Fact Sheet 3.2: Wall Systems and Openings

The mitigation objective of this Fact Sheet is to decrease the likelihood of building damage or failure from the pressure of floodwaters or wind forces or wind infiltration and wind-driven rain.

Floodwaters and wind can easily enter buildings through joints in wall systems and openings such as doors and windows. Strengthening these points of entry will help improve a building's performance during floods and hurricanes. When considering mitigation options for historic buildings, check with the state historic preservation office to determine which solutions and options meet historic preservation requirements. The text box below provides some additional information about wall systems and openings.

Definitions

Load Path—The route taken by a force as it makes its way through a structure. When a building has a continuous load path, the force is eventually transferred to and resisted by the supporting soils on which the building sits. A continuous load path usually requires the use of metal connectors and fasteners and a strong wall system design.

Framing—Pieces that are fit together to provide structural support for the wall system, which can be built from wood or metal studs, steel, reinforced masonry, reinforced concrete, insulating concrete form (ICF) and common brick.

Connectors and Fasteners—Hardware that links wall framing systems to roof and floor systems, transferring the load from system to system. They include hurricane straps and ties or concrete or grout with steel reinforcing bars.

Sheathing—Plywood or oriented strand board (OSB) wall framing covering that adds strength to wood or metal studs. Gypsum board may be used for metal stud or steel-framed walls.

Exterior Wall Finishes—Covering that protects the wall system from wind pressure, wind-driven rain and debris. Some finishes may even offer some protection from flooding. Finishes include wood, vinyl, aluminum, fiber-cement board siding, brick or stone veneer, stucco or exterior insulation and finish system (EIFS).

A range of mitigation strategies for wall systems and openings for small and large public buildings are shown in Table 3.2.1. These strategies then are discussed in the sections that follow.

Table 3.2.1. Wall Systems and Openings Mitigation Solutions

Solutions and Options	***Wind***	***Wind-Driven Rain***	***Riverine Flooding***	***Coastal Flooding***
Mitigation Solution: For Wall Systems				
Option 1: Strengthen Framing Materials and Connections	✓		✓	✓
Option 2: Improve Sheathing	✓	✓	✓	✓
Option 3: Upgrade Exterior Wall Finishes	✓	✓	✓	✓
Mitigation Solution: For Door Openings				
Option 1: Prevent Water Intrusion	✓	✓	✓	
Option 2: Upgrade Exterior Doors	✓	✓		
Option 3: Upgrade Garage Doors	✓	✓		
Mitigation Solution: For Window Openings				
Option 1: Strengthen Windows	✓			
Option 2: Retrofit with Impact-Resistant Glazing	✓			
Option 3: Install Storm Shutters	✓	✓		

Mitigation Solution: For Wall Systems

Exterior wall systems help to enclose a building to protect the interior spaces from the environment. According to the *Whole Building Design Guide*, one of the most common threats to the soundness and performance of a building is when rain penetrates the interior. Water penetration can weaken parts of the wall system that are part of the continuous load path, which transfers loads throughout the building from the point where the loads are applied. If there is not a continuous load path in a building, the loads can cause a failure related to the missing connection point. It is important to take steps to prevent water from getting into buildings through wall systems to continue to protect during floods and hurricanes.

Option 1: Strengthen Framing Connections and Materials

Structural failures frequently occur at connections instead of in the framing itself. Especially in coastal areas where the environment is wetter and more humid and buildings are exposed to salt spray, corroded metal connectors and fasteners often fail to transfer loads correctly along the load path. Connectors and fasteners must have enough strength to resist all forces that will act on a building during a hurricane or flood (Figure 3.2.1.)

