current code adoption status for an authority having jurisdiction. The National BCAT Portal is an interactive WebGIS map that shows flood, seismic, tornado, hurricane wind, and damaging wind hazards. The map also displays the code adopted in each county for each individual hazard. The portal can be accessed at https://www.fema.gov/emergency-managers/risk-management/building-science/bcat.

Properly designing and constructing a building to locally adopted building codes provides the minimum level of protection for the wind hazard at a particular site for new construction. However, older houses may not be wind resistant when compared to today's codes and standards, even if constructed to adopted building codes at the time they were built. This Guide describes retrofits for those older buildings and for newer structures that were not designed or constructed to comply with modern hazard-resistant building codes. Residential buildings can suffer extensive wind damage when wind speeds exceed the design levels or when they are improperly designed and constructed. For example, even though Hurricane Irma's wind speeds were below the design wind speeds for much of the impacted area, many residential buildings suffered wind damage, some of which was disproportionate to the reported wind speeds. During Hurricane Irma, the house in Figure 5 sustained structural damage from wind speeds estimated at 113 mph, which was well below the estimated design wind speed of 180 mph for that location.

Figure 5: House with structural damage to roof system from Hurricane Irma where the estimated wind speed was 113 mph. This is far less than the design wind speed of 180 mph for the structure at that location. The close-up shows severed truss upper chords (blue circles) and intact connection of lower top chord and top of wall (yellow rectangles).

The winds and floodwaters of Hurricane Irma tested many residential retrofits, and recent MATs observed the results of these retrofits. The MAT observations showed that planning for retrofit deployment is inconsistent, installation of retrofits is not always effective, and even when installed,

the level of effectiveness of the operation and implementation of retrofits is variable. The MAT also observed that when retrofits were implemented in a piecemeal, rather than holistic fashion, damage could still occur even if the retrofits performed as expected. For example, if a building was retrofitted to provide protection for windows against windborne debris with impact-resistant glazing, but not to address wind-driven rain, extensive damage to the building could still result from the wind-driven rain even if the window glazing remained intact.

2.2.1. WIND HAZARDS ADDRESSED IN BUILDING CODES AND STANDARDS

Many states and communities now regulate the construction of buildings by adopting and enforcing building codes. Most locally adopted building codes in the United States are based on model building codes. Examples of the most recent model building codes at the time of publication of this Guide[4] promulgated by the International Code Council (ICC) include:

- 2021 International Building Code (IBC) (ICC, 2020d)
- 2021 International Residential Code (IRC) (ICC, 2020f)
- 2021 International Existing Building Code (IEBC) (ICC, 2020e)

The approaches to wind design in these model codes are based on modern wind engineering provisions of ASCE 7, as well as acceptable methods for enhancing wind hazard resistance. The IRC also incorporates, by reference, industry standards in addition to ASCE 7 that are specifically recognized as accepted engineering practice for one- and two-family dwellings in high-wind regions. These standards include:

- *Wood Frame Construction Manual for One- and Two-Family Dwellings* (AWC, 2018)
- *Standard for Residential Construction in High-Wind Regions* (ICC 600) (ICC, 2020g)
- *Standard for Cold-Formed Steel Framing—Prescriptive Method for One- and Two-Family Dwellings* (AISI S230) (AISI, 2019)

While compliance with codes and standards for new construction is not the subject of this Guide, construction methods within those documents may serve as additional guidance for improving resistance to high winds. As populations in coastal areas continue to increase and hurricanes continue to affect coastlines, more states began adopting and mandating the use of nationally recognized building codes and standards. Furthermore, building codes and standards are often updated to incorporate lessons learned after natural disasters.

Following Hurricane Andrew, Florida became proactive with hazard-resistant codes with its first edition of the Florida Building Code (FBC) becoming effective March 1, 2002. Buildings like the one shown in Figure 6 that were built using codes that incorporated lessons learned after Hurricane

[4] At the time of publication of this Guide, ICC was preparing to officially release the 2024 edition of the model codes. The 2024 IRC references ASCE 7-22.

Andrew performed better than older buildings during recent hurricanes. Jurisdictions that lack a locally adopted code, or use older codes, are more likely to have houses vulnerable to wind damage.

Figure 6: House with a sealed roof deck that successfully prevented the entry of wind-driven rain during Hurricane Michael after windborne debris punctured the metal roof covering.

Prior to Hurricane Katrina in 2005, Louisiana communities had varying building and residential codes, and in many communities, no established building codes at all. In 2007, Louisiana adopted the 2003 IRC and IBC, with state-specific amendments and has continued adopting more modern codes. Currently, Louisiana follows the 2015 IRC and IBC, with state-specific amendments in 2018. At the time of publication, Louisiana was working toward adoption of the 2021 IRC and IBC.

2.2.2. RECOMMENDED PROTECTION AND BEST PRACTICES

Post-disaster investigations of areas impacted by hurricanes are conducted by FEMA, academia, the building and materials industry, and the insurance industry to collect data on successes and failures that we can learn from. Both independently and collaboratively, these groups have identified similar performance issues in older buildings. In general, the buildings that performed poorly did not have:

- Roof and wall coverings capable of resisting high winds or the intrusion of wind-driven rain through the use of sealed roof decks or similar mitigation
- Protection for openings (windows, doors, garage doors, soffits, and vents) to resist high winds, windborne debris, and wind-driven rain (this applies both to the inside and outside of the windborne debris region)
- A continuous load path for all loads (gravity, uplift, and lateral) to be passed from the building envelope to the ground through the foundation

This Guide presents Mitigation Packages that, if implemented correctly, will reduce the risks of damage to a residential building from a long-duration, high-wind event. However, there are several factors to consider in the decision-making process to implement wind retrofit measures, such as:

- Is the risk level of the house high enough to make it a good candidate for a wind retrofit project?

- Which Mitigation Packages are cost-effective for the desired level of protection for the house?
- How much risk of wind-related damage is acceptable to the homeowner?

NEED FOR RETROFITS IN PACKAGES

Based on observations from previous post-disaster investigations conducted by FEMA, a single retrofit measure alone is unlikely to provide improved protection and risk reduction from a wind event. This Guide presents groups of retrofit measures in "Mitigation Packages" for a more comprehensive and cost-effective solution to risk reduction. The Mitigation Packages are presented in Chapter 4.

These factors and others are discussed in further detail in Chapters 3 and 4 of this Guide. Although the individual retrofit measures of the Mitigation Packages are based on design methods in current building codes and standards, not all of the design elements required by modern building codes for wind hazard resistance will be included in the retrofit project. Therefore, depending on the Mitigation Package(s) implemented, residual risk will likely still exist, even though some of the strengthened elements of the implemented retrofits may meet or exceed local building code requirements. More information on residual risk and addressing other hazards can be found in Section 5.3. Homeowners should always follow mandatory evacuation orders, even if wind Mitigation Packages are implemented.

RESIDUAL RISK

Residual risk is the level of risk that is not offset by hazard-resistant design or insurance, and that must be accepted by the property owner.

Implementing mitigation measures to reduce risk is a personal decision for homeowners to protect their house and property. Having made the decision to pursue a wind retrofit project, the homeowner will also have to decide what level of protection is desired. A homeowner's decision regarding the desired level of protection will likely involve weighing the wind hazard risk with the cost of mitigating that risk. The FEMA BCA Tool can be used as a reference point for determining whether the mitigation measures being considered are cost-effective. Use of this software is required when submitting a grant application to one of FEMA's HMA programs (refer to Chapter 5 and Appendix C). However, the BCA results should not be the only factor used to make decisions regarding the wind retrofit project.

DETERMINING COST-EFFECTIVENESS

The FEMA BCA Toolkit determines that a project is cost-effective when the benefit-cost ratio (BCR) is 1 or greater. The tool, along with resource documents to guide users through the BCA process, can be downloaded from https://www.fema.gov/grants/tools/benefit-cost-analysis. Appendix C of this Guide provides a step-by-step guide on using the FEMA BCA Toolkit with the Mitigation Packages presented in this Guide, as well as guidance on precalculated benefits.

Each house is unique and exposed to risks that may be specific to a particular site or region. For example, implementing the Basic Mitigation Package may reduce risk, but may also leave too much residual risk; in this case, a homeowner may decide the additional cost of implementing the Intermediate Mitigation Package is more acceptable. Another cost consideration homeowners may face is the need to make improvements to their house before the Basic Mitigation Package can be implemented. Some houses may be previously damaged or may be undergoing improvements (addition or renovation). These houses may be very good candidates for a wind retrofit project, as components that are normally difficult to access may already be exposed. However, such conditions may also trigger substantial improvement/substantial damage (SI/SD) provisions of governing building codes and local regulations for houses in the floodplain, requiring further work on the house outside the scope of the wind retrofit project type. See Section 5.2.1 for more information. Refer to Section 3.1 for more guidance on evaluating whether a house is a good candidate for one of the Mitigation Packages.

SAFE ROOM: NEAR-ABSOLUTE PROTECTION

The level of occupant protection provided by a safe room is much greater than the protection provided by buildings that comply with the minimum requirements of most building codes or any level of protection detailed in this Guide. Safe rooms offer near-absolute protection (a very high probability of being protected from injury or death). FEMA P-320, *Taking Shelter from the Storm: Building a Safe Room for Your Home* (Fifth Edition, 2021c), includes prescriptive design plans that provide homeowners and their builders/contractors with information on how to construct a safe room to serve one- and two-family dwellings. For solutions not covered by FEMA P-320, FEMA P-361, *Design and Construction Guidance for Community Safe Rooms* (Fourth Edition, 2021b), includes criteria needed for RDPs to develop custom residential safe room designs.

FEMA continues to advocate for the design and construction of residential safe rooms as evidenced by its continuing support of safe room initiatives through several grant programs. Since the initiation of its safe room program, FEMA has provided support for over 20,000 residential safe rooms with federal funds totaling more than $147,000,000 (as of November 2020). A growing number of these safe rooms have already saved lives in actual events. There have been no reported failures of any safe rooms constructed to FEMA criteria, or fatalities of anyone using them for shelter during a storm event.

The installation of any safe room in a hurricane-prone region should be coordinated with local emergency management and law enforcement personnel to ensure its use during extreme-wind events is not a violation of any local or state evacuation plan.

For answers to safe room questions, contact the FEMA Safe Room Helpline by email at Saferoom@fema.dhs.gov or by phone at 866-927-2104. Additional safe room publications and resources are also available to homeowners along with FEMA P-320 and FEMA P-361 at https://www.fema.gov/emergency-managers/risk-management/safe-rooms/resources.

3. Evaluating Existing Houses

Retrofitting existing buildings has always been a potentially complicated task. Existing houses may be complex shapes and configurations because of an original custom design or additions over the years. Material types and construction methods can vary widely. Codes to which buildings were originally designed and constructed can be well below modern code requirements and, as previously mentioned, houses may even have been constructed in a location that had no adopted code at the time of construction. Therefore, in order to execute a successful retrofit on any house, an evaluation of its existing condition should be performed to determine:

- Age and condition of the house
- Overall structural integrity of the house
- Weaknesses in the house's envelope
- Weaknesses in the house's structure
- Weaknesses in the house's foundation (refer to *2020 FORTIFIED Home Standard* Section 2.4, Qualifying Foundation Types, for updated guidance on foundation connection requirements: search for 'foundation' under Technical Documents List at https://fortifiedhome.org/technical-documents/ and download the latest technical bulletin)
- Whether the house meets the conditions required to be a good candidate for retrofitting to effectively improve resistance to wind-related damage
- How a house can best be retrofitted for the different Mitigation Packages—Basic, Intermediate, or Advanced—and approximately how much the more feasible options would cost
- The most cost-effective retrofit project for the house

A qualified individual should evaluate the house and provide recommendations to the homeowner based on their findings. For the purposes of this Guide, this person will be referred to as an *evaluator.* Acceptable evaluators may include building science professionals such as registered architects and engineers, building officials, and evaluators that are certified through state or locally recognized wind retrofit programs. IBHS's FORTIFIED program requires evaluations of existing buildings be performed by a "Certified FORTIFIED Evaluator;" therefore, homeowners who plan to seek FEMA funding for wind retrofits and wish to achieve 2020 FORTIFIED Home Hurricane designation [5] should use Certified FORTIFIED Evaluators to coordinate criteria across both programs. IBHS provides an online directory to help property owners find a Certified FORTIFIED Evaluator at https://ibhs.force.com/s/find-a-provider. Property owners can also contact IBHS's partner, Pilot, at 866-450-9214 or IBHSAssign@pilotcat.com to find an evaluator in their state. See Appendix A for

[5] Achieving a 2020 FORTIFIED Home Hurricane designation in participating states may earn property owners insurance benefits. Levels of state participation are available at https://fortifiedhome.org/incentives/.

more information. Other state or locally adopted wind retrofit programs, such as those discussed in Chapter 5, may have additional evaluator requirements. Furthermore, an RDP will be needed if existing conditions disallow implementation of the prescriptive solutions presented in Chapter 4 of this Guide for the homeowner-selected Mitigation Package.

3.1. Evaluating a House

The purpose of the evaluation is to determine whether the house is a good candidate for any of the wind retrofit Mitigation Packages. It also serves to identify any repairs that must be performed before a wind retrofit project can be undertaken and clarify the applicability of the wind retrofit Mitigation Packages from a construction standpoint. The evaluation will also identify whether the applicable prescriptive retrofits can be implemented or a custom engineered solution should be developed. The purpose of the evaluation is not to determine whether the building meets current code.

Before an evaluation is performed, homeowners should compile any available documentation on the design and construction of the house, including previous upgrades such as roof recovering and replacement of windows and doors. Where available, the following information should be provided to the evaluator:

- Documentation regarding the existing roof
    - If the roof covering has not been replaced, the purchase contract, building permit, or property tax record showing the age of the property
    - If at least a portion of the roof covering has been replaced, installation documentation
    - If a sealed roof deck has been installed, installation documentation
    - If a two-part spray polyurethane foam (SPF) adhesive has been applied to the underside of the roof deck, installation documentation (reference Section 4.1.1 of *2020 FORTIFIED Home Standard* Section 3.2)
- If a termite inspection has been conducted within 12 months on the house, the termite inspection report or bond issued
- Installation documentation for windows, entry doors, garage doors, and impact-rated products (such as shutters systems) as applicable
- Any additional documentation regarding the condition of the building or previous work done to the building, such as design plans or inspection reports
- Photographic documentation of the building and any improvements (such as previous work performed, renovations, or deck construction)

DOCUMENTATION

"Evidence that a specific requirement has been met, either in the form of a test report, manufacturer's installation guidelines, product markings, or other evidence that proves that a specific requirement has been met" (IBHS, 2020).

Homeowners should check with FEMA HMA to confirm the required documentation needed to obtain FEMA funding. Homeowners can contact FEMA HMA through its Helpline by calling 1-866-222-3580.

If, in addition to FEMA funding, a homeowner wishes to obtain a 2020 FORTIFIED Home Hurricane designation, other documentation may be required. Please refer to 2020 FORTIFIED Section 2.12, "Documentation Requirements," for general information on acceptable documentation needed to achieve corresponding FORTIFIED designations. For specific descriptions of documentation needed for individual FORTIFIED designations, please refer to FORTIFIED Documentation Requirements (aka Evaluator Checklists) available for download at https://fortifiedhome.org/technical-documents/.

Having all available information prepared for the evaluator when they arrive can greatly increase the accuracy and timeliness of the evaluation. When the evaluation begins, homeowners (and other parties involved in the decision-making process) should have an idea of which Mitigation Package they will implement based on available budget, perceived condition and age of the house, perceived cost-effectiveness of retrofits, federal assistance, and other savings. The evaluator should be able to provide preliminary advice on which Mitigation Package to consider; this can be discussed before the evaluation begins. The selected Mitigation Package will affect how invasive the evaluation will be.

The evaluator should conduct a full walkthrough of the house, assessing the condition of the areas that will be retrofitted as well as the overall condition of the house. For example, if there are significantly damaged components within the roof system, the evaluator should provide a detailed description of the damage in the evaluation report, including a description of any needed repairs required before the house is a suitable wind retrofit project candidate and whether those repairs will require an RDP's consultation.

The following sections address the evaluation process for the building envelope and structure. Additional guidance on evaluating buildings before starting a wind retrofit project, including what should be documented in the building evaluation, is presented in Appendix B of this Guide.

3.1.1. ALL MITIGATION PACKAGE EVALUATIONS

As described in the introduction to Chapter 4, each successive Mitigation Package must also meet the requirements of any lower-level Mitigation Package(s). Therefore, evaluations for all wind retrofit projects should start with the roof. The roof framing and roof deck must be observed to determine whether they meet the minimum requirements described in Section 3.2. In most cases, the attic will need to be accessed to evaluate the roof structure.

Next, the roof covering must be evaluated to determine whether it needs to be replaced as part of the wind retrofit project. While the homeowner may already know whether they want to replace the roof covering, the evaluation will identify whether the roof covering is required to be replaced for project eligibility. A house with a roof covering assessed as having 5 or more years of remaining useful life is a candidate for retrofit options that do not require roof covering replacement. The evaluator should use any available documentation provided by the homeowner as well as visual observations of the roof covering condition to determine the remaining useful life of the roof covering. Lastly, the evaluator should note the condition, type (ridge, off ridge, or gable end), and rating (where applicable, see *2020 FORTIFIED Home Standard* Section 4.9) of all existing attic ventilation assemblies.

3.1.2. INTERMEDIATE MITIGATION PACKAGE EVALUATIONS

For projects implementing the Intermediate Mitigation Package, the evaluation should focus primarily on the building envelope. The following building elements should be inspected, and their material type and existing condition documented during the evaluation:

- **Roof** (roof covering and roof structural system beneath) as described in Section 3.1.1
- **Attic ventilation assemblies** (ridge, off-ridge, and gable end vents) as described in Section 3.1.1
- **Gable end wall assemblies** (wall framing and coverings)
- **Soffits**
- **Chimney attachment**
- **Opening Impact Protection** (windows, skylights, entry doors)
- **Opening Impact Protection and Design Pressures** (garage doors only)
- **Attached structures** (porches, awnings, and carports)

Evaluation of these building elements for the Intermediate Mitigation Package usually involves only minimal disturbance to the building.

After evaluating the roof covering, roof structural system, and attic ventilation assemblies as described in Section 3.1.1, the evaluator should observe and document the gable end walls, soffits, openings, and attached structures. For each observed element, the evaluator should check to see whether the house already complies with any of the Mitigation Package requirements. For example, a house may already have window protection that meets the opening protection requirements of the Intermediate or Advanced Mitigation Package. The evaluator should verify that the opening protection (e.g., shutters over openings or pressure- and impact-rated windows and doors) provides the level of protection for the respective Mitigation Package as defined in Chapter 4 of this Guide and is in operable condition (e.g., shutters are functional and are properly anchored to the building). Opening protection components are typically verified through labeling or documentation that the homeowner may have for the product(s), as shown in Figure 7. Identifying whether the house already

has any completed retrofit projects will increase the cost-effectiveness of the overall mitigation effort. Refer to Appendix B, Evaluation Guidance, for more details on evaluation criteria.

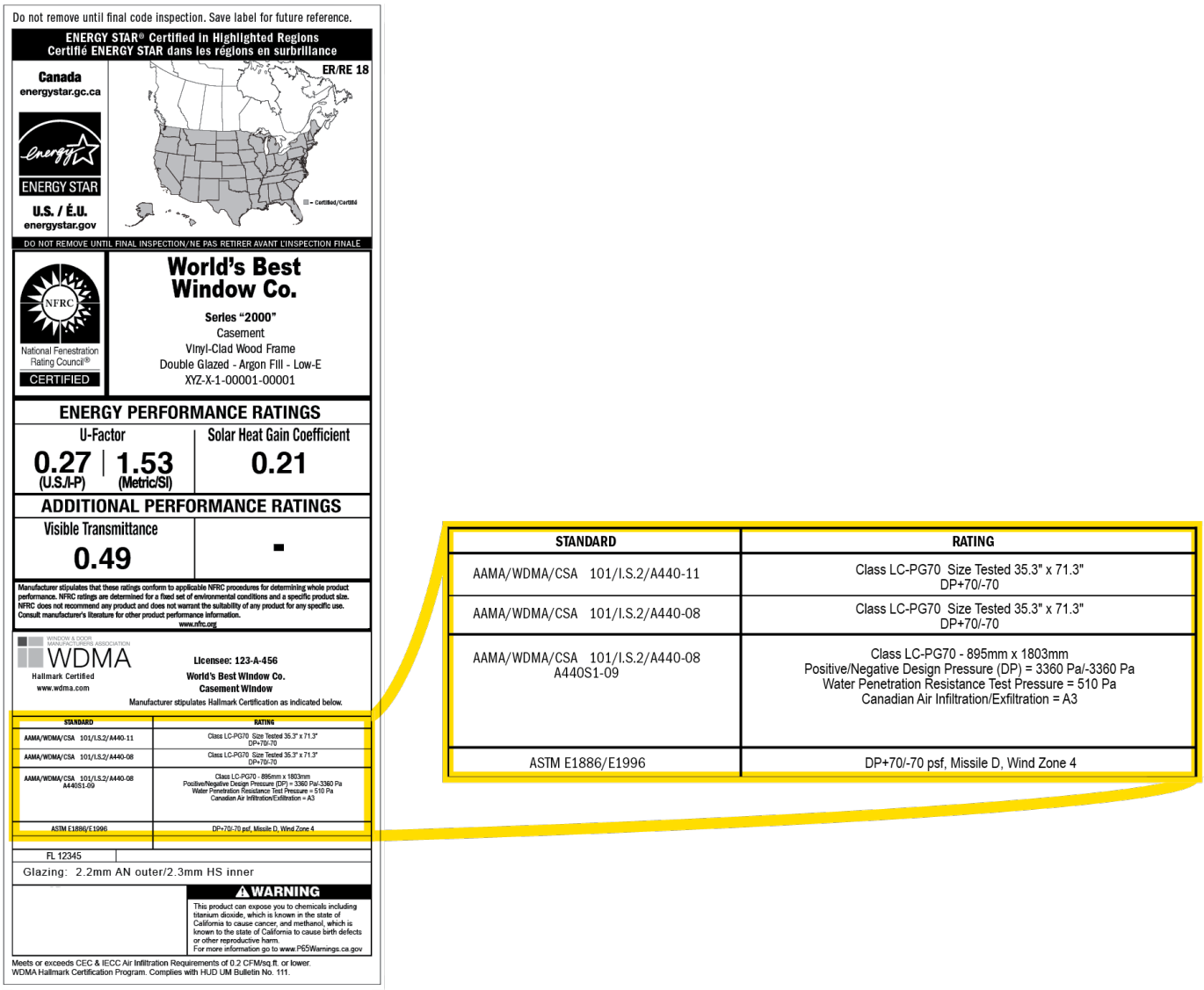


Figure 7: Example of window label product

3.1.3. ADVANCED MITIGATION PACKAGE EVALUATIONS

For the Advanced Mitigation Package, the evaluation starts by revisiting the openings in the house's walls (windows and entry doors) and roof (skylights) that were checked for impact protection in accordance with the Intermediate Mitigation Package to determine whether they have been designed and installed to resist design wind pressures.

Next, the structural connections that create a continuous load path from the roof to the foundation must be evaluated. The evaluator will need to identify any locations where the continuous load path is incomplete or broken. Some controlled, destructive actions may be necessary to access structural

connections. The level of invasiveness of an assessment for the Advanced Mitigation Package will depend on the construction type and structural configuration of the house.

A continuous load path is an important part of a building's ability to resist wind loads. The continuous load path ensures that loads applied to any part of the building can be transferred through the building from the point of application (such as the roof or exterior walls) through the structure of the building and to the foundation (see Figure 8). A house for which the Advanced Mitigation Package is being sought does not have to have an existing continuous load path before the wind retrofit project is performed. However, the more incomplete or broken the continuous load path is, the higher the costs could be when retrofitting the house to the Advanced Mitigation Package.

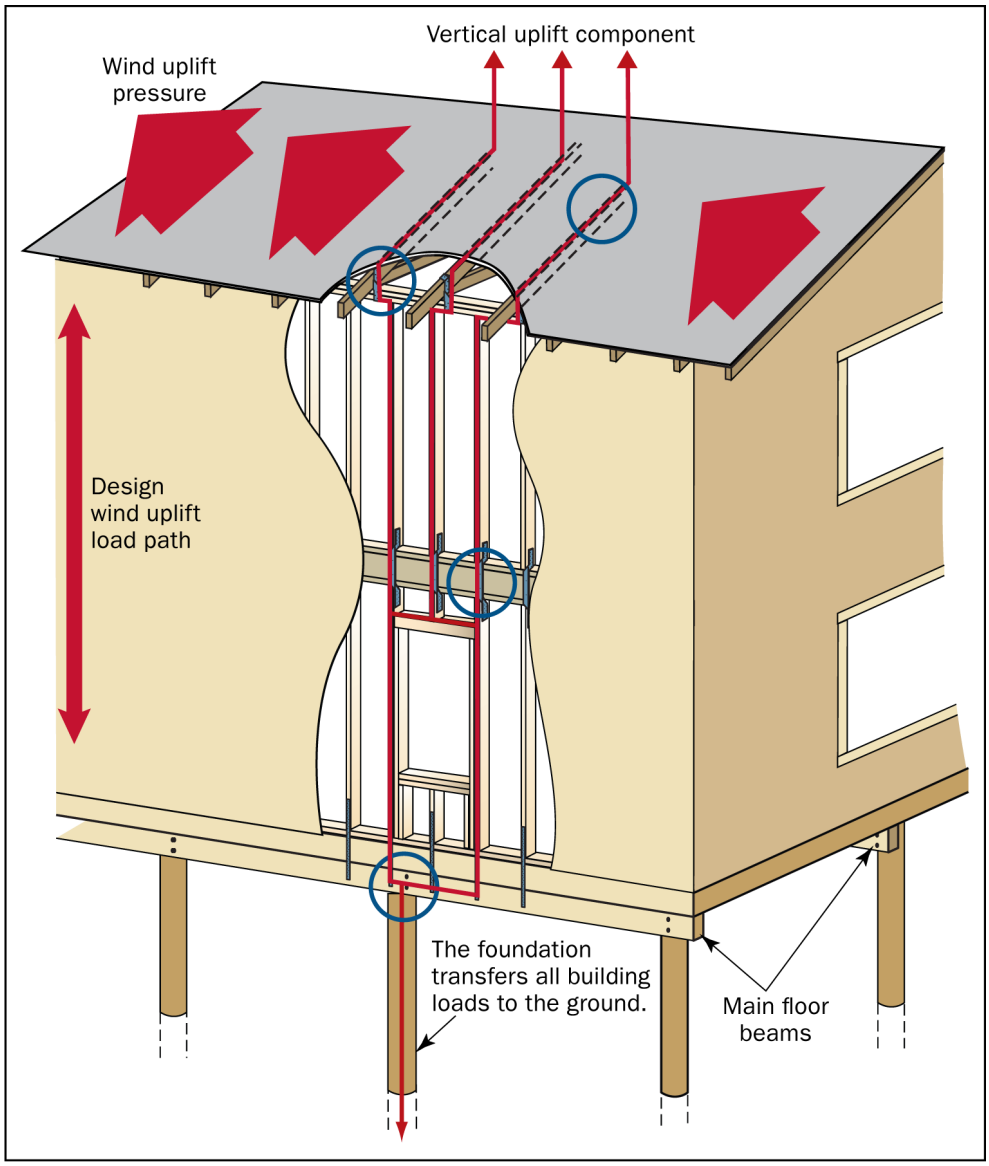


Figure 8: Continuous load path for wind uplift of a residential, wood-frame building (blue circles show some of the connections in the load path)

PROJECT SUCCESS DEPENDS ON THOROUGH EVALUATIONS

Regardless of which Mitigation Package is selected, the evaluation should cover the entire building envelope and conditions that would limit the effectiveness of the wind retrofit project. For example, if the wall covering is deteriorated, damaged, or not sufficiently fastened to the building, implementing a wind retrofit project would not provide the intended level of performance because other elements are likely to fail.

3.2. Evaluation Report

Once the evaluation has been completed, the evaluator should develop an evaluation report with significant findings, recommendations, and determinations to share and discuss with the homeowners. The report should include a description of the existing condition of the building as described in this section and a recommendation for one or more of the Mitigation Packages. If repairs are needed before the wind retrofit project can proceed, the report should provide a general assessment of the work required. Some conditions, if found to exist in the house, can require extensive and invasive work and have very high associated costs. Appendix B contains further guidance on such situations.

To facilitate the homeowner's decision on selecting which Mitigation Package is the best fit for their house, the evaluation report should describe the following findings:

1. Existing conditions needing repair
2. Existing conditions that may prevent implementation of the prescriptive retrofit solutions
3. Existing conditions that already meet the intent of Mitigation Package requirements

Based on the three types of findings, the evaluation report should provide one or more of the determinations described at the end of this section.

3.2.1. EXISTING CONDITIONS NEEDING REPAIR

The evaluation for a wind retrofit project may identify existing conditions that need to be remedied. Although any house can be retrofitted, some may include deficiencies or defects (e.g., flawed or inadequate construction, previous damage, etc.) that must be addressed for any of the proposed Mitigation Packages to be effective. In these instances, additional work may be needed before, or during, the wind retrofit project. This does not mean that such a house cannot undergo cost-effective wind retrofits in accordance with this Guide, but additional effort and associated expense will increase the overall project costs and may disqualify FEMA grant funds as described in Section 5.1.1.

3.2.2. EXISTING CONDITIONS THAT MAY PREVENT IMPLEMENTATION OF THE PRESCRIPTIVE RETROFIT SOLUTIONS

The evaluation should also determine whether the prescriptive solutions provided in this Guide can be used for the project. If the evaluation finds that any prescriptive solution for the homeowner's selected wind Mitigation Package does not apply, an RDP must be consulted to develop an engineered solution in place of the prescriptive solution.

Upon evaluation, if the following roof and gable end wall framing conditions are met or exceeded, then the prescriptive roof and gable end wall retrofits specified in this Guide may be considered; refer to Chapter 4 for additional requirements.

- Roof framing:
  - Maximum spacing 24 inches on-center (o.c.)
  - Minimum nominal 2-inch thickness
  - Minimum roof deck panel thickness equal to or greater than nominal 15/32-inch thickness for wood structural panels
- Gable end walls:
  - Minimum wood structural panel sheathing nominal 7/16-inch thickness
  - Maximum stud height 16 feet

Although the majority of houses should meet most of the above-described conditions, many existing roof deck panels are less than 15/32-inch thick. In such cases, an RDP can analyze the existing roof deck to determine whether it complies with ASCE 7-16 for a minimum design wind-speed of 130 mph or the site-specific design wind speed, whichever is greater. Alternatively, minimum 15/32-inch sheathing can be installed over the existing roof deck by attaching the sheathing to the rafters or trusses below in accordance with Detail F-RR-5 in Appendix A of the *2020 FORTIFIED Home Standard*.

3.2.3. EXISTING CONDITIONS THAT ALREADY MEET THE INTENT OF MITIGATION PACKAGE REQUIREMENTS

In contrast, some houses may already incorporate some of the elements of the Mitigation Packages even before the retrofit process has begun. In this situation, the evaluator should verify that the existing components of the building are in accordance with the retrofits defined for the selected Mitigation Package.

Whenever feasible, the evaluation report should include approximate cost estimates for the recommended Mitigation Package(s) to facilitate the homeowner's decision-making process. Homeowners may obtain more accurate and comprehensive cost estimates from local building contractors as needed.

3.2.4. REPORT RECOMMENDATIONS AND DETERMINATIONS

Based on the findings of the evaluation process, the report should result in one or more of the following three determinations for each of the recommended Mitigation Packages:

1. The evaluated house does not qualify for all of the prescriptive retrofits in this Guide for the recommended Mitigation Package. The report should identify which retrofits cannot be implemented using the prescriptive solutions in this Guide. Where prescriptive solutions cannot be used, engineered solutions must be developed and sealed by an RDP prior to being approved for implementation.
2. The evaluated house qualifies for all of the prescriptive retrofits in this Guide needed for the recommended Mitigation Package.
3. Existing conditions of the evaluated house already meet some of the prescriptive retrofits in this Guide for any given Mitigation Package. The report should identify which retrofits are already met by existing conditions and document the compliant existing conditions.

