Coastal Construction: Retrofitting the Buildings for Natural Hazards

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15 Retrofitting Buildings for Natural Hazards

This chapter provides guidance on retrofitting existing residential structures to resist or mitigate the consequences of natural hazards in the coastal environment. The natural hazards that are addressed are wildfires, seismic events, floods, and high winds. Specific retrofitting methods and implementation are discussed briefly, and resources with more in-depth information are provided. Some retrofitting methods are presented together with broader, non-retrofitting mitigation methods when retrofitting and non-retrofitting methods are presented together in the referenced guidance. For retrofitting to mitigate high winds, the new three-tiered wind retrofit program that is provided in FEMA P-804, *Wind Retrofit Guide for Residential Buildings* (FEMA 2010c), is discussed. The program includes systematic and programmatic guidance.

Retrofitting opportunities present themselves every time maintenance is performed on a major element of a building. Retrofitting that increases resistance to natural hazards should focus on improvements that provide the largest benefit to the owner.

CROSS REFERENCE

For resources that augment the guidance and other information in this Manual, see the Residential Coastal Construction Web site (http://www.fema.gov/rebuild/mat/fema55.shtm).

NOTE

FEMA's Hazard Mitigation Assistance (HMA) grant programs provide funding for eligible mitigation activities that reduce disaster losses and protect life and property from future disaster damage. Currently, FEMA administers the following HMA grant programs: Hazard Mitigation Grant Program, Pre-Disaster Mitigation, Flood Mitigation Assistance, Repetitive Flood Claims, and Severe Repetitive Loss.

If an existing building is inadequate to resist natural hazard loads, retrofitting should be considered.

15.1 Wildfire Mitigation

Thousands of residential and non-residential buildings are damaged or destroyed every year by wildfires, resulting in more than $200 million in property damage annually. More than $100 million is spent every year on fire suppression and even more on recovering from catastrophic natural and manmade hazards. Studies cited by IBHS in *Mega Fires* (IBHS 2008) have shown that financial losses can be prevented if simple measures are implemented to protect existing buildings.

TERMINOLOGY: RETROFITTING

Retrofitting is a combination of adjustments or additions to existing building features that are intended to eliminate or reduce the potential for damage from natural hazards. Retrofitting is a specific type of hazard mitigation.

FEMA offers funding through the HMGP and the PDM Program for wildfire mitigation projects. Projects funded through these programs involve retrofits to buildings that help minimize the loss of life and damage to the buildings from wildfire. Eligible activities for wildfire mitigation per FEMA's *Hazard Mitigation Assistance Unified Guidance* (FEMA 2010a) may include:

- Provision of defensible space through the creation of perimeters around residential and non-residential buildings and structures by removing or reducing flammable vegetation. The three concentric zones of defensible space are shown in Figure 15-1.

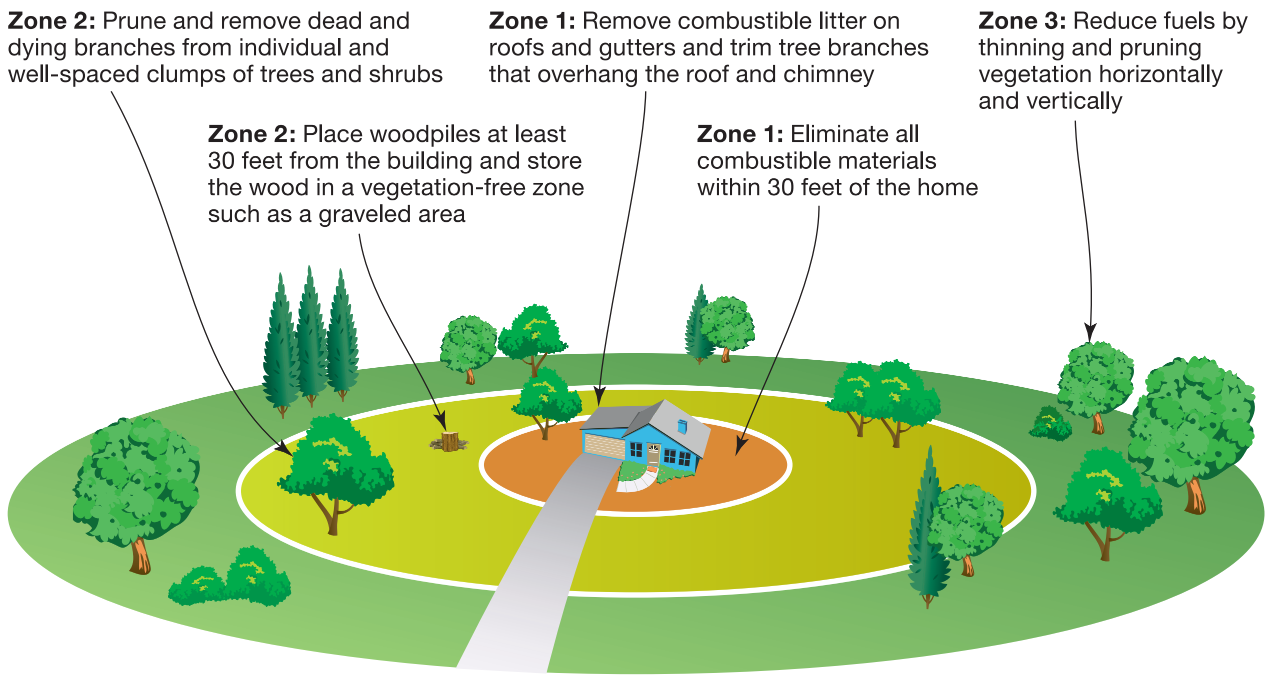


Figure 15-1.
The three concentric zones of defensible space
SOURCE: ADAPTED FROM FEMA P-737

- Application of non-combustible building envelope assemblies that can minimize the impact of wildfires through the use of ignition-resistant materials and proper retrofitting techniques. The components of the building envelope are shown in Figure 15-2.
- Reduction of hazardous fuels through vegetation management, vegetation thinning, or reduction of flammable materials. These actions protect life and property that are outside the defensible space perimeter but close to at-risk structures. Figure 15-3 shows a fire that is spreading vertically through vegetation.