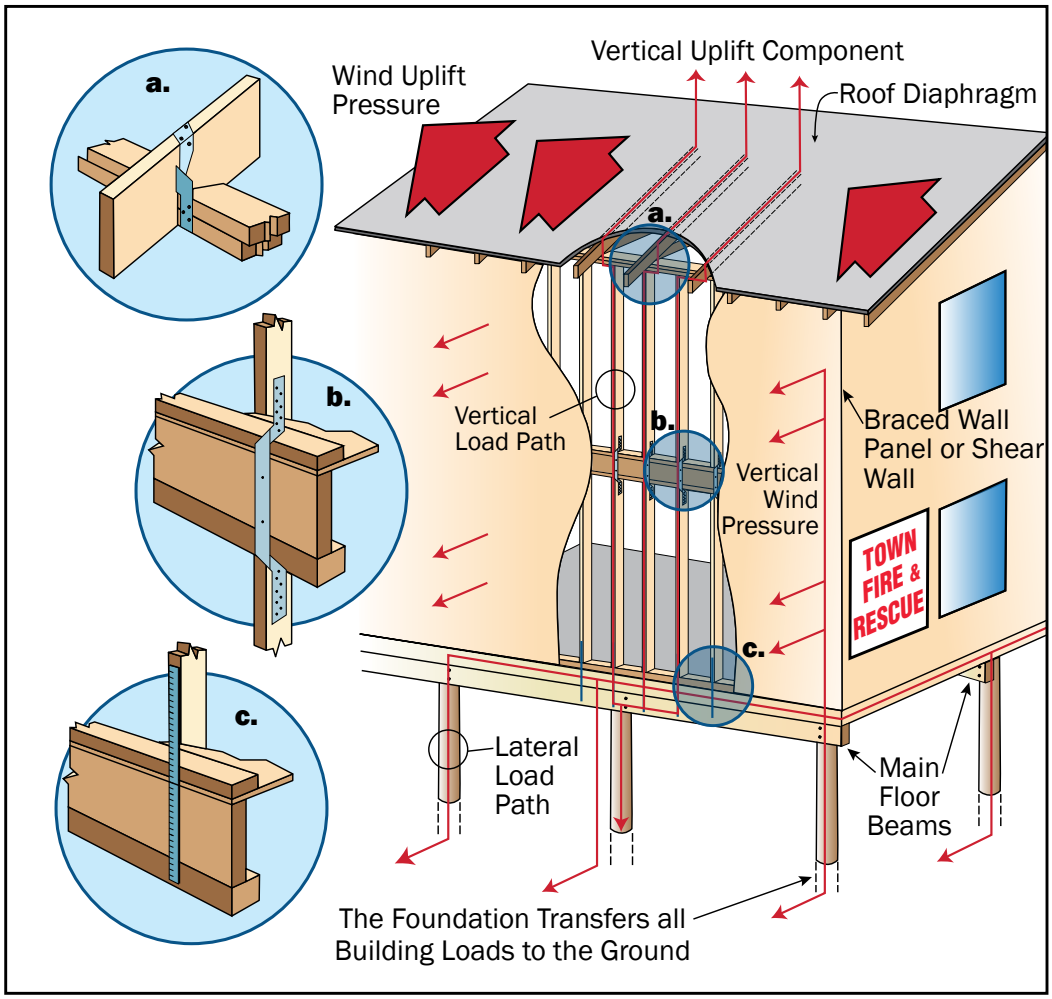


Figure 3.2.1. Connectors help create an adequate building load path.

Strengthen framing connections and materials to establish a continuous load path throughout the wall system to transfer all horizontal, gravity and uplift forces imposed on a building during hurricanes and floods, including:

- Roof framing to wall framing connections
- Wall framing connections and wall-to-wall connections
- Wall framing to foundation connections

When evaluating this option, keep these considerations in mind:

- All framing connectors and fasteners within 3,000 feet of the coastline should be either hot-dipped galvanized or stainless steel.
- Where possible, inspect, maintain, and replace materials as needed to keep a continuous load path.
- Refer to NFIP Technical Bulletin 8, *Corrosion Protection for Metal Connectors and Fasteners in Coastal Areas.*

CONSIDERATIONS:

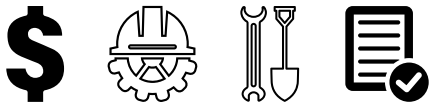
Option 2: Improve Sheathing

In exterior wall systems, sheathing is the board or panel used to cover the wall frame. Sheathing helps strengthen the wall system and provides a surface to which other materials can be applied. Sheathing material can be chosen that provides some amount of resistance to floods, hurricanes, and other weather-related events.