Houses that fall under one of the last two determinations are typically the most cost-effective candidates, as less site-specific design work is needed.

3.3. Deciding What Level of Protection to Achieve

Once an evaluation has been performed, the homeowner—in consultation with the evaluator—should make a final decision on which Mitigation Package to implement. Homeowners should select the appropriate Mitigation Package based on the level of risk that is acceptable to them and their families and how much they are willing to spend to mitigate the potential damage. Part of the initial cost of retrofitting may be returned though cost savings from lower insurance premiums if their insurance company provides discounts for retrofitting. The greatest return on investment will be realized when damage from future high-wind events is mitigated by the recommended retrofits.

Each level of the three Mitigation Packages described in this Guide—Basic, Intermediate, and Advanced— provides increasing resistance to wind-related damage and each level of protection can only be achieved if the retrofit projects included in the lower levels have been effectively implemented. For instance, the level of protection provided by the Advanced Mitigation Package can only be met if the projects included in both Basic and Intermediate Mitigation Packages have been properly implemented.

Different houses will be better suited to different levels of retrofitting. Newer houses that are built to more recent codes and standards may require less changes to meet the Advanced Mitigation Package level of protection and alternatively, older houses may require more changes. As discussed in Section 3.1, some houses may even already meet some or all of one or more of the Mitigation Packages described in this Guide so higher-level Mitigation Packages would be more cost-effective and easier to achieve. However, a homeowner may wish to include qualitative benefits of remaining in their existing home or neighborhood, such as better protecting family memories, lifestyle, environment, other assets, or reasons not easily quantifiable. These may result in a decision to

retrofit their house even if it is not technically cost beneficial to do so from a purely quantitative standpoint. It is important to note these are personal financial decisions. If FEMA grant funds are used to implement the wind retrofit project, then FEMA is required to use quantitative analysis that result in a BCR of at least 1.0.

When considering whether to undertake a retrofit project, homeowners should consider all the benefits and costs of the project. The benefits and costs associated with implementing a wind retrofit project should be effectively conveyed by the evaluator and well understood by the homeowner before a decision is made. Some factors to consider when understanding the costs and benefits are included in the following sections.

3.3.1. COSTS

The total cost for the wind retrofit project. The cost of the project is often the primary factor when determining whether to undertake a wind retrofit project and which Mitigation Package to implement. The project cost will be affected by several factors, one of which is whether the prescriptive solutions of this Guide are applicable for the project. If prescriptive solutions cannot be used for the project, then the services of an RDP will need to be obtained to develop custom solutions. This may result in higher costs for the project. Other factors that affect the project cost are the level of protection selected (i.e., which Mitigation Package will be implemented) and the location of the house (which can affect opening protection and design wind speed requirements).

Compliance with codes and local building departments. Modern building codes include provisions for existing buildings that, when triggered by proposed work on the house, may require additional work beyond that initially desired or envisioned by the homeowner. Similarly, requirements of local building departments can vary, and in some circumstances can place additional requirements on the wind retrofit project process. The evaluator should have a good understanding of the applicable building code provisions and local permitting and inspection requirements, because these are often specific to the community in which the project is being performed. Section 5.2 further addresses these issues.

Effects of construction. When considering a wind retrofit project, homeowners may be temporarily relocated; the costs and other obstacles associated with being temporarily relocated should be considered. The current HMA Guide indicates that “reasonable living expenses (except food and personal transportation)” can be included in the grant costs. These costs should all be factored into the BCA.

3.3.2. BENEFITS

Damage resistance. The reduction in anticipated damage for retrofitted houses is a quantifiable benefit to society and the individual. Houses that survive high-wind events achieve the benefits of avoided building damage, reduced damage to building contents, and reduced or no displacement of the occupants. When a BCA is performed for a house undergoing a wind retrofit project, these benefits are taken into account in determining the cost-effectiveness of the project.

Wind hazard insurance plans and premiums. In most of the country, a homeowners' insurance policy includes coverage for wind damage. In some coastal areas where the risk for wind damage is increased this coverage will be excluded from a standard homeowners' policy and it will be necessary for the homeowner to purchase a separate insurance policy for wind damage. This can be through either private carriers or state-run wind pools, which provide coverage in these high-risk areas. For houses with wind damage coverage, risk-based premiums should account for the higher risk the houses face due to their location, as well as the increased likelihood and greater severity of losses after frequent high-wind events. Many insurance companies encourage their policyholders to retrofit their houses to resist wind-related damage, and some companies have established discount programs to reduce premiums, or offer other types of financial incentives, to reflect the risk reduction for houses that have been properly retrofitted. Some state insurance departments also have established insurance discount programs for properly retrofitted houses. The IBHS FORTIFIED Home Program is one that can provide insurance benefits to property owners in participating states. For a list of participating states and more information, visit https://fortifiedhome.org/incentives/.

Federal assistance through HMA grant programs. As described in Chapter 5, homeowners can obtain federal funding assistance for hazard mitigation projects. Applications for an individual house or group of houses undergoing wind retrofit projects can be submitted to FEMA's HMA grant programs. If applications are approved, federal funding is generally provided for 75 percent of the total project cost, significantly reducing the homeowner's expenses for the project. The remaining 25 percent of eligible project costs can be paid for directly, or covered by donated labor, time, and materials. Consult FEMA's HMA Guide and/or the applicable program NOFO for more details on cost sharing. More information on federal assistance through HMA programs is provided in Chapter 5.

FEMA P-804 HMA FUNDING AND FORTIFIED HOME PROGRAM INSURANCE BENEFITS

Mitigation Package requirements in FEMA P-804 meet or exceed the criteria of the respective 2020 FORTIFIED Home Hurricane designations. Where FEMA P-804 includes more conservative requirements than 2020 FORTIFIED, the criteria are referred to as "FEMA Grant Requirements" and are required to receive FEMA funds. Furthermore, additional eligibility or administrative documentation may be required to achieve a FORTIFIED Designation, which may qualify property owners for insurance benefits in participating states.

3.3.3. BENEFIT-COST ANALYSIS

Homeowners should consider both qualitative and quantitative benefits and costs when deciding on a wind retrofit project. To apply for federal assistance through HMA programs (as described in Chapter 5), the benefits must be compared to the cost of the project. Benefits such as reduced insurance premiums are not considered because they are an individual benefit. FEMA created the BCA Tool to create a consistent approach for calculating the quantitative benefits and costs (refer to Appendix C for additional information on using the FEMA BCA Tool for wind retrofit projects). Communities are encouraged to use the tool, regardless of whether they will apply for federal funding. The tool will calculate benefits gained by completing the project, such as avoided damage to

the house, avoided displacement costs, and avoided loss of building contents. The evaluation report discussed in Section 3.2 should identify all the necessary input data needed for using the FEMA BCA Tool. Appendix C provides a step-by-step guide to using the FEMA BCA Tool to evaluate the cost-effectiveness of a wind retrofit project.

4. Technical Design and Construction Methods

The wind retrofit projects described in this Guide are grouped into three Mitigation Package solutions: the Basic Mitigation Package (Section 4.1), the Intermediate Mitigation Package (Section 4.2), and the Advanced Mitigation Package (Section 4.3). Additional recommended mitigation measures not included in the Mitigation Packages are discussed in Section 4.4.

Each Mitigation Package consists of several wind retrofit mitigation measures intended to reduce future losses. The Mitigation Packages should be implemented cumulatively, beginning with the Basic Mitigation Package. This means that for a house to successfully meet the criteria of the Advanced Mitigation Package, it must also meet the criteria of the Basic and Intermediate Mitigation Packages.

If implemented correctly, the wind mitigation retrofits for each Mitigation Package will improve the performance of residential buildings when subjected to high winds. Although the information in this chapter will be helpful to homeowners, it is primarily intended for evaluators, contractors, and RDPs. The retrofits described for each Mitigation Package and throughout this chapter are not necessarily listed in the order in which they should be completed. The order in which retrofits should be completed depends on the configuration of the house and should be determined once the desired Mitigation Package is selected. For example, a homeowner that seeks to achieve the Advanced Mitigation Package should consider retrofitting the roof-to-wall connections when retrofitting the soffits or replacing the roof covering (part of the Basic Mitigation Package) while the connections are more easily accessible. Therefore, the reader is encouraged to read this entire chapter and consider the most cost-effective way to implement the wind retrofit project before starting construction.

This Guide primarily references the methodologies specified in the *2020 FORTIFIED Home Standard*. Differences between this Guide and *2020 FORTIFIED Home Standard* are noted in each Mitigation Package as "FEMA Grant Requirements," where applicable. FEMA Grant Requirements are more conservative than the "Basis of Requirements," which meet the *2020 FORTIFIED Home Standard* criteria for each retrofit. If FEMA funds are being used for the retrofit project, then all FEMA Grant Requirements must be met in addition to the basic eligibility requirements described in the Basis of Requirements. The *2020 FORTIFIED Home Standard* specifies requirements for Hurricane designations and High Wind designations. The Mitigation Packages in this Guide require the use of the recommendations specified for Hurricane designations as shown in the text box below.

REFERENCED BASIS OF REQUIREMENT CRITERIA FROM 2020 FORTIFIED HOME HURRICANE DESIGNATIONS

Mitigation Package requirements in FEMA P-804 meet or exceed the criteria of the respective 2020 FORTIFIED Home Hurricane designations (Figure 9). Chapters 1 and 4 address the correlation between 2020 FORTIFIED and FEMA P-804. Additional eligibility or administrative documentation may be required to achieve a FORTIFIED Designation, which may qualify property owners for insurance benefits in participating states.

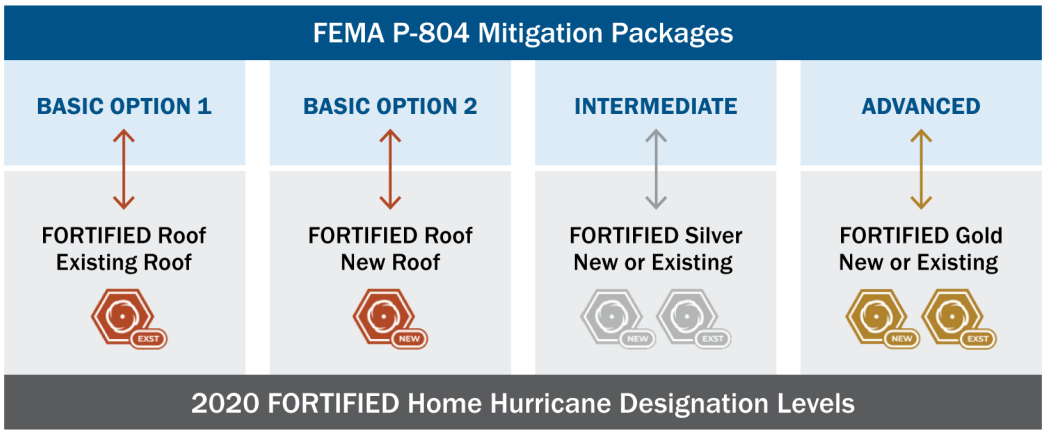


Figure 9: FEMA P-804 Mitigation Package requirements meet or exceed the criteria of the respective 2020 FORTIFIED Home Hurricane designations shown

PRESCRIPTIVE SOLUTIONS LIMITATIONS AND WIND DESIGN CRITERIA OR TESTING REQUIREMENTS

Prescriptive Solutions Limitations

Many of the prescriptive solutions specified to meet the Mitigation Packages are limited to a maximum **Basic Wind Speed of 130 mph** and **Exposure Category C**. This limitation is specified, as applicable, for each prescriptive solution in the *2020 FORTIFIED Home Standard*. Some of the Mitigation Package requirements, such as Sealing the Roof Deck in Section 4.1.2 of this Guide, are applicable to any wind speed and exposure category. **It is important for users of this Guide to carefully read all of the requirements and limitations specified in Chapter 4 of this Guide and the *2020 FORTIFIED Home Standard* for each retrofit being considered.** Where a prescriptive method limitation or minimum design requirement applies, a text box is provided for each specified retrofit identifying the prescriptive solution limitations and/or minimum design requirement. **Where site conditions exceed the limitations of the prescriptive solutions in this Guide, an engineered solution by an RDP in accordance with ASCE 7-22 is required.** Prescriptive high wind standards such as the *2024 AWC Wood Frame Construction Manual* are permitted to be used if they are based on ASCE 7-22.

Prescriptive solutions in the *2020 FORTIFIED Home Standard* are provided for ASCE 7-10 and ASCE 7-16. The Mitigation Packages in the Guide require the use of the prescriptive solutions specified for ASCE 7-16 in the *2020 FORTIFIED Home Standard*.

Minimum Wind Design Criteria or Testing Requirements

Where this Guide requires systems and components to be designed or tested to meet the applicable wind loads, they must be determined in accordance with ASCE 7-22 for site-specific conditions, but not less than the following:

- Basic Wind Speed, $V \geq 130$ mph
- Exposure Category C

Where permitted in this Guide, the simplified wind loads from Table R301.2.1(1) of the 2024 IRC can be used to determine wind loads for the minimum conditions specified above.

Table 2 in Chapter 2 provides a summary of the prescriptive solutions limitations for the Mitigation Packages detailed in this chapter (Chapter 4). Where site conditions exceed the limitations of any given prescriptive solution, Table 3 provides the minimum wind design criteria needed to develop an engineered solution. Additionally, Table 3 in Chapter 2 includes product testing requirements where applicable to the corresponding retrofit criteria.

4.1. Basic Mitigation Package

The Basic Mitigation Package is the initial, most basic Mitigation Package for a residential wind retrofit project. It focuses on securing the roof components and improving the water intrusion resistance of the roof.

BASIC MITIGATION PACKAGE RETROFITS:

Option 1 – Improvements without Roof Covering Replacement

- Sealing and strengthening the roof deck
- Improving the water intrusion resistance of attic vents

Option 2 – Improvements with Roof Covering Replacement

- Inspecting and improving attachment of the existing roof deck
- Sealing the roof deck
- Improving underlayment details at eaves (drip edge)
- Installing wind-resistant roof coverings
- Improving the water intrusion resistance of attic vents

One of the first decisions to make when implementing the Basic Mitigation Package is whether to use Option 1 or Option 2. The evaluation process will identify whether the roof covering needs to be replaced (see Section 3.1.1 for more information).

4.1.1. OPTION 1 – IMPROVEMENTS WITHOUT ROOF COVERING REPLACEMENT

Option 1 of the Basic Mitigation Package is recommended when the existing roof covering is not replaced as part of the wind retrofit project. A key element of Option 1 involves applying SPF adhesive to the underside of the roof deck at the joints between roof sheathing panels and along all intersections between the roof deck and framing members as shown in Figure 10. This retrofit serves two purposes:

1. The connection between the roof deck and supporting structural members is enhanced, which increases the ability of the roof deck to resist uplift during high-wind events.
2. The SPF adhesive seals the joints of the roof deck to help prevent water intrusion. While not as effective as installing an underlayment, the SPF adhesive will help minimize water infiltration.

Figure 10: Example of SPF adhesive application to secure and seal roof deck panels

Qualifying roof structural members and roof covering

To qualify for Option 1 of the Basic Mitigation Package, the roof structural members (decking and sheathing) must be capable of resisting the applicable design wind loads and be of a minimum size or thickness. These conditions will ensure that the enhancements recommended in this Mitigation Package perform as intended. The existing roof covering also has to be in good condition with an estimated remaining roof life of at least 5 years. Importantly, there must be sufficient access to the attic to perform the retrofits required of this Mitigation Package.

Basis of Requirements: To qualify for Option 1, the roof deck, roof framing members, and roof covering must meet Section 3.1 of the *2020 FORTIFIED Home Standard* for Hurricane Designations.

Sealing and strengthening the roof deck

When the primary roof covering is lost or damaged by wind, the roof deck is particularly susceptible to water intrusion because of gaps between the panels that allow water to pass through into the building. Water intrusion can cause extensive damage to interior finishes, furnishings, and other contents, and can lead to ceiling collapse when attic insulation is saturated. When power is lost and/or a building cannot otherwise be dried out within 24–48 hours, additional issues such as mold can develop, potentially extending the period during which the property may not be available for use.

The use of a closed cell SPF in the attic can provide significant resistance to water intrusion through the roof. Given its expansive nature, it can easily fill cracks and gaps and provide a water-tight seal. Additionally, when applied as specified, it will significantly enhance the connection of the roof sheathing to the roof framing members. For this method to effectively resist water intrusion through the roof, it is critical that all cracks and gaps be filled with foam.

Basis of Requirements: The roof deck is required to be sealed and strengthened by applying a two-part SPF adhesive to the underside of the roof deck in accordance with Section 3.2 of the *2020 FORTIFIED Home Standard*.

Improving the water intrusion resistance of attic vents

Ventilation openings into attic areas are often required by code to facilitate air flow throughout the attic space. Adequate ventilation of attics is generally required to promote the health of wood structural members and sheathing in the attic. Attic ventilation can reduce the temperatures of roof coverings, which will typically prolong the life of the roof covering. However, these openings can also be an entry point for water intrusion. Ridge and off-ridge vents should be tested for resistance to water intrusion and be anchored to the roof sheathing to resist the applicable wind loads.

Basis of Requirements: Ridge, off-ridge, and gable end vents are required to comply with Section 3.3 of the *2020 FORTIFIED Home Standard*.

4.1.2. OPTION 2 – IMPROVEMENTS WITH ROOF COVERING REPLACEMENT

Option 2 of the Basic Mitigation Package involves removing the existing roof covering, securing the roof deck, installing a sealed roof deck for protection against water infiltration, and installing a new roof covering that meets the applicable wind loads. Option 2 is generally preferred over Option 1 because replacing the roof covering ensures that the roof deck connections to the framing below will be checked and an adequate underlayment will be installed. Houses retrofitted to Option 2 will likely receive a greater reduction in insurance premiums than houses retrofitted to Option 1.

Qualifying roof structural members

To qualify for Option 2 of the Basic Mitigation Package, the roof structural members (decking and sheathing) must be capable of resisting the applicable design wind loads and be of a minimum size or thickness. These conditions will ensure that the enhancements recommended in this Mitigation Package perform as intended.

Basis of Requirements: To qualify for Option 2, the roof deck must meet Section 4.1 of the *2020 FORTIFIED Home Standard for Hurricane Designations*.

PRESCRIPTIVE SOLUTIONS LIMITATIONS

The prescriptive solutions for minimum roof decking thickness is limited to a **maximum** Basic Wind Speed of 130 mph and Exposure Category C. For site conditions that exceed a Basic Wind Speed of 130 mph and Exposure Category C, the roof decking is required to be a sufficient thickness to resist the site-specific design loads specified in ASCE 7-22 determined through an engineering analysis by an RDP. Prescriptive high wind standards such as the *2024 AWC Wood Frame Construction Manual* are permitted to be used if they are based on ASCE 7-22.

Inspection and attachment of the existing roof deck

Strengthening the connections from the roof sheathing to the roof framing members is a cost-effective and critical retrofit to implement when the roof covering is being replaced. The evaluation process should identify any areas of the roof deck and roof framing members that are damaged or deteriorated (refer to Chapter 3 and Appendix B). Any damaged members should be repaired or replaced.

Basis of Requirements: The roof deck is required to be inspected and renailed (if required) in accordance with Section 4.3 of the *2020 FORTIFIED Home Standard* for Hurricane Designations.

PRESCRIPTIVE SOLUTIONS LIMITATIONS

The prescriptive solutions for minimum roof deck attachment is limited to a **maximum** Basic Wind Speed of 130 mph and Exposure Category C. For site conditions that exceed a Basic Wind Speed of 130 mph and Exposure Category C, the roof decking is required to be attached to resist the site-specific design loads specified in ASCE 7-22 determined through an engineering analysis by an RDP. Prescriptive high wind standards such as the *2024 AWC Wood Frame Construction Manual* are permitted to be used if they are based on ASCE 7-22.

FEMA Grant Requirements: Where the roof sheathing thickness exceeds 15/32 inch, supplemental fasteners required in the *2020 FORTIFIED Home Standard* must be ASTM F1667 RSRS-03 (2 ½ inch x 0.131 inch) nails.

Sealing the roof deck

Damage due to water intrusion continues to be a significant problem for buildings impacted by hurricanes. When the primary roof covering is lost or damaged by wind, the roof deck is particularly susceptible to water intrusion because of the gaps between the panels. Water intrusion can cause extensive damage to interior finishes, furnishings, and other contents, and can lead to ceiling collapse when attic insulation is saturated. When power is lost and/or a building cannot otherwise be dried out within 24–48 hours, additional issues such as mold can develop, potentially extending the period during which the property may not be available for use. Tests performed by IBHS have consistently demonstrated that a sealed roof deck significantly reduces water intrusion rates when one of these strategies is employed.

Before sealing the roof deck, the roof deck should be dry and be broom-cleaned to ensure a smooth surface.

Basis of Requirements: For roof slopes 2:12 and greater, the roof deck is required to be sealed in accordance with Section 4.4 of the *2020 FORTIFIED Home Standard*.

FEMA Grant Requirements: For mechanically fastened concrete and clay tile roof coverings, the roof deck is required to be sealed in accordance with Sections 4.4.2.1 or 4.4.2.2 of the *2020 FORTIFIED*

Home Standard. For adhered concrete and clay tile roof coverings, the roof deck is required to be sealed in accordance with Section 4.4.2.2 of the *2020 FORTIFIED Home Standard*.

Improving underlayment details at eaves and rakes

A drip edge should be installed at gable rakes and eaves. A drip edge protects the edge of the roof sheathing and helps wick water away from the fascia board. The drip edge is required to be installed over the underlayment to help secure the underlayment in place at the edges of the roof and provide a continuous load path for the roof edge detail.

Basis of Requirements: Drip edge and underlayment are required to be installed in accordance with Section 4.5 of the *2020 FORTIFIED Home Standard*.

Flashings

Flashings are used to weatherproof or seal roof assembly edges at perimeters, penetrations, walls, expansion joints, valleys, drains, and other places where the roof covering is interrupted or terminated.

Basis of Requirements: Flashings are required to comply with Section 4.6 of the *2020 FORTIFIED Home Standard.*

Installing wind-resistant roof coverings

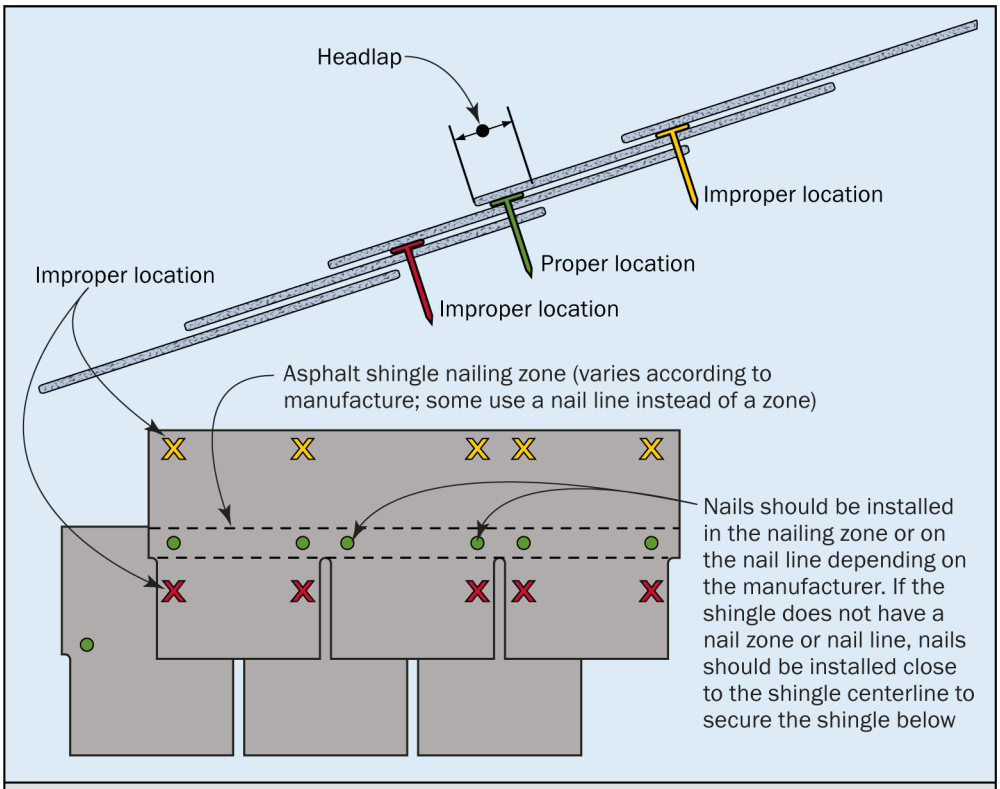
Historically, damage to roof coverings is one of the leading causes of building performance problems in high-wind events. The failure of roof covering on a house can lead to substantial water damage to interior finishes and contents. The existing roof covering should be removed entirely. The new roof covering should not be installed over an existing roof covering (roof recover). The new roof covering should be rated for the design wind speed for the project location or meet the applicable design wind pressures and should be installed in accordance with the manufacturer's recommendations for high-wind regions.

Asphalt Shingles

Asphalt shingles are required to be installed in accordance with the manufacturer's installation instructions. Understanding the wind-resistance ratings and special fastening requirements for asphalt shingles installed in hurricane-prone regions is important. Figure 11 shows the proper location of fasteners for asphalt shingles.

GUIDANCE: PROPER LOCATION FOR ASPHALT SHINGLE FASTENERS

Asphalt shingle fasteners should be installed on the nail line or in the nail zone, as specified by the manufacturer. If the shingle does not have a nail line or nail zones, nails should be installed such that they secure the shingle underneath as shown in Figure 11.



Source: Modified from FEMA Hurricane Michael in Florida Recovery Advisory 2, modified from the *Asphalt Roofing Residential Manual: Design and Application Methods* (ARMA 2014).

Figure 11: Example of proper installation of asphalt shingles using nailing zone (note nail line is not shown)

Durability ratings (indicated by warranty life) are relative and not standardized. While shingles with a longer warranty (e.g., 30-year instead of 20-year) may have greater durability in coastal climates, the durability rating is not an indicator of the shingle's ability to resist a particular wind speed. The warranty for a shingle product indicates the ability of the product to resist deterioration from climate conditions. The warranty is an important characteristic to consider when selecting a shingle product, but it does not signify wind resistance. A shingle product that has a class rating equal to or greater than the design wind speed (for the location as specified) should be selected.

Concrete and Clay Tiles

Concrete and clay roof tiles are available in a variety of profiles and attachment methods. Mitigation Assessment Team (MAT) investigations have found that tile coverings applied using adhesive and mechanical attachment methods have historically performed better than those applied using the mortar-set attachment method. Therefore, tile roof coverings in high-wind areas should be mechanically fastened or adhesive set. However, all methods are prone to failure when not properly installed. Tile should be installed to resist the overturning moment specified by the building code.

All Other Roof Coverings

Roof coverings other than those specified above may be used. When using other roof coverings, documentation showing that the roof covering and attachments were designed or tested for the applicable component and cladding wind pressures should be obtained from the manufacturer. All roof coverings, regardless of type, should be installed in accordance with the manufacturer's installation instructions for the appropriate design wind speed.

Roof slopes 2:12 and greater

Basis of Requirements: For roof slopes 2:12 and greater, roof coverings and their attachments are required to comply with Section 4.7 of the *2020 FORTIFIED Home Standard*.

MINIMUM WIND DESIGN REQUIREMENT

Roof covering systems that are tested to be pressure-rated are required to have a design pressure rating that meets or exceeds site-specific design pressures specified in ASCE 7-22, but not less than a design pressure rating corresponding to a minimum Basic Wind Speed of 130 mph and Exposure Category C.

FEMA Grant Requirements: Design wind speeds are required to be determined in accordance with ASCE 7-22. Component and cladding loads on roofs are required to be determined in accordance with ASCE 7-22 or Table R301.2.1(1) of the 2024 IRC.

Roof slopes less than 2:12

Basis of Requirements: For roof slopes less than 2:12, roof coverings and their attachments are required to comply with Section 4.8 of the *2020 FORTIFIED Home Standard*.

MINIMUM WIND DESIGN REQUIREMENT

Roof covering systems that are tested to be pressure-rated are required to have a design pressure rating that meets or exceeds the site-specific design pressures specified in ASCE 7-22, but not less than a design pressure rating corresponding to a minimum Basic Wind Speed of 130 mph and Exposure Category C.

FEMA Grant Requirements: Design wind speeds are required to be determined in accordance with ASCE 7-22. Component and cladding loads on roofs are required to be determined in accordance with ASCE 7-22 or Table R301.2.1(1) of the 2024 IRC.

Improving the water intrusion resistance of attic vents

Adequate ventilation of attics is generally required to promote the health of wood structural members and sheathing in the attic. Attic ventilation can reduce the temperatures of roof coverings, which will typically prolong the life of the roof covering. However, these openings can also be an entry point for water intrusion. Ridge and off-ridge vents should be tested for resistance to water intrusion and be anchored to the roof sheathing to resist the applicable wind loads.

Basis of Requirements: Ridge, off-ridge, and gable end vents are required to comply with Section 4.9 of the *2020 FORTIFIED Home Standard*.

Corrosion protection

Metal connectors and fasteners can corrode when exposed to moisture and salt laden air. While minimum corrosion protection requirements apply to all metal connectors and fasteners exposed to moisture, metals exposed to salt laden air are susceptible to accelerated corrosion. The level of corrosion protection depends on the proximity to the salt air source.

Basis of Requirements: Metal fasteners and connectors are required to comply with corrosion protection requirements of Section 2.11 of the *2020 FORTIFIED Home Standard* and Technical Bulletin FH 2021-02*, Corrosion-Resistant Fasteners*.

4.2. Intermediate Mitigation Package

The Intermediate Mitigation Package is the second level of high-wind mitigation described in this Guide. The Intermediate Mitigation Package includes retrofits to protect openings, further strengthen gable ends that are greater than 3 feet in height (if applicable) and improve the anchorage of attached structures such as porches and carports.

INTERMEDIATE MITIGATION PACKAGE RETROFITS:

- Protecting windows and doors from windborne debris
- Garage doors rated for the design wind pressure and protecting garage doors with glazing from windborne debris
- Strengthening gable end walls
- Strengthening soffits
- Strengthening chimney attachment
- Strengthening connections of attached structures

4.2.1. PREREQUISITE REQUIREMENTS

As previously mentioned, the Mitigation Packages specified in this Guide are cumulative. To qualify for the Intermediate Mitigation Package, the Basic Mitigation Package must be successfully completed as well as the additional requirements specified in the Intermediate Mitigation Package.

4.2.2. PROTECTING OPENINGS FROM WINDBORNE DEBRIS

Building openings include windows, skylights, entry doors, and garage doors. When windborne debris penetrates most materials, typically a small opening is created. However, when debris penetrates most glazed openings, a very large opening is created. Exterior glazed openings that are not impact-resistant (such as annealed, heat-strengthened, or tempered glass) or not protected by shutters are

extremely susceptible to breaking if struck by debris. Even small, low-momentum debris can easily break glazing that is not protected. If these components fail, wind-driven rain can enter the building and cause costly water damage. In addition, the resulting increase in internal wind pressure increases the likelihood for some type of structural failure. Opening protection can be provided by one of two methods for the Intermediate Mitigation Package:

- An approved impact-resistant covering capable of resisting windborne debris impacts can be installed over an existing, unprotected opening (such as a window or door). Types of impact-resistant coverings include metal shutter systems and fabric and screen products.
- An approved, impact-resistant product (such as a new impact-resistant window or door assembly) can be installed in place of a product that is not capable of resisting windborne debris impacts or as an alternative to impact-resistant shutters or screens. However, these products are systems or "assemblies," and replacing only the glass (or glazing) is not adequate. A tested and approved system that includes the frame and the glazing system must be used. New impact-resistant products will also include a design pressure (DP) rating and performance grade (PG) rating (See Section 4.3.2 of the Guide for further discussion on DP and PG ratings for windows and doors). However, the locally adopted building code or the Advanced Mitigation Package may require a higher DP and PG rating than the Intermediate Package requirement.

