Pacific Northwest
NATIONAL LABORATORY

Providing Content for the Building America Solution Center

October 2023
Revised 2-3-2025

Theresa L Gilbride
Christian E Kaltreider

U.S. DEPARTMENT OF ENERGY
Prepared for the U.S. Department of Energy
under Contract DE-AC05-76RL01830

Click here to enter text.

Providing Content for the Building America Solution Center

October 2023

Revised 2-3-2025

Theresa L Gilbride
Christian E Kaltreider

Prepared for
the U.S. Department of Energy
under Contract DE-AC05-76RL01830

Pacific Northwest National Laboratory
Richland, Washington 99354

Summary

This document provides guidance for researchers and contractors who are providing content for the U.S. Department of Energy's Building America Solution Center, a free, online resource for builders, contractors, and others in the residential construction industry. The Solution Center was developed and is maintained for DOE by the Pacific Northwest National Laboratory.

Contents

1.0 Introduction

Most Solution Center content is in the form of Guides, which provide information for builders, contractors, and others on how to install various energy-efficiency measures and other aspects of home construction. Each Guide describes one topic or measure. Most guides contain nine tabs. (These tabs are described in detail in the sections below.)

1. Scope
2. Description
3. Success
4. Climate
5. Training
6. CAD
7. Compliance
8. Retrofit
9. More.

Please submit each Guide as a separate Microsoft Word document with no EERE formatting.

Building America Research Teams

Before preparing a guide for submission, if you have not already done so, please contact your NREL research coordinator Connor Dennehy or Nick Cindrich. Please submit a draft of your guide to NREL as a Word file, along with any graphics files and CAD files. NREL will facilitate the peer review of the guide and will forward the reviewed draft files to PNNL for final review.

National Laboratories, Contractors to National Laboratories, and Other Submitters

Before preparing content for submission, please check with Theresa Gilbride at PNNL, 509-371-6047, Theresa.gilbride@pnnl.gov. Please review and clear any content for submission to the Building America Solution Center using your organization's internal peer review process. Please send the final reviewed and approved Solution Center content and image files to Theresa Gilbride. Contractors, please submit your content to your national laboratory contact for review and submission to PNNL. If your submission includes numerous files and/or large files, contact Theresa to send you a link for transmitting files via PNNL's file transfer tool. PNNL staff cannot access DropBox.

1.1 Time-Saving Tips for Submitting Solution Center Content

Avoid formatting the Word document for BASC content. Avoid the EERE template, don't center images or text, avoid using different colored fonts.

Keep it simple. Utilize text, images, and schematics you have previously created.

Don't duplicate effort. Copy and paste relevant information from similar guides that are already in the Solution Center or link to those guides where relevant rather than repeating information.

No need to type full references. Just provide the source URL. We can create the full reference.

No need to provide an exhaustive list of resources. Name a few of your favorite related resources. Use resources that are less than 10 years old if possible.

Use images from Building America, DOE, EPA, or other government programs so you don't need to fill out a permission form.

Avoid follow up after your final deliverable. Provide all of the relevant image files with your final report. Give your text a second read-through, or have someone else in your organization do a read-through before submitting it.

2.0 Writing your Guide

Use the tab titles as headings to organize your content.

2.1 General Tips

Here are general tips for writing Building America Solution Center content:

- Use Microsoft Word for the text.
- If there is no content for a tab, such as CAD files, state "None Available" after that heading in the Word file.
- If tables are to be included, type them in the Word file, rather than inserting them as an image.
- Avoid using brand names.
- If you would like any text to be a link (for example, a link to another Solution Center guide, to a program, or to a reference) use MS Word's hyperlink feature to hyperlink the text and include the url in brackets after the hyperlink.

Please include the following information at the beginning of the Guide document.

- Date content was submitted to NREL or PNNL.
- Guide Title (also note if this is a full guide or an information guide)
- Authors: your company name, your name, phone and email of best author to contact.

Specific instructions regarding content for each Guide tab are provided below.

2.2 Scope Tab

This is an outline of the steps a contractor should take to complete this task. If this guide is more informative that instructive, this bullet list should include the key points.

2.3 Description Tab

This tab is where most of the information in the guide is located. Provide an overall explanation of the measure, including an introduction, one or more options for techniques or materials to use in completing the measures, and pros and cons of each if more than one is given. Include as many images as reasonable. Images and schematics are often the best way to explain a concept and keep readers' interest.

If the guide is a guide specifically for existing homes, include in the Description how you will access the area of the home that will be renovated as described in the measure.

Under a "How to …." heading (usually at the end of this tab), write out specific numbered steps for implementing the measure. Use drawings and/or photos to illustrate the steps. See Appendix A for guidance on submitting images.

In-Text References: Please directly link any references, resources, codes, standards, or programs mentioned in the text to the source URL. We can provide a properly formatted reference based on the source you link. When stating a fact backed by a reference, list the author and date in parentheses and link to the report, etc. This guidance applies to all tabs.

Figures:

Include images in text in the Word file. Also please submit images as separate jpg, png, or gif files. In the Word file, immediately after the image, please include the following:

- a full-sentence caption that describes what the image shows
- the image source.

If the image has been used in a published report or article, cite that published document as the source (include title, author, organization, date, and url). If the reference is already in the Solution Center, just list the exact title and the Solution Center url. If the image was produced by you and has not been published elsewhere, list your company name and url as the source and note "unpublished".

Because all images in the Solution Center are available to the public for free download, if the image was from a nongovernment, private or commercial source, please obtain that organization's permission to make the photo or drawing publicly available via the Solution Center and include their permission when providing the guide and images to PNNL. See the appendix to this document for a copyright permission form that can be used to obtain permission from non-government sources for any artwork or photographs obtained for use in the Building America Solution Center. If you or your organization is the source of the image, you don't need to fill out the copyright form. Permission for use and dissemination of the artwork is included in the contract.

2.4 Ensuring Success Tab

This is somewhat of a catch-all tab to reiterate vital concepts for a successful project as well as to list any health, safety, durability, and performance issues, and test-in/test-out requirements that need to be considered when completing this measure. Content for this tab is often short. If the guide is specifically for existing homes, you can address assessment of the home's current condition by referencing one or more of the Assessment Guides for Existing Homes that can be found in the BASC.

Pre-Retrofit Assessment of Attics, Ceilings, and Roofs

Pre-Retrofit Assessment of Walls, Windows, and Doors

Pre-Retrofit Assessment of Crawlspaces and Basements

Pre-Retrofit Assessment of Combustion Appliances

Pre-Retrofit Assessment of Hazardous Materials

Pre-Retrofit Assessment of Existing HVAC Systems

Pre-Retrofit Assessment of Ventilation Systems.

If the guide is