When evaluating this mitigation option, consider the following:

- Remove flood-damaged sheathing and replace it with thicker, stronger, flood-damage-resistant, exterior-grade sheathing.
- Add a water-resistant barrier between the sheathing and exterior wall finish to provide another layer of protection.
- Replace existing framing and sheathing with reinforced concrete or reinforced masonry. This approach may be desirable in areas subject to high winds with windborne debris, such as island construction in the U.S. territories.
- Refer to NFIP Technical Bulletin 2, *Flood Damage-Resistant Materials Requirements,* for a list of flood-damage-resistant sheathing materials.

CONSIDERATIONS:



Option 3: Upgrade Exterior Wall Finishes

Exterior wall finishes are materials applied to the outside sheathing on wall systems. They help to protect the building while also providing some decoration. Examples of exterior finishes include, but are not limited to, siding, stucco and masonry veneer.

When evaluating this mitigation option, consider the following:

- Replace existing damaged exterior finishes with materials that are stronger and/or more resistant to wind and water.
- Improve siding connections to enhance wind protection.
- EIFS and vinyl siding are especially at risk to wind and debris damage; replace these materials with fiber cement siding, high-wind-rated vinyl siding or another impact-resistant exterior finish (Figure 3.2.2).

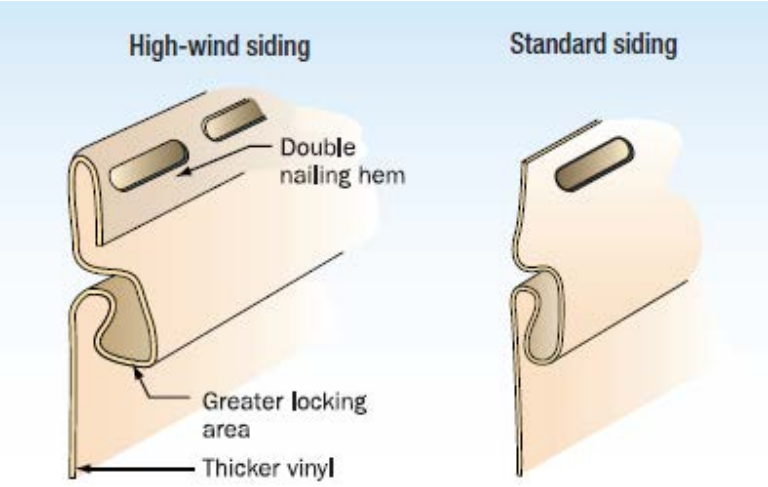


Figure 3.2.2. Features of typical high-wind siding and standard siding.

CONSIDERATIONS:

Mitigation Solution: For Door Openings

Exterior doors are susceptible to damage from hurricanes and floods. Hurricane winds can blow in doors or tear them from their hinges, allowing water to enter the building. Doors and related components such as door frames, connections and hardware can be mitigated to strengthen them and prevent wind and water from entering.

Option 1: Prevent Water Intrusion

Mitigating doors against water entry can protect the building, its interior finishes, and the contents of the building. Some considerations when evaluating this mitigation option include:

- Add weather stripping to the base of the door or drip protection along the top, as shown in Figure 3.2.3.