USING FILMS FOR OPENING PROTECTION

Opening protection products such as films and other overlays are not appropriate methods of opening protection for a wind retrofit project. An overlay on glazing does not provide adequate protection for the opening unless the whole assembly—including the glazing, opening frame, and overlay product—are tested together and are labeled to indicate compliance with the appropriate test criteria.

Windows and skylights

Windows can be retrofitted using either of the previously described opening protection methods for the Intermediate Mitigation Package. Although installing an impact-resistant window is typically more expensive than installing an impact-resistant covering, it is also a more complete method of protecting the window. This is because impact-resistant coverings, such as shutter systems, do not typically cover openings at all times. Many shutter systems must be set in place before the wind event occurs to be effective. This can be problematic if no one is present to install or operate the shutter system or, if operated electronically, if the power fails before someone has a chance to close them. The product selected should be labeled to indicate compliance with the appropriate standards. Some pros and cons of opening impact protection methods are shown in Table 4.

Impact-resistant covering products should be tested to demonstrate compliance with the prescribed missile size and speed. Testing includes both missile impact testing and cyclical pressure testing.

The manufacturer's instructions for the appropriate design wind speed or design wind pressure should be followed when installing any form of opening protection.

The 2024 IBC and IRC both require labeling on exterior windows, doors, and impact resistant coverings. Although some jurisdictions may not have adopted this requirement, products such as windows, doors, and shutter systems should have an affixed label indicating the level of protection to which the product has been tested.

Shutter systems are the most common form of impact-resistant covering products and are either temporarily or permanently installed. Temporary shutters are lower in cost compared to permanent shutters but require ongoing efforts on the part of the homeowner to use them effectively for opening protection.

Given their varying configurations, approved impact-resistant coverings for skylights are not readily available. If a house has skylights, replacing the existing skylights with impact-resistant skylights or removing the skylight and securing the opening (this may require an RDP) is recommended.

Table 4: Pros and Cons of Opening Impact Protection Methods

Measure	Pros	Cons
Impact-Resistant Windows and Doors	Passive protection; no need to deploy or install other protection	Generally, more expensive option and may still require replacement following an event
Impact-Protective Devices (Hurricane Shutters)	Generally, the most economical option	Must deploy or close in advance of approaching storm Installation of some types can be difficult to handle Some must be stored

Temporarily Installed Shutters

Though lower in cost than permanent shutters, temporary shutters must be installed and removed every time they are needed and require storage space when not in use. The installation of temporary shutters before a storm is often left to the homeowner and can be difficult on upper-level windows of houses that are two or more stories. For this reason, FEMA recommends that windows above the ground floor be protected by a permanent shutter system or an electronically operated shutter system, or that existing windows be replaced with impact-resistant windows.

One form of commonly used temporary shutters is wood structural panels, but because they may not provide the desired level of protection, wood structural panel shutters are not eligible for an HMA grant. Furthermore, although wood structural panels are inexpensive, they tend to have shorter useful life spans and require storage conditions in which the wood will not become warped, which causes rapid installation to be difficult and can reduce effectiveness. Wood structural panel shutters typically comprise of a variety of combinations of panels, fasteners, and anchoring hardware.

Detailed installation instructions, storage, handling, and maintenance procedures for specific combinations of materials needed for the shutter system to perform as expected are generally not available. Further, a standard "missile" will breach the code-prescribed wood structural panel shutter, and the desired level of protection is no breaching of the shutter.

Permanently Installed Shutters

Shutter systems that are permanently installed are more expensive than temporary shutters, but they are always in place and ready to be closed. Permanent shutter systems are operated either manually or by a motor. Manually operated shutters are less expensive than motorized shutters but are closed from the outside. Motorized shutters are easily closed from the interior but are among the most expensive type of shutter system. Motorized shutters should also be able to be operated manually in the event of a loss of power. If a shutter system is used to protect windows, it should be sufficiently anchored into the wall around the window frame so that wind loads are transferred to the structure of the building.

Basis of Requirements: Windows and skylights are required to be protected in accordance with Section 5.2 of the *2020 FORTIFIED Home Standard*.

MINIMUM WIND DESIGN REQUIREMENT

Windows and skylights are required to be impact-resistant or protected with an impact-resistant covering meeting the Large Missile D from ASTM E1886 and ASTM E1996 and AAMA 506, or the 7th Edition (2020) Florida Building Code Testing Application Standards TAS 201 and TAS 203.

FEMA Grant Requirements: Wood structural panels are not permitted as opening protection for any basic wind speed.

Entry doors

As part of the Intermediate Mitigation Package, all exterior entry doors should be protected from windborne debris. At least one entry door should be operable from inside the living space if opening protection is in place to permit egress in the event of an emergency. Entry doors should be protected by either protecting the existing door with an impact-resistant covering or providing an impact-resistant door. Regardless of whether the selected product is an impact-resistant covering or an impact-resistant door, it should be tested to demonstrate compliance with the prescribed missile size and speed.

Basis of Requirements: Entry doors are required to be protected in accordance with Section 5.3 of the *2020 FORTIFIED Home Standard*.

MINIMUM WIND DESIGN REQUIREMENT

Entry doors are required to be impact-resistant or protected with an impact-resistant covering meeting the Large Missile D from ASTM E1886 and ASTM E1996 and AAMA 506, or the 7th Edition (2020) Florida Building Code Testing Application Standards TAS 201 and TAS 203.

Garage doors

Garage doors are typically large, unreinforced openings that are commonly damaged during high-wind events. As part of the Intermediate Package, any garage doors on a house must be capable of resisting the design wind pressure. If the new garage door has glazing, it must also be impact-resistant or protected with an impact-resistant covering.

The 2021 IBC and IRC both require labeling on garage doors. Although some jurisdictions may not have adopted this requirement, products such as windows, doors, and shutter systems should have an affixed label showing the level of protection to which the product has been certified. The label is required to identify the garage door manufacturer, the garage door model/series number, the positive and negative design wind pressure rating, the installation instruction drawing reference number, and the applicable test standard.

Basis of Requirements: Garage doors are required to be protected in accordance with Section 5.4.1 of the *2020 FORTIFIED Home Standard* for the Hurricane Designation.

MINIMUM WIND DESIGN REQUIREMENT

Garage doors with glazed openings are required to be impact-resistant or protected with an impact-resistant covering meeting the Large Missile D from ASTM E1886 and ASTM E1996 and AAMA 506, or the 7th Edition (2020) Florida Building Code Testing Application Standards TAS 201 and TAS 203. Additionally, garage doors are required to have a design pressure rating that meets or exceeds the site-specific design pressures specified in ASCE 7-22, but not less than a design pressure rating corresponding to a minimum Basic Wind Speed of 130 mph and Exposure Category C.

Garage doors without glazed openings are required to have a design pressure rating that meets or exceeds the site-specific design pressures specified in ASCE 7-22, but not less than a design pressure rating corresponding to a minimum Basic Wind Speed of 130 mph and Exposure Category C.

4.2.3. GABLE ENDS

A gable end is the triangular section of wall at the end of a gable roof. When using “platform construction” (defined term in 2024 IRC; most common wood frame construction method), gable end walls are particularly vulnerable to failure from out-of-plane wind loads due to the “hinge”

created at the intersection of the triangular portion of the gable and the top of the wall below. Figure 12 depicts typical gable end wall failures due to wind loads.

Gable end wall sheathing

Gable end wall sheathing should be capable of resisting the applicable out-of-plane wind loads.

Figure 12: Typical gable end wall failure due to wind loads

Basis of Requirements: Gable end wall sheathing is required to be in accordance with Section 5.5.1 of the *2020 FORTIFIED Home Standard*.

PRESCRIPTIVE SOLUTIONS LIMITATIONS

The prescriptive solution for gable end wall sheathing minimum thickness is limited to a **maximum** Basic Wind Speed of 130 mph and Exposure Category C. For site conditions that exceed a Basic Wind Speed of 130 mph and Exposure Category C, gable end wall sheathing is required to be a sufficient thickness to resist the site-specific design loads specified in ASCE 7-22 determined through an engineering analysis by an RDP. Prescriptive high wind standards such as the *2024 AWC Wood Frame Construction Manual* are permitted to be used if they are based on ASCE 7-22.

Gable end wall framing and bracing

Gable ends over 3 feet in height are required to be braced at the intersection of the triangular portion of the gable and the wall below.

A prescriptive option to retrofit gable end walls for the Intermediate Mitigation Package involves:

1. Strengthening vertical framing members of the gable end using retrofit studs.
2. Bracing the top and bottom of the gable end with horizontal braces to allow lateral loads to transfer to the roof and ceiling diaphragms.

3. Making connections between horizontal braces and retrofit studs using metal straps and fasteners.
4. Connecting the bottom of the gable end to the wall below using metal bracket connectors.

The construction details for this prescriptive option are provided in Appendix C of the 2024 IEBC and/or Chapter 17 of the 7th Edition 2020 Florida Building Code, Existing Building, which are referenced in the 2020 FORTIFIED Home Standard. For retrofits within the State of Florida, the use of Chapter 17 of the 7th Edition (2020) Florida Building Code, Existing Building will be required. Outside the State of Florida either the 2024 IEBC or the 7th Edition (2020) Florida Building Code, Existing Building may be permitted to be used depending on the locally adopted building codes within the jurisdiction. This gable end retrofit method can be used on houses that meet the specified eligibility conditions in Appendix C of the 2024 IEBC and/or Chapter 17 of the 7th Edition 2020 Florida Building Code, Existing Building. It cannot be used on houses with vaulted or cathedral ceilings.

The prescriptive option requires the ceiling diaphragm to meet the following minimum requirements:

- ½-inch minimum thickness for a gypsum board (commonly referred to as drywall) ceiling
- ⅜-inch minimum thickness for wood structural panel ceiling
- Fastening and blocking of the gypsum board ceiling is required to be verified or retrofitted to meet the minimum criteria specified in the 2024 IRC for gypsum board diaphragm ceiling assemblies.

Figure 13 provides a representative illustration of the prescriptive option for retrofitting gable end walls over 3 feet in height.

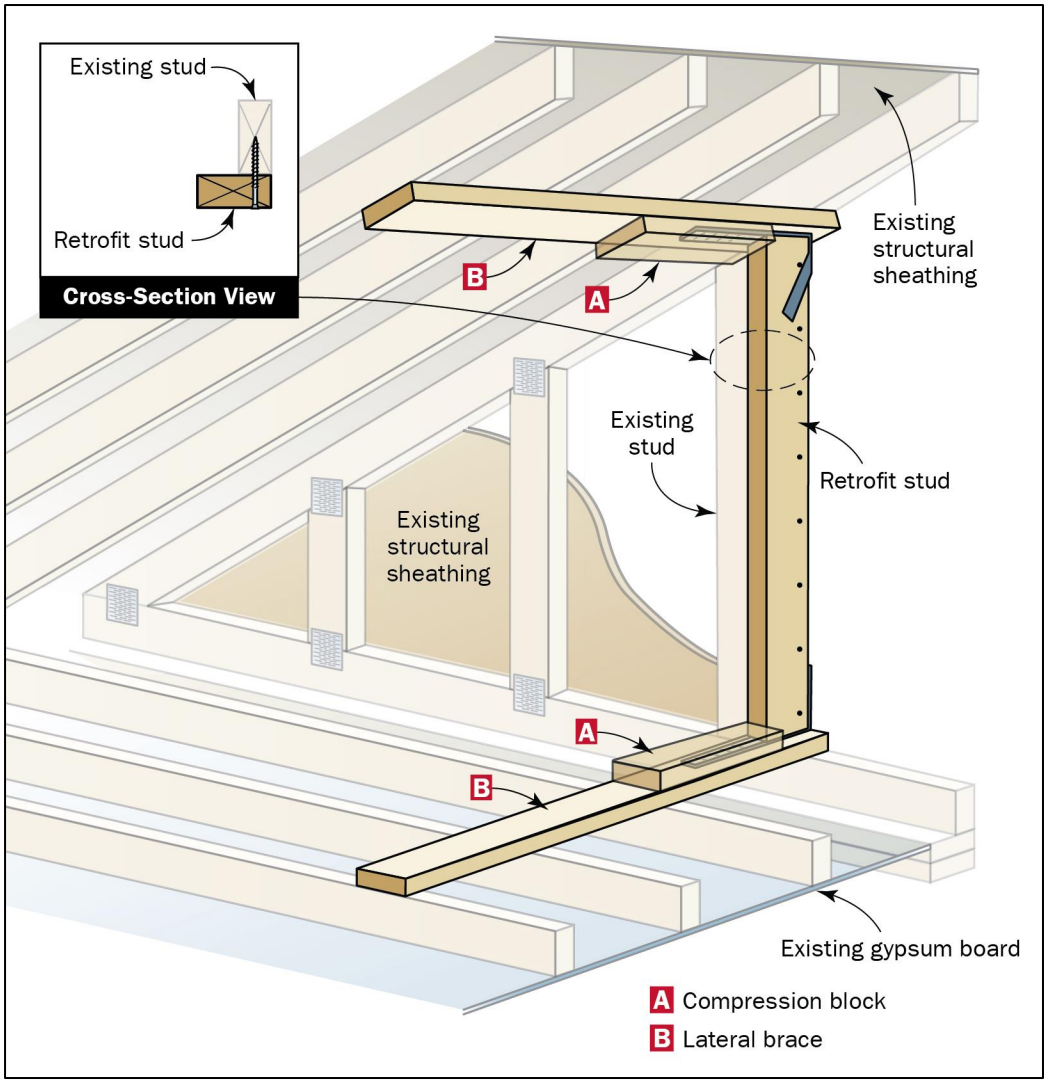


Figure 13: Representative illustration of the prescriptive gable end wall framing and bracing retrofit

Where the prescriptive solutions are not practical or where existing conditions are determined to be outside the scope of the prescriptive solutions, an RDP will be needed to provide a site-specific solution. A common engineered solution includes the use of diagonal braces connected to the intersection of the triangular portion of the gable and the wall below. Figure 14 provides a representative illustration of using diagonal braces to retrofit gable end walls, as well as photograph.

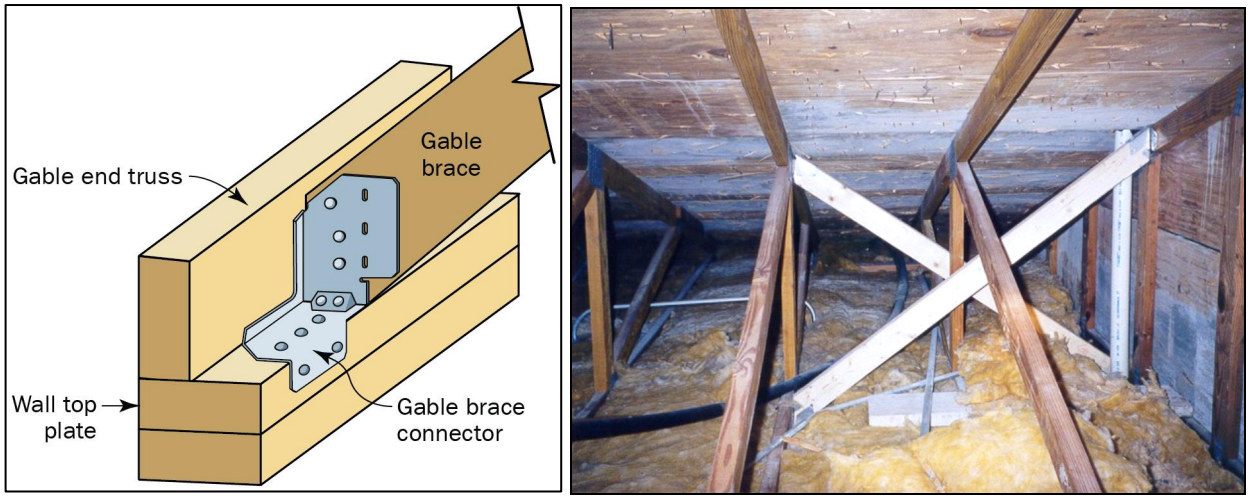


Figure 14: Representative illustration of using diagonal braces to retrofit a gable end wall (left), as well as photograph of diagonal braces (right)

Basis of Requirements: Gable end walls over 3 feet in height are required to be braced in accordance with Section 5.5.2 of the *2020 FORTIFIED Home Standard*.

FEMA Grant Requirements: When using the prescriptive option to retrofit a gable end wall, the following additional limitations apply:

1. Mean roof height ≤ 33 feet
2. Exposure Categories B and C
3. Wall height ≤ 10 feet (wall height of the wall underneath of the gable wall)
4. Where a gypsum board ceiling diaphragm is used to brace the gable end wall, the minimum length of the gypsum board ceiling diaphragm is required to be in accordance with Table 5 (see example of how to use Table 5 to determine the required length of gypsum board ceiling diaphragm).
5. Fastening and blocking of the gypsum board ceiling is required to be verified or retrofitted to meet the minimum criteria specified in the 2024 IRC for gypsum board diaphragm ceiling assemblies.
6. The horizontal braces specified by the 2024 IEBC are required to be continuous along the required length of ceiling diaphragm, as determined by Table 5, or be spliced together as permitted for interrupted horizontal braces along the required length of the ceiling diaphragm, as determined by Table 5.
7. The lateral braces specified by the 7th Edition (2020) Florida Building Code, Existing Building are required to be continuous along the required length of ceiling diaphragm, as determined by Table 5, or be spliced together as permitted for interrupted lateral braces along the required length of the ceiling diaphragm, as determined by Table 5.

Where these limitations are exceeded or the eligibility conditions in Appendix C of the 2024 International Existing Building Code or Chapter 17 of the 7th Edition (2020) Florida Building Code,

Existing Building are not met, an RDP will be required to design the bracing method for the gable end wall.

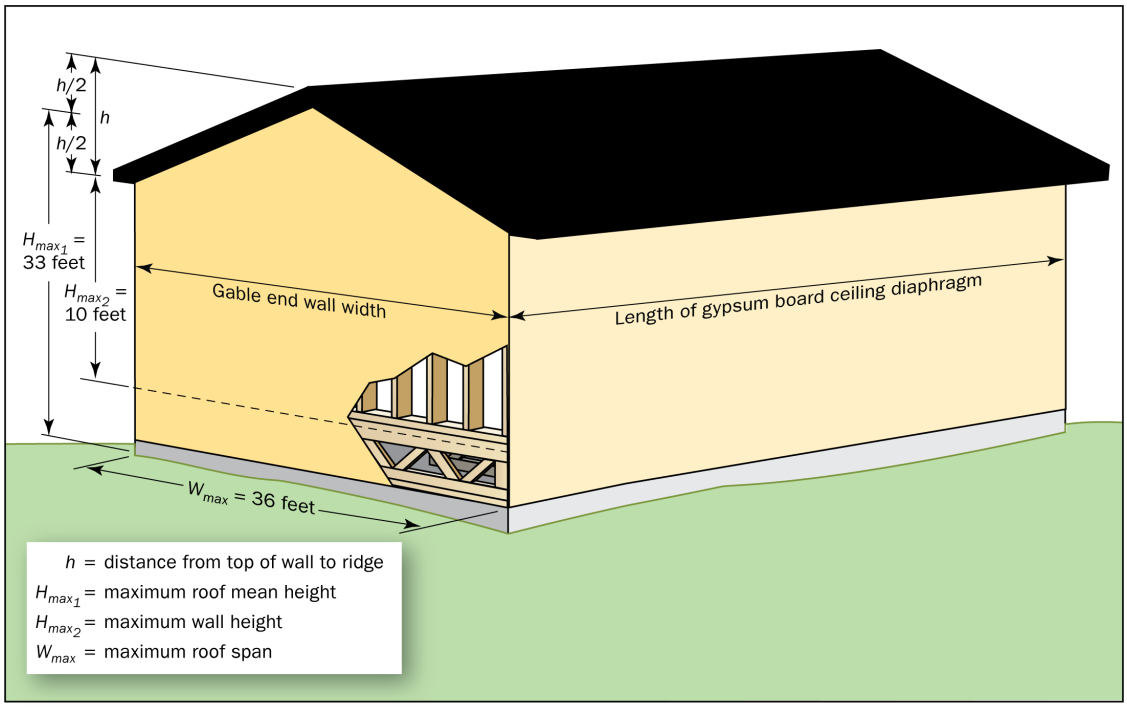
Table 5: Required Length of Gypsum Board Ceiling Diaphragm

ADAPTED FROM 2018 AWC WOOD FRAME CONSTRUCTION MANU*AL TABLE 3.17; USED WITH PERMISSION*

Basic Wind Speed		130 mph	140 mph	150 mph	160 mph	170 mph	180 mph
Roof Slope	Gable end wall width (feet)	REQUIRED Length of Gypsum Board Ceiling Diaphragm (feet)					
1.5:12 – 3:12	12	8	10	11	12	14	16
	24	16	19	22	25	28	31
	36	26	30	34	39	44	49
4:12	12	9	10	11	13	14	16
	24	17	20	23	26	29	32
	36	27	32	36	41	46	52
5:12	12	9	10	12	13	15	16
	24	18	21	24	27	30	34
	36	29	33	38	43	49	55
6:12	12	9	10	12	13	15	17
	24	19	21	25	28	31	35
	36	30	35	40	46	51	58
7:12	12	9	11	12	14	15	17
	24	19	22	25	29	33	36
	36	32	37	42	48	54	61
8:12	12	9	11	12	14	16	17
	24	20	23	26	30	34	38
	36	33	39	44	50	57	64
9:12	12	10	11	12	14	16	18
	24	21	24	27	31	35	39
	36	35	40	46	53	59	67
10:12	12	10	11	13	14	16	18
	24	21	25	28	32	36	40
	36	36	42	48	55	62	70
11:12	12	10	11	13	15	17	18
	24	22	25	29	33	37	42
	36**	38	44	50	57	65	72
12:12	12	10	12	13	15	17	19
	24	23	26	30	34	38	43
	36**	40	46	53	60	67	75

*interpolation of roof slope, gable end wall width, and basic wind speed is permitted

**value provided for interpolation purposes only, as gable end wall stud height may exceed 16 feet



Note: See the 2024 AWC Wood Frame Construction Manual for the same requirements

EXAMPLE: DETERMINING THE REQUIRED LENGTH OF GYPSUM BOARD CEILING DIAPHRAGM

Determine the required length of gypsum board ceiling diaphragm for a house with a gable end wall width of 30 feet, a roof slope of 7:12, and a Basic Wind Speed of 150 mph.

Tabular lengths are provided for gable end wall widths of 12 feet, 24 feet, and 36 feet. Use linear interpolation to determine the required length of ceiling gypsum board ceiling diaphragm between 24 feet and 36 feet.

Basic Wind Speed		130 mph	140 mph	150 mph	160 mph	170 mph	180 mph
Roof Slope	Gable end wall width (feet)	Length of Gypsum Board Ceiling Diaphragm (feet)					
7:12	12	9	11	12	14	15	17
	24	19	22	25	29	33	36
	36	32	37	42	48	54	61

Required diaphragm length for end wall width of 24 feet = 25 feet

Required diaphragm length for end wall width of 36 feet = 42 feet

x = required length of gypsum board ceiling diaphragm

$$\frac{36-30}{36-24} = \frac{42-x}{42-25}$$

$$\frac{6}{12} = \frac{42-x}{17}$$

$$x = 42 - (17 \times \frac{6}{12})$$

x = 33.5 feet

Where these limitations are exceeded or the eligibility conditions in Appendix C of the 2024 International Existing Building Code or Chapter 17 of the 7th Edition (2020) Florida Building Code, Existing Building are not met, an RDP will be required to design the bracing method for the gable end wall.

MINIMUM WIND DESIGN REQUIREMENT AND PRESCRIPTIVE SOLUTIONS LIMITATIONS

Gable end walls are required to braced to be capable of resisting wind loads based on a minimum Basic Wind Speed of 130 mph and Exposure Category C. The prescriptive bracing option is limited to a **maximum** Basic Wind Speed of 180 mph and Exposure Category C. See **FEMA Grant Requirements** for additional limitations on using the prescriptive bracing option. If any of these limitations are exceeded, an engineered solution by an RDP in accordance with ASCE 7-22 is required.

Gable end overhang construction

Gable end overhangs are particularly vulnerable to failure because of how they are typically constructed and because they have to be able to resist wind pressures on the top surface of the overhang in addition to wind loads on the bottom surface of the overhang. Where the length of a gable end overhang exceeds 9 inches, it must be retrofitted to be constructed and connected as an outlooker. Figure 15 provides a representative retrofit for gable end overhangs.

Basis of Requirements: Gable end overhangs exceeding 9 inches in length are required to be strengthened in accordance with Section 5.5.3 of the *2020 FORTIFIED Home Standard*.

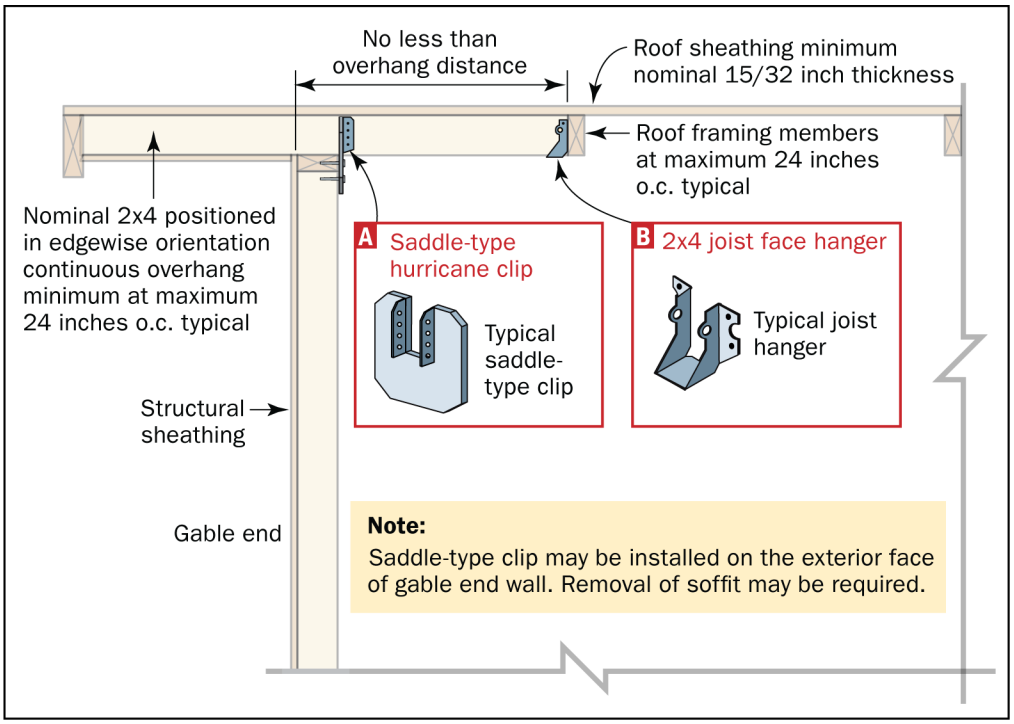


Figure 15: Representative illustration for strengthening gable end overhangs

PRESCRIPTIVE SOLUTIONS LIMITATIONS

The prescriptive solutions for gable end overhang construction details are limited to a **maximum** Basic Wind Speed of 180 mph and Exposure Category D. For gable end overhangs that exceed 9 inches in length and site conditions that exceed a Basic Wind Speed of 180 mph and Exposure Category D, gable end overhangs are required to be capable of resisting the site-specific design loads specified in ASCE 7-22 determined through an engineering analysis by an RDP.

4.2.4. SOFFITS

Adequate ventilation of attics is generally required to promote the health of wood structural members and sheathing in the attic. Attic ventilation can reduce the temperatures of roof coverings, which typically prolongs their life. However, these openings can also be an entry point for water intrusion. Hurricane winds can drive large amounts of water through attic ventilation openings. The accumulating water soaks insulation and gypsum board, which can lead to mold growth and, in some cases, to the collapse of ceilings. Soffit vents in combination with gable end vents and/or ridge vents are often used to provide attic ventilation.

Much of the damage caused by recent hurricanes has been the result of poor performance of soffits. The Hurricane Irma and Hurricane Michael FEMA MAT reports specifically note the relatively poor performance of soffits even on newer construction. It is important to keep the soffit material in place. Although some water can be blown into the attic through almost any type of soffit vent, the amount of water intrusion increases dramatically when the soffit material is missing. Depending on the

condition of existing soffits (determined during the evaluation process described in Chapter 3 and Appendix B), the soffit panels should be either removed and reinstalled with reinforced support and fastening or replaced with new material with reinforced support and fastening. The most vulnerable soffits are those with vinyl or aluminum soffit panels. Aluminum soffit panels have an additional vulnerability because of aluminum's corrosion potential in a salt environment. **If the house is within 3,000 feet of saltwater, aluminum soffits should not be used.** Figure 16 shows a representative detail for retrofitting soffits. Although many houses have different soffit configurations from the one depicted here, the intent of the retrofit as shown in Figure 16 is to provide continuous edge support and appropriate intermediate support for the soffit (an alternate configuration is provided in Section 5.6 of the *2020 FORTIFIED Home Standard*). Additionally, the selected soffit products may have more restrictive installation instructions when installed in high-wind regions, in which case the more restrictive installation method should be used.

Basis of Requirements: Soffits are required to be strengthened in accordance with Sections 5.5.4 and 5.6 of the *2020 FORTIFIED Home Standard*.

MINIMUM WIND DESIGN REQUIREMENT

Soffits are required to be capable of resisting the design pressure that meets or exceeds site-specific design pressures specified in ASCE 7-22, but not less than a design pressure corresponding to a minimum Basic Wind Speed of 130 mph and Exposure Category C.

FEMA Grant Requirements: Soffits are required to be fastened at the wall (using a ledger board), at the fascia/subfascia connection point, and at any intermediate supports. Soffits are required to be capable of resisting wind loads determined in accordance with ASCE 7-22 or Table R301.2.1(1) of the 2024 IRC for walls using an effective wind area of 10 square feet. Soffits are required to be capable of resisting a design pressure corresponding to a minimum Basic Wind Speed of 130 mph and Exposure Category C. Wood structural panel soffits are permitted to be installed in accordance with Table R704.3.4 of the 2024 IRC.

PRESCRIPTIVE SOLUTIONS LIMITATIONS

The prescriptive wood structural panel soffit installation details are limited to a **maximum** design pressure of 90 psf. For site conditions that exceed a maximum design pressure of 90 psf, wood structural panel soffits are required to be capable of resisting the site-specific design pressures specified in ASCE 7-22 determined through an engineering analysis by an RDP.