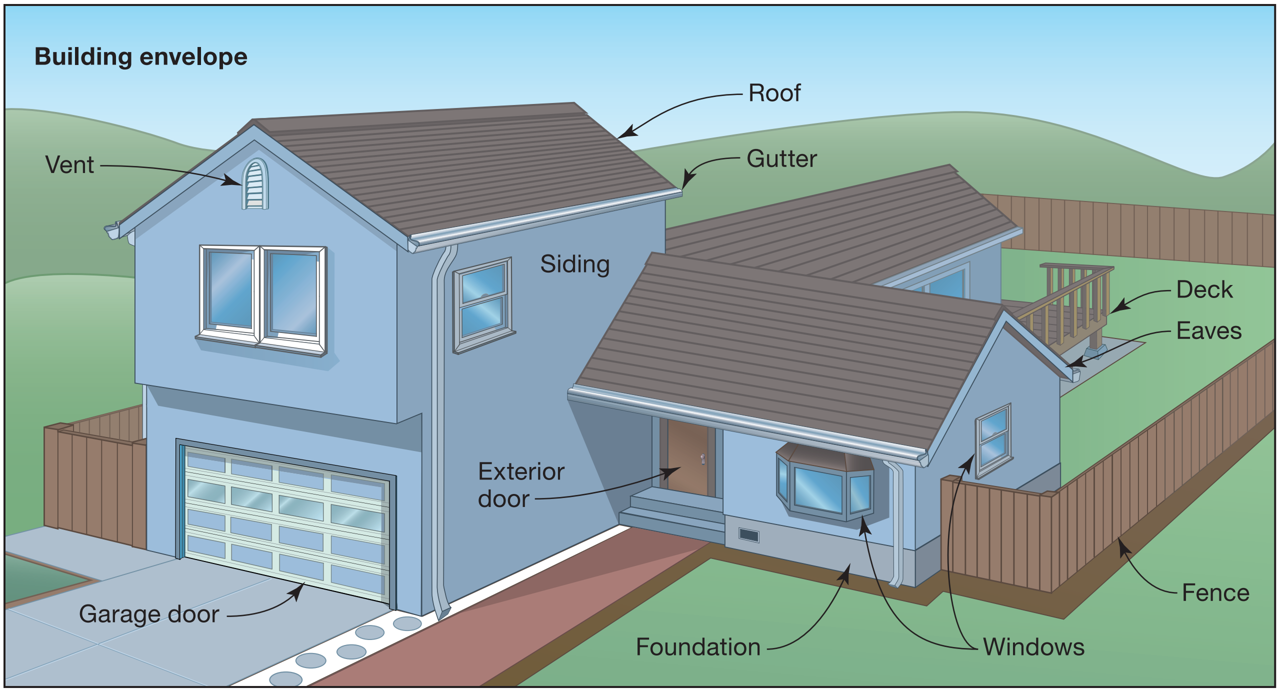


Figure 15-2.
The building envelope
SOURCE: ADAPTED FROM FEMA P-737

Figure 15-3.
Fire spreads vertically through vegetation

FEMA may fund above-code projects in communities with applicable fire-related codes. For homes and structures constructed or activities completed prior to the adoption of local building codes, FEMA may fund mitigation that meets or exceeds the codes currently in effect. For communities without fire codes, FEMA may fund mitigation when the materials and technologies are in accordance with the ICC, FEMA, U.S. Fire Administration, and the National Fire Protection Association (NFPA). Firewise recommendations, as appropriate. The Firewise program provides resources for communities and property owners to use in the creation of defensible space. Additional fire-related information and tools can be found at http://www.firewise.org and http://www.nfpa.org.

Wildfire mitigation is required to be in accordance with the applicable fire-related codes and standards, including but not limited to the following:

- IWUIC, *International Wildland-Urban Interface Code* (ICC)
- NFPA 1144, *Standard for Reducing Structure Ignition Hazards from Wildland Fire*
- NFPA 1141, *Standard for Fire Protection Infrastructure for Land Development in Suburban and Rural Areas*
- NFPA 703, *Standard for Fire-Retardant Treated Wood and Fire-Retardant Coatings for Building Materials*
- *Code for Fire Protection of Historical Structures* (NFPA)

FEMA P-737, *Home Builder's Guide to Construction in Wildfire Zones* (FEMA 2008a), is a Technical Fact Sheet Series (see Figure 15-4) that provides information about wildfire behavior and recommendations for building design and construction methods in the wildland/urban interface. The fact sheets cover mitigation topics for existing buildings including defensible space, roof assemblies, eaves, overhangs, soffits, exterior walls, vents, gutters, downspouts, windows, skylights, exterior doors, foundations, decks and other attached structures, landscape fencing and walls, fire sprinklers, and utilities and exterior equipment. Implementation of the recommended design and construction methods in FEMA P-737 can greatly increase the probability that a building will survive a wildfire.

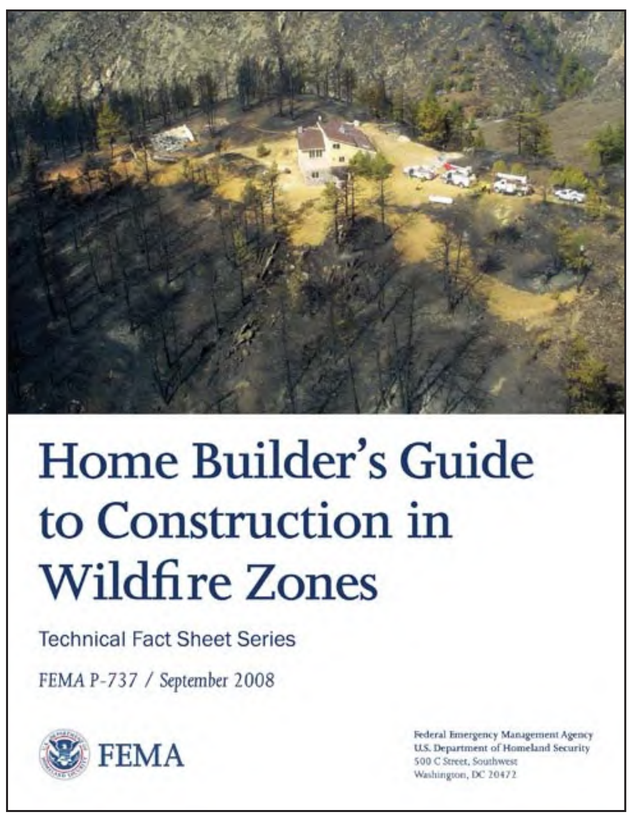


Figure 15-4.
FEMA P-737, *Home Builder's Guide to Construction in Wildlife Zones: Technical Fact Sheet Series*

Since it may not be financially possible for the homeowner to implement all of the measures that are recommended in FEMA P-737, homeowners should consult with local fire and building code officials or their fire management specialists to perform a vulnerability assessment and develop a customized, prioritized list of recommendations for remedial work on defensible space and the building envelope. Helpful information about the vulnerabilities of the building envelope is available at http://firecenter.berkeley.edu/building_in_wildfire_prone_areas. The homeowner can use the Homeowner's Wildfire Assessment survey on this Web site to learn about the risks a particular building has and the measures that can be taken to address them.

15.2 Seismic Mitigation

Seismic hazard, which is well documented and defined in the United States, is mitigated in existing residential buildings primarily through retrofitting. Although modifications to existing residential structures have the potential to reduce earthquake resistance, it is possible to take advantage of these modifications to increase resistance through earthquake retrofits (upgrades). FEMA has produced documents, including those referenced below, that address the evaluation and retrofit of buildings to improve performance during seismic events. For nationally applicable provisions governing seismic evaluation and rehabilitation, the design professional should reference ASCE 31 and ASCE 41.

In addition, FEMA offers funding for seismic retrofits through the HMGP and the PDM Program to reduce the risk of loss of life, injury, and damage to buildings. Seismic retrofits, which are classified as structural and non-structural, are subject to the same HMGP and PDM funding processes as wind retrofits (see Section 15.4.3).

FEMA 232, *Homebuilders' Guide to Earthquake Resistant Design and Construction* (FEMA 2006) (see Figure 15-5), contains descriptions of eight earthquake upgrades that address common seismic weaknesses in existing residential construction. The upgrades are foundation bolting, cripple wall bracing, weak- and soft-story bracing, open-front bracing, hillside house bracing, split-level floor interconnection, anchorage of masonry chimneys, and anchorage of concrete and masonry walls. The upgrades are summarized below. For in-depth information on these upgrades, see FEMA 232.

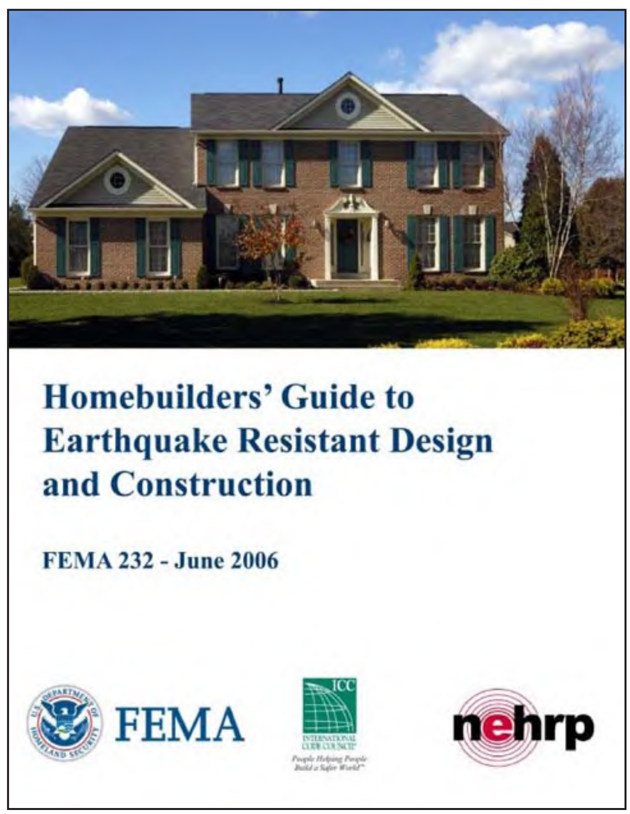


Figure 15-5.
FEMA 232, *Homebuilders Guide to Earthquake Resistant Design and Construction*

- **Foundation bolting.** Inadequate attachment of the sill plate to the foundation can allow the framed structure to separate and shift off the foundation. Sill plate anchor bolts (either adhesive or expansion type depending on the foundation material) can be added provided there is sufficient access to the top surface of the sill plate. Alternately, proprietary anchoring hardware is available that is typically attached to the face of the foundation wall for greater ease of installation when access is limited. Reinforcing sill plate anchorage offers a generally high benefit in return for low cost.