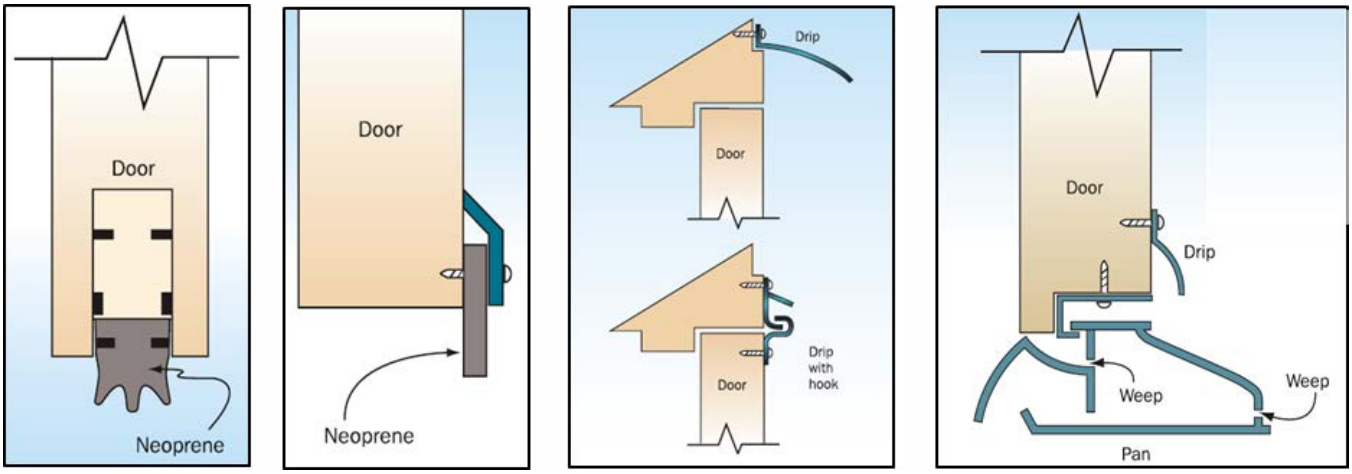


Figure 3.2.3. Examples of weather stripping (far left and center left) and drip protection (center right and far right) to prevent wind-driven rain entry at doors.

- Install flood shields and barriers—a type of dry floodproofing—to prevent floodwater from entering a building through the building exterior. Dry floodproofing should be designed and implemented as a system, as discussed in Fact Sheet 3.1, *Foundations*.
  - All areas of a building that contact floodwaters, including the floor slab, must be considered part of the flood barrier and made strong enough to resist all flood forces and be sealed enough to be substantially impenetrable.
  - Flood barriers should be considered around the exterior of a building, around critical equipment, and around areas that need to provide critical functions.
  - Flood shields with gaskets can provide up to three feet of protection during floods lasting less than 24 hours. This approach works well for concrete or masonry buildings in riverine flood zones. (Figure 3.2.4).
  - Interior door protection can be prioritized to protect areas with critical functions or equipment.

- Some door flood shields or barriers deploy automatically, while others must be placed manually. Manual shield placement is an active mitigation measure that requires a person to place the shield before the event and remove it after the event.
- Replace existing doors with debris-impact-rated doors.
- Make sure any replacement doors are rated for the design wind speed and wind pressure in the area where the building is located.
- Build a vestibule around the entry door to reduce or block water from getting into the interior.
- Residual seepage may occur, requiring drainage, pumping, clean-up, and sanitation. ASCE 24 requires sump pumps to be installed in dry floodproofed buildings.