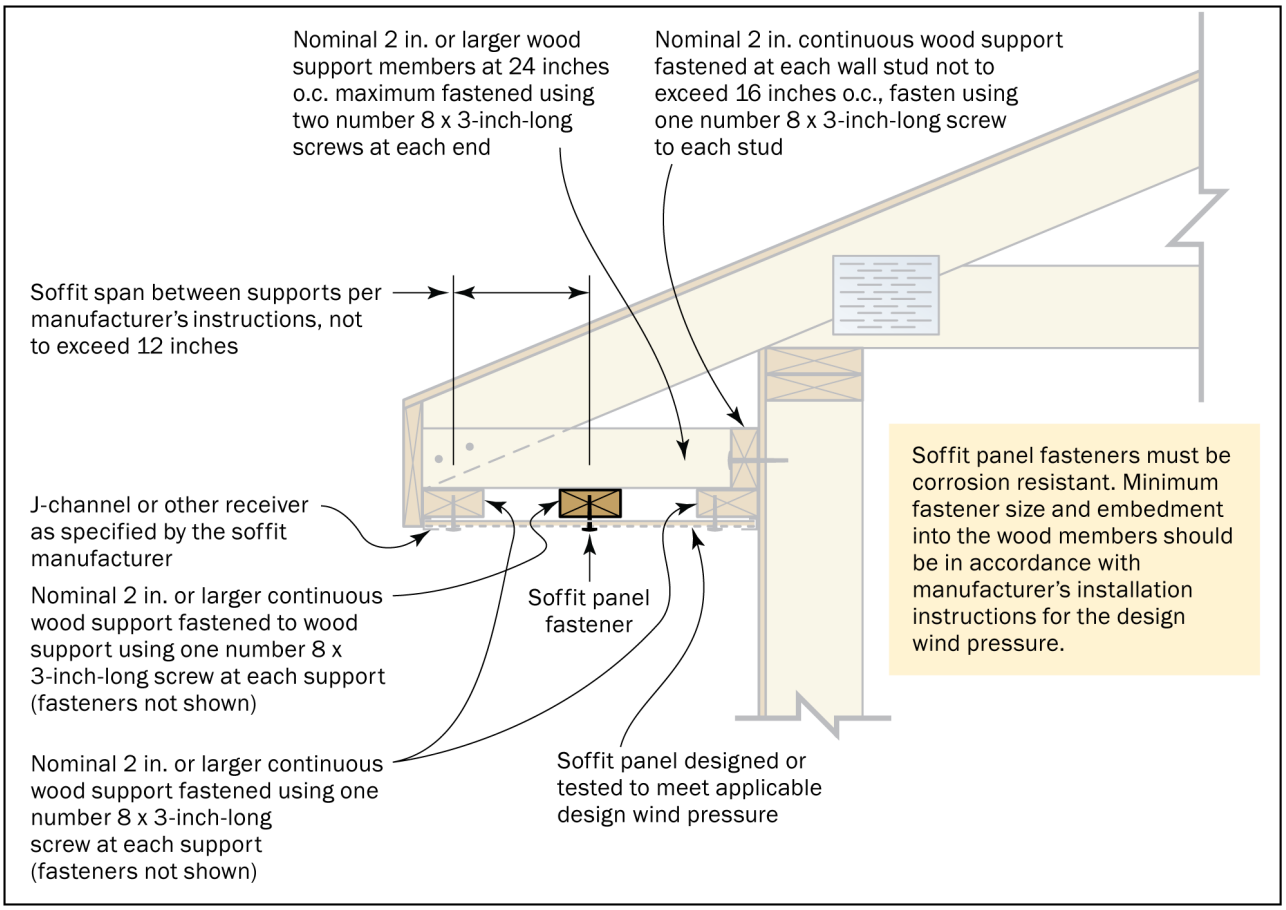


Figure 16: Representative soffit retrofit using wood supports

4.2.5. CHIMNEYS

If a wood-frame chimney on a house collapses during a high-wind event, significant damage can occur to the house as well as surrounding buildings. Therefore, the Intermediate Mitigation Package requires wood-framed chimneys that are attached to the roof framing to be anchored sufficiently to the structure. Wood-frame chimneys that are not located along the edge of the roof and extend 5 feet or less from the roof deck can be retrofitted using prescriptive methods. If the wood-frame chimney is not located along the edge of the roof, the entire chimney structure is supported by the roof framing members, which allows the use of a prescriptive solution. If the chimney is located along the roof edge, the chimney structure is supported by both roof framing members and a load-bearing wall on the exterior of the building, making a prescriptive retrofit more difficult. Similarly, larger chimneys may require a more detailed and less generic solution to adequately anchor the chimney to the structure. If a chimney exists on the house that extends farther than 5 feet above the roof deck or extends along the roof perimeter, an RDP should be engaged to develop a detailed solution. The solution should address the following:

- Chimney wall framing adequacy
- Overturning stability and base shear requirement

- Adequacy and bracing requirements for roof support members
- Attachment schedule of chimney structure to the roof structure

An engineered solution may involve installing additional metal connectors at the roof level if the side wall framing members are continuous from the bearing wall framing. It may include altering the member size and spacing of roof framing members to support the load from the chimney, installing wood posts at each end of the wall if the chimney side wall framing members start from the top of the supporting wall, or setting posts at the interior side of the wall framing at each corner. A retrofit solution for a masonry chimney will be more difficult than for a wood-frame chimney and may require rebuilding the chimney (at least for the portions above the roof line).

Basis of Requirements: Chimneys are required to comply with Section 5.7 of the *2020 FORTIFIED Home Standard*.

MINIMUM WIND DESIGN REQUIREMENT AND PRESCRIPTIVE SOLUTIONS LIMITATIONS

Chimneys are required to be capable of resisting wind loads that meet or exceeds the site-specific design wind loads specified in ASCE 7-22, but not less than design wind loads corresponding to a minimum Basic Wind Speed of 130 mph and Exposure Category C. Alternatively, the prescriptive provisions in the *2020 FORTIFIED Home Standard* are permitted to be used for chimneys meeting the following :

- Chimney extends less than 5 feet above the roof deck
- Chimney is not located within 4 feet of the roof edge

4.2.6. STRENGTHENING CONNECTIONS OF ATTACHED STRUCTURES

For the purpose of this Guide, “attached structures” are connected to the house (and the main wind force resisting system of the house) and have a roof. Examples may include porches and carports. Attached structures can be significant hazards to a house during high-wind events if there is insufficient capacity to resist forces. Attached structures are typically supported by horizontal beam members connected to vertical columns, which are in turn connected to the foundation. If the structure has this typical configuration, the connections should be retrofitted by adding metal connectors that meet or exceed loads and are installed according to manufacturer’s recommendations. These measures will strengthen the load path for the attached structure to transfer applied wind loads to the foundation. The connectors should be added to the following areas of the attached structure:

Between supporting roof members and horizontal beams. Wood-to-wood connections should be strengthened using a saddle-type hurricane clip. If the uplift load required is less than 800 pounds, the clip may be installed on either side of the beam. If the uplift load required is greater than 800 pounds, the clip should be installed on both sides of the beam.

At each beam-to-column connection. A connector should be selected that is appropriate for the location of the connection (e.g., corner beam-to-column connections will require a different connector than inside beam-to-column connections), the required uplift load, and the dimensions of the beam and column.

At each column-to-foundation connection. A metal column-to-foundation connector should be used to strengthen the column-to-foundation connection. A moisture barrier should be provided between the connector and concrete foundation. The metal connector should be rated for exterior weather exposure.

If the attached structure is not supported in the configuration described above, it should be evaluated to determine whether it can be retrofitted to resist the required uplift loads using a different prescriptive solution. If no prescriptive solution exists, an RDP should be engaged to provide a site-specific retrofit solution. Required loads should be calculated using the wind load criteria in ASCE 7-22.

Basis of Requirements: Attached structures are required to be strengthened in accordance with Section 5.8 of the *2020 FORTIFIED Home Standard*.

MINIMUM WIND DESIGN REQUIREMENT AND PRESCRIPTIVE SOLUTIONS LIMITATIONS

Connections of attached structures are required to be capable of resisting wind loads that meet or exceeds the site-specific design wind loads specified in ASCE 7-22, but not less than design wind loads corresponding to a minimum Basic Wind Speed of 130 mph and Exposure Category C. Alternatively, the prescriptive provisions in the *2020 FORTIFIED Home Standard* for attached structures are permitted to be used provided the attached structure meets the following limitations:

- **Maximum** Basic Wind Speed of 180 mph and Exposure Category D
- Rectangular or square plan
- Attached structure extends 20 feet or less from the house
- Attached structure has width of 25 feet or less
- Maximum overhang length of attached structure is 1.5 feet or less
- Weight of roof is minimum 7 psf
- Mean roof height of attached structure does not exceed 15 feet
- The framing geometry of the attached structure is as shown in Figure 5.3 of the *2020 FORTIFIED Home Standard*

4.3. Advanced Mitigation Package

ADVANCED MITIGATION PACKAGE RETROFITS:

- Wind pressure resistance for openings
- Exterior wall impact resistance
- Developing a continuous load path

The Advanced Mitigation Package is the most comprehensive package of retrofits in this Guide. The Advanced Mitigation Package requires a more invasive inspection protocol than the previous two Mitigation Packages. Houses that are undergoing substantial renovation or are being rebuilt after a disaster are typically the best candidates for the Advanced Mitigation Package. The Advanced Mitigation Package includes retrofits to provide a continuous load path and to further protect openings (beyond the requirements of the Intermediate Mitigation Package).

4.3.1. PREREQUISITE REQUIREMENTS

As previously mentioned, the Mitigation Packages specified in this Guide are cumulative. To qualify for the Advanced Mitigation Package, the Basic Mitigation Package and the Intermediate Mitigation Package must be successfully completed as well as the additional requirements specified in the Advanced Mitigation Package.

4.3.2. WIND PRESSURE RESISTANCE OF OPENINGS

The Advanced Mitigation Package requires more stringent requirements for openings than the retrofits specified in the Intermediate Mitigation Package. The Intermediate Mitigation Package opening protection retrofit (see Section 4.2.2) can be completed by installing protection that mitigates only windborne debris impacts. In contrast, the Advanced Mitigation Package retrofits address resistance for windows, entry doors, and garage doors (both glazing and door) to both windborne debris impacts and design wind pressures. The design wind pressure for an opening is based on factors such as the design wind speed for the project location, exposure category applicable for the surrounding terrain, and the size and location of the opening on the building. Existing opening products that do not have a design pressure rating that will meet or exceed the design wind pressure specific to the project location should be removed and replaced with products that do.

Window, skylight, and door products should be tested to demonstrate compliance with AAMA/WDMA/CSA 101/I.S.2/A440-22, *North American Fenestration Standard/Specification for windows, doors, and skylights* (2022), for the applicable design wind pressures. Garage doors should be tested to demonstrate compliance with ANSI/DASMA 108-17, *Standard Method for Testing Sectional Garage Doors, Rolling Doors and Flexible Doors: Determination Of Structural Performance Under Uniform Static Air Pressure Difference* (2017), for the applicable design pressures.

For windows, entry doors, and garage doors, this retrofit should be done using one of the following two methods:

1. Use window and door assemblies in building openings that are rated to resist design wind pressures (regardless of whether they are existing products or new products installed as part of the wind retrofit project). Protection from windborne debris impacts must then be provided by impact-resistant coverings that are installed on windows and doors (see Section 4.2.2 of this Guide). Coverings should be provided to protect the entire opening and transfer loads to the structural system of the house.
2. Use window and door assemblies in building openings that are rated to resist both design wind pressures and windborne debris impacts. Thus, this configuration does not require a covering product to be installed.

The homeowner should work with the contractor, evaluator, and RDP (if engineering services are solicited) to determine the most cost-effective method to provide opening protection for the scenario. For example, a house could already have a shutter system in place over the windows and doors that is certified to meet the appropriate standards for impact resistance. In such a situation, the most cost-effective retrofit might be to replace any existing windows and doors that are not rated to resist the design pressure with new products that are appropriately rated rather than with windows and doors that are rated to resist the design pressure and are impact-resistant.

Given the lack of readily available impact-resistant covering products for skylights, they should be replaced by a product that is certified to resist design wind pressures and windborne debris impacts, rather than be protected by an impact-resistant covering.

Water infiltration

Water infiltration in and around windows and doors can occur during the high winds and heavy rain that typically accompany hurricanes. Flashing and sealing methods are often used to mitigate the effects of water intrusion, but each method presents challenges. Windows and doors must comply with AAMA/WDMA/CSA 101/I.S.2/A440-22, which also includes a water infiltration test at 15 percent or 20 percent of the required positive design pressure rating depending on the product class. Products complying with AAMA/WDMA/CSA 101/I.S.2/A440-22 are assigned a PG rating correlating to the required design pressure based on the product's performance under structural design pressure, water infiltration, and air leakage. For example, a PG 40 window has a minimum design pressure rating of ± 40 pounds per square foot (psf) and was tested for water infiltration at 6 psf (15 percent of 40 psf). The PG rating should be identified on the product label.

Basis of Requirements: All openings (windows, skylights, glass block, doors, and garage doors) must have a design wind pressure rating in accordance with Section 6.2 of the *2020 FORTIFIED Home Standard*.

MINIMUM WIND DESIGN REQUIREMENT

All openings (windows, skylights, glass block, doors, and garage doors) are required to have a design pressure rating that meets or exceeds the site-specific design pressures specified in ASCE 7-22, but not less than a design pressure rating corresponding to a minimum Basic Wind Speed of 130 mph and Exposure Category C.

FEMA Grant Requirements: All windows, doors, and skylights are required to be tested to indicate compliance with AAMA/WDMA/CSA 101/I.S.2/A440-22 and have a PG rating corresponding to the required positive design pressure rating.

4.3.3. EXTERIOR WALL IMPACT RESISTANCE

While exterior walls are also subjected to windborne debris in high-wind events, impacts to exterior walls typically do not result in large openings as often occurs when debris impacts glazed openings. However, they must provide some minimal level of impact resistance in addition to meeting the design wind pressures.

Basis of Requirements: Exterior walls are required to meet the impact resistance specified according to Section 6.3 of the *2020 FORTIFIED Home Standard*.

4.3.4. DEVELOPING A CONTINUOUS LOAD PATH

For buildings built to modern building codes, structural failures due to wind loads are typically not as common as building envelope damage or water intrusion. However, structural failures are still observed and are usually related to poor or undersized connections or the breach of a large opening in the building envelope. The performance of the house's structural system during a high-wind event depends on whether there is a continuous load path that can transfer loads applied anywhere on the building envelope through the structure and to the foundation. If there is not a continuous load path in the building, the loads may cause a failure related to the missing point of connection. For example, Figure 17 shows a house observed by the Hurricane Michael MAT. This house had inadequate connections to transfer loads at the gable end.

Blue dashed outlines show where connectors were missing at points of support for the gable end wall. The yellow solid outline shows lack of connection at the outlooker to the end truss in some cases.

(Source: FEMA P-2077)

Figure 17: Gable end failure on house due to Hurricane Michael

Implementing a continuous load path through an existing building typically requires the assistance of an RDP, although some retrofit programs and guides contain prescriptive solutions to provide continuous load paths through existing residential structures. However, given the large potential variation in structural configuration, construction techniques, and material types, prescriptive solutions for continuous load paths are limited to very simple structures. As a result, most houses will not be eligible for the prescriptive retrofits and will need to engage the services of an RDP to develop a load path retrofit solution specific to the house.

FEMA P-499, *Home Builder's Guide to Coastal Construction* (2010a), contains several fact sheets including, Technical Fact Sheets No. 4.1, *Load Paths*, and 4.3, *Use of Connectors and Brackets*, which provide guidance on the concept of a continuous load path through the house. FEMA P-55, *Coastal Construction Manual* (2011), provides more detailed guidance and examples of each link through the continuous load path. A solution should be followed that starts at the top of the house (at the roof sheathing), implementing an appropriate fastening schedule and attachment to the roof framing members, and continuing to the foundation.

The connections between the roof and walls should be capable of transferring design loads corresponding to the design wind speed (see Figure 18). If the complete retrofit cannot be performed, priority should also be given to connecting the corners of the roof to the wall below and where the roof members have the greatest span. While these priorities will address the more vulnerable areas of a home, a partial retrofit will not qualify for the Advanced Mitigation Package.

The retrofits should ensure that the roof truss and rafter retrofitted tie-down is adequate to resist the uplift loads and lateral loads in two directions at the top of the supporting wall.

Technical Fact Sheet No. 4.3 also discusses wall-to-floor and wall-to-wall connections (see Figure 19). These connections are also part of the continuous load path that transfers loads from the roof (as well as those picked up by exterior walls) all the way to the foundation and into the ground. Figure 20 shows foundation connections. The foundation is the last link in a continuous load path to the ground. It is critical to ensure that the loads are being transferred to the foundation and into the ground where large loads must be resisted.

Note: For information on evaluating shear wall capacity, see Appendix B, Evaluation Guidance.

As previously indicated, an RDP will typically be required to complete the continuous load path retrofit portion of the Advanced Mitigation Package.

Basis of Requirements: All houses are required to be retrofitted to have a continuous load path in accordance with Section 6.5 of the *2020 FORTIFIED Home Standard*.

MINIMUM WIND DESIGN REQUIREMENT

The continuous load path is required to be capable of resisting wind loads that meet or exceed the site-specific design wind loads specified in ASCE 7-22, but not less than the design wind loads corresponding to a minimum Basic Wind Speed of 130 mph and Exposure Category C.

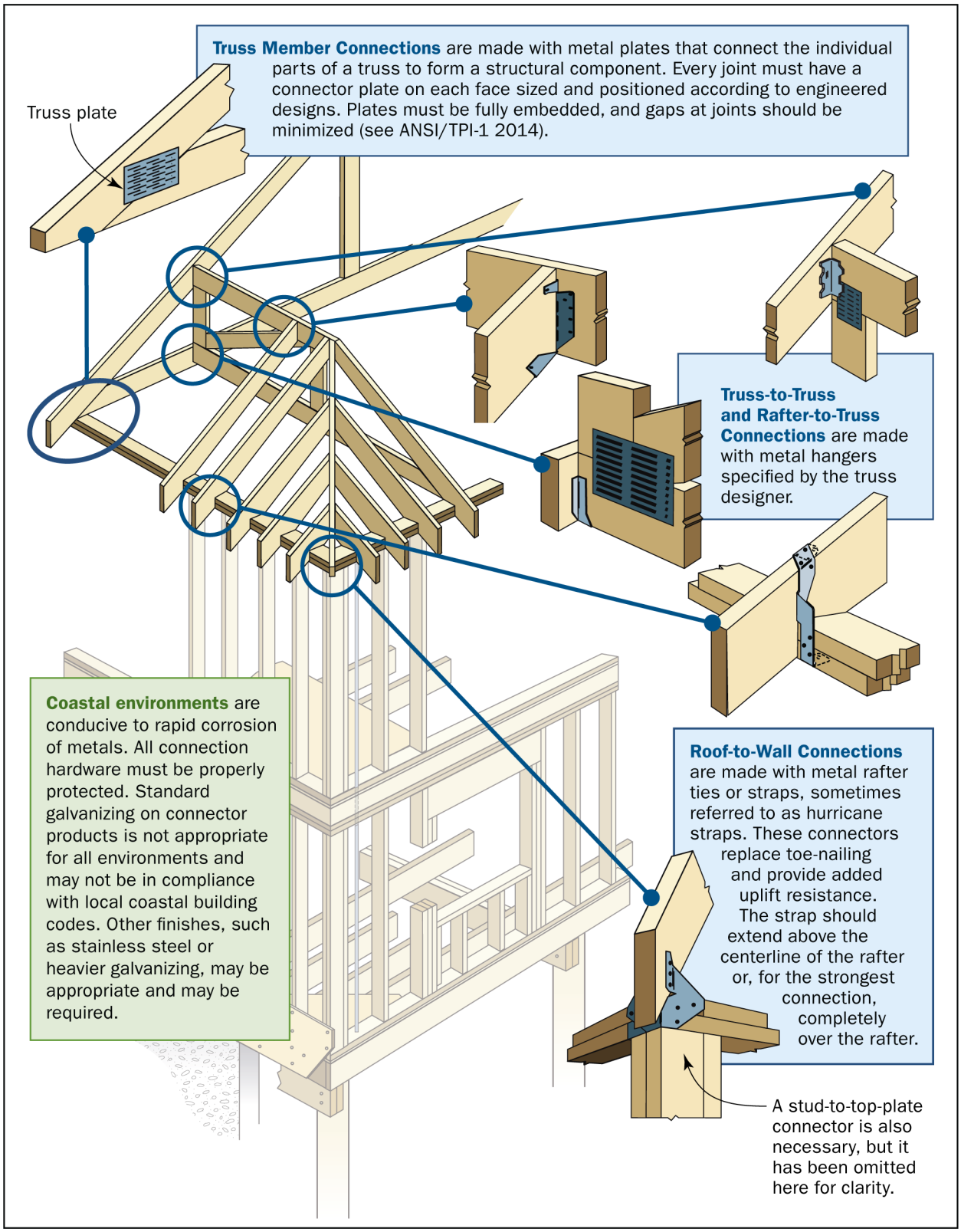


Figure 18: Load path connections of a roof system

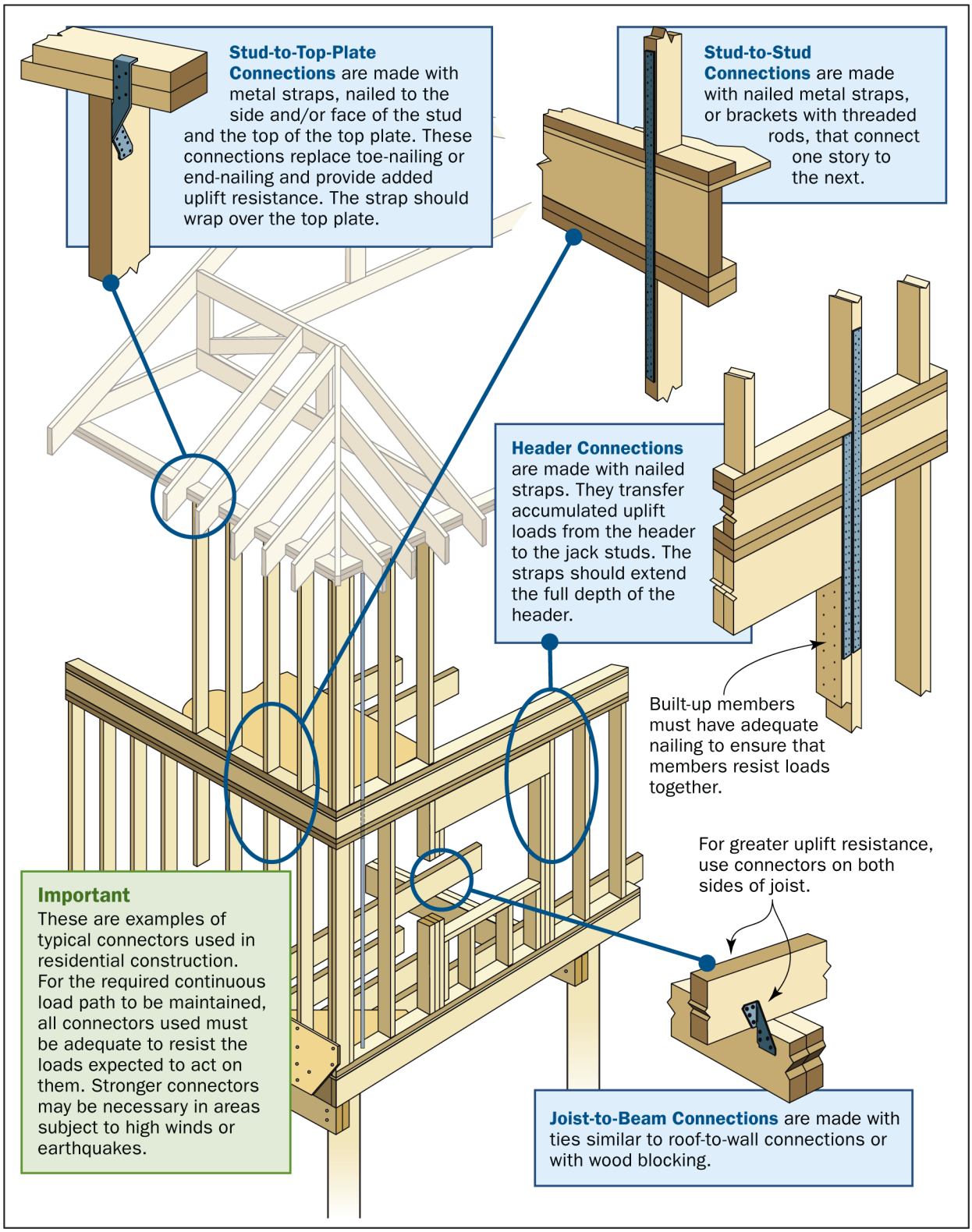


Figure 19: Load path connections of a wall system

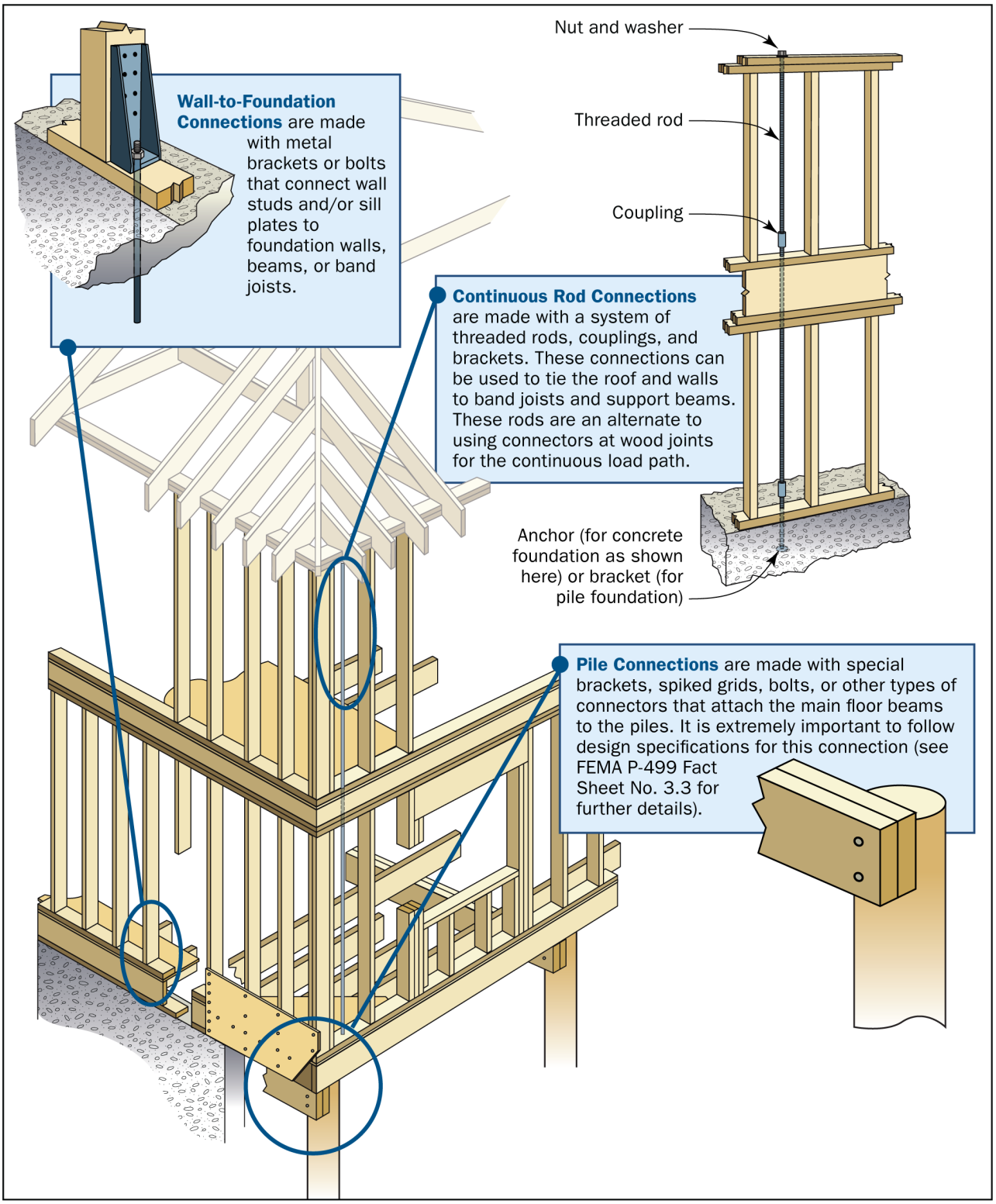


Figure 20: Load path connections of a foundation

4.4. Additional Mitigation Measures

The remainder of this chapter discusses retrofits that can further mitigate the risk of wind-related damage if the Mitigation Packages are implemented. The Mitigation Packages described in this Guide include important retrofits to reduce the risk that a house will experience wind-related damage. However, the risk of damage from a high-wind event cannot be eliminated entirely. By maintaining awareness of the vulnerabilities of and around a house, the risk from wind-related damage can be mitigated even further. While these issues are important to understand, they are not a part of the Mitigation Packages and are not eligible for HMA Program funding.

4.4.1. EXTERIOR WALL COVERINGS

Exterior wall coverings can be susceptible to damage from wind when not properly installed or rated for the applicable design wind pressure. Common exterior wall coverings include vinyl siding, brick veneer, fiber-cement siding, and wood and hardboard siding. All types of wall coverings can perform well in high winds if they are rated and properly installed for high winds.

Guidance on the proper installation of vinyl, wood, and fiber cement siding material types is provided in the Hurricane Michael in Florida Recovery Advisory 2, *Best Practices for Minimizing Wind and Water Infiltration Damage* (2019a). Guidance on the proper installation of brick veneer is provided in FEMA Technical Fact Sheet 5.4, *Attachment of Brick Veneer in High-Wind Regions*.

Polymeric cladding, which includes vinyl siding, polypropylene siding, and insulated vinyl siding as well as soffit and fascia must be installed properly to perform in high-wind events. While these products must be tested and rated for the applicable design wind pressures, a few key installation techniques are also critical to their performance and resilience during hurricanes.

- Manufacturer-approved starter strips should be used where the first course of siding starts, both at the bottom of the wall and at start points on the wall such as trim breaks.
- Utility trim and punch locks should be used at the top of walls and underneath windows and other wall penetrations.
- Soffits (See Section 4.2.4) should be fastened at both the wall (using a ledger board) and at the fascia/subfascia connection point.
- Fascias should be fastened at the leg and on the face near the drip cap or a utility trim/punch lock system should be used to secure the fascia at the drip edge.

Previous MAT reports have identified the lack of these installation techniques as contributing to the poor performance of these types of siding systems. If these systems and/or fasteners are not installed, they can be easily retrofitted. For additional details on performing these retrofits, see the *Polymeric Cladding Building Code Reference Guide* (Vinyl Siding Institute, 2020), which can be downloaded at **www.vinylsiding.org**.

4.4.2. TREE FALL

Damage caused by tree fall is commonly observed following high-wind events (see Figure 21). Beyond damaging buildings, trees can block roads and driveways, down powerlines, and create a fire hazard. Branches near and over a house should be trimmed back. Although trees provide many benefits, root systems of large trees that are close to a house can cause damage to the house's foundation. Homeowners should consult an arborist or a tree removal professional to assess the vulnerabilities of any trees on their property. Trees that are diseased, have voids in trunks that significantly reduce their ability to withstand wind forces, or are otherwise vulnerable to collapse on nearby structures should be considered for removal.

(SOURCE: FEMA 549)

Figure 21: A home damaged by fallen trees during Hurricane Katrina (Diamondhead, MS)

4.4.3. EXTERIOR EQUIPMENT

Damage may result from exterior equipment that either falls from or is torn off a building during a high-wind event. Although the Basic Mitigation Package includes retrofits to some rooftop elements such as vents and turbines, not all potential rooftop equipment is covered. Any exterior equipment should be protected from wind-related damage. Unsecured exterior rooftop equipment, such as exhaust fans, fan cowlings, and vent hoods, can blow off during high-wind events. When this occurs, water can infiltrate the area where they are ripped off the house. Additionally, the equipment can become windborne debris and cause damage to surrounding property. Generally, inadequate anchorage, inadequate strength of the equipment itself, and corrosion of fasteners and straps are the causes of failure of these elements. FEMA P-55 provides guidance on mitigating these elements.

5. Implementing Mitigation Projects

This chapter offers guidance for implementing residential building wind retrofit projects and potential funding sources. It also identifies factors to consider for wind retrofit projects, including building code compliance, local permitting and inspection requirements, and general construction challenges, as well as hazards other than high-wind events.

5.1. Wind Retrofit Programs

Several federal, state, and nonprofit retrofit programs are currently available to homeowners and local governments. These programs include FEMA's HMA Grant Programs, the IBHS FORTIFIED Home program, state programs, and Smart Home America. This section briefly describes each of these opportunities. This Guide does not provide an exhaustive list of all such programs; however, Appendix D provides links to FEMA's HMA program and other funding programs. Other retrofit programs are offered through various states but are generally disaster specific and have limited operational time frames. Each of the retrofit programs discussed in this section provides guidance on mitigating wind hazards; some of the programs also offer funding assistance. Homeowners are encouraged to research potential wind retrofit programs and incentives prior to beginning a wind retrofit.