- **Cripple wall bracing.** Another relatively inexpensive foundation-level retrofit is bracing the cripple walls. Cripple walls are framed walls occasionally installed between the top of the foundation and first-floor framing in the above-grade wall sections of basements and crawl spaces. Because of their location, cripple walls are particularly vulnerable to seismic loading, as shown in Figure 15-6. These walls can be braced through the prescribed installation of wood structural panel sheathing to the interior and/or exterior wall surface.

- **Weak- and soft-story bracing.** Although first-story framed walls must bear greater seismic loads than the roof and walls above, they frequently have more openings and therefore less bracing. As a result, first-story framed walls, and any other level with underbraced wall sections, may be referred to as weak or soft stories. These walls can be retrofit by removing the interior finishes at wall corners and installing hold-down anchors between the corner studs and continuous reinforced foundation below. If renovations or repairs require removing larger areas of interior wall sheathing, additional hold-down anchors can be installed to tie in the floor or roof framing above. Additional wall bracing can be achieved by adding blocking for additional nailing and wood structural panel sheathing.

- **Open-front bracing.** An open-front configuration is one in which braced exterior walls are absent or grossly inadequate. Frequently, open-front configurations are found in garage entry walls where overhead garage doors consume most of the available wall area, as shown in Figure 15-7. Possible retrofits include reinforcing the existing framed end walls and replacing the framed wall ends with steel moment frames; common heights and lengths of steel moment frames are available commercially.

Figure 15-6.
A house with severe damage due to cripple wall failure

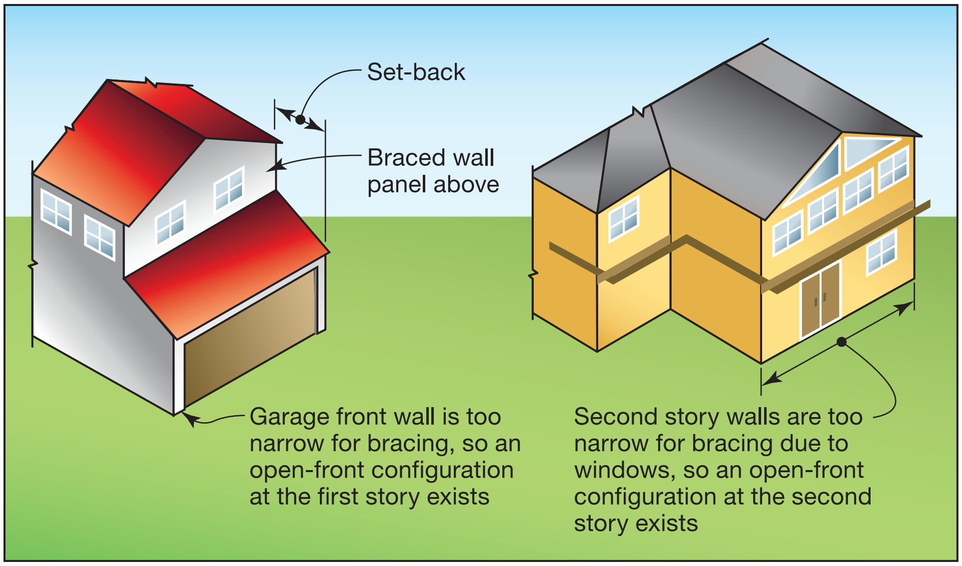


Figure 15-7. Common open-front configurations in one- and two- family detached houses

- **Hillside house bracing.** Houses built on steep hillsides are vulnerable to damage when the floor system separates from the uphill foundation or foundation wall. Retrofitting to mitigate this type of seismic damage requires an engineered design that should include anchoring each floor system to the uphill foundation and the supplemental anchorage, strapping, and bracing of cripple walls.

- **Split-level floor interconnection.** Houses with vertical offsets between floor elevations on a common wall or support are exposed to seismic damage that is similar to hillside houses. The potential for separation of the floor system from the common wall may be reduced by adequately anchoring floor framing on either side of the common wall. Prescriptive solutions may apply where a direct tension tie can be provided between both floors, but an engineered design may be necessary where greater floor offsets exist.

- **Anchorage of masonry chimneys.** Unreinforced masonry chimneys can be anchored to the roof and adjacent or surrounding floor systems with metal straps but will still be subject to brittle failure. The benefit of this type of anchoring may be limited to collapse prevention. A chimney collapse reportedly caused one fatality in the 1992 earthquake in Landers, CA, but other mitigation measures may be more cost-effective. These measures include the practical approaches provided on the Association of Bay Area Governments Web site (http://quake.abag.ca.gov/residents/chimney).

- **Anchorage of concrete and masonry walls.** Floor systems in houses with full-height concrete or masonry walls may be supported by a weight-bearing ledger strip only. With this type of existing construction, a tension connection can be installed between the walls and floor system to provide the necessary direct anchorage. An engineering evaluation and design are recommended for this type of seismic retrofit.

FEMA 530, *Earthquake Safety Guide for Homeowners* (FEMA 2005) (Figure 15-8) includes guidance similar to FEMA 232 on seismic structural retrofits along with tips on strengthening a variety of existing foundation types. One non-structural retrofit in FEMA 530 is to brace water heaters, which can cause gas leaks, fires, or flooding if toppled during an earthquake. Written for the homeowner, FEMA 530 provides information on the relative cost of prevention versus the cost of post-disaster repair or replacement and on plans, permitting, and selecting contractors.

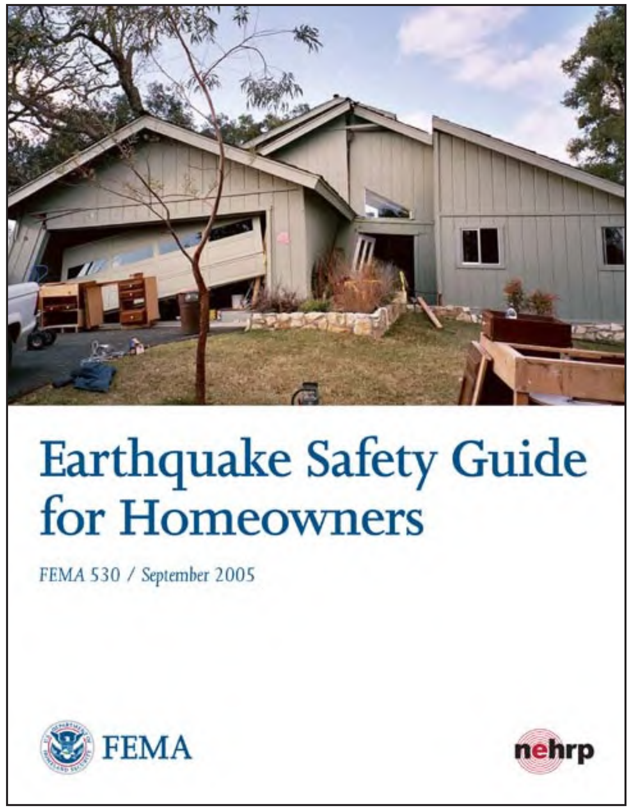


Figure 15-8.
FEMA 530, *Earthquake Safety Guide for Homeowners*

15.3 Flood Mitigation

FEMA 259, *Engineering Principles and Practices of Retrofitting Floodprone Structures* (FEMA 2011), addresses retrofitting flood-prone residential structures. The objective of the document is to provide engineering design and economic guidance to engineers, architects, and local code officials about what constitutes technically feasible and cost-effective retrofitting measures for flood-prone residential structures.