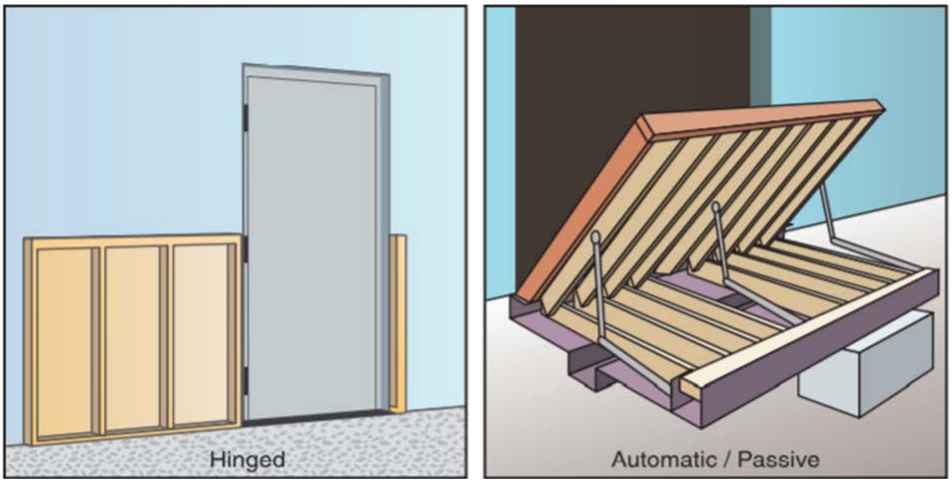


Figure 3.2.4. Examples of hinged (left) and lift out (right) flood shields with gaskets at entry doors. Some flood shields are automatic while others must be placed manually.

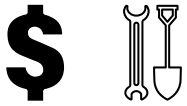
CONSIDERATIONS:

Option 2: Upgrade Exterior Doors

Upgrading exterior doors can improve their strength and impact resistance, which can improve the strength of the wall system. When evaluating this mitigation option, consider the following:

- Replace damaged exterior doors, frames, hinges, and hardware with wind-resistant components.
- Replace a hollow-core door with a solid wood door, standard lock and deadbolt lock.
- For protection against high winds and wind-borne debris, install a steel door with multiple hinges and deadbolt locks.
- Replace inward swinging doors with outward swinging doors rated for high wind and debris impacts.
- Replace screws that secure hinges with longer screws that penetrate the wood jamb of the door.

CONSIDERATIONS:



Option 3: Upgrade Garage Doors

Garage doors can be relatively large, making them one of the largest openings in a building. Because of their relative size, garage doors can be vulnerable to the wind blowing them in, pulling them out, or twisting them off their tracks. Refer to Figure 3.2.5 for details on garage door retrofitting techniques.