5.1.1. FEDERAL EMERGENCY MANAGEMENT AGENCY

FEMA administers several programs that provide grant funding for mitigation projects (see Appendix D for links to FEMA resources). FEMA funds both structural and non-structural retrofits to existing buildings for wind hazard mitigation. Wind mitigation retrofit projects are defined as modifications to the elements of a building to reduce or eliminate the risk of future wind damage and to protect inhabitants. Wind retrofit projects are eligible through both the BRIC program and HMGP. These programs comply with local, state, or national building codes, standards, and regulations—such as the IBC, the FBC, and the ASCE and ASTM standards—for structural retrofits.

Building Resilient Infrastructure and Communities. FEMA's BRIC program provides nationally competitive grants to states, territories, federally recognized Indian tribal governments, and local governments for hazard mitigation planning and implementing mitigation projects *before* a disaster event. Funding these plans and projects reduces overall risks to the population and structures, as well as reliance on funding from actual disaster declarations to rebuild after disasters.

Hazard Mitigation Grant Program. FEMA's HMGP provides grants to states, territories, federally recognized Indian tribal governments, local governments, and private nonprofit organizations to implement long-term hazard mitigation measures *after* a major disaster declaration in each state. The purpose of HMGP is to reduce the loss of life and property due to natural disasters and to enable mitigation measures to be implemented during recovery from a disaster.

Figure 22 illustrates the five-stage process for FEMA grant applications and approvals (both BRIC and HMGP), starting with mitigation planning and ending with the successful execution of a project.

The process requires coordination among FEMA, the state, and the local government (represented by the three rings in Figure 22). Although the process is shown as a circle, it does not mean that individual buildings need to be retrofitted continually; rather the circle represents a community's continual process to use grants to improve community-wide resiliency.

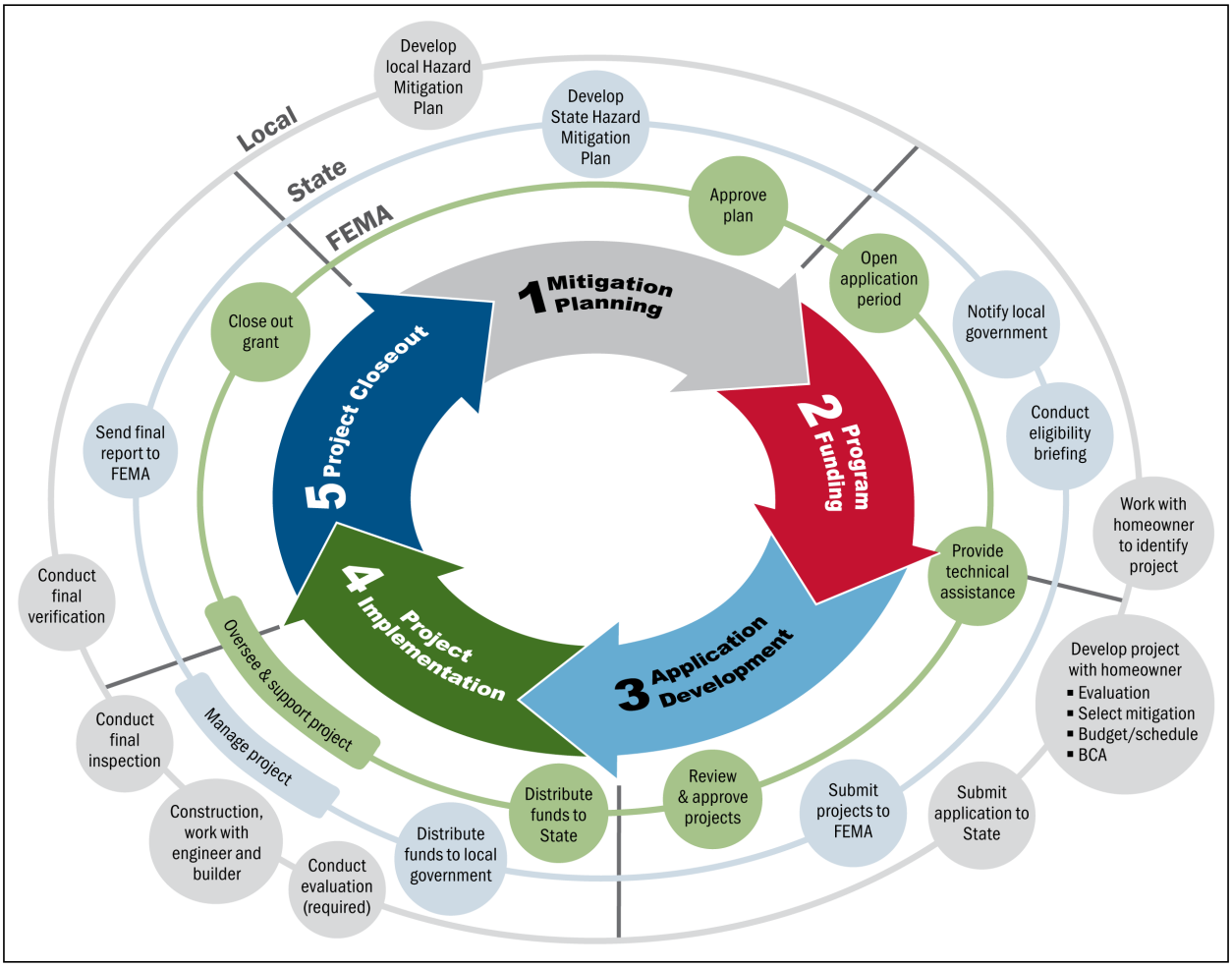


Figure 22: HMA grants cycle process showing roles and responsibilities of each stakeholder

Stage 1. Mitigation Planning

A current approved Hazard Mitigation Plan is a prerequisite for all HMA project grants. Mitigation Plans lay out the process for identifying the hazard risks of a community and the actions that will help reduce those risks. Wind retrofit projects that are proposed for FEMA funding under these programs must be consistent with the state's mitigation plan. The mitigation planning process requires public participation and identification of measures to reduce risks and is, therefore, a good opportunity for homeowners to address concerns about high-wind hazards. More information is available on the FEMA website at https://www.fema.gov/emergency-managers/risk-management/hazard-mitigation-planning.

Stage 2. Program Funding

HMA programs enable hazard mitigation measures to be implemented before and after disasters. Funding depends on the availability of appropriation funding or is based on disaster recovery expenditures, as well as any directive or restriction made with respect to such funds. HMGP funding depends on federal assistance provided for disaster recovery following a Presidential disaster declaration in a state, while BRIC funding is appropriated annually by Congress on a competitive basis to all states, territories, and tribes. Once the application period is open, the state or territory notifies the local governments of the availability of funds and relays information on the application process, project requirements, and eligibility criteria for the local government. Homeowners should work with their local government to express their interest in participating in a wind retrofit project; the local government can then submit a subapplication to the state and request HMA funding.

Stage 3. Application Development

Individuals and businesses are not eligible to directly apply for HMA funds, so individual homeowners must work with their local government to develop a complete project subapplication (which is submitted as part of a larger state application to FEMA) on their behalf. Local governments may submit a retrofit project for a single house as an individual subapplication or combine it with other houses as part of an aggregate subapplication. Aggregating benefit and cost values is allowed for multiple structures if they are all vulnerable to damage as a result of similar hazard conditions. Users of this Guide should refer to the latest HMA Guide at https://www.fema.gov/grants/mitigation/hazard-mitigation-assistance-guidance for information on aggregating projects in an application.

Key steps for wind retrofit applications are:

1. Identify the property to be mitigated
2. Identify key project personnel and roles such as evaluator, inspector, and RDP (if needed)
3. Identify the approach that will be used, such as the IBHS FORTIFIED Home program, to establish the target level of risk to which the structure will be mitigated
4. Have an evaluator or RDP inspect the structure utilizing the approach identified in Stage 3 (if possible; if not done at this stage, it must be done during Stage 4, Project Implementation)
5. Select a Mitigation Package (Basic, Intermediate, Advanced) and its associated retrofit projects based on the evaluation
6. Develop a project cost estimate and work schedule
7. Conduct a BCA using the FEMA BCA Tool (refer to Appendix C for additional information); if the BCR is 1.0 or greater, the project is cost-effective. FEMA requires a BCR of 1.0 or greater for funding. (A BCR can help a homeowner funding their own retrofit project to make an informed decision, but is not needed, nor does it have to be greater than 1.0.)
8. Ensure that properties located in designated Special Flood Hazard Areas (SFHAs) will obtain flood insurance and that this designation is recorded on the property deed.

SPECIAL FLOOD HAZARD AREA (SFHA)

The SFHA is the area covered by the floodwaters of the 1 percent annual-chance flood event. The National Flood Insurance Program's (NFIP's) floodplain management regulations must be enforced in the SFHA.

The local government submits the subapplication to the state. The state then selects projects based on its priorities and submits applications to FEMA for review. FEMA reviews the projects for eligibility, completeness, engineering feasibility, cost-effectiveness, cost reasonableness, and environmental planning and historic preservation documentation. The review process also confirms that all hazard mitigation activities adhere to all relevant statutes, regulations, and program requirements, including other applicable federal, state, territorial, Indian tribal, and local laws, implementing regulations, and executive orders, which are detailed in the HMA Guide. Once FEMA approves and awards the project, the grant funds are distributed by the state to the local governments, who will distribute funding to individuals, as appropriate. No construction activities should begin until after the grant has been awarded because HMA funding is not available for activities initiated or completed prior to award or final approval.

FEMA grant programs include a cost-share component or non-federal match. The percent of the cost share can vary depending on the grant requirements and Notice of Funding Opportunity, but it is often a 25 percent non-federal match with FEMA providing 75 percent of the funds. Grant program guidance will indicate what percent must be monetary and what percent of in-kind services by the local government can be considered part of the match. In some instances, the cost share or local match is covered by the community, while some communities use homeowner-provided funds to cover the cost share.

Communities should check with the FEMA grant program they are applying to for any documentation or submission requirements related to their project. They should also confirm the verification and reimbursement process so that this can be included in the planning stages when determining scope and schedule. It may be necessary for funding to be available prior to reimbursement to pay for aspects of the project as they are completed. Prior to developing a subapplication, local governments and other eligible entities are strongly encouraged to review Title 2 of the Code of Federal Regulations Part 200, which provides details on administrative requirements, cost principles (e.g., classifying costs, accounting standards, taxes), and audit requirements for federal awards of funds.

ALTERNATIVE COST-EFFECTIVENESS METHODOLOGY

For the fiscal year 2022 (FY 2022), the BRIC grant program application cycle utilizes an alternative cost-effectiveness methodology. For mitigation activities that benefit disadvantaged communities, address climate change impacts, have difficult-to-quantify benefits, and/or are subject to higher costs due to the use of low-carbon building materials, projects may be considered cost-effective under the following conditions:

When using the 7% discount rate, the BCR is at least 0.75 or greater

When using the 3% discount rate, the BCR is at least 1.0 or greater

Future fiscal year policies may vary from the FY 2022 policy. Before utilizing the aforementioned alternative cost-effectiveness methodology for BRIC, check for updates to the policy, which are available at https://www.fema.gov/grants/mitigation/building-resilient-infrastructure-communities. Additional inquiries can be made to the FEMA BCA Helpline by calling 1-855-540-6744.

Stage 4. Project Implementation

Once the applicant (e.g., state) has awarded the funds to the local government, the next stage in the process is project implementation. HMA projects must be completed within a set amount of time, called a period of performance, as indicated in the award agreement. The homeowner or local government should secure the professional services of a contractor (and engineer for non-prescriptive solutions) at this stage to develop a detailed construction plan. If the scope of work or cost estimate changes as a result, consult the HMA Guide for direction on how to revise the scope of work prior to construction.

During the period of performance, the local government must maintain a record of work and expenditures for the quarterly reports that the applicant submits to FEMA. To ensure that mitigation retrofits are being implemented in a manner that will effectively reduce the house's risk to wind-related damage as approved, inspections should be conducted during the project. For example, if a wind retrofit project involves replacing the roof covering, the selection and spacing of fasteners should be verified by an evaluator before the underlayment and new roof covering are installed. Conducting inspections while the project is underway can ensure that any improperly installed components can be corrected before additional work is implemented, which can help reduce or eliminate unanticipated construction costs. Depending on how the grant is structured, some of the following steps may be completed in Stage 3, but with other grants, all steps may be required for an HMA mitigation wind retrofit:

1. Evaluate the building to identify the viable Mitigation Package(s) and associated hazard mitigation projects (unless already completed during Stage 3, Application Development)
2. Select viable Mitigation Package(s) and eligible hazard mitigation projects (unless already completed during Stage 3, Application Development)

3. Secure professional services to complete the approved project
4. Complete installation of the approved hazard mitigation
5. Inspect the completed hazard mitigation elements and verify other program requirements

Stage 5. Project Closeout

Once the wind retrofit project has been completed, an evaluator (or RDP if prescriptive solutions were utilized) should conduct a final verification to ensure that the project was implemented as intended. This will facilitate project closeout documentation and confirm that the building provides the desired level of protection. In addition, the applicant or the FEMA Region will verify that the work was completed in accordance with the approved scope of work and closeout procedures. If the house is located in an SFHA, the local government must provide documentation of flood insurance for the structure and a copy of the recorded deed amendment. The HMA Guide should be referenced to ensure all closeout requirements are addressed.

Eligible and Ineligible Costs

Allowable mitigation costs for FEMA wind retrofit projects are for project components, such as inspections and design and building costs, directly related to and necessary for providing increased hazard protection from wind and wind-driven rain intrusion during a high-wind event. FEMA will only compensate costs that are consistent with the Basic, Intermediate, and Advanced Mitigation Packages described in this Guide. Eligible costs consistent with these Mitigation Packages include:

- Labor for key personnel (such as the evaluator, inspector, and RDP)
- Other costs to complete the structure evaluation and inspection
- Planning and design activities
- Site preparation, building materials, and construction
- Structural systems capable of resisting design wind loads (including roof decking and roof support structures)
- Soffits, vents, and turbines
- Protective envelope components such as walls, ceiling/roof systems, and doors
- Other retrofit hardening activities that meet the criteria in this Guide.
- Performance-related improvements may also be eligible costs under FEMA's grant programs

FEMA wind retrofit projects are not intended to result in activities such as structure elevation or mitigation reconstruction (demolition of an existing structure and reconstruction of a compliant structure). The structure evaluation process, as discussed in Chapter 3 and Appendix B, should identify existing conditions that must be addressed for the proposed Mitigation Packages to be effective. The structure evaluation may identify alternate or additional hazard mitigation measures that should be completed, such as a wind retrofit in combination with a structure elevation. In these

cases, the local government developing the HMA project subapplication should modify the scope of work to accurately reflect all eligible hazard mitigation activities being requested.

Ineligible costs include, but are not limited to:

- Project activities and components not consistent with the Basic, Intermediate, or Advanced Mitigation Packages described in this Guide
- Uncertified construction products
- Costs related to functionality or outfitting such as furniture, interior or exterior decorative elements and fixtures, floor treatments, electrical and plumbing utilities, and other finishing materials that do not enhance the structural performance of the house
- Costs associated with the repair of gross negligence by a homeowner, previous homeowner, or bank. This includes, but is not limited to, negligence, lack of maintenance and subsequent damage, termite infestation, and damage where there was a lack of termite inspections and termites were a known hazard.

5.1.2. STATE PROGRAMS

State officials recognize the value of encouraging homeowners to undertake wind retrofits. Many of the hurricane-prone states have enacted laws and programs to assist homeowners with the financial burden of wind retrofits through grant programs or by reducing the tax burden on the cost of retrofits. To help incentivize homeowners to implement wind retrofits, once the retrofits are completed and inspected, states and insurance companies have worked together to offer homeowners discounts on insurance premiums to reflect the improved building performance.

Table 6 provides examples of state programs and organizations that educate homeowners, fund wind retrofit projects, provide tax benefits, and reduce insurance premiums for residential buildings.

Table 6: Summary of State Wind Retrofit Grant Programs as of September 2022

State	State Grant Programs	Tax Benefits	Insurance Discounts
Alabama	Strengthen Alabama Homes - Up to $10,000 for resilient roofing	Lesser of 50% of the retrofit cost or $3,000 for wind or flood mitigation to houses	Discounts on the wind portion of property insurance ranging from 25%–55% depending on the type of wind retrofits
Connecticut			Premium discounts for shutters or impact-resistant glazing

State	State Grant Programs	Tax Benefits	Insurance Discounts
Florida	Florida Hurricane Loss Mitigation Program Retrofit Grant		A variety of insurance premium discounts specific to location, building characteristics, and type of retrofit
Georgia			5%–10% credit for wind peril on homeowners insurance depending on the type of wind retrofit
Louisiana		Retrofitting deduction in an amount equal to 50% of the cost paid or incurred for the retrofit, less the value of any other state, municipal, or federally sponsored financial incentives for the cost paid. The tax deduction can be no more than $5,000 per retrofitted residential structure and is claimed on the tax return for the year in which the work is completed.	State program for one- or two-family owner-occupied houses and modular homes. Discounts are based on improvements in the Louisiana Hurricane Loss Mitigation Form.
Maryland			Insurers may offer discounts for hurricane or storm-related mitigation measures
Mississippi			12%–55% for FORTIFIED Gold on wind portions of homeowners insurance depending on insurance carrier
New Jersey			Some insurers offer premium discounts for shutters or impact-resistant glazing

State	State Grant Programs	Tax Benefits	Insurance Discounts
New York			Some insurers offer premium discounts for shutters or impact-resistant glazing
North Carolina	Grants up to $6,000 for resilient roofing		Up to $700 discounts on homeowners insurance for wind retrofits
Rhode Island			Homeowners may have their deductible waived if their house contains certain mitigation measures and it has been inspected by the insurer
South Carolina	South Carolina Safe Home Program - Wind retrofit grants up to $5,000, awards based on project cost and economic factors.	25% of the total cost of wind retrofits or $1,000, whichever is less. Up to $1,500 income tax credits for sales and use taxes on retrofits.	Up to 50% of the wind portion of the homeowners insurance policy
Texas			The Texas Windstorm Insurance Association provides Building Code Credits, which are available for various wind mitigation measures

States such as Florida, Alabama, Mississippi, South Carolina, and Louisiana have had wind retrofit programs for several years. Many of these states have had post-storm-related grant programs, some of which have become longer-running programs to provide financial assistance to homeowners. Homeowners are also encouraged to research whether their state has a program that has begun since the publication of this document in order to determine whether a state program might be able to provide financial assistance.

Homeowners may be incentivized to undertake wind retrofits by the potential for insurance discounts. Table 6 outlines many states where property insurance policies may be eligible for a discount following the successful completion of a wind retrofit. Ranges were provided in the table when there were different discounts based on either the type of retrofit or different insurance providers offered varying discounts. FEMA recommends that homeowners contact their insurance

provider to understand the potential amount of the premium discount and what inspections and paperwork are necessary to receive the discount. Tools such as the Florida Wind Insurance Savings Calculator may be available to determine the potential discounts available. In some instances, calculating a return on investment for the wind retrofit may be possible. If loans are required to complete the retrofit, evaluating the difference in the loan repayment as compared to the insurance discount may be worthwhile because it could make the cost of the retrofit more viable. While many retrofits may have a long return on investment, it would only take a storm or a few avoided insurance deductibles for the retrofits to be well worth the investment.

FLORIDA WIND INSURANCE SAVINGS CALCULATOR

The Florida Division of Emergency Management has an online wind insurance savings calculator. It allows homeowners and builders to estimate wind insurance savings that Florida insurance companies make available for new construction and retrofits, such as those outlined in the Florida retrofit programs and this Guide.

The calculator is available at https://apps.floridadisaster.org/wisc/.

5.1.3. SMART HOME AMERICA

Smart Home America (https://www.smarthomeamerica.org/) is a not-for-profit [501(c)(3)], started in 2009, that works with experts, service providers, and the public on developing better mitigation solutions by promoting the benefits of mitigation and insurance coverage to improve resilience to natural disasters. The organization operates in 10 states to educate business owners and homeowners on the importance of adequate insurance, mitigation measures that can result in lower property insurance premiums, and potential funding sources to help pay for mitigation measures. Smart Home America also encourages constructing buildings beyond the minimum building code requirements and educates communities on the value of proper code enforcement. The organization provides resources on FORTIFIED construction, insurance, building codes, funding, roofing, legislation and policy, and hurricanes and flooding risk.

5.1.4. FORTIFIED HOME™ PROGRAM

The FORTIFIED Home program was developed by the IBHS in conjunction with the first edition of this Guide, and as a result, the framework for these two programs is similar. Years of research at the IBHS full-scale wind testing and building science lab, FEMA's MAT observations and guidance documents, and modern engineering codes and standards have informed both guides. Although the FORTIFIED Home program does not provide grants, IBHS has developed the program in coordination with many prominent insurance companies that offer reduced home insurance premiums in those states listed in Table 6 and potentially other states.

Similar to the Mitigation Packages in this Guide, FORTIFIED Home outlines three levels of increasing protection to retrofit a house: Roof, Silver, and Gold. More information on FORTIFIED Home is provided in Appendix A.

5.2. Factors to Consider When Implementing Wind Retrofit Projects

Retrofitting existing buildings can be a complicated process. Building configurations, material types, construction methods, and local codes and ordinances can all differ widely. This section discusses these issues so that the homeowner, local government, evaluator, contractor, and RDP (if needed) can consider how such concepts may apply to their project and what potential issues may need to be addressed over the course of the project. Building code compliance, local permitting and inspection requirements, and general construction hazards are also covered in this section.

5.2.1. BUILDING CODE COMPLIANCE CHECK

Modern building codes contain provisions for existing buildings to ensure that renovations, alterations, repairs, and relocations of space are completed in a manner that does not compromise the structural integrity of the building. Although a wind retrofit project should improve the structural integrity of a house rather than reduce it, every wind retrofit project should still undergo a building code compliance check to verify that the project does not trigger provisions for existing buildings. These types of provisions can potentially disrupt a wind retrofit project by requiring additional work to implement the selected Mitigation Package. Additional information on these provisions, and the type of work they apply to, can be found in FEMA P-499, Technical Fact Sheet No. 9.2, *Repairs, Remodeling, Additions, and Retrofitting—Wind* (2010a).

As with new construction, individual retrofit measures and the measures that are part of the Mitigation Packages should comply with the ICC model building codes (or the effective building code adopted by the community, if it is more restrictive). This Guide does not intend for any retrofit measures to be performed that would result in a conflict with the building code as it applies to the hardening of residential buildings.

One type of provision that is prevalent in existing building codes is for houses undergoing extensive repairs or improvements, including those being repaired because of damage, to be brought into compliance with specific regulations. For example, compliance with flood-resistant requirements in building codes and local floodplain ordinances are generally triggered when work on a building in the designated flood hazard area is determined to be a substantial improvement or repair of substantial damage. Typically, with wind retrofit projects, the substantial improvement or substantial damage provisions are not likely to be triggered unless other work is being done at the same time as the retrofit measures. The determination of whether the SI/SD requirements are triggered is made by the local building official or floodplain manager. In some jurisdictions, the value of the work that triggers the SI/SD requirements is cumulative over multiple years (e.g., 5 years, 10 years), which may be a consideration when planning retrofits and other updates to a house. More information on SI/SD determinations and compliance requirements can be found in FEMA 213, *Answers to Questions about Substantially Improved/Substantially Damaged Buildings* (2018a).

Some existing buildings may need to comply with building code provisions when communities have adopted provisions related to Substantial Structural Damage (SSD), although most one- and two-story residential buildings are exempt. The SSD provisions often apply to elements of the building that are necessary for carrying and distributing structural loads and damage resulting in a loss in

structural capacity. A local building official will be involved in the determination of SSD for a building and the building codes will outline triggers and methods for determination. If a building needs to comply with SSD provisions, the building may require additional structural retrofits.

SUBSTANTIAL IMPROVEMENT / SUBSTANTIAL DAMAGE (SI/SD)

The I-Codes require that buildings in flood hazard areas undergoing substantial improvement or repair of substantial damage must meet the design and construction requirements for flood hazards in the area in which the building is located. The I-Code definitions of substantial improvement and substantial damage match the NFIP definitions:

Substantial damage means damage of any origin sustained by a structure whereby the cost of restoring the structure to its before-damaged condition would equal or exceed 50 percent of the market value of the structure before the damage occurred.

Substantial improvement means any reconstruction, rehabilitation, addition, or other improvement of a structure, the cost of which equals or exceeds 50 percent of the market value of the structure before the "start of construction" of the improvement. This term includes structures that have incurred "substantial damage," regardless of the actual repair work performed.

Table 7 summarizes the code compliance checks for the 2021 IEBC and 7th Edition 2020 FBC: Existing Building (based on the 2018 IEBC) and includes a brief commentary on how the provisions in these codes may apply to a wind retrofit project. Note that Table 7 may not include all applicable provisions and is not a substitution for consulting the building code in its entirety. Homeowners should work with their designer or contractor to verify which building codes the proposed wind retrofit project must comply with before beginning the project. Although the 2021 IRC is not covered in the table, when applicable Sections R105.3.1.1, AJ102.5 indicate that where work constitutes SI/SD, the building shall comply with flood-resistant requirements for new construction.

Table 7: Building Code Compliance Checks

Code Check	2021 IEBC[1]	7th Edition 2020 FBC: Existing[2]	Comments
Flood Hazard Areas	104.2.1, 401.3, 405.2.6, 502.3, 503.2, 701.3, 1103.3, 1301.3.3: Where work constitutes SI/SD, the building shall comply with flood-resistant requirements for new construction.	401.3, 406.2.4, 502.2,503.2, 701.3, 1103.5, 1401.3.3: Where work constitutes SI/SD, the building shall comply with flood-resistant requirements for new construction.	SI/SD is a minimum requirement of floodplain management ordinances in communities that participate in the NFIP, regardless of whether a building code is adopted. All Mitigation Packages: Applicable if done simultaneously with SI/SD and located in a flood hazard area.
Existing Structural Elements Carrying Gravity Load	503.3: Any existing gravity load-carrying structural element, for which an alteration causes an increase in design load of more than 5%, shall be strengthened, supplemented, replaced, or otherwise altered to carry the increased load.	807.4: "Alterations shall not reduce the capacity of existing gravity load-carrying structural elements unless the elements demonstrate the capacity to carry the applicable design gravity loads required by the Florida Building Code, Building. Existing structural elements supporting any additional gravity loads as a result of the alterations, including the effects of snow drift, shall comply with the Florida Building Code, Building. Exceptions: 1. Structural elements whose stress is not increased by more than 5 percent. 2. Buildings of Group R occupancy with not more than five dwelling or sleeping units used solely for residential purposes where the existing building and its alteration comply with the conventional light-frame construction methods of the Florida Building Code, Building or the provisions of the Florida Building Code, Residential."	Basic Mitigation Package: New roof covering may weigh more than the previous roof covering (or greater than 5% of the previous in the case of the FBC). IEBC: Existing load-carrying structural elements should not require strengthening to carry increased gravity loads from retrofits. FBC: Selection of a roof covering product less than 5% heavier than the existing roof covering is recommended.

Code Check	2021 IEBC[1]	7th Edition 2020 FBC: Existing[2]	Comments
Wall Anchors for Concrete and Masonry Buildings	706.3.1: If re-roofing more than 25% of the roof area of an unreinforced masonry building in seismic design category D, E, or F, work shall include installation of wall anchors to resist IBC seismic forces.		Basic Mitigation Package: Applicable if re-roofing in an area that is both hurricane- and earthquake-prone (e.g., Charleston, SC) with concrete and masonry construction.
Voluntary Lateral- Force-Resisting System Alterations	503.13: Structural alterations of existing and new structural elements intended to increase the lateral force-resisting strength need not be designed for the IBC forces if all the following conditions apply: the capacity of the existing system isn't reduced, new or relocated elements are detailed and connected to existing or new structural elements according to IBC for new construction, and the alteration doesn't create a structural irregularity per ASCE 7 or make a structural irregularity more severe.	807.6: "Structural alterations that are intended exclusively to improve the lateral force-resisting system and are not required by other sections of this code shall not be required to meet the requirements of Section 1609 or Section 1613 of the Florida Building Code, Building, provided that all of the following apply: 1. The capacity of existing structural systems to resist forces is not reduced. 2. New structural elements are detailed and connected to the existing or new structural elements as required by the Florida Building Code, Building for new construction. 3. New or relocated nonstructural elements are detailed and connected to existing or new structural elements as required by the Florida Building Code, Building for new construction. 4. The alterations do not create a structural irregularity as defined in ASCE 7 or make an existing structural irregularity more severe."	All Mitigation Packages: Applicable if wind retrofit project qualifies as a Level 2 alteration;[3] an engineer may be needed to conduct an analysis. Wind retrofit projects should not qualify as a Level 2 alteration unless additional work is being done to the house.

Code Check	2021 IEBC[1]	7th Edition 2020 FBC: Existing[2]	Comments
Structural Alterations	906.1: If a Level 3 alteration results, all structural elements of the lateral force-resisting system in the building shall comply with 906.2 (next row of this table). Additional structural provisions may apply to buildings based on seismic provisions of Section 906.		All Mitigation Packages: Applicable if the wind retrofit project results in a Level 3 alteration. Wind retrofit projects should not qualify as a Level 3 alteration unless additional work is being done to the house.
Level 3, Substantial Structural Alterations	906.2: For a Level 3 alteration where more than 30% of the total floor and roof areas of the building have been proposed to be involved in a structural alteration in a 1-year period, an analysis must show the altered building complies with the IBC for wind loading and reduced seismic forces.		All Mitigation Packages: Applicable if the wind retrofit project results in Level 3 alterations. Wind retrofit projects should not qualify as a Level 3 alteration unless additional work is being done to the house. NOTE: 30% of the total floor and roof area includes tributary areas to vertical load-carrying components.

Code Check	2021 IEBC[1]	7th Edition 2020 FBC: Existing[2]	Comments
Roof Diaphragm	706.3.2: Where roofing materials are removed from more than 50% of the roof diaphragm or if the building is located where the ultimate wind speed is greater than 130 mph, the integrity of the roof diaphragm shall be evaluated, and connections must be provided or replaced to meet IBC requirements. There is an exception for buildings that comply with the wind load provisions of ASCE 7-88 or later editions.	707.3.2: "Where the structural roof deck is removed from more than 30 percent of the structural diaphragm of a building or section of a building located where the ultimate design wind speed, V_{ult}, determined in accordance with Figure 1609.3(1) of the Florida Building Code, Building, is greater than 115 mph (51 m/s), as defined in Section 1609 (the High-Velocity Hurricane Zone shall comply with Section 1620) of the Florida Building Code, Building, roof diaphragms, connections of the roof diaphragm to roof framing members, and roof-to-wall connections shall be evaluated for the wind loads specified in the Florida Building Code, Building, including wind uplift. If the diaphragms and connections in their current condition are not capable of resisting at least 75 percent of those wind loads, they shall be replaced or strengthened in accordance with the loads specified in the Florida Building Code, Building. Exception: This section does not apply to buildings permitted subject to the Florida Building Code."	Basic Mitigation Package: Applicable only if house has "defective" roof sheathing, and, therefore, is not generally considered a good candidate for a retrofit project. Wind speed triggers differ for the IEBC and the FBC. IEBC: Provision applies only if roof structure and not roof covering is at least 50% replaced. This condition should not occur for eligible candidates. FBC: Provision applies when the roof deck is removed from more than 30% of the roof diaphragm. An exception may apply to some buildings based on permitting dates and applicable codes.

Code Check	2021 IEBC[1]	7th Edition 2020 FBC: Existing[2]	Comments
Roof Covering		706.1.1: "Not more than 25 percent of the total roof area or roof section of any existing building or structure shall be repaired, replaced or recovered in any 12-month period unless the entire existing roofing system or roof section is replaced to conform to requirements of this code. Exception: If an existing roofing system or roof section was built, repaired, or replaced in compliance with the requirements of the 2007 Florida Building Code, or any subsequent editions of the Florida Building Code, and 25 percent or more of such roofing system or roof section is being repaired, replaced, or recovered, only the repaired, replaced, or recovered portion is required to be constructed in accordance with the Florida Building Code in effect, as applicable. Pursuant to s. 553.844(5), Florida Statutes, a local government may not adopt by ordinance an administrative or technical amendment to this exception."	Basic Mitigation Package: Applicable when reroofing. The entire roof system and section must conform to the FBC when more than 25% of the roof covering is replaced within a 12-month period. Some exceptions apply to roof systems built to the 2007 or later editions of the FBC.