The focus in this chapter in regard to retrofitting for the flood hazard is retrofitting one- to four-family residences that are subject to flooding without wave action. The retrofitting measures that are described in this section include both active and passive efforts and wet and dry floodproofing. Active efforts require human intervention preceding the flood event and may include activities such as engaging protective shields at openings. Passive efforts do not require human intervention. The flood retrofitting measures are elevating the building in place, relocating the building, constructing barriers (levees and floodwalls), dry floodproofing (sealants, closures, sump pumps, and backflow valves), and wet floodproofing (using flood damage-resistant materials and protecting utilities and contents).

Flood retrofitting projects may be eligible for funding through the following FEMA Hazard Mitigation Programs: HMGP, PDM, Flood Mitigation Assistance, Repetitive Flood Claims, and Severe Repetitive Loss. More information on obtaining funding for flood retrofitting is available in *Hazard Mitigation Assistance Unified Guidance* (FEMA 2010a).

15.3.1 Elevation

Elevating a building to prevent floodwaters from reaching damageable portions of the building is an effective retrofitting technique. The building is raised so that the lowest floor is at or above the DFE to avoid damage from the design flood. Heavy-duty jacks are used to lift the building. Cribbing is used to support the building while a new or extended foundation is constructed. In lieu of constructing new support walls, open

CROSS REFERENCE

For definitions of DFE and BFE, see Section 8.5.1 of this Manual.

Figure 15-9.
Home elevated on piles

foundations such as piers, columns, posts, and piles are often used (see Figure 15-9). Elevating the building on fill may be an option. Closed foundations are not permitted in Zone V and are not recommended in Coastal A Zones. See Table 10-1 for the types of foundations that are acceptable in each flood zone.

The advantages and disadvantages of elevation are listed in Table 15-1.

Table 15-1. Advantages and Disadvantages of Elevation

Advantages	Disadvantages
• Brings a substantially damaged or improved building into compliance with the NFIP if the lowest horizontal member is elevated to the BFE • Reduces flood risk to the structure and its contents • Eliminates the need to relocate vulnerable items above the flood level during flooding • Often reduces flood insurance premiums • Uses established techniques • Requires qualified contractors who are often readily available • Reduces the physical, financial, and emotional strain that accompanies flood events • Does not require the additional land that may be needed for floodwalls or levees	• May be cost-prohibitive • May adversely affect the building's appearance • Prohibits the building from being occupying during a flood • May adversely affect access to the building • Cannot be used in areas with high-velocity water flow, fast-moving ice or debris flow, or erosion unless special measures are taken • May require additional costs to bring the building up to current building codes for plumbing, electrical, and energy systems • Requires a consideration of forces from wind and seismic hazards

SOURCE: FEMA 259

BFE = base flood elevation
NFIP = National Flood Insurance Program

15.3.2 Relocation

Relocation involves moving a structure to a location that is less prone to flooding or flood-related hazards such as erosion. The structure may be relocated to another portion of the current site or to a different site. The surest way to eliminate the risk of flood damage is to relocate the structure out of the floodplain. Relocation normally involves preparing the structure for the move (see Figure 15-10), placing it on a wheeled vehicle, transporting it to the new location, and setting it on a new foundation.

Relocation is an appropriate measure in high hazard areas where continued occupancy is unsafe and/or owners want to be free of the risk of flooding. Relocation is also a viable option in communities that are considering using the resulting open space for more appropriate floodplain activities. Relocation may offer an alternative to elevation for substantially damaged structures that are required under local regulations to meet NFIP requirements. Table 15-2 lists the advantages and disadvantages of relocation.

Figure 15-10. Preparing a building for relocation

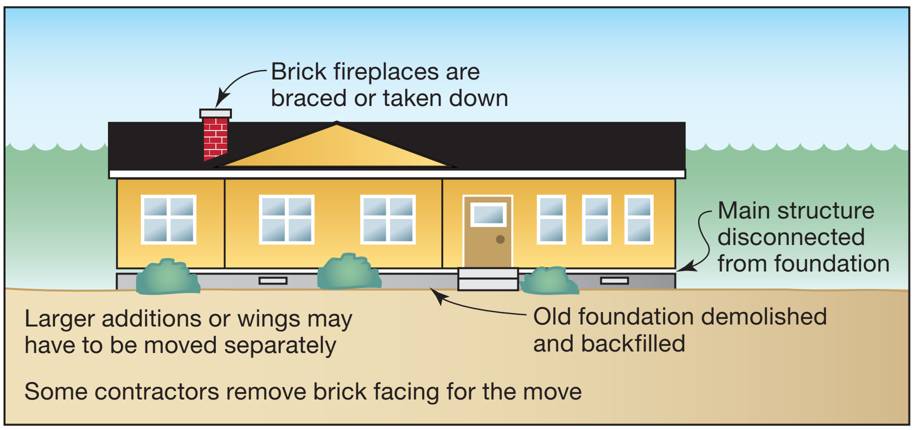


Table 15-2. Advantages and Disadvantages of Relocation

Advantages	Disadvantages
• Allows for substantially damaged or improved structure to be brought in to compliance with the NFIP • Significantly reduces flood risk to the structure and its contents • Uses established techniques • Requires qualified contractors who are often readily available • Can eliminate the need to purchase flood insurance or reduce the premium because the house is no longer in the floodplain • Reduces the physical, financial, and emotional strain that accompanies flood events	• May be cost-prohibitive • Requires locating a new site • Requires addressing disposition of the flood-prone site • May require additional costs to bring the structure up to current building codes for plumbing, electrical, and energy systems

SOURCE: FEMA 259

NFIP = National Flood Insurance Program

15.3.3 Dry Floodproofing

In dry floodproofing, the portion of a structure that is below the chosen flood protection level (walls and other exterior components) is sealed to make it watertight and impermeable to floodwaters. The objective is to make the walls and other exterior components impermeable to floodwaters. Watertight, impervious membrane sealant systems include wall coatings, waterproofing compounds, impermeable sheeting, and supplemental impermeable wall systems, such as cast-in-place concrete. Doors, windows, sewer and water lines, and vents are closed with permanent or removable shields or valves. Figure 15-11 is a schematic of a dry floodproofed home. Non-residential techniques are also applicable in residential situations. See Table 15-3 for the advantages and disadvantages of dry floodproofing.

WARNING

Dry floodproofing is not allowed under the NFIP for new and substantially damaged or improved residential structures in an SFHA. For additional information on dry floodproofing, see FEMA FIA-TB-3, *Non-Residential Floodproofing – Requirements and Certification for Buildings Located in Special Flood Hazard Areas in Accordance with the NFIP* (FEMA 1993a) and the *Substantial Improvement/Substantial Damage Desk Reference* (FEMA 2010b).

The expected duration of flooding is critical when deciding which sealant system to use because seepage can increase over time, rendering the floodproofing ineffective. Waterproofing compounds, sheeting, and sheathing may deteriorate or fail if exposed to floodwaters for extended periods. Sealant systems are also subject to damage (puncture) in areas that experience water flow of significant velocity, ice, or debris flow.