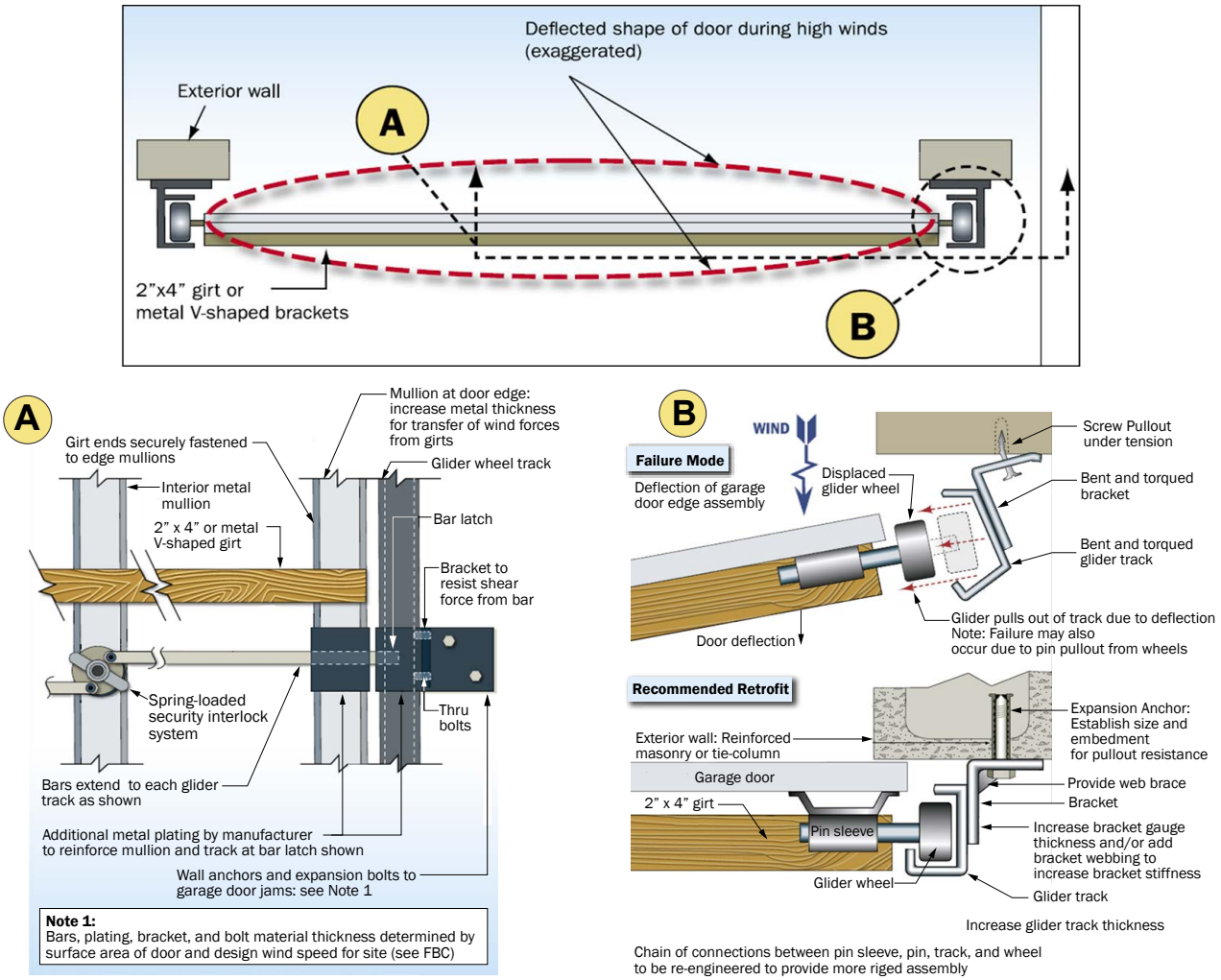


Figure 3.2.5. Recommended details for upgrading garage doors.

When evaluating this option, consider the following:

- Extend latches, add wooden 2" x 4" or steel girts, strengthen glider tracks and wheel axles and improve anchor connection of garage door brackets into the walls of apparatus bays.
- Install a center post brace to the garage door that is anchored into the garage slab and the ceiling framing to reduce the unbraced length of the garage door for additional protection. This approach is active mitigation, requiring a person to install the brace, which prevents the garage door from opening until the brace is removed.
- Install impact-resistant shutters in front of existing garage doors. This is an active mitigation measure, so a person must be available to close and secure the shutters before the event and then open them after the event.

- Replace existing doors with debris-impact-rated doors.
- Make sure any replacement doors are rated for the wind speed and wind pressure in the area where the building is located.
- For added protection, install garage doors that exceed code requirements.
- Design professionals should consider new sectional and rolling door assemblies that comply with wind load testing in accordance with ASTM E1233, *Standard Test Method for Structural Performance of Exterior Windows, Doors, Skylights, and Curtain Walls by Cyclic Air Pressure Differential* or the Door and Access Systems Manufacturers Association International (DASMA) Technical Data Sheet 115, *Standard Method for Testing Garage Doors: Determination of Structural Performance Under Missile Impact and Cyclic Wind Pressure*, respectively.

CONSIDERATIONS:

Mitigation Solutions: For Window Openings

Like exterior doors, windows can allow wind and water to enter buildings, resulting in damage to structural components, inside finishes, and contents. Mitigation solutions can prevent wind and wind-driven rain from entering windows and related components.