Roof-to-Wall Connections		706.8: "When a roof covering on an existing structure with a sawn lumber, wood plank or wood structural panel roof deck is removed and replaced on a building that is located in the wind-borne debris region as defined in the Florida Building Code, Building and that has an insured value of $300,000 or more or, if the building is uninsured or for which documentation of insured value is not presented, has a just valuation for the structure for purposes of ad valorem taxation of $300,000 or more: Roof to wall connections shall be improved as required by Section 706.8.1. Mandated retrofits of the roof-to-wall connection shall not be required beyond a 15 percent increase in the cost of reroofing. Exception: Structures permitted subject to the Florida Building Code are not required to comply with this section." 706.8.1: "Where required by Section 706.8, the intersection of roof framing with the wall below shall provide sufficient resistance to meet the uplift loads specified in Table 706.8.1 either because of existing conditions or through retrofit measures. As an alternative to an engineered design, the prescriptive retrofit solutions provided in Sections 706.8.1.1 through 706.8.1.7 shall be accepted as meeting the mandated roof-to-wall retrofit requirements. Exceptions: Where it can be demonstrated (by code adoption date documentation and permit issuance date) that roof-to-wall connections and/or roof-to-foundation continuous load path requirements were required at the time of original construction.	Basic Mitigation Package: These provisions are applicable when reroofing a house unless the gable-end work costs less than 15% of the roof replacement work. There may be an exception applicable to the building based on the permitting date and the applicable code adoption date. If these provisions are triggered, some roof-to-wall connections may have to be installed, even for the Basic Mitigation Package.

Code Check	2021 IEBC[1]	7th Edition 2020 FBC: Existing[2]	Comments
		Roof-to-wall connections shall not be required unless evaluation and installation of connections at gable ends or all corners can be completed for 15 percent of the cost of roof replacement."	

1 The IBC states that there is an alternative compliance with the IEBC in place of the IBC for existing structures (any retrofit projects would fall into this category). Most of the provisions of the IBC are similar to the IEBC, but the IBC is not as stringent in its requirements.
2 7th Edition 2020 FBC: Existing Building – Additionally, Chapter 17 – *Retrofitting* should also be consulted during wind retrofits.
3 Levels of alteration correspond to the three levels defined in the IEBC, IBC, and FBC: Existing Building.

5.2.2. PERMITTING AND INSPECTIONS

Homeowners should ensure that their retrofit projects are properly permitted and inspected as required by the local building department. Permitting and inspection procedures in coastal areas are usually more involved than those in inland areas, and, if unanticipated, can complicate a wind retrofit project. For instance, in addition to meeting all of the federal, state, and local requirements, the design plans and specifications may need to be sealed by an RDP. Building permit submittals must often include detailed drawings and information for all elements of the wind-resisting load path, including sheathing material, sheathing nailing, strap and tie-down descriptions, bolted connections, and pile description and placement. Local building department requirements vary with each community and should be considered as early as possible in the process of developing a wind retrofit project.

This Guide provides only an overview of the permitting and inspection process. Homeowners should be aware that most of the retrofit projects described in Chapter 4 of this Guide would be considered *repairs, alterations,* or *additions.* These terms have specific meanings with respect to building codes, and may trigger a special permitting process, depending on local code provisions as described above.

To begin the permitting process homeowners or their contractors will need the following: (1) construction documents consisting of plans and a bill of materials; and (2) descriptions of the proposed project, including a scope of the work that complies with the requirements of any funding source that may be sought (refer to Section 5.1) and references the local building code to ensure code compliance.

VARIANCE

A variance is a process that allows a building to be constructed in a manner that is usually prohibited by either the building code or local ordinances. The criteria for a variance are usually very specific, and typically will be granted only if there is a unique characteristic to the land or historically significant structures.

Homeowners should be aware that retrofit actions may trigger the requirement for code verification; additionally, those elements of the house affected by the retrofit may be required to be brought up to the current building code as discussed in Section 5.2.1. These elements may include the structural, electrical, mechanical, or plumbing systems, or the method by which the structure provides fire protection. If there is a local building department, inspections may be required throughout the process in addition to a final inspection.

If there is no building department or building codes are not being enforced, the evaluator who performs the house evaluation (or the designer involved in the project, if applicable) must inspect the construction of the retrofit to ensure that the work was performed as outlined in the Mitigation Package. Multiple evaluations during the project (as well as once the project has been completed) should be performed to verify that the work is completed in a manner consistent with the plans (see

Chapter 3). At the conclusion of the retrofit, the homeowner must obtain written documentation from the individual performing the final inspection to verify that the retrofit was properly installed and that the materials used were consistent with the requirements of the construction plans. If the homeowner is anticipating an insurance premium adjustment, a passing "notice of the final inspection" from the building department or written documentation from an RDP will need to be submitted.

ADDITIONAL INFORMATION ON PERMITTING AND INSPECTIONS

Chapter 4 of FEMA P-762, *Local Officials Guide for Coastal Construction* (2009), presents important regulatory facts, management tools, detailed information for conducting effective and efficient building permit application reviews, sample organizational structures, and a permit-processing flowchart.

If the building is located in a delineated flood hazard area, it is important to verify whether the retrofit project, or other types of projects being done simultaneously with the retrofit project, constitute a substantial improvement (refer to Section 5.2.1 for additional discussion). If the project meets the substantial improvement definition, per the building code or local ordinances, additional work may be required. Property owners can use cost estimates and estimates of market value to screen whether the proposed work is likely to meet the substantial improvement definition prior to submitting the permit application. This can help the owner anticipate whether or not to expect additional work associated with the SI/SD requirements. The local official reviews the permit application to determine whether the proposed work is SI/SD. If the local official determines that the proposed work constitutes SI/SD, the permit application will need to be resubmitted along with plans and specifications that incorporate the additional work required to bring the building into compliance with flood requirements.

Ensuring that the retrofits performed comply not only with the building codes, but also with local ordinances is important. Historic structures may need to comply with additional standards to maintain the designation as a historic structure. Noncompliance can lead to fines, work stoppage, and possibly legal issues. While variances are granted by local building departments for certain projects and are considered part of the construction process, granting of a variance is rare and should not be considered an alternative to compliance with codes and ordinances.

5.2.3. CONSTRUCTION CHALLENGES

The process for implementing a retrofit project should be carefully planned before removing the first piece of siding or pulling off the first shingle. Homeowners should consider a variety of factors, including how the exterior of their house will look after the retrofit is completed, how to optimize labor versus material costs for the retrofit project, selection and proper use of connectors, availability of materials, and house maintenance.

Ideally, the resulting retrofitted house will have an exterior that looks similar to the house before the retrofit. Exterior building materials should be carefully removed if they are to be reused.

Careful planning if access to the soffit or rafter system is necessary for the retrofit. One method of retrofitting may cost more in construction materials but require less labor to install or may be less intrusive to complete the retrofit. For example, it could be more cost-effective to retrofit a gable end wall with lumber and fewer connectors. Although this appears to be a cost-effective solution, if the attic access is very small, a retrofit using more metal connectors may be a more practical solution. The work (and associated cost of labor) required to implement a retrofit should be discussed among the homeowner, evaluator, contractor, and RDP (if applicable) in detail and considered in the homeowner's decision process.

ADDITIONAL CONSIDERATIONS

Additional information on issues to consider before starting a retrofit can be found in FEMA P-499 Technical Fact Sheet No. 9.2, *Repairs, Remodeling, Additions, and Retrofitting—Wind* (2010a).

The selection of the proper fasteners and connectors is critical to the success of a retrofit. Connectors are designed to use specific fasteners and to be used in specific situations. Manufacturers provide information on how the connectors should be used, how many fasteners are required, and what size fasteners are required. Connectors should never be bent or forced into a location; this compromises the strength of the connector and can result in an ineffective retrofit. In some situations, longer fasteners may be required. For example, if uplift connectors are being attached between the rafter and the wall top plate, a longer fastener may be needed if exterior sheathing is covering the top plate. The connectors are designed to be used with fasteners that have a minimum embedment into the top plate, so the fastener would need to be longer to account for the thickness of the exterior sheathing. The construction techniques used to build the house and the accessibility of the work space may dictate the selection of the connectors and fasteners.

Another consideration is the availability of materials. Consider that although a nominal 2x2 may be the minimum required size, a nominal 2x4 may be a cheaper alternative. An experienced contractor can assist homeowners with this type of decision before beginning the retrofit project. Terms such as "minimum" used in retrofitting guides (e.g., those described in Section 5.1) may be clues that other design solutions exist and, if the work space permits, that a more cost-effective solution may be available that provides the same or better level of protection. Retrofit guides may list numerous fastener options. Some construction materials may respond better to certain types of fasteners, or some fasteners may be easier to use in specific locations.

Remember that the effectiveness of a retrofit rests on the ability of the materials to maintain their strength over time. Maintenance of the house is critical to maintaining the level of protection desired; this is especially true in corrosive environments common to coastal areas, where wood should be regularly inspected for decay, and metal connectors and fasteners should be inspected for corrosion. Replacement of these materials may be required periodically to maintain the strength of the system. When determining which Mitigation Package to implement, it is important to evaluate the ease with which materials can be accessed for inspection and maintenance or replacement as needed. The level of effort required for maintenance is generally proportionate to the accessibility of

the retrofit. More information on the selection of construction materials can be found in FEMA P-499 Technical Fact Sheet No. 1.7, *Coastal Building Materials* (2010a). Additional information on selecting appropriate corrosion protection for metal connectors and fasteners can be found in NFIP Technical Bulletin 8*, Corrosion Protection for Metal Connectors and Fasteners in Coastal Areas* (2019b).

5.3. Addressing Other Hazards

The retrofits described in this Guide are intended to be implemented in hurricane-prone regions but may be applied elsewhere. Additionally, homeowners should be aware that residual risk to their house always exists, even when properly implemented hazard-resistance projects are undertaken. When applying for a FEMA grant, residual risk must be identified.

While homeowners may retrofit their houses to mitigate wind hazards, residual risk will remain. No wind retrofit project completely protects a house against wind damage; furthermore, the risk from other hazards described below will remain unless specifically addressed. The failure to properly identify and design to mitigate other hazards in coastal areas and hurricane-prone regions can lead to severe consequences, such as building damage or even destruction. When following the guidance presented in this Guide, homeowners should understand the elements of risk that remain to their houses. Publications such as FEMA P-55, FEMA P-762, and FEMA P-499 can help homeowners further understand the residual risks from wind retrofit projects and how to successfully account for and mitigate other relevant coastal hazards. Appendix D of this Guide includes a list of links to FEMA and other building science publications that should be considered when planning a wind retrofit project.

Homeowners should consider the residual risk from other coastal hazards and whether to address other hazards in a retrofit project. The most significant natural hazards that affect the coastlines of the United States and its territories include tornadoes, coastal flooding, storm surge, erosion, earthquakes, and other hazards.

Tornadoes: Although a tornado is a high-wind hazard, it is not specifically addressed in this Guide. Tornadoes require special consideration for mitigation. HMA funds may be used for the construction of a tornado or combined hurricane/tornado safe room that provides near-absolute protection if constructed according to guidelines of FEMA P-320 and FEMA P-361. For more information on the FEMA safe room program, see Chapter 2 of this Guide. HMA funds are not available for construction of general population shelters, including evacuation or recovery shelters intended to provide longer-term services and housing. For more information, refer to the HMA Guide.

Flooding: Coastal flooding often results in significant damage to houses in coastal areas. Hurricanes, tropical cyclones, other coastal storms, and tsunamis generate the most significant coastal flood hazards. Their floodwater can create hydrostatic and hydrodynamic forces, wave effects, and floodborne debris effects that can significantly affect the performance of residential buildings. In addition, buildings farther from the coast can be at risk of riverine flooding. For guidance on

retrofitting houses for flood hazards, see FEMA P-259, *Engineering Principles and Practices of Retrofitting Floodprone Structures* (FEMA, 2012). Houses located in coastal areas may incorporate breakaway wall systems for enclosures below the living area. Wind requirements for breakaway enclosures are covered in NFIP Technical Bulletin 9, *Design and Construction Guidance for Breakaway Walls* (FEMA 2021a) If the house is in an SFHA and retrofitting is considered a substantial improvement (see text box in Section 5.2.1), the construction must comply with local or NFIP floodplain regulations (and flood-resistant provisions of adopted building codes). To determine whether a house is in an SFHA, visit the FEMA Map Service Center (msc.fema.gov) or check with your local floodplain management official. Guidance on minimum NFIP compliance for houses located in floodplains can be found in the NFIP Technical Bulletins (https://www.fema.gov/emergency-managers/risk-management/building-science/national-flood-insurance-technical-bulletins).

Storm Surge: Storm surge is distinct from the coastal flooding that defines the SFHA. Storm surge is the water that is pushed toward the shore by the high winds associated with tropical storms and hurricanes. Storm surge increases the mean water level and can cause severe flooding that reaches farther inland, beyond the SFHA. It is particularly high when combined with the normal high tide. The Sea, Lake, and Overland Surge from Hurricanes (SLOSH) model maps five categories of storm surge. SLOSH models and storm surge maps are available from state emergency management departments. For examples of coastal storm surge maps, see MSEMA's webpage on hurricanes (https://www.msema.org/preparedness-2/hurricanes/).

Erosion: Erosion is the wearing or washing away of land and is one of the most complex hazards to understand and predict at a given site. Typically, erosion refers to the horizontal recession of a shoreline. Erosion is capable of threatening coastal buildings by destroying dunes or other natural protective features, destroying erosion control devices, lowering ground elevations, undermining shallow foundations, reducing depths of deep foundations such as piles, supplying overwash sediments that can bury structures farther landward, breaching low-lying coastal barrier islands, and sometimes exposing structures on the mainland to increased flood and wave effects. For guidance on how building siting can reduce risk from erosion, see FEMA P-499, *Home Builder's Guide To Coastal Construction*, Technical Fact Sheets 2.1 and 2.2 (2010a).

Earthquakes: Earthquakes can affect coastal areas through ground shaking, liquefaction, surface fault ruptures, other ground failures, and the generation of tsunamis. Therefore, coastal construction in seismic hazard areas must take earthquake hazards into account. Proper design in seismic hazard areas employs techniques to stabilize or brace the building against violent accelerations and shaking due to earthquakes. For guidance on seismic retrofits of existing houses, see FEMA 232, *Homebuilders' Guide to Earthquake Resistant Design and Construction* (FEMA, 2006).

Other Hazards: Other hazards that coastal construction may be exposed to include a wide variety of hazards whose incidence and severity may be highly variable and localized. Examples include subsidence and uplift; landslides and ground failures; salt spray and moisture; rain, hail, wood decay, and termites; wildfires; floating ice; snow; and atmospheric ice. These hazards do not always come to mind when coastal hazards are discussed, but they should be considered in design and construction decisions.

6. References and Resources

6.1. References

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Technical Fact Sheet No. 2.1, *How Do Siting and Design Decisions Affect the Owner's Costs?*

Technical Fact Sheet No. 2.2, *Selecting a Lot and Siting the Building*

Technical Fact Sheet No. 3.3, *Wood Pile-to-Beam Connections*

Technical Fact Sheet No. 4.1, *Load Paths*

Technical Fact Sheet No. 4.3, *Use of Connectors and Brackets*,

Technical Fact Sheet No. 5.4, *Attachment of Brick Veneer in High-Wind Regions*

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6.2. Resources

Federal Emergency Management Agency (FEMA)

Building Resilient Infrastructure and Communities (BRIC) website. https://www.fema.gov/grants/mitigation/building-resilient-infrastructure-communities

Building Science Helpline by email at FEMA-BuildingScienceHelp@fema.dhs.gov or by phone at 1-866 927-2104

Flood Map Service Center (MSC) website. https://msc.fema.gov/portal/home

Hazard Mitigation Assistance (HMA) Funding website. https://www.fema.gov/grants/mitigation/applying

HMA Guide website. https://www.fema.gov/grants/mitigation/hazard-mitigation-assistance-guidance

HMA Helpline by phone at 1-866-222-3580

Mitigation Planning website. https://www.fema.gov/emergency-managers/risk-management/hazard-mitigation-planning/requirements

Mitigation Assessment Team (MAT) website. https://www.fema.gov/mitigation-assessment-team-program

Safe Room Resources website. https://www.fema.gov/emergency-managers/risk-management/safe-rooms/resources

Safe Room Helpline by email at Saferoom@fema.dhs.gov or by phone at 1-866-927-2104

State Hazard Mitigation Officer (SHMO) contact website. https://www.fema.gov/grants/mitigation/state-contacts

Florida Division of Emergency Management (DEM)

Florida Windstorm Insurance Savings Calculator website. https://apps.floridadisaster.org/wisc/

Insurance Institute for Business & Home Safety (IBHS)

IBHS FORTIFIED incentives website. https://fortifiedhome.org/incentives

IBHS FORTIFIED general website. https://ibhs.org/fortified/

IBHS Find a Provider website. https://ibhs.force.com/s/find-a-provider

IBHS Pilot contact information by email at IBHSAssign@pilotcat.com or by phone at 1-866-450-9214

Appendix A: FORTIFIED Home™ – Hurricane for Existing Houses

Program Overview

The Insurance Institute for Business & Home Safety (IBHS) FORTIFIED Home™ Program provides prescriptive solutions for both new construction and the retrofitting of single-family houses and other qualifying dwelling types to mitigate them from the effects of hurricanes, high winds, and hail. The FORTIFIED Home program has 24 designations. Achieving a "designation" per FORTIFIED means "a home meets all requirements of a level of the FORTIFIED Home Program, required documentation of materials and installation has been submitted by an authorized third party and reviewed by IBHS, and a certificate of compliance for the property has been issued by IBHS" (IBHS, 2020). The FORTIFIED Home Program is applicable in high-wind and hurricane-prone regions of the United States, which are defined in Section 2.1 of the *2020 FORTIFIED Home Standard* (IBHS, 2020).

The FORTIFIED Home Program was developed by focusing on the observed damages and losses caused by different hurricane events, as well as physical testing at the IBHS Research Center. Information on the FORTIFIED Home Program, as well as the *2020 FORTIFIED Home Standard* (IBHS, 2020) is available at https://ibhs.org/residential/. Answers to "Frequently Asked Questions" regarding FORTIFIED Home are available at https://fortifiedhome.org/frequently-asked-questions/.

IBHS developed the FORTIFIED Home Program in consultation with the insurance industry to ensure that the houses achieving a FORTIFIED designation are safer during storms. Additionally, homes that achieve a FORTIFIED Home designation may also receive a discount on insurance premiums in participating states. Greater insurance premium reductions are awarded at the higher designation levels. Levels of state participation are available at https://fortifiedhome.org/incentives/.

Inspections and Evaluations

One notable component of the FORTIFIED Home Program is the standardized inspection process each house must undergo prior to and throughout the construction process. To determine whether the house is suitable for a wind retrofit project, a Certified FORTIFIED Evaluator performs an evaluation of the house in accordance with the FORTIFIED Home Program inspection criteria. A "Certified FORTIFIED Evaluator" is defined by IBHS as "an individual who has met the professional requirements for certification by IBHS, has completed the FORTIFIED training course, and has achieved a passing score on the designation certification exam." They document and verify the entire construction process to ensure program requirements are met so a designation can be received. The Certified FORTIFIED Evaluator works with the property owner, contractor, and IBHS.

IBHS provides an online directory to help property owners find a Certified FORTIFIED Evaluator at https://ibhs.force.com/s/find-a-provider. Property owners can also contact IBHS' partner, Pilot, at 866-450-9214 or IBHSAssign@pilotcat.com to find an Evaluator in their state.

All eligibility and minimum requirements for the FORTIFIED Home Program are summarized in Section 2 of the *2020 FORTIFIED Home Standard* (IBHS, 2020).

Summary of Designations and those for Existing Houses in Hurricane-Prone Regions

The 2020 *FORTIFIED Home Standard* (IBHS, 2020) has 24 total designations (Figure A-1). There are three main sequential designation levels, which are, in order, FORTIFIED Roof™, FORTIFIED Silver™, and FORTIFIED Gold™. Each of these main designations build on the previous and focus on different systems of the house.

Of the 24 total designations, six can be applied in hurricane-prone regions for existing houses and are discussed in this Appendix: FORTIFIED Home™ – Hurricane FORTIFIED Roof™ Existing and New Roof, FORTIFIED Silver™ Existing and New Roof, and FORTIFIED Gold™ Existing and New Roof (see Figure A-1).

	DESIGNATION LEVELS					
	FORTIFIED Roof™		FORTIFIED Silver™		FORTIFIED Gold™	
STANDARDS	*NEW ROOF*	*EXISTING ROOF*	*NEW ROOF*	*EXISTING ROOF*	*NEW ROOF*	*EXISTING ROOF*
FORTIFIED Home™–Hurricane						
FORTIFIED Home™–High Wind						
+ HAIL SUPPLEMENT						
FORTIFIED Home™–Hurricane & Hail						
FORTIFIED Home™–High Wind & Hail						

Figure A-1: FORTIFIED Home designation levels. The designation levels circled in red are the ones that can be applied in hurricane-prone regions for existing houses.

Hurricane-prone regions are defined by the American Society of Civil Engineers (ASCE) / Structural Engineering Institute (SEI) standard ASCE 7, Minimum Design Loads and Associated Criteria for Buildings and Other Structures, and its definition in the 2020 *FORTIFIED Home Standard* (IBHS, 2020) is shown in Figure A-2.

Hurricane designations are applicable for homes where the ultimate design wind speed (V_{ult}) is greater than 115 mph as specified in ASCE 7-10 through ASCE 7-16 or the nominal design wind speed (V_{asd}) is greater than 90 mph as specified in ASCE 7-98 through ASCE 7-05.

Figure A-2: FORTIFIED Home "Hurricane designation" definition

FORTIFIED defines "Existing Roof" designations as those that "are appropriate for existing homes that have a roof and roof covering with greater than five useful years of life remaining that do not show visible signs of damage or deterioration" (IBHS, 2020).

FORTIFIED defines "New Roof" designations as those that "are only appropriate for new construction or re-roofing projects where all roof sheathing, sealed roof deck, and roof covering systems are newly installed (less than 5 years old) and installation in compliance with FORTIFIED Home requirements is verifiable at the time of designation" (IBHS, 2020).

If a house qualifies for a FORTIFIED Roof – Existing Roof designation, then any higher-level designation or FORTIFIED Silver or Gold will also be indicated as "Existing Roof." If the house qualifies for a FORTIFIED Roof – New Roof designation, then any higher-level designation of FORTIFIED Silver or Gold will also be indicated as "New Roof." The requirements for FORTIFIED Silver or FORTIIFIED Gold are the same for both the "Existing Roof" and "New Roof" designations.

Summary of the FORTIFIED Roof Hurricane for Existing Houses

Hurricane FORTIFIED Roof™ Existing Roof is the lowest hurricane-resistance designation a house can achieve. The FORTIFIED Roof Existing Roof designation provides prescriptive methods to create a qualified roof without requiring roof covering replacement on an existing house. Alternatively, the FORTIFIED Roof New Roof designation for an existing house provides prescriptive methods for re-roofing.

This designation focuses on retrofitting of the house to minimize roof damage, attic water intrusion, and associated damage by a hurricane. FORTIFIED does this by providing prescriptive solutions for roof sheathing and attachment and requiring a sealed roof deck, code-compliant roof covering, and approved roof and gable end vents/covers.

Requirements for FORTIFIED Roof Existing Roof are in Chapter 3 of the *2020 FORTIFIED Home Standard* (IBHS, 2020).

Requirements for FORTIFIED Roof New Roof are in Chapter 4 of the *2020 FORTIFIED Home Standard* (IBHS, 2020).

Summary of the FORTIFIED Silver Hurricane

Hurricane FORTIFIED Silver™ Existing and New Roof requires all the retrofits in the Hurricane FORTIFIED Roof™ designation plus minimizes damage from the failure of windows and doors, garage doors, gable ends, chimney tie-downs, soffits, and attached structures such as porches and carports.

Requirements for FORTIFIED Silver are in Chapter 5 of the *2020 FORTIFIED Home Standard* (IBHS, 2020).

Summary of the FORTIFIED Gold Hurricane

Hurricane FORTIFIED Gold™ Existing and New Roof requires all of the retrofits in the Hurricane FORTIFIED™ Roof and FORTIFIED™ Silver designation and requires a continuous load path from the roof to the foundation in order to minimize the risk of structural failure. The FORTIFIED™ Gold designation also requires appropriately wind pressure-rated windows and doors, as well as minimum wall sheathing requirements.

Requirements for FORTIFIED Gold are in Chapter 6 of the *2020 FORTIFIED Home Standard* (IBHS, 2020).

Appendix B: Evaluation Guidance

This appendix provides information, guidance, and a framework for house evaluators on the evaluation process that should be followed to initiate a wind retrofit project. This guidance is not intended to be used as a comprehensive "checklist" for evaluators, but rather to outline the type of information that should be obtained during the evaluation process and how it should be conveyed as findings and recommendations that can be used to identify and select appropriate wind mitigation activities. The evaluation process set forth in this appendix, when executed by a qualified evaluator, will enable a consistent and thorough evaluation that accurately assesses the condition of the house and its vulnerability to damage from wind and windborne debris. With this guidance, an evaluator can recommend the course of action moving forward.

Qualifications of an Evaluator

Evaluators must possess sufficient knowledge of the design and construction of residential buildings to perform these evaluations, but they need not be a registered design professional (RDP). However, an RDP would be needed when the retrofit solution is outside of the prescriptive solutions presented in this Guide. The evaluator should have knowledge of and familiarity with the wind retrofit Mitigation Packages and their intent as described in this Guide. For additional guidance, please refer to Chapter 3.

Evaluation Report

The evaluation process should result in a report that describes the building condition, building characteristics, and building vulnerability information to identify which Mitigation Package from this Guide should be implemented. This information will help homeowners determine whether they should proceed with a wind retrofit project, and specifically which Mitigation Package would be the most appropriate. The evaluation report must specifically address the proposed Mitigation Package(s) being considered. The level of protection associated with the different Mitigation Packages will reduce risk from wind hazards to some degree. It is important for the evaluation report to convey how much existing risk will be mitigated by the retrofit project and how much residual risk may remain; this is especially true if only the Basic Mitigation Package is being considered and the house is in a well-defined wind hazard area. The report should also have a clearly marked "BCA Input" section that lists all data needed to perform a wind retrofit benefit-cost analysis (BCA), as described below in *Key Information to Collect for an Evaluation Report*. Similarly, the guidance provided in *Condition Assessment: Identifying Damage and Deficiencies* should facilitate development of the report's assessment of the existing building. The last section in this appendix, *Summary of Guidance for Evaluators*, contains questions regarding each component of the building being evaluated to guide the evaluation process for each mitigation package.

Benefit-Cost Considerations

The evaluation process should obtain all information necessary for a grant program manager, local official, homeowner, or other entity to perform a BCA using the FEMA BCA Tool (Version 6.0). This is

important because the results of the BCA may be used to understand whether the proposed wind retrofit Mitigation Package is a cost-effective project for the house, and whether the proposed wind retrofit Mitigation Package addresses risk adequately or leaves homeowners with residual risk after mitigation that they may find unacceptable.

Key Information to Collect for an Evaluation Report

The following information should be collected during the evaluation process and shown in the report:

- The verified qualifying dwelling and foundation type
- Owner information (name, contact information)
- Property information (building address, replacement cost, year of construction)
- Building dimensions (total square footage, mean roof height, number of stories)
- Design wind and flood hazard information (basic wind speed[6] for American Society of Civil Engineers (ASCE) / Structural Engineering Institute (SEI) standard, ASCE 7-22, *Minimum Design Loads and Associated Criteria for Buildings and Other Structures*, Risk Category II building, exposure category, flood zone for the property per the applicable Flood Insurance Rate Map, and Elevation Certificate)
- Photographs of the exterior of the house
- Design information of the house (construction and renovation plans, if available)
- Observations on the following components (see summary section for Mitigation Package-level details):
    - Roof covering
    - Roof structure
    - Windows, skylights, entry doors, and garage doors
    - Exterior envelope components that will be affected by the proposed mitigation action
    - Exterior envelope components that would reduce risk if mitigated, but are not part of any Mitigation Package (such as wall coverings)
    - Exterior walls (both load-bearing and non-load bearing)
    - Attached structures
    - Structural connections
    - Foundation

[6] Use **ASCE 7 Hazard Tool** (**https://asce7hazardtool.online**) to address-specific basic wind speed.

- Information to support the development of cost estimates for Mitigation Packages (such as roof square footage, soffit area to be mitigated, number and sizes of openings to be protected, etc.)

In addition to collecting data on the construction type and condition of the building, the data required to evaluate the cost-effectiveness of a project using the FEMA BCA Tool should be collected and provided to the homeowners. This will allow a user to easily follow the guidance in Appendix C of this Guide; completing a BCA is a necessary step when applying for FEMA grant funding. The following should be provided in a clearly marked "BCA Input" section of the evaluation report:

- Wind hazard information for the area
- Building type (wood or masonry; note: for masonry structures, existing reinforcement should be documented, if possible)
- Number of stories
- Roof shape (hip, gable, low-slope or combined)
- Whether sealed roof deck has been installed on the roof (homeowner documentation needed)
- Roof-to-wall connection type and spacing
- Whether there is impact-protective glazing or impact-protective systems (shutters) on the house's glazed openings (visible label marking or homeowner documentation needed)
- If a garage is present, the condition of the garage door

Regardless of whether the homeowner is considering applying for funding for the wind retrofit project, these BCA inputs should be provided on the report. The FEMA BCA Tool will help determine whether a project is cost-effective (i.e., whether the benefits of the project outweigh the costs). More information on using the FEMA BCA Tool to analyze a wind retrofit project is provided in Appendix C of this Guide.

Condition Assessment: Identifying Damage and Deficiencies

The evaluation process should identify whether any significant damage, deficiencies, or conditions exist that must be addressed for the proposed solutions of the Mitigation Packages to be effective mitigation. Construction quality issues, poor condition of building materials, or existing assemblies may need to be addressed or corrected, in addition to the actual retrofit action, to ensure the house meets the basic performance assumptions of this Guide. However, the corrective work may or may not be an eligible cost under the wind retrofit project type. Building elements that require corrective work may include, but are not limited to, the following:

- Foundations with no load path from the floor or wall to the foundation or damaged/undermined foundations

- Building elements weakened by insect damage or infestation
- Rot or deterioration of the structure or envelope systems that would prevent the house from carrying the loads it was designed to withstand
- Roof Framing:
    - For houses with engineered wood trusses:
        - Damaged or deteriorated truss members and connector plates
        - Alterations or repairs of any truss member
    - For houses with conventional dimensional lumber roof rafter and ceiling joist framing:
        - Damaged or deteriorated roof framing members
- Roof Sheathing:
    - Damaged or broken sheathing panels observable in the attic
    - "Shiners" (fasteners that have penetrated the sheathing but missed the intended framing member below) visible from inside the attic. If observed, then note where and approximately how many have missed framing members throughout the roof (this provides context).
- Elevation of the lowest floor if located in a flood hazard area (check Flood Insurance Rate Map). If in Zone V or Coastal A Zone, then note whether the foundation type complies with the 2024 International Residential Code. In the case that Mitigation Package implementation contributes to a substantial improvement determination, compliance with local floodplain ordinance and National Flood Insurance Program requirements will be triggered.

If any such deficiency exists for an element in the house being evaluated, an estimate of the degree of repair required should be provided, if possible. In some situations, an RDP may need to be involved to effectively assess the magnitude of the condition and the work required to repair it. If the conditions are difficult to repair and have high associated costs, it is possible that the house is not a cost-effective candidate for wind mitigation retrofitting using the Mitigation Packages in this Guide. Information regarding a house's deficiencies and overall condition can greatly aid homeowners, both for the purpose of executing the wind retrofit project and to better understand the vulnerabilities and condition of their house.

Summary of Guidance for Evaluators

The following guidance can help evaluators collect the data necessary to produce the evaluation report. The guidance is organized according to Mitigation Package requirements from Basic to Advanced, so the evaluator may choose to limit the data collected based on the homeowner preference or evaluator's existing condition assessment.