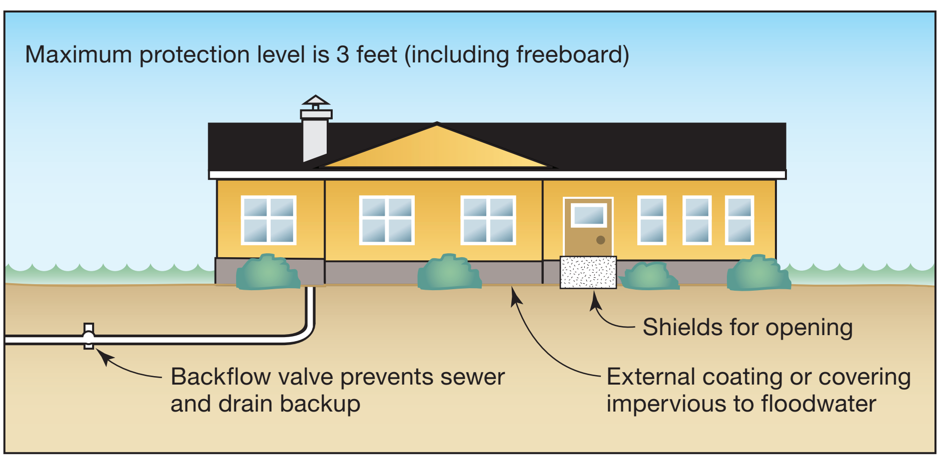


Figure 15-11. Dry floodproofed structure

Table 15-3. Advantages and Disadvantages of Dry Floodproofing

Advantages	Disadvantages
• Reduces the flood risk to the structure and contents even when the DFE is not exceeded • May be less costly than other retrofitting measures • Does not require the extra land that may be needed for floodwalls or reduced levees • Reduces the physical, financial, and emotional strain that accompanies flood events • Retains the structure in its present environment and may avoid significant changes in appearance	• Does not satisfy the NFIP requirement for bringing substantially damaged or improved residential structures into compliance • Requires ongoing maintenance • Does not reduce flood insurance premiums for residential structures unless community-wide basement exception is granted • Usually requires human intervention and adequate warning time for installation of protective measures • May provide no protection if measures fail or are exceeded during large floods • May result in more damage than flooding if design loads are exceeded, walls collapse, floors buckle, or the building floats • Prohibits the building from being occupied during a flood • May adversely affect the appearance of the building if shields are not aesthetically pleasing • May not reduce damage to the exterior of the building and other property • May lead to damage of the building and its contents if the sealant system leaks

SOURCE: FEMA 259

NFIP = National Flood Insurance Program
DFE = design flood elevation

15.3.4 Wet Floodproofing

Wet floodproofing involves modifying a building to allow floodwaters to enter it in such a way that damage to the structure and its contents is minimized. A schematic of a home that has been wet floodproofed is shown in Figure 15-12. See Table 15-4 for a list of the advantages and disadvantages of wet floodproofing.

Wet floodproofing is often used for structures with basements and crawlspaces when other mitigation techniques are technically infeasible or too costly. Wet floodproofing is generally appropriate if a structure has space available to temporarily store damageable items during the flood event. Utilities and furnaces situated below the DFE should be relocated to higher ground while remaining sub-DFE materials vulnerable to flood damage should be replaced with flood damage-resistant building materials. FEMA TB-2, *Flood Damage-Resistant Materials Requirements* (FEMA 2008b), provides guidance concerning the use of flood damage-resistant building components.

WARNING

Wet floodproofing is not allowed under the NFIP for new and substantially damaged or improved structures located in an SFHA. Refer to FEMA FIA-TB-7, *Wet Floodproofing Requirements for Structures Located in Special Flood Hazard Areas in Accordance with the NFIP* (FEMA 1993b).

CROSS REFERENCE

For additional information about wet floodproofing, see FEMA P-348, *Protecting Building Utilities From Flood Damage: Principles and Practices for the Design and Construction of Flood Resistant Building Utility Systems* (FEMA 1999).

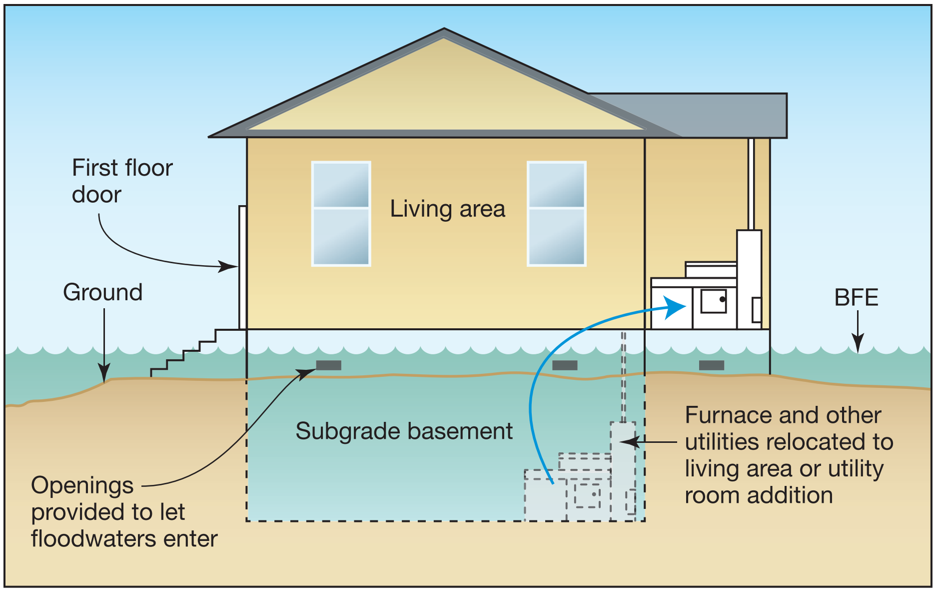


Figure 15-12. Wet floodproofed structure

Table 15-4. Advantages and Disadvantages of Wet Floodproofing

Advantages	Disadvantages
• Reduces the risk of flood damage to a building and its contents, even with minor mitigation • Greatly reduces loads on walls and floors due to equalized hydrostatic pressure • May be eligible for flood insurance coverage of cost of relocating or storing contents, except basement contents, after a flood warning is issued • Costs less than other measures • Does not require extra land • Reduces the physical, financial, and emotional strain that accompanies flood events	• Does not satisfy the NFIP requirement for bringing substantially damaged or improved structures into compliance • Usually requires a flood warning to prepare the building and contents for flooding • Requires human intervention to evacuate contents from the flood-prone area • Results in a structure that is wet on the inside and possibly contaminated by sewage, chemicals, and other materials borne by floodwaters and may require extensive cleanup • Prohibits the building from being occupied during a flood • May make the structure uninhabitable for some period after flooding • Limits the use of the floodable area • May require ongoing maintenance • May require additional costs to bring the structure up to current building codes for plumbing, electrical, and energy systems • Requires care when pumping out basements to avoid foundation wall collapse

SOURCE: FEMA 259

NFIP = National Flood Insurance Program

15.3.5 Floodwalls and Levees

Another retrofitting approach is to construct a barrier between the structure and source of flooding. The two basic types of barriers are floodwalls and levees. Small levees that protect a single home can be built to any height but are usually limited to 6 feet due to cost, aesthetics, access, water pressure, and space. The height of floodwalls is usually limited to 4 feet. Local zoning and building codes may also restrict use, size, and location.

A levee is typically a compacted earthen structure that blocks floodwaters from coming into contact with the structure. To be effective over time, levees must be constructed of suitable materials (i.e., impervious soils) and have the correct side slopes for stability. Levees may completely surround the structure or tie to high ground at each end. Levees are generally limited to homes where floodwaters are less than 5 feet deep. Otherwise, the cost and the land area required for such barriers usually make them impractical for the average owner. See Table 15-5 for a list of the advantages and disadvantages for retrofitting a home against flooding hazards using floodwalls and levees.

WARNING

While floodwalls and levees are allowed under NFIP regulations, they do not make a noncompliant structure compliant under the NFIP.

Table 15-5. Advantages and Disadvantages of a Floodwall or Levee

Advantages	Disadvantages
• Protects the area around the structure from inundation without significant changes to the structure • Eliminates pressure from floodwaters that would cause structural damage to the home or other structures in the protected area • Costs less to build than elevating or relocating the structure • Allows the structure to be occupied during construction • Reduces flood risk to the structure and its contents • Reduces the physical, financial, and emotional strain that accompanies flood events	• Does not satisfy the NFIP requirements for bringing substantially damaged or improved structures into compliance • May fail or be overtopped by large floods or floods of long duration • May be expensive • Requires periodic maintenance • Requires interior drainage • May affect local drainage, possibly resulting in water problems for others • Does not reduce flood insurance premiums • May restrict access to structure • Requires considerable land (levees only) • Does not eliminate the need to evacuate during floods • May require warning and human intervention for closures • May violate applicable codes or regulations

SOURCE: FEMA 259

NFIP = National Flood Insurance Program

Floodwalls are engineered barriers designed to keep floodwaters from coming into contact with the structure. Floodwalls can be constructed in a wide variety of shapes and sizes but are typically built of reinforced concrete and/or masonry materials.