Option 1: Strengthen Windows

Wind pressure can blow windows into the building's interior. Windows also can fail when struck by flying debris. To improve window performance during hurricanes and floods, consider the following:

- Install windows in stronger frames and ensure window frames are securely attached to the building wall framing to improve resistance to hurricane wind pressures.
- Where windows are not strong enough to resist the wind pressures, reinforce these frames by installing screws through the window jamb into the house framing.
- Install screw anchors through the window jamb into block walls (Figure 3.2.6). The screw anchors must be long enough to penetrate the window jamb, shim space, and buck strip in addition to penetrating the masonry wall by about 1 ½ inches similar to methods included in Florida Division of Emergency Management, Bureau of *Mitigation's Hurricane Retrofit Guide Openings (Windows and Doors)*. The depth and size of fastener as well as spacing of required fasteners depends on the size of the opening and the design wind requirements at the building site. The design engineer should determine these requirements.

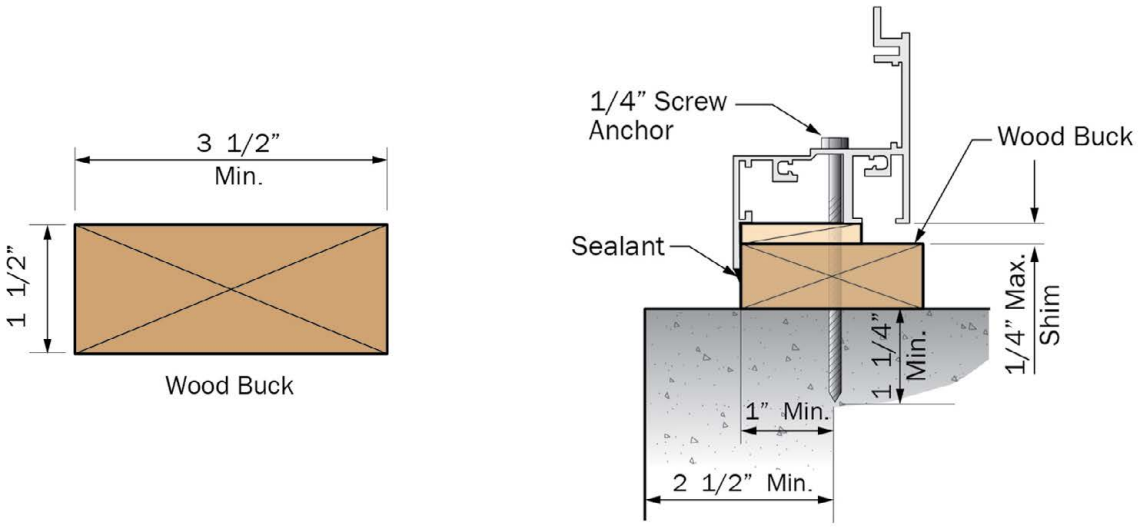


Figure 3.2.6. Use screw anchors to fasten window frames directly to concrete.

- Ensure that wall sheathing and wall framing connections to the window header are strong enough to resist wind uplift and positive and negative horizontal wind pressures, as shown in Figure 3.2.7.