Basic Mitigation Package

Roof Covering (not required if replacing roof covering):

- What is the existing roof covering type? (e.g., asphalt shingles, clay or concrete tile)
- What is the existing roof covering age? (in years)
- What is the expected remaining useful life of the roof covering? (in years)
- What is the rating (test method designation, class and associated wind speed) for the existing asphalt shingles? (homeowner documentation needed)

("Unknown" if roof covering has no wind speed rating or rating is not documented)

Roof Framing:

- What is roof framing type (roof trusses or conventional framing)?
- What is the thickness of framing members? (in inches) Verify and document that the minimum framing member thickness is nominal 2-inch thickness.
- What is the spacing of roof framing members? Verify and document that spacing is no greater than 24 inches on center.

Roof Sheathing and Connections:

- What is the roof sheathing type? (e.g., wood boards, wood structural panels)
- What is the roof sheathing thickness? (in inches) Verify and document that the minimum roof deck panel thickness is equal to or greater than nominal 15/32-inch thickness for wood structural panels; refer to *2020 FORTIFIED Home Standard* Section 4.1 and Section 3.3.1 of this Guide for more details.
- How is the roof sheathing secured to the roof framing (fastener type, size, and spacing)?
    - Within 4 feet of eaves, hips, ridges, and gable ends?
    - In other areas of the roof deck?

Attic Ventilation Systems:

- What attic ventilation system(s) are in place? (ridge vents, off-ridge vents, gable end vents, etc.) Note sizes and locations.
- Do existing vents comply with *2020 FORTIFIED Home Standard* Section 3.3?
- What are the lengths of overhangs at gables (if applicable) and eaves?

Intermediate Mitigation Package

Protecting Windows and Doors from Windborne Debris:

- Windows and Skylights
  - What are the sizes and quantities of all windows?
  - For each window, is glazing impact protection present? If yes, then is protection impact-resistant glazing or are permanently installed systems (e.g., shutters, screens) present? Note: Temporarily installed systems (wood structural panel shutters) are not eligible for inclusion in a Hazard Mitigation Assistance grant application.
  - For each protected window, is the product impact rating of the window or impact protective system provided? If so, provide details.
  - Are skylights present on the house? If so, are they protected?
- Entry Doors and Garage Doors:
  - What are the sizes and quantities of all entry doors?
  - For each entry door, is an impact rating provided? If so, provide details.
  - What are the sizes and quantities of all garage doors?
  - For garage doors, is the design pressure rating provided? If so, provide details.
  - For each garage door with glazing, is the impact rating for the glazing provided? If so, provide details.

Gable End Walls:

- What is the sheathing type for the gable end walls?
- What is the thickness of any wood structural panel sheathing? Verify and document sheathing is equal to or greater than nominal 7/16-inch thickness (or no wood structural panel sheathing).
- Identify all gable end wall studs equal to or greater than 3 feet in height and any stud heights greater than 16 feet.
- Check that gypsum board ceiling diaphragm meets the minimum length required in Table 5.
- Does gable end wall have overhang construction (see Section 4.2.3.3)? If so, does overhang exceed 9 inches?
- Are any attached structures present? (e.g., porches, carports) If so, is there a continuous load path?

Soffits:

- What are the width(s) of roof overhang soffits?
- What is the material and condition of soffit panels?
- How are the soffit panels fastened to the roof framing?

- What is the thickness of any wood structural panel sheathing? Verify and document sheathing is equal to or greater than nominal 7/16-inch thickness (or no wood structural panel sheathing).

Wood-Frame Chimneys

- Does the chimney extend less than 5 feet above the roof deck?
- Is the chimney located along the edge of the roof?
- How is chimney framed and sheathed?

Attached Structures:

- Are any attached structures present? (e.g., porches, carports)
- If yes, then:
  - Are there continuous load paths throughout the attached structures?
  - How are the structures attached to the house?

Advanced Mitigation Package

Wind Pressure Resistance of Openings:

- What are the sizes and quantities of all windows and skylights?
- For each window and skylight, are design pressure (DP) and performance grade (PG) ratings provided? If yes, provide rating information.
- What are the sizes and quantities of all entry doors?
- For each entry door, are DP and PG ratings provided? If yes, provide rating information.

Exterior Wall Impact Resistance:

- Are above-grade exterior walls framed or masonry?
- For framed walls, what is the thickness(es) of exterior wall wood structural panel sheathing? Verify and document where minimum panel thickness is nominal 7/16-inch thickness or greater.

Continuous Load Path:

- Are there continuous and adequate load paths from the roof to the foundation?
- Are roof-to-wall connections capable of resisting uplift loads?
- For multi-story houses, are wall-to-wall connections capable of resisting accumulated uplift and shear forces?

- Are wall-to-foundation connections capable of resisting accumulated uplift and shear forces?
- Is the foundation capable of transferring all accumulated uplift and shear forces into the supporting soils?

Appendix C: Using the FEMA BCA Toolkit Hurricane Wind Module for Determining Cost-Effectiveness of Retrofit Projects

Introduction

The FEMA BCA Tool (Version 6.0) is used to determine the cost-effectiveness of proposed mitigation projects submitted for funding under FEMA mitigation grant programs. The software estimates the economic consequences that may occur during a natural disaster (flood, hurricane, tornado, earthquake, or wildfire) based on two scenarios, with and without the proposed mitigation measure.

For hurricane winds, losses are estimated using wind-damage functions developed to predict wind impacts to the building, its contents, and loss of use of the building following a storm. The wind-damage functions relate peak gust wind speeds to predicted percentages of damage that would be expected for a building exposed to storms at a given recurrence interval. The recurrence intervals of hurricane wind speeds are based on the building's location (using either the building zip code or latitude/longitude and wind speed data derived from the Hazus Multi-Hazard software [Hazus-MH]). Alternatively, wind speed information can be obtained from the American Society of Civil Engineers (ASCE) / Structural Engineering Institute (SEI) standard ASCE 7 Hazard tool (https://asce7hazardtool.online/) or from the Applied Technology Council (ATC) Hazard by Location tool (https://hazards.atcouncil.org/) and entered into the program. The anticipated damage varies based on the type of building and its construction attributes. Wind-damage functions are a critical factor in the economic analysis for determining the cost-effectiveness of proposed mitigation measures aimed at reducing losses during high-wind events.

The purpose of this appendix is to provide guidance on using the FEMA BCA Tool to complete a BCA for the retrofit solutions and best practices for single-family houses outlined in this Guide. This appendix identifies the wind-damage functions in the FEMA BCA Tool that best represent the Mitigation Packages outlined in this Guide (see Chapter 4); it provides a brief background and introduction to the software and step-by-step instructions on how to complete a BCA to evaluate cost-effectiveness.

Background

The FEMA BCA Tool contains common characteristics and construction attributes for residential structures. Changes to these characteristics help with the selection of the wind-damage functions for a residential single-family building to be used in the FEMA BCA Tool (see Table C-1).

Table C-1: FEMA BCA Tool Characteristics

Characteristic	Value	Comments
Building Type	Wood, Masonry, Steel, Concrete, or Manufactured Home	Indicates the primary structure type of the single-family residence.
Number of Stories	One Story, or Two or More Stories	Indicates whether the single-family residence is one or more stories. For house with basements or split level with basements, the number of stories is based on the number of above grade stories.
Roof Shape	Hip or Gable	Indicates whether the single-family residence has a hip or gable roof. Help menu in the BCA tool provides definitions with pictures of hip and gable roofs.
Secondary Water Resistance	Yes or No	Identifies whether there is a secondary water resistance barrier to prevent water penetration through the roof decking after the loss of the roof covering.
Roof Deck Attachment	6d Nails at 6/12, 8d Nails at 6/12, 6d/8d Mix at 6/6, or 8d Nails at 6/6	Refers to the size (e.g., 6d nails) and spacing of the nails (6/12 is 6d nails at 12 inches o.c., 6/6 is 6d nails at 6inches o.c.) that attach the roof decking.
Roof-Wall Connection	Toe-Nail or Strap	Indicates whether the load path of the single-family residence can transfer loads from the roof to the foundation. In general, a strap provides a better connection from the roof framing to the walls than solely nails. The roof-wall connection has been a primary point of failure in past hurricanes.
Shutters	Yes or No	This characteristic indicates whether the single-family residence has shutters, thereby reducing windborne debris damage to the building and contents. In the BCA Tool, shutters are synonymous with opening protection, meaning if a house were to incorporate impact resistant glazing, the performance would be the same as if shutters were installed.
Garage	None, Weak Door, Standard Door, or South Florida Building Code (SFBC) 94 (if shuttered)	Indicates whether the residence has a garage, and, if present, the strength of the garage door. Reinforced garage doors are considered standard and unreinforced doors are considered weak.
Masonry Reinforcing	Yes or No	This characteristic indicates whether a masonry single-family residence has reinforcement (Yes) or is unreinforced masonry (No).

Based on the expected building performance accomplished by the retrofits associated with the Mitigation Packages outlined in this Guide, the scenarios presented in Figure C-1 represent before- and after-mitigation conditions in the FEMA BCA Tool (Version 6.0). Building properties in bold-outlined, yellow highlighted cells values that normally change as a result of implementing the retrofit project and therefore differ before versus after the mitigation, depending on the existing building properties.

After a user selects the characteristics outline in Figure C-1, the FEMA BCA Tool (Version 6.0) automatically applies wind-damage functions to reflect before- and after-mitigation conditions. If necessary, the user can override the wind-damage functions with proper justification and documentation. Figure C-2 shows an example of a wind-damage function. It illustrates the expected ratio of building damages to building value before and after implementing each of the Mitigation Packages described in this Guide.

Mitigation Package	Roof Replacement	Exposure	Garage	Construction Type	Building Type	Shutters	Garage		Roof Shape	Masonry Reinforcing[3]	Secondary Water Resistance	Roof Wall Connection	Roof Deck Attachment
							Without Shutters[1]	With Shutters[2]					
User Chooses		B/C	Yes/No	Wood or Masonry	Single-Family/ One/Two or More Stories	Yes/No	None/ Weak/ Strong/ SFBC 1994		Hip/ Gable	N/A, Yes (RM), No (URM)	Yes/No	Toe-Nail/ Strap	
Before Mitigation													
Existing Building[4]	No		Yes			No	Weak	N/A			No	Toe-Nail	6d at 6/12
	Yes		No			No	None	N/A			No	Toe-Nail	6d at 6/12
After Mitigation													
Basic	No		Yes			No	Weak	N/A			Yes	Toe-Nail	8d at 6/12
			No			No	None	N/A			Yes	Toe-Nail	8d at 6/12
	Yes		Yes			No	Weak	N/A			Yes	Toe-Nail	8d at 6/6
			No			No	None	N/A			Yes	Toe-Nail	8d at 6/6
Intermediate	No		Yes			Yes	N/A	SFBC 1994			Yes	Toe-Nail	8d at 6/12
			No			Yes	N/A	None			Yes	Toe-Nail	8d at 6/12
	Yes		Yes			Yes	N/A	SFBC 1994			Yes	Toe-Nail	8d at 6/6
			No			Yes	N/A	None			Yes	Toe-Nail	8d at 6/6
Advanced	No		Yes			Yes	N/A	SFBC 1994			Yes	Strap	8d at 6/12
			No			Yes	N/A	None			Yes	Strap	8d at 6/12
	Yes		Yes			Yes	N/A	SFBC 1994			Yes	Strap	8d at 6/6
			No			Yes	N/A	None			Yes	Strap	8d at 6/6

1) This characteristic will be N/A when the building has shutters.
2) This characteristic will be N/A when the building does not have a garage or shutters.
3) This characteristic will be N/A when the building construction type is wood.
4) This is representative of the worst case scenario.

Figure C-1: Scenarios representing before-mitigation and after-mitigation conditions (bold-outlined, yellow highlighted cells are values that normally change as a result of implementing the retrofit project)

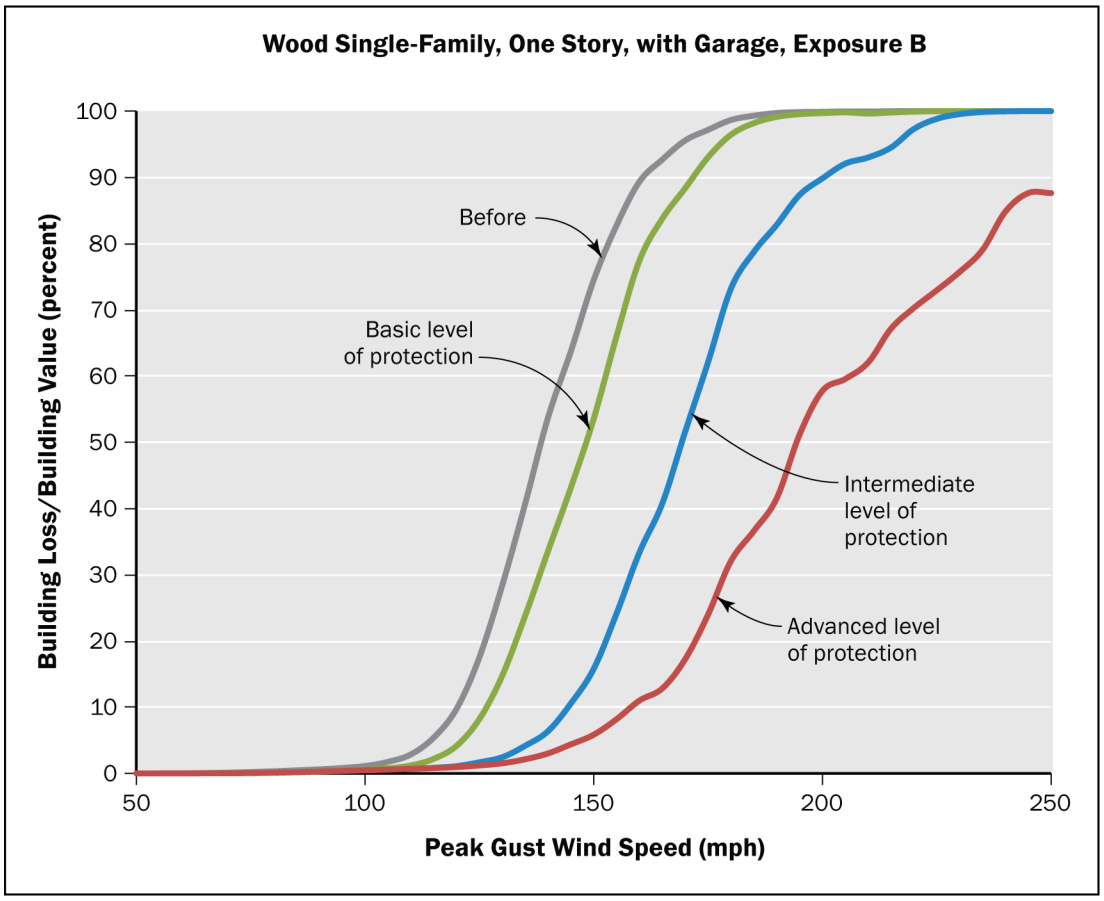

Figure C-2: Example wind-damage function for a wood single-family (one-story) building

As an alternative to performing a BCA within the FEMA BCA Tool (Version 6.0), Precalculated Benefits for the Intermediate and Advanced Mitigation Packages, with and without roof replacement, have been developed. In the 2010 edition of P-804, BCAs were performed to determine whether a residential wind retrofit project was cost-effective. This analysis was followed up with a "Cost Effectiveness Determination for Residential Hurricane Wind Retrofit Measures Funded by FEMA" in 2014, which established precalculated benefits for the Intermediate and Advanced Mitigation Packages, with and without roof replacement. The precalculated benefits that were determined in 2014 looked at 50 locations throughout hurricane-prone regions and Alaska, with wind speeds in excess of 120 miles per hour and analyzed 10,000 structures per location. The structures per location utilized a variety of construction materials, roof shape, presence of a garage, number of stories, and exposure for the Intermediate and Advanced Mitigation Packages.

BCAs were performed for eight locations (Galveston, TX; Lake Charles, LA; Daytona Beach, FL; Miami, FL, San Juan, PR, St. Croix, USVI, Myrtle Beach, SC; and Boston, MA) to determine the change in precalculated benefits between the 2014 analysis and present day. These locations vary widely in their risk of experiencing hurricane winds, thereby allowing for sensitivity of the model and the likelihood of each Mitigation Package being cost-effective. The analysis considered changes in wind

likelihood of each Mitigation Package being cost-effective. The analysis considered changes in wind speed data, average size of houses, and building replacement value (BRV) for single-family houses. The wind speed data in ASCE 7-10, used in the 2014 analysis, was compared with the wind speed data for ASCE 7-16 and ASCE 7-22 for the 50 locations used in this 2022 analysis. The comparison indicated that there was not a significant change in the wind speed data; however, a slight increase in wind speeds was observed on the Texas Coast and slight decreases were observed along the Northeast Atlantic Coast. House size data from the U.S. Census, indicated that since the 2000 Census, house size has continued to increase, with the median house size increasing from 2,169 square feet to 2,426 square feet. Since 2014, the BRV for single-family houses has increased from $94.54 per square foot to $112.00 per square foot.

Mitigation benefits for building and contents increased by an average of 33% for the Intermediate Mitigation Package and 34% for the Advanced Mitigation Package for the eight-location sample. When social benefits for displacement, mental stress and anxiety, and loss of productivity are included, the combined benefits increased by an average of 17% for the Intermediate Mitigation Package and 20% for the Advanced Mitigation Package for the eight-location sample.

As a comparison, the increase in benefits was compared to inflation. Per the U.S. Bureau of Labor Statistics, Consumer Price Index Inflation Calculator (https://www.bls.gov/data/inflation_calculator.htm), inflation between January 2014 and January 2022 increased by 20%. The increase in benefits calculated in the FEMA BCA Tool, from the 2014 analysis to 2022, closely aligns with inflation. Therefore, FEMA recommends that the increase in precalculated benefits utilize inflation. The residential wind retrofit projects for the Intermediate and Advanced Mitigation Packages are cost-effective as long as the total project costs are less than the maximum costs listed in Table C-2.

Table C-2: Precalculated Benefits for Residential Wind Retrofit

Mitigation Package	Roof Replacement Project	Maximum Costs
Intermediate	No	$15,784.00
Intermediate	Yes	$29,904.00
Advanced	No	$48,302.00
Advanced	Yes	$62,422.00

For FEMA grant projects, cost estimates submitted for a hurricane wind retrofit project that use the pre-determined benefits must be developed using industry-accepted cost-estimation standards, vendor estimates, or other sources. The costs identified in this Appendix cannot be used to estimate or develop application project costs. Only documented, eligible costs for completed work will be reimbursed. The estimated costs above may be adjusted by the Applicant or subapplicant using the

most current locality multipliers that are included in industry-accepted cost and pricing guides for construction.

If a multiplier is used, a copy of the source document must be included as part of the grant application for review and the methodology used to determine the increase must be demonstrated. Benefits for wind retrofit cannot be combined with other benefits, such as those from the cost-effectiveness determination for acquisitions and elevations or from the FEMA BCA Tool (Version 6.0).

Refer to the HMA Guide to determine which components of retrofit process are eligible as part of a mitigation project. Eligible costs/scope should include inspection of the structure to determine its condition, the Mitigation Package that would be best suited for the structure, design of the retrofits, labor and materials associated with implementing the retrofit, and construction/post-construction inspections certifying that the work was performed in accordance with the design.

This methodology for wind retrofit cost-effectiveness determinations can be used when submitting applications to Building Resilient Infrastructure and Communities, the Hazard Mitigation Grant Program (including HMGP Post Fire), and the Pre-Disaster Mitigation program and can be applied to new applications as well as projects under review, as long as projects are designed in accordance with the updated requirements. Additionally, predetermined benefits can be used to evaluate cost overruns for approved projects if a new cost-effectiveness review is required. Applicants and subapplicants are not required to use the pre-determined benefits and can continue to perform analysis using FEMA's BCA Toolkit for each structure.

This determination advances FEMA's commitment to streamline the Hazard Mitigation Assistance programs by eliminating the need for an individual BCA for each structure in hurricane-prone and windborne debris regions. It also reduces the time and resources needed for data collection, analysis, and review and allows communities to recover from disasters more quickly.

Mitigation Package Inputs

If precalculated benefits for the Mitigation Package are not used, the project type selection criteria, shown in Table C-3, are to be used when utilizing the FEMA BCA Tool (Version 6.0).

Table C-3: Mitigation Package Project Parameters

Mitigation Package	Roof Replacement Project	Version 6.0 Mitigation Action Type
Intermediate	No	Shutters
Intermediate	Yes	Shutters, Roof
Advanced	No	Shutters, Load Path
Advanced	Yes	Shutters, Load Path, Roof

Instructions

Table C-4 provides parameters for a hypothetical mitigation project in Fort Lauderdale, FL, developed for the purpose of illustrating the steps required for a user to complete a BCA using the FEMA BCA Tool (Version 6.0). Note that the software has a built-in help feature that addresses frequently asked questions while the user navigates the BCA.

Table C-4: Hypothetical Wind Mitigation Project Parameters

Mitigation Project	Intermediate Mitigation Package without replacing roof cover
Address	123 1st Street, Fort Lauderdale, FL 33301 (26.1224, -80.1373)
Project Useful Life	20 years
Cost	$50,250
Annual Maintenance Cost	$150
Exposure	B (urban and dense suburban)
Building Size	2,575 square feet
Building Replacement Value	$115.25/square foot
Before-Mitigation Building Description	Wood-framed, single-family, one-story residence with a gable roof, without shutters, without reinforced garage, without secondary water resistance, without a load path, and minimal roof sheathing nailing (6d at 6/12).
After-Mitigation Building Description	Wood-framed, single-family, one-story residence with a gable roof, with shutters, with reinforced garage, with secondary water resistance, with a load path, and roof sheathing nailing (8d at 6/6).

Step 1: Getting Started

- Install FEMA BCA Toolkit in Excel via Add-ins (Figure C-3) or download the BCA Toolkit Version 6.0 Template from **https://www.fema.gov/grants/guidance-tools/benefit-cost-analysis/full-bca#download.**
- Additional information is available at **https://www.fema.gov/grants/tools/benefit-cost-analysis#toolkit.**
- Press the information button (white circle around the letter “i”) at any time for the built in help menu.

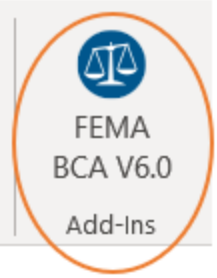

Figure C-3: FEMA BCA V6.0 Add-ins button

Step 2: Project Configuration (Figure C-4)

- Provide the Project Title
- Provide the Property Location either utilizing the street address or the latitude and longitude
- Select the Property Structure Type from the pull-down menu

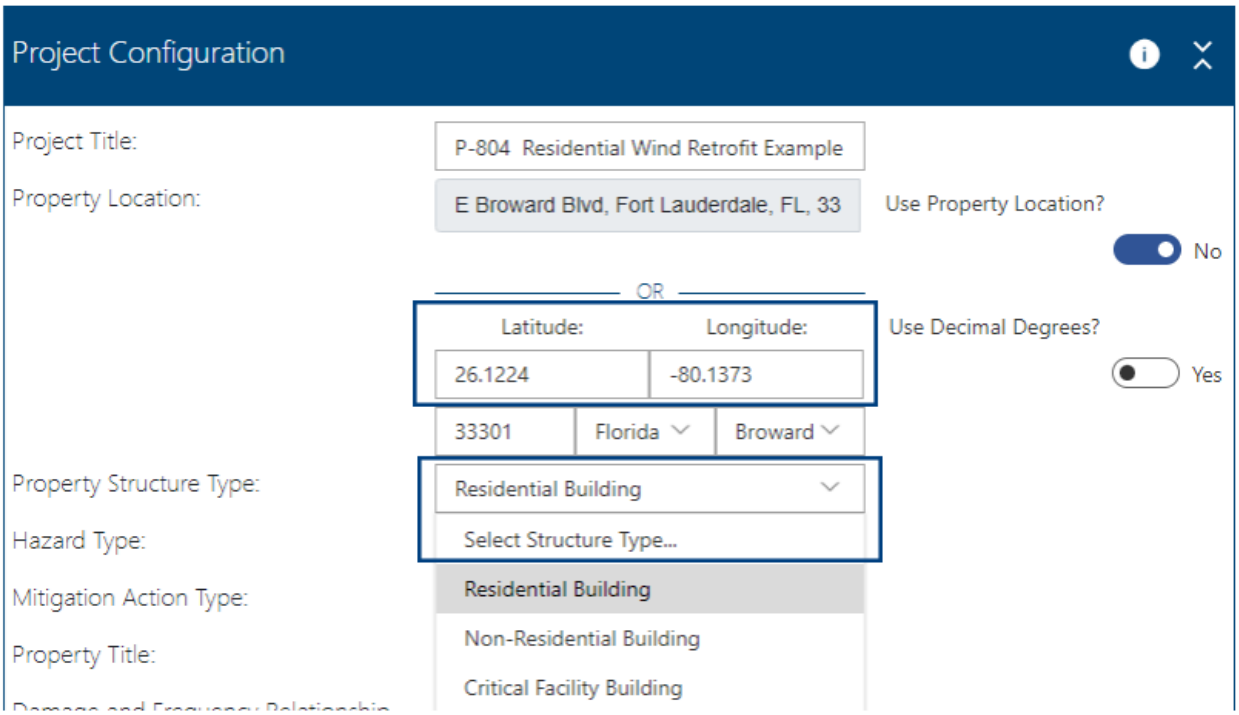

Figure C-4: Example screenshot of FEMA BCA V6.0 Project Configuration screen project information

Step 3: Hazard and Mitigation Action Type

- Select the Hazard Type from the pull-down menu (Figure C-5)
- Select the Mitigation Action Type from the pull-down menu (Figure C-5)
- Select Modeled Damages for damage and frequency relationship (Figure C-6)

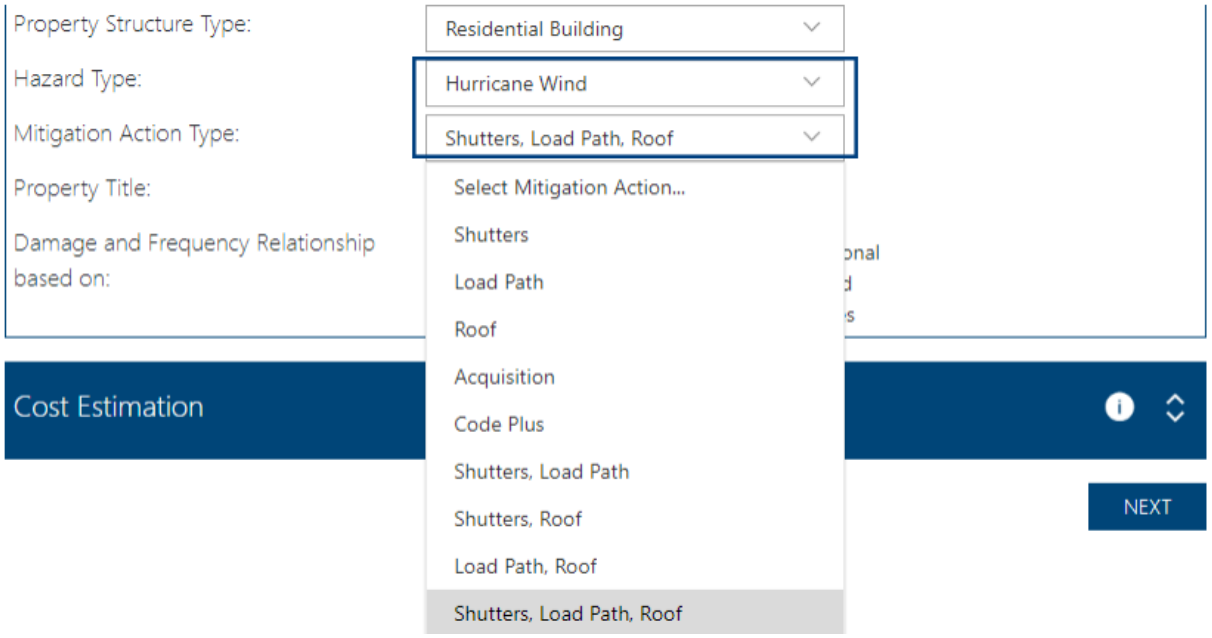

Figure C-5: Example screenshot of FEMA BCA V6.0 Hazard Type and Mitigation Action Type selections

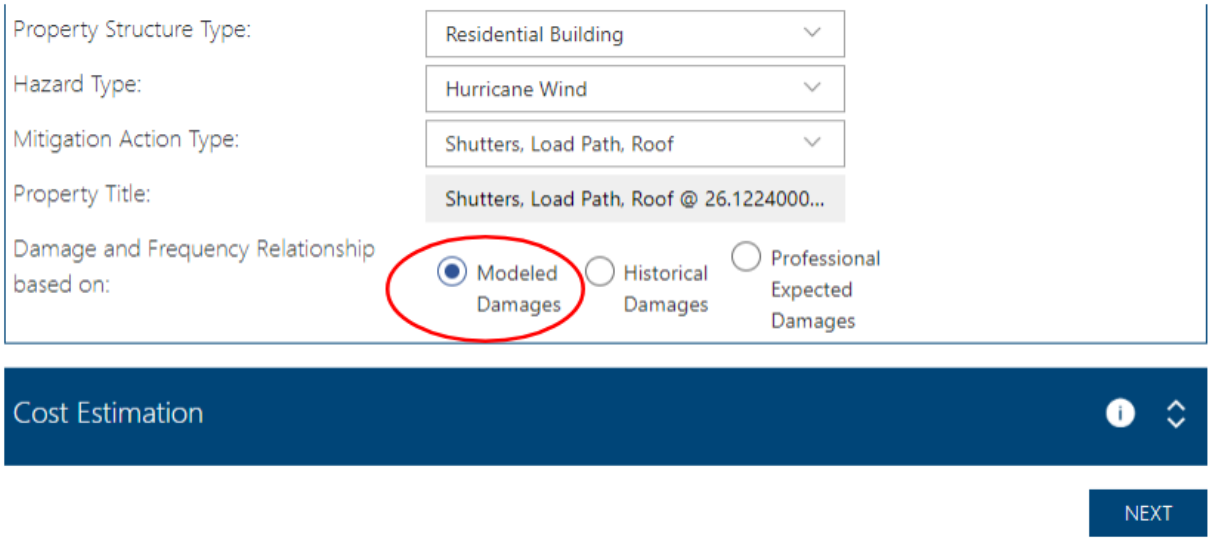

Figure C-6: Example screenshot of FEMA BCA V6.0 Modeled Damages selection

Step 4: Cost Estimation (Figure C-7)

- Provide the Project Useful Life
- Provide the Initial Project Costs
- Provide the Annual Maintenance Costs

- Click NEXT

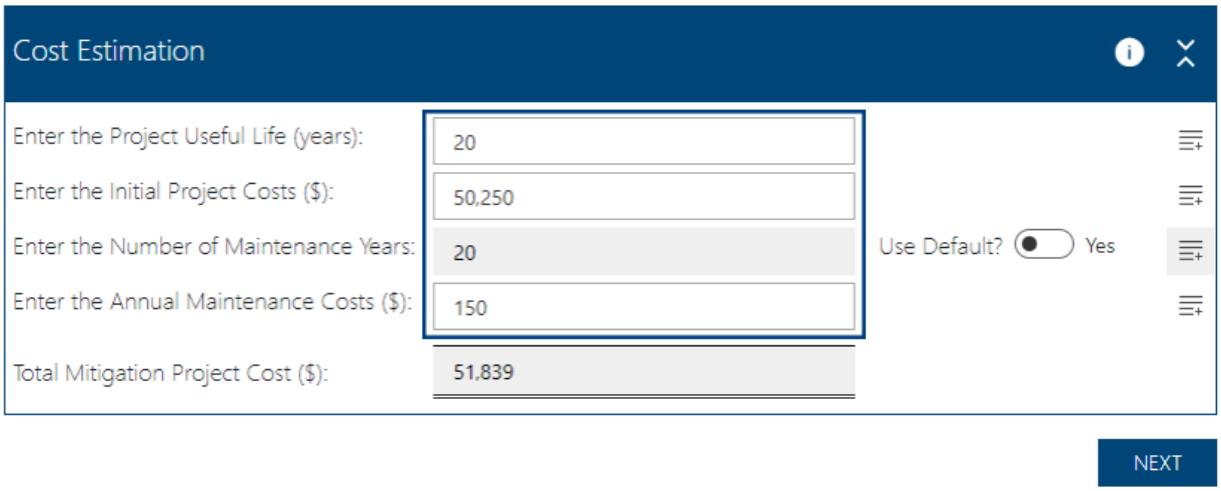

Figure C-7: Example screenshot of FEMA BCA V6.0 inputs for Project Useful Lift, Initial Project Costs, and Maintenance Costs