See Figure 15-13 for an example of a home protected by both a floodwall and a levee.

15.3.6 Multihazard Mitigation

The architect, engineer, or code official must recognize that retrofitting a residential structure for flooding may affect how the structure will react to hazards other than flooding. Non-flood-related hazards such as earthquake and wind forces should also be considered when retrofitting for flood-related hazards such as water-borne ice and debris-impact forces, erosion forces, and mudslide impacts. Retrofitting a structure to withstand only floodwater forces may impair the structure's resistance to the multiple hazards mentioned above. Thus, it is important to approach retrofitting with a multi-hazard perspective.

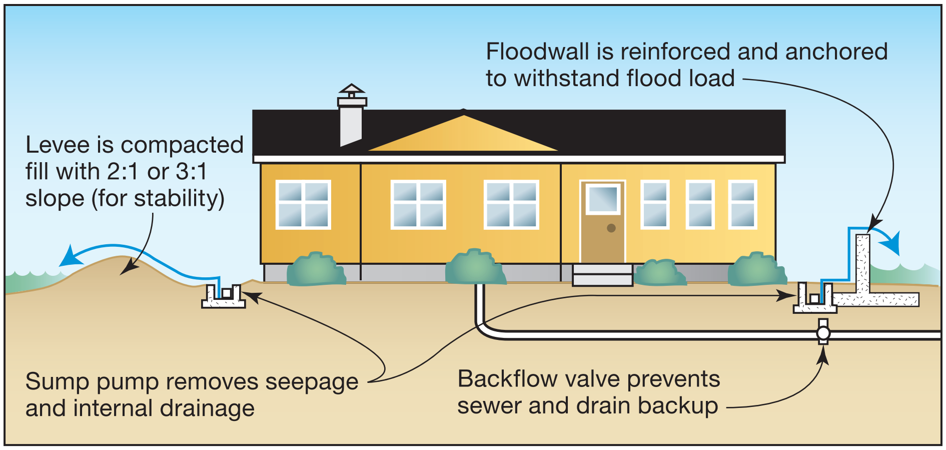


Figure 15-13. Home protected by a floodwall and a levee

15.4 High-Wind Mitigation

The high-wind natural hazards that affect the hurricane-prone regions of the United States are hurricanes, tropical storms, typhoons, nor'easters, and tornadoes. This section addresses protecting existing residential structures from hurricane damage. The evaluation process and implementation methods for wind retrofit projects discussed in this section are described more fully in FEMA P-804, *Wind Retrofit Guide for Residential Building* (FEMA 2010c) (see Figure 15-14).

> **NOTE**
>
> Unless otherwise stated, all wind speeds in FEMA P-804 are ASCE 7-05 3-second gust wind speeds and correspond to design requirements set forth in ASCE 7-05 and 2006 IRC and 2009 IRC. Because of the changes in the ASCE 7-10 wind speed map, it is not appropriate to use the ASCE 7-10 wind speed map in combination with the provisions of ASCE 7-05 and the older codes.

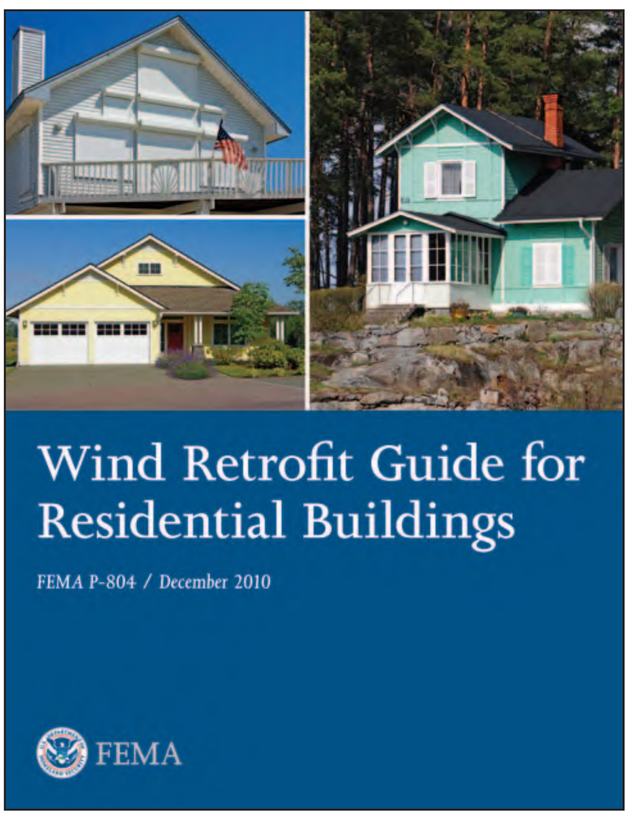


Figure 15-14. FEMA P-804, *Wind Retrofit Guide for Residential Buildings*

Hurricane-force winds are most common in coastal areas but also occur in other areas. ASCE 7-05 defines the hurricane-prone regions as the U.S. Atlantic Ocean and Gulf of Mexico coasts where the design wind speed is greater than 90 mph, and Hawaii, Puerto Rico, Guam, Virgin Islands, and American Samoa.

15.4.1 Evaluating Existing Homes

Executing a successful retrofit on any home requires an evaluation of its existing condition to determine age and condition; overall structural integrity; any weaknesses in the building envelope, structure, or foundation; whether the home can be retrofitted to improve resistance to wind-related damage; how the home can be retrofit for the Mitigation Packages (see Section 15.4.2); how much the Mitigation Packages would cost; and the most cost-effective retrofit project for the home.

A qualified individual should evaluate the home and provide recommendations to the homeowner. Qualified professionals may include building science professionals such as registered architects and engineers, building officials, and evaluators who are certified through other acceptable wind retrofit programs such as the FORTIFIED *for Existing Homes* Program from the Insurance Institute for Business & Home Safety (IBHS 2010).

The purposes of the evaluation are to identify any repairs that are needed before a wind retrofit project can be undertaken, the feasibility of the retrofit project, whether prescriptive retrofits can be performed on the home or whether an engineering solution should be developed, and whether the home is a good candidate for any of the wind retrofit Mitigation Packages described in Section 15.4.2. The purpose of the evaluation is ***not*** to determine whether the building meets the current building code.

15.4.2 Wind Retrofit Mitigation Packages

NOTE

In wind retrofitting, the most cost-effective techniques normally involve strengthening the weakest structural links and improving the water penetration resistance of the building envelope. To identify the weakest links, the designer should start at the top of the building and work down the load path.

The wind retrofit projects described in this section, and more fully in FEMA P-804, are divided into the Basic Mitigation Package, Intermediate Mitigation Package, and Advanced Mitigation Package. Additional mitigation measures are presented at the end of this section. The packages should be implemented cumulatively, beginning with the Basic Mitigation Package. This means that for a home to successfully meet the criteria of the Advanced Mitigation Package, it must also meet the criteria of the Basic and Intermediate Mitigation Packages. The retrofits in each package are shown in Figure 15-15.

The wind mitigation retrofits for each package, if implemented correctly, will improve the performance of residential buildings when subjected to high winds. Although the information in this section can be helpful to homeowners, it is intended primarily for evaluators, contractors, and design professionals. The retrofits described for each Mitigation Package and throughout this section are not necessarily listed in the order in which they should be performed. The order in which retrofits should be performed depends on the configuration of the home and should be determined once the desired Mitigation Package is chosen. For example, when the Advanced Mitigation Package is selected, the homeowner should consider retrofitting the roof-to-wall connections when retrofitting the soffits (part of the Basic Mitigation Package).