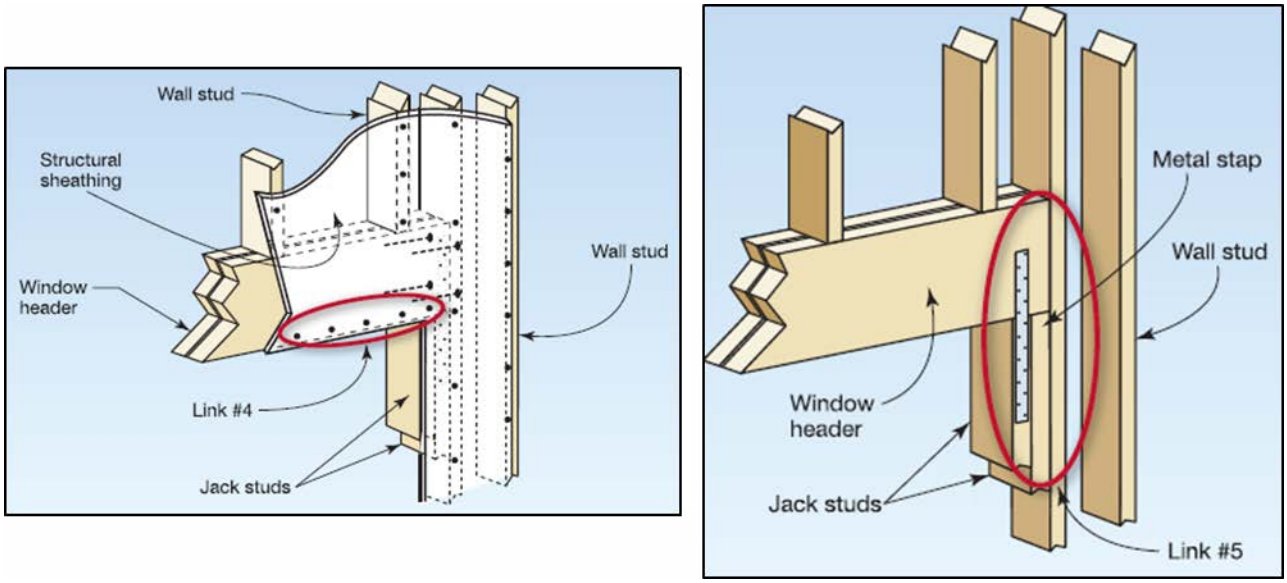


Figure 3.2.7. Connection of wall sheathing to window header (left) and window header to exterior wall (right) as part of a wall framing system.

CONSIDERATIONS:

Option 2: Retrofit with Impact-Resistant Glazing

Wind-borne debris can shatter windows, posing a safety threat to building occupants from flying glass shards and allowing rain, floodwater, and wind to enter the building through the window opening. Impact-resistant glazing can help strengthen windows. Impact-resistant glazing can include laminated glazing systems and polycarbonate systems:

- Laminated glazing systems are made with two or more glass panes and an interlayer of film laminated into the assembly. The glass panes may be broken by wind-borne debris, but the interlayer will remain intact to prevent wind and wind-driven rain entry. Laminated glazing systems also may increase the energy efficiency of the building.
- Polycarbonate systems are plastic resins that are molded into sheets that provide lightweight, clear panels with high impact-resistance qualities. The strength of the polycarbonate sheets can be up to 200 times higher than existing non-laminated glazing.

When evaluating this mitigation option, consider the following:

- Replace existing glass windows with impact-resistant glazing that mitigates hurricane wind pressures and wind-borne debris impact.

CONSIDERATIONS:

Option 3: Install Storm Shutters

Install storm shutters to prevent windows from breaking because of hurricane wind pressure and wind-borne debris impact. Storm shutters must be securely connected to the wall framing. Storm shutter deployment is an active mitigation measure that requires manual installation, so adequate time must be available before the storm to complete the task. It may require equipment in addition to labor to reach the upper levels of buildings. Figure 3.2.8 shows a variety of available shutter types.

Figure 3.2.8. Examples of storm shutter styles.

Consider the following when evaluating this mitigation option:

- Only install shutters that have a label indicating they have been tested and are building code compliant.
- The Engineered Wood Association's Hurricane Shutter Design (APA T450) provides guidance for building and installing wood panel shutters. If wood panels are installed, it is important to adequately anchor them so that they do not become wind-borne debris. The International Building Code, Section 1609.2, gives guidance regarding panel thickness.
- Detailed information about window installation is provided in Standard Practice for Installation of Exterior Windows, Doors and Skylights (ASTM E2112), which concentrates on detailing and installation procedures to minimize water entry.

CONSIDERATIONS:

REFERENCES:

Detailed technical information on hurricane mitigation of wall systems and openings can be found in these publications. Much of the residential information also applies to non-residential buildings.

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