Step 5: Hurricane Wind (Figure C-8)

- Indicate whether the Default Wind Speeds will be used
- Wind speeds and recurrence intervals from the ASCE 7 Hazard tool (https://asce7hazardtool.online/) or from the ATC Hazard by Location tool (https://hazards.atcouncil.org/) can be utilized in lieu of default values
- Select the Exposure Type from the pull-down menu

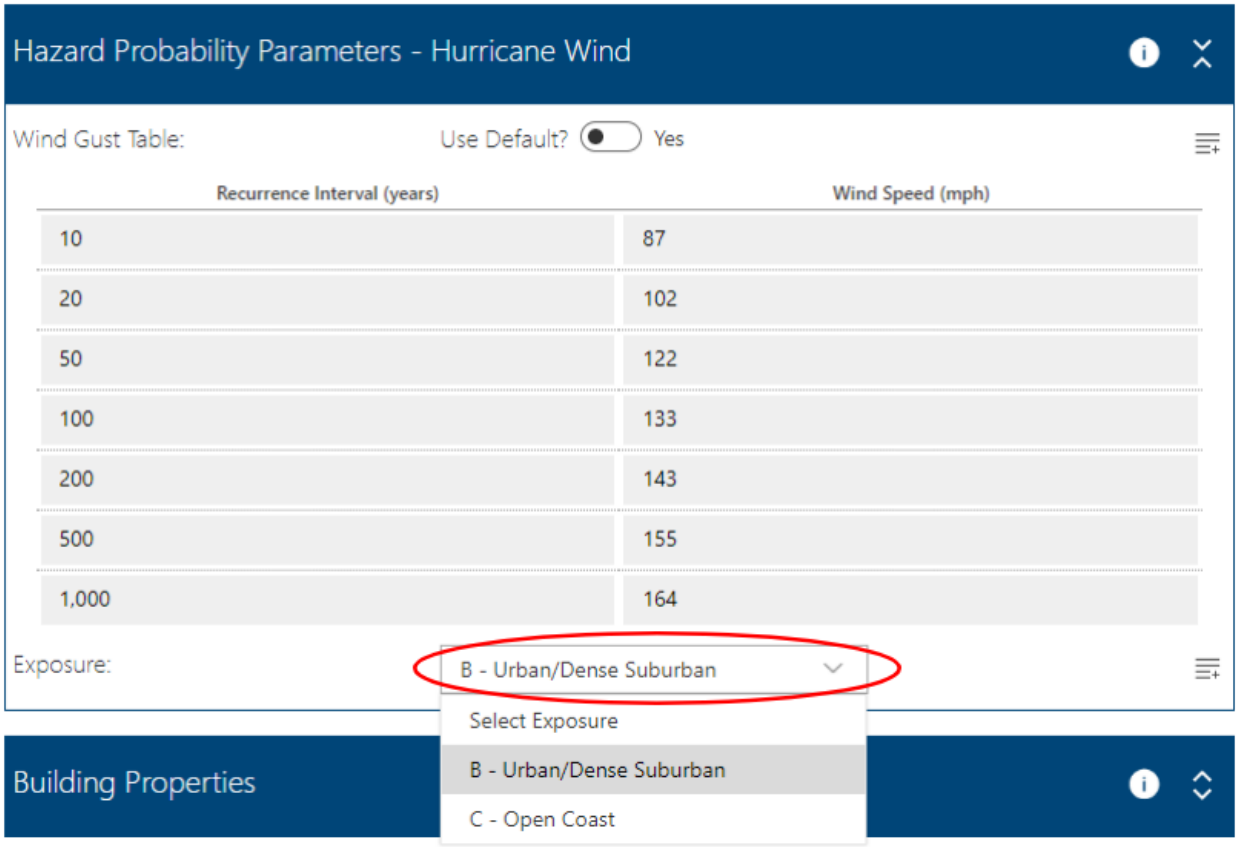

Figure C-8: Example screenshot of FEMA BCA V6.0 Default Wind Speeds and Exposure selections

Step 6: Building Properties (Figure C-9)

- Select the Type of Construction from the pull-down menu
- Select the Building Type form the pull-down menu

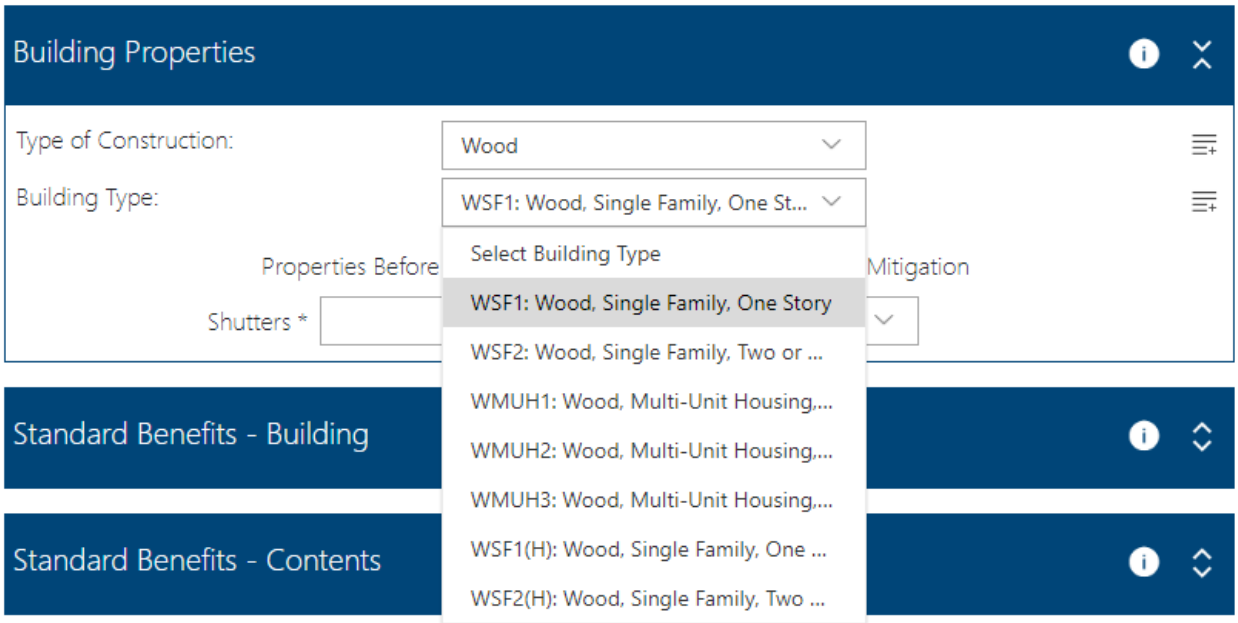

Figure C-9: Example screenshot of FEMA BCA V6.0 Type of Construction and Building Type selections

Step 7: Building Properties for Before and After Mitigation (Figure C-10)

- Indicate whether the following components are present from the pull-down menu for both Properties Before Mitigation and Properties After Mitigation:
  - Shutters
  - Garage Door type
  - Roof Shape
  - Secondary Water Resistance
  - Type of Roof-Wall Connection
  - Type of Roof Deck Attachment

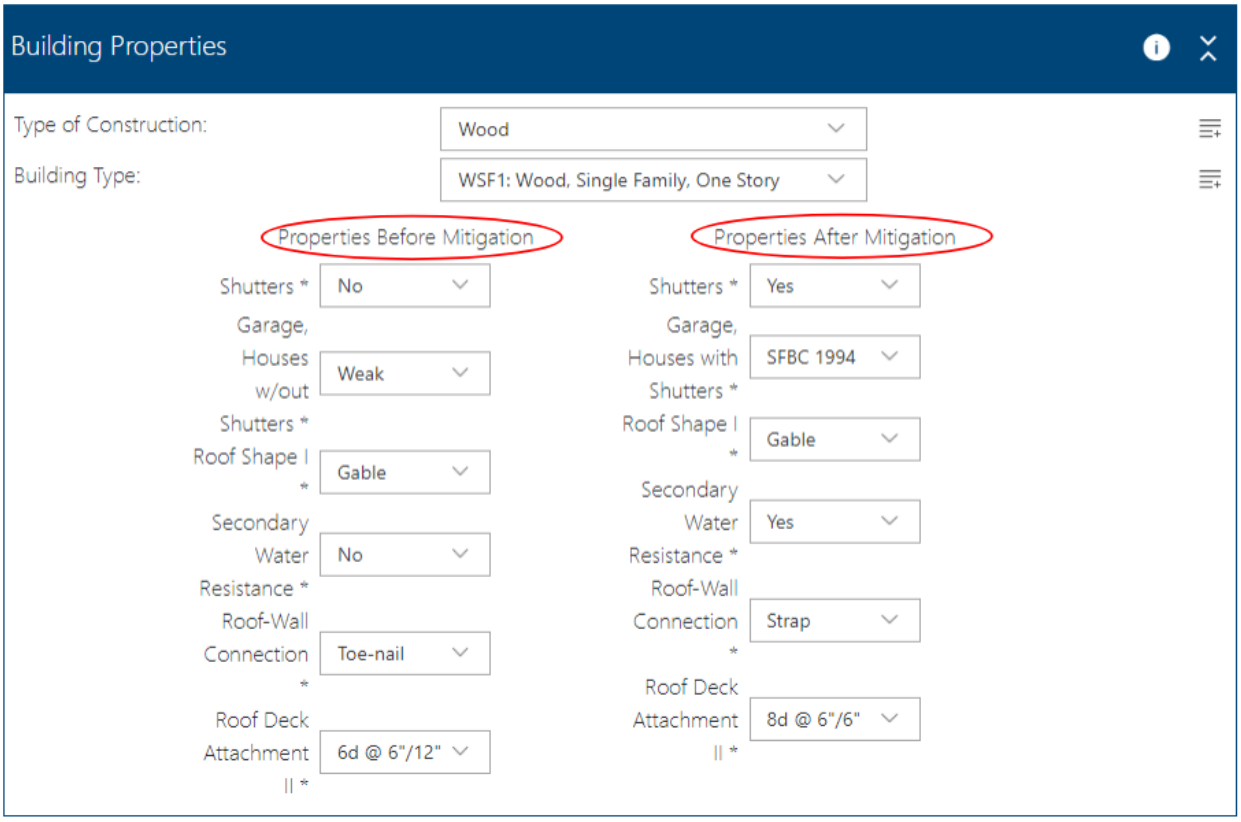

Figure C-10: Example screenshot of FEMA BCA V6.0 for Before and After Mitigation Properties selections

Step 8: Standard Benefits – Building (Figure C-11)

- Indicate the Total Size of the Building
- Enter the BRV if other than the default of $100/sf
- If BRV other than the default is to be used, supporting documentation must be provided as part of the grant application package.

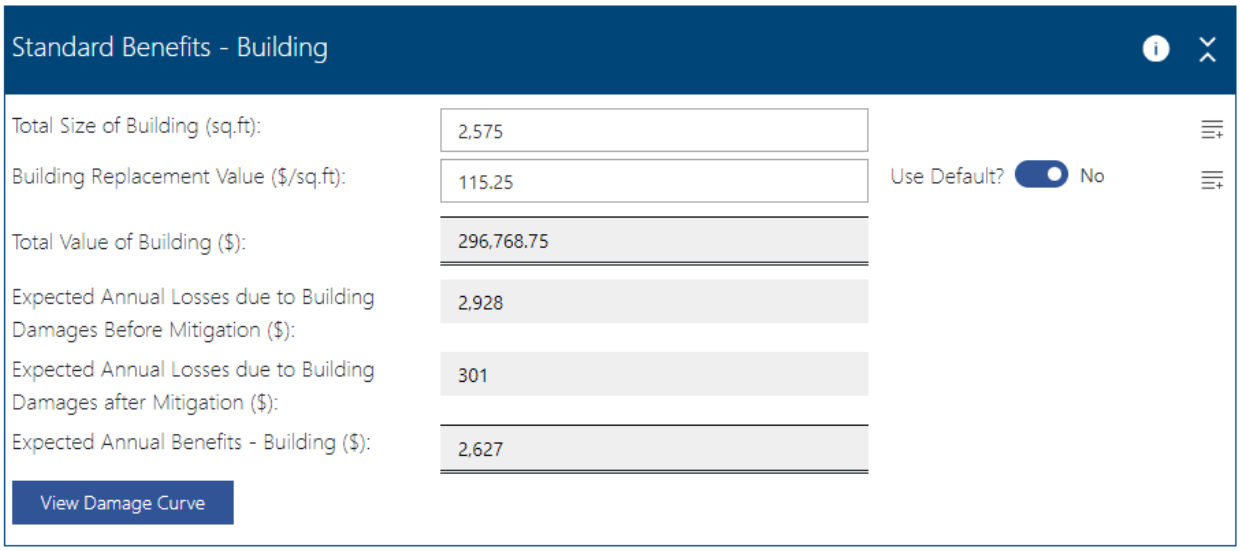

Figure C-11: Example screenshot of FEMA BCA V6.0 for Building Size and Building Replacement Value selections

Step 9: Standard Benefits – Contents (Figure C-12)

- Indicate whether the default 50% of the BRV will be used for the Contents Value
- If a Contents Value other than the default is used, supporting documentation must be provided as part of the grant application package

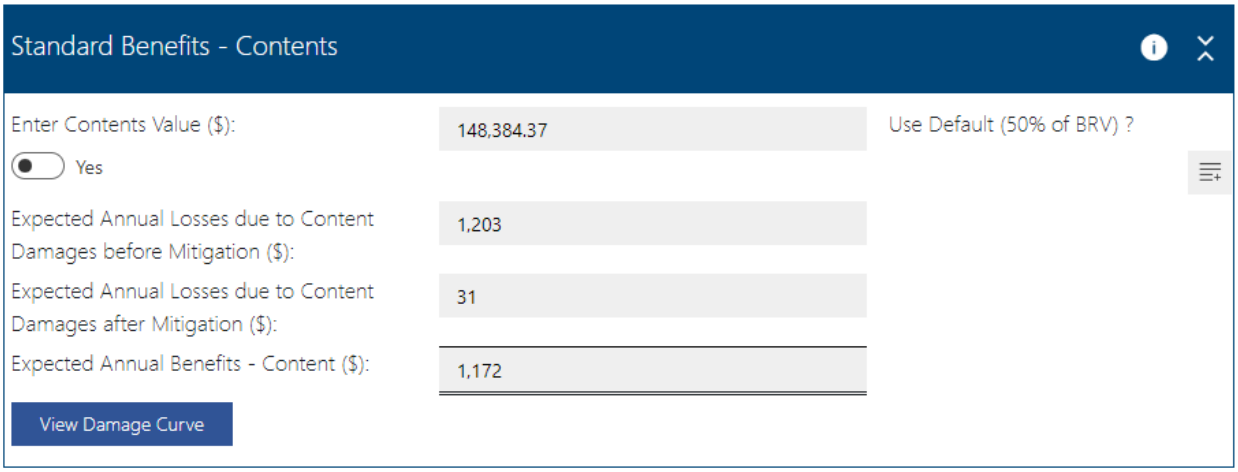

Figure C-12: Example screenshot of FEMA BCA V6.0 for Contents Value selections

Step 10: Standard Benefits - Displacement + Loss of Function/Loss of Income (Figure C-13)

- Indicate the Number of Building Residents or, if a rental property, provide the Loss of Rent in $/month

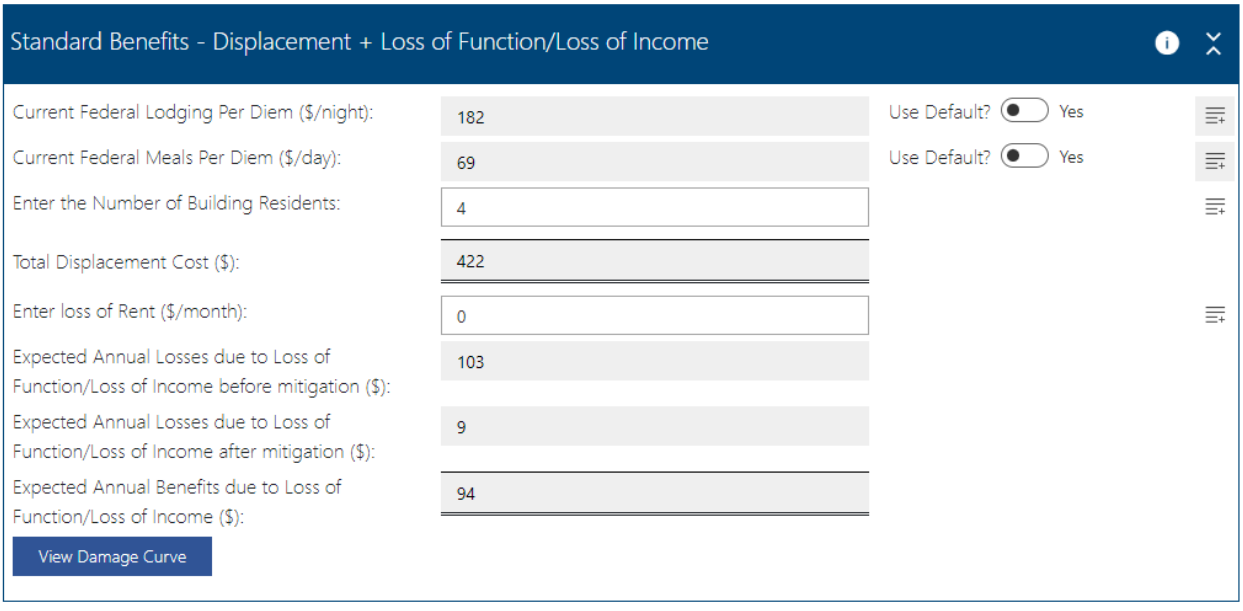

Figure C-13: Example screenshot of FEMA BCA V6.0 for Displacement + Loss of Function/Loss of Income selections

Step 11: Standard Benefits - Volunteer Costs (Figure C-14)

- Indicate the Number of Volunteers and enter the Number of Days Lodging for Volunteers
- Typically, volunteer costs are not utilized in residential wind retrofit projects

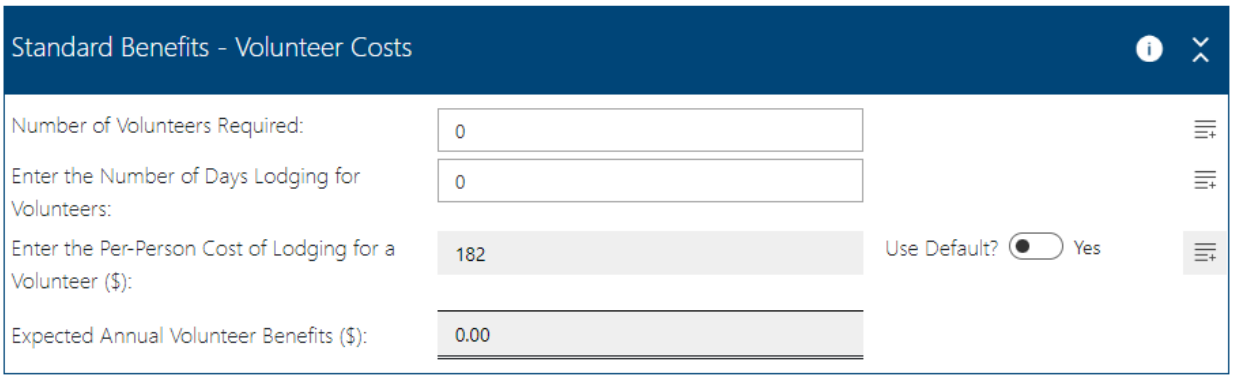

Figure C-14: Example screenshot of FEMA BCA V6.0 for Volunteer Costs selections

Step 12: Additional Benefits - Social

- Indicate how many of the Residents work (Figure C-15)

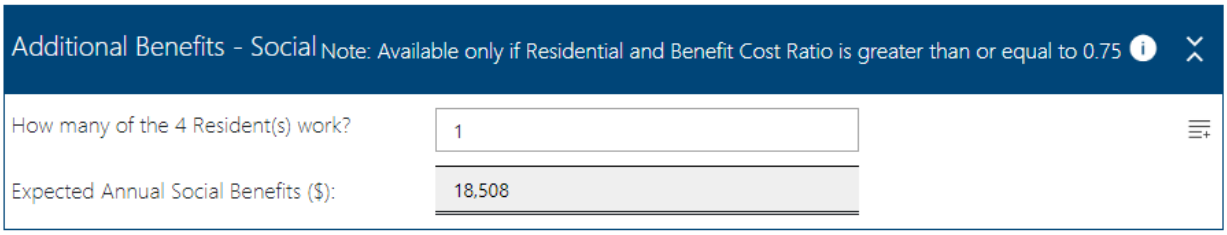

Figure C-15: Example screenshot of FEMA BCA V6.0 for Working Residents selections

Step 13: Benefit-Cost Summary (Figure C-16)

- Review results
- The proposed mitigation project is considered cost-effective if the Benefit-Cost Ratio (BCR) is greater or equal to 1.0

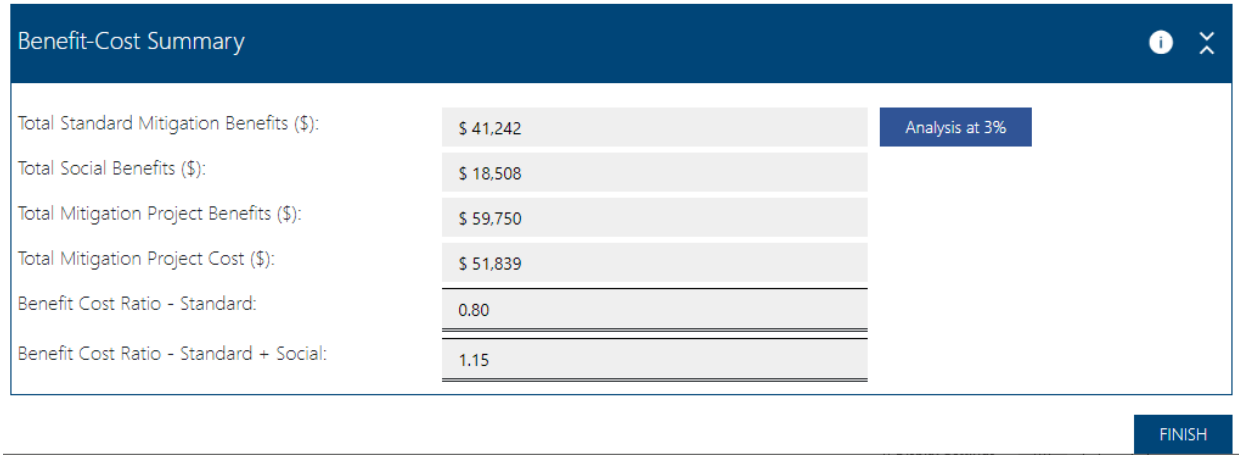

Figure C-16: Example screenshot of FEMA BCA V6.0 for Benefit Cost Summary indicating a cost-effective project

Step 14: Save PDF and Print (Figure C-17)

- To save or print a report, return to the Project Summary Page (by clicking FINISH)
- Select the **View Report** button to print the report to PDF, which can then either be saved or printed

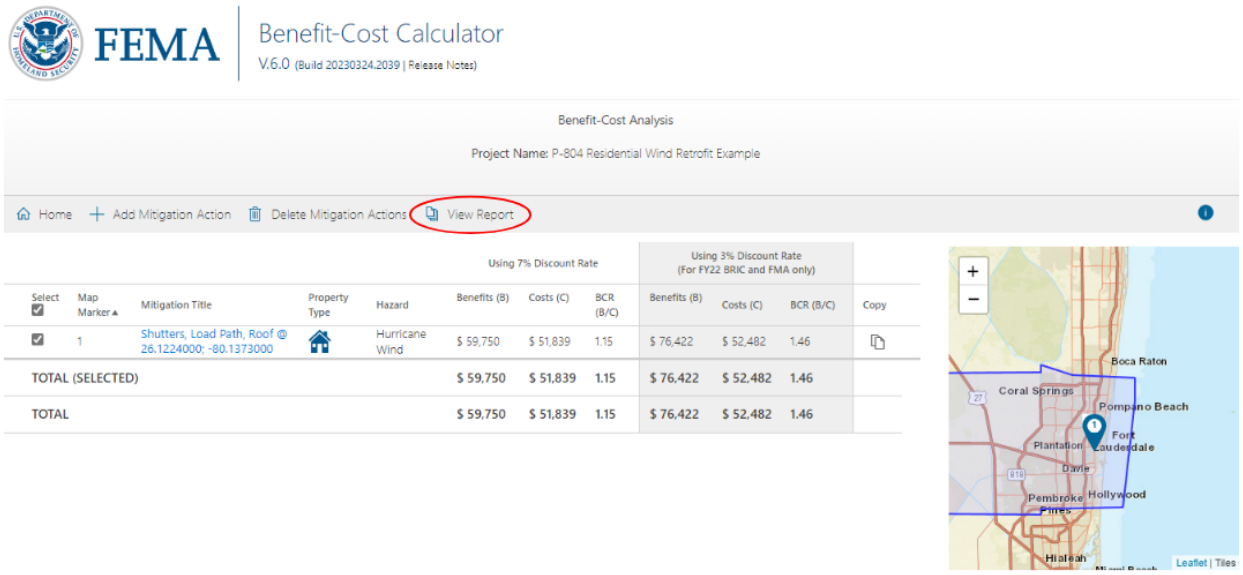

Figure C-17: Example screenshot of FEMA BCA V6.0 for Printing or Saving a BCA Report

Step 15: Export

- To export, return to the Home Page (by clicking on Home)
- Select Project and click Export Projects (Figure C-18)
- Files can be exported as an .xlsx file, .zip file (available for online version Excel only), or text file. The text file can be copied and saved into work document. (Figure C-19)

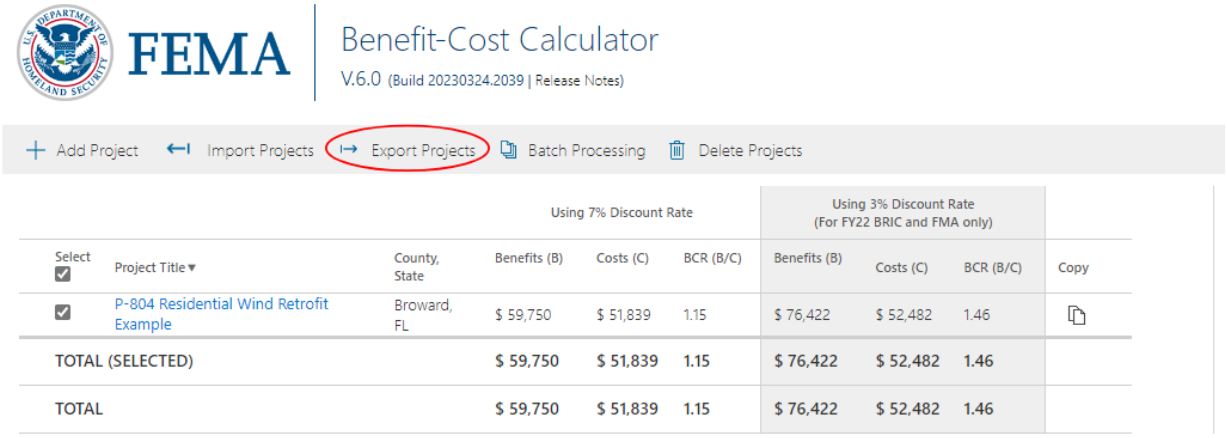

Figure C-18: Example screenshot of FEMA BCA V6.0 for Exporting a Project

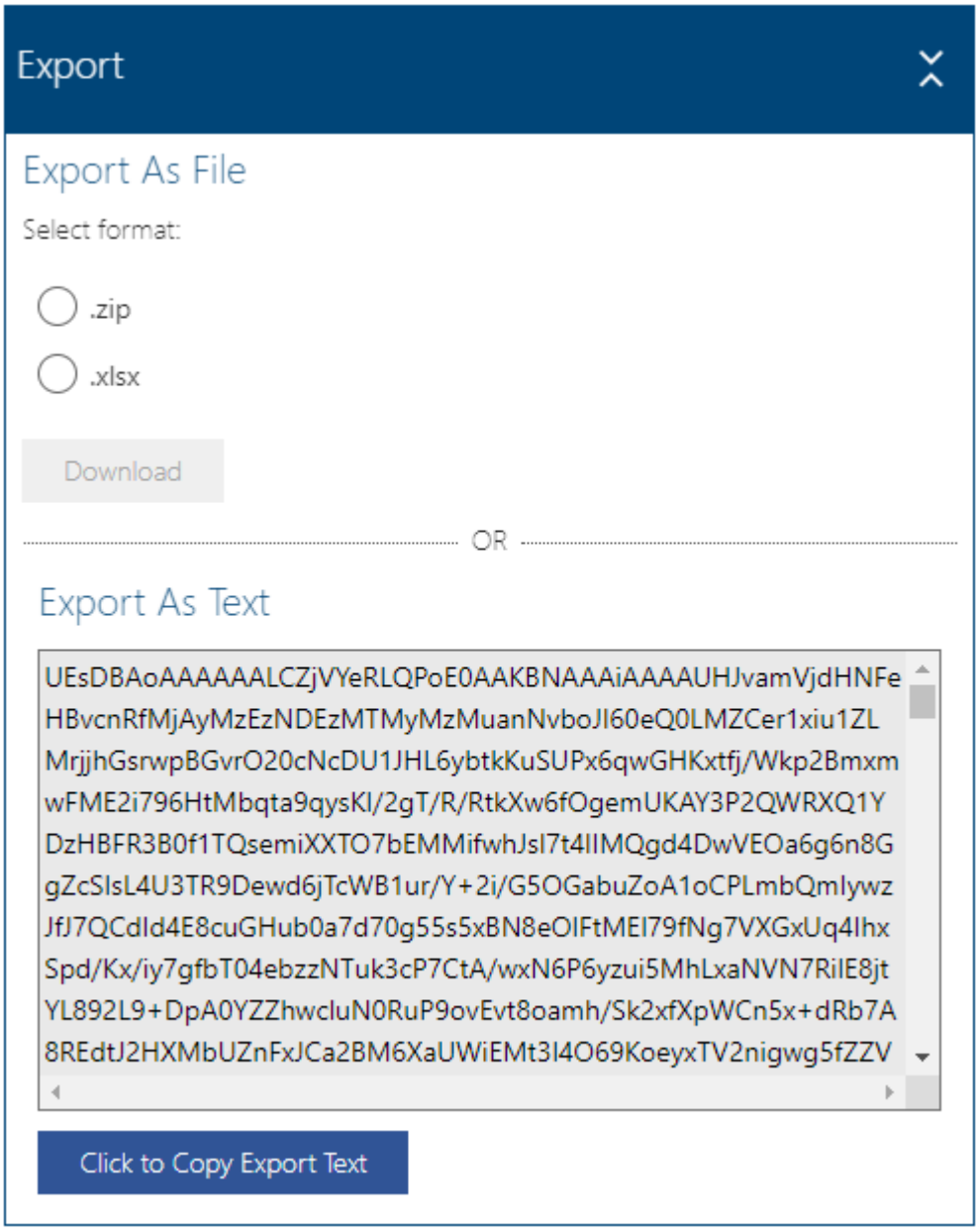

Figure C-19: Example screenshot of FEMA BCA V6.0 for Exporting a Project as either a file or Export as Text

Appendix D: Acknowledgements

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