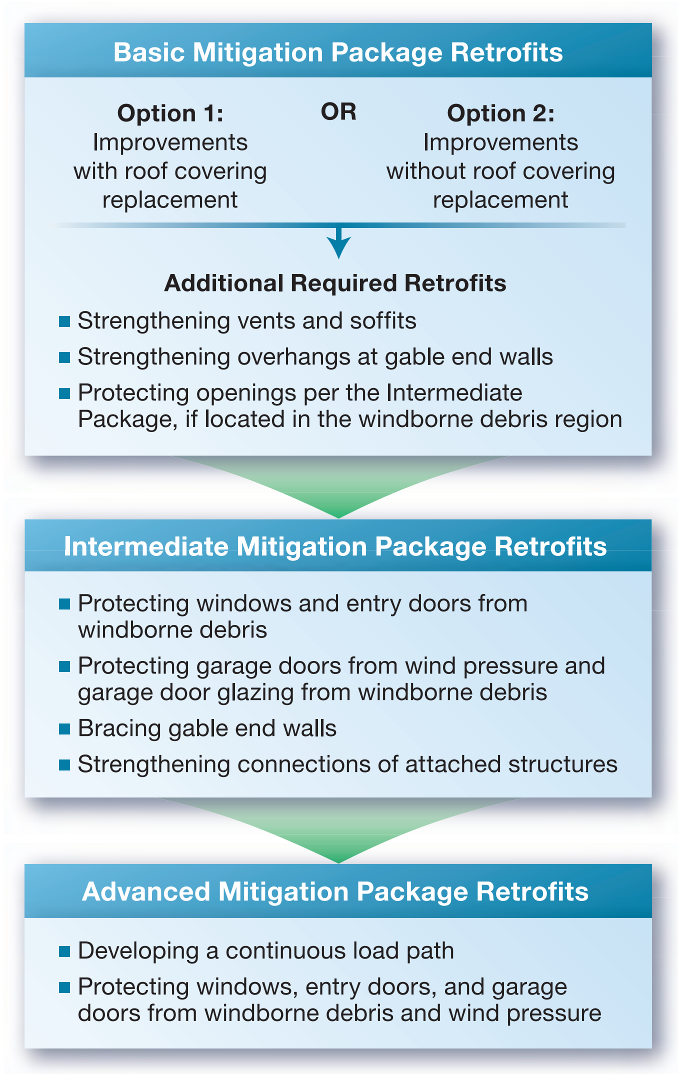


Figure 15-15.
Wind Retrofit Mitigation Packages
SOURCE: FEMA P-804

15.4.2.1 Basic Mitigation Package

The Basic Mitigation Package focuses on securing the roof system and improving the water intrusion resistance of the home. Figures 15-16 and 15-17 show two retrofits that fall into the Basic Mitigation Package. One of the first decisions to make when implementing the Basic Mitigation Package is whether to use Option 1 or Option 2. The evaluation will identify whether the roof covering needs to be replaced (see Section 3.1.1 of FEMA P-804 for more information).

If the home is located in a wind-borne debris region, the opening protection measures described in the Intermediate Mitigation Package should be performed for the Basic Mitigation Package in addition to the other retrofits. The opening protection measures include installing an approved impact-resistant covering or component at each exterior window, skylight, entry door, and garage door opening.

FEMA P-804 includes procedures, material specifications, and fastening schedules (when applicable) to facilitate implementation of the Basic Mitigation Package. Alternative methods and materials are also discussed to facilitate installation for a variety of as-built conditions.

Figure 15-16.
Bracing gable end overhangs

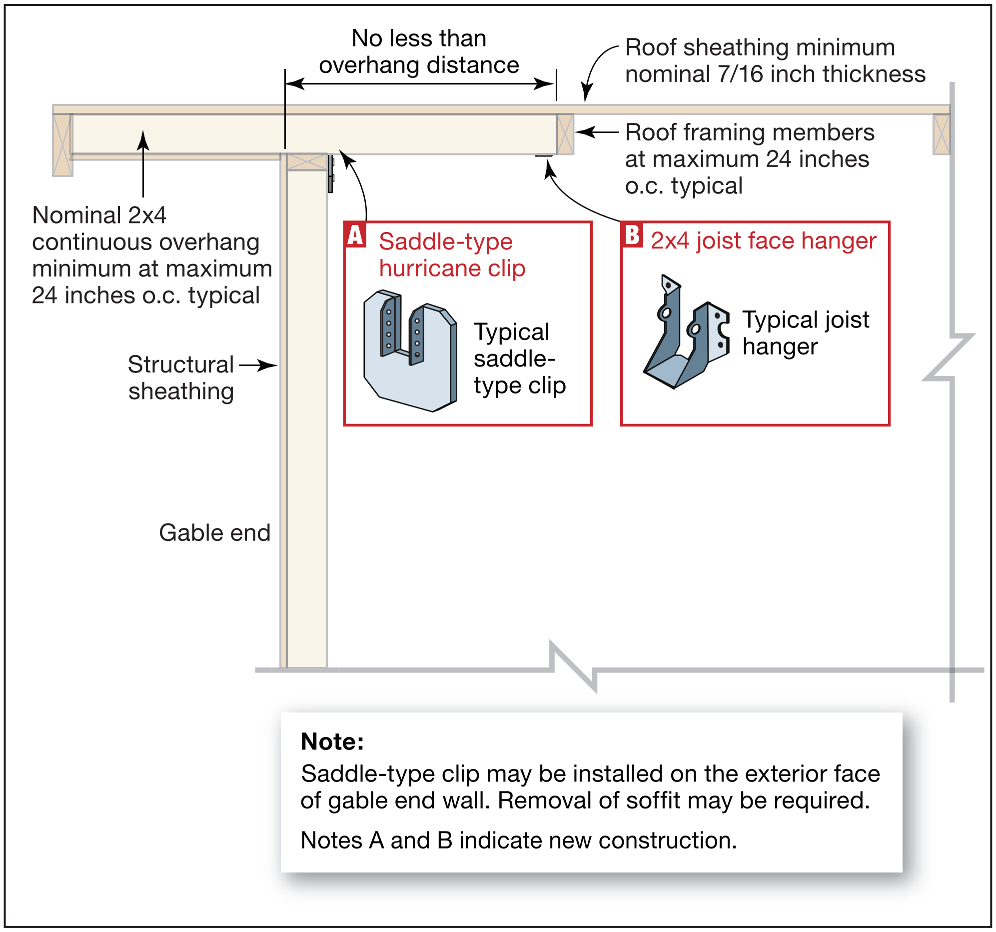


Figure 15-17.
Sprayed polyurethane foam adhesive to secure roof deck panels

15.4.2.2 Intermediate Mitigation Package

For the Intermediate Mitigation Package to be effective, the measures in the Basic Mitigation Package must first be successfully completed. The Intermediate Mitigation Package includes protecting windows and entry doors from wind-borne debris, protecting garage doors from wind pressure and garage door glazing from wind-borne debris, bracing gable end walls over 4 feet tall, and strengthening the connections of attached structures such as porches and carports.

15.4.2.3 Advanced Mitigation Package

The Advanced Mitigation Package is the most comprehensive package of retrofits. This package can be effective only if the Basic Mitigation Package (with or without replacing the roof covering) and Intermediate Mitigation Package are also implemented. The Advanced Mitigation Package requires a more invasive inspection than the other two packages. Homes 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 requires the homeowner to provide a continuous load path as shown in Figure 15-18 and further protect openings.

15.4.2.4 Additional Mitigation Measures

The wind retrofit Mitigation Packages include important retrofits that reduce the risk of wind-related damage, but the risk cannot be eliminated entirely. By maintaining an awareness of vulnerabilities of and around a home, the homeowner can reduce the risk of wind-related damage even further. Although the mitigation measures prescribed to address these vulnerabilities are important to understand, they are not a part of the Mitigation Packages and are not eligible for HMA program funding. These additional measures, described in greater detail in FEMA P-804, include securing the exterior wall covering, implementing tree fall prevention measures, and protecting exterior equipment.

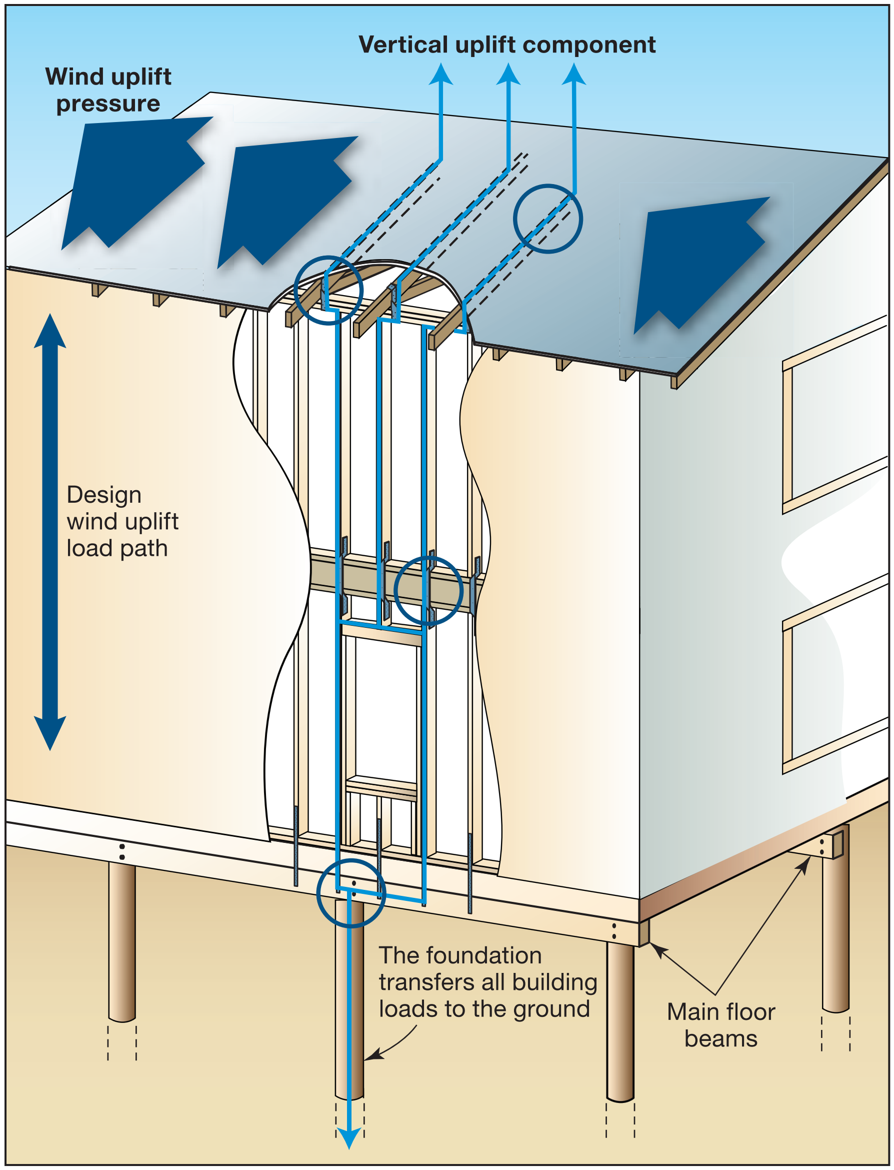
15.4.3 FEMA Wind Retrofit Grant Programs

Despite the significant damage experienced by all types of buildings during high-wind events, grant applications for wind retrofit projects have focused more on non-residential and commercial buildings than on residential buildings. FEMA developed FEMA P-804 to encourage wind mitigation of existing residential buildings.

FEMA administers two HMA grant programs that fund wind retrofit projects: HMGP and the PDM Program. Hazard mitigation is defined as any sustained action taken to reduce or eliminate long-term risk to people and property from natural hazards and their effects. The HMA process has five stages, starting with mitigation planning and ending with successful execution of a project (see Figure 15-19).

Through FEMA's HMA grant programs, applications for an individual home or groups of homes undergoing wind retrofit projects can be submitted for approval. If applications are approved, Federal funding is 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. Refer to current HMA guidance for more details on cost-sharing (FEMA 2010a). More information on Federal assistance through HMA programs is also available in Chapter 5 of FEMA P-804.

Figure 15-18.
Continuous load path for wind-uplift of a residential, wood-frame building



Homeowners should consider both qualitative and quantitative benefits and costs when deciding on a wind retrofit project. Applying for Federal assistance through HMA programs (as described in Chapter 5 of FEMA P-804) requires an analysis or comparison of the benefits to society compared to the cost of the project. Benefits such as reduced insurance premiums are not considered because they are an individual benefit. To assist with calculating the quantitative benefits and costs of implementing a project, FEMA developed Benefit-Cost Analysis (BCA) software, Version 4.5.5 (FEMA 2009). See Appendix C of FEMA P-804 for additional information on using the BCA software. Communities are encouraged to use the software regardless of whether they will apply for Federal funding. The software can be used to calculate project benefits such as avoided damage to the home, avoided displacement costs, and avoided loss of building contents. The evaluation discussed in Section 15.4.1 should identify all of the necessary input data needed for using the BCA software. Appendix C of FEMA P-804 provides a step-by-step guide to using the software to evaluate the cost-effectiveness of a wind retrofit project.

Figure 15-19.
HMA grant process
SOURCE: FEMA P-804

15.5 References

ASCE (American Society of Civil Engineers). 2005. *Minimum Design Loads for Buildings and Other Structures*. ASCE 7-05.

ASCE. *Seismic Evaluation of Existing Buildings*. ASCE 31

ASCE. *Seismic Rehabilitation of Existing Buildings*. ASCE 41.

FEMA (Federal Emergency Management Agency). 1993a. *Non-Residential Floodproofing – Requirements and Certification for Buildings Located in Special Flood Hazard Areas in Accordance with the National Flood Insurance Program*. FIA-TB-3.

FEMA. 1993b. *Wet Floodproofing Requirements for Structures Located in Special Flood Hazard Areas in Accordance with the National Flood Insurance Program*. FIA-TB-7.

FEMA. 1999. *Protecting Building Utilities from Flood Damage*. FEMA P-348.

FEMA. 2005. *Earthquake Safety Guide for Homeowners*. FEMA 530.

FEMA. 2006. *Homebuilders' Guide to Earthquake-Resistant Design and Construction*. FEMA 232.

FEMA. 2008a. *Home Builder's Guide to Construction in Wildfire Zones*. FEMA P-737.

FEMA. 2008b. *Flood Damage-Resistant Materials Requirements*. Technical Bulletin 2.

FEMA. 2009. Benefit-Cost Analysis Tool, Version 4.5.5. Available at http://www.bchelpline.com/Download.aspx. Accessed January 2011.

FEMA. 2010a. *Hazard Mitigation Assistance Unified Guidance*. Available at http://www.fema.gov/library/viewRecord.do?id=4225. Accessed June 2011.

FEMA. 2010b. *Substantial Improvement/Substantial Damage Desk Reference*. FEMA P-758.

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

FEMA. 2011. *Engineering Principles and Practices of Retrofitting Floodprone Structures*. FEMA 259.

IBHS (Insurance Institute for Business & Home Safety). 2008. *Mega Fires: The Case for Mitigation – The Witch Creek Wildfire, October 21-31, 2007.*

IBHS. 2010. *FORTIFIED for Existing Homes Engineering Guide*.

ICC (International Code Council). 2006. *International Residential Code for One- and Two-Family Dwellings*. 2006 IRC.

ICC. 2009a. *International Residential Code for One- and Two-Family Dwellings*. 2009 IRC.

ICC. *International Wildland-Urban Interface Code* (IWUIC).

NFPA (National Fire Protection Association). *Code for Fire Protection of Historical Structures*.

NFPA. *Standard for Fire Protection Infrastructure for Land Development in Suburban and Rural Areas*. NFPA 1141.

NFPA. *Standard for Fire-Retardant Treated Wood and Fire-Retardant Coatings for Building Materials*. NFPA 703.

NFPA. *Standard for Reducing Structure Ignition Hazards from Wildland Fire*. NFPA 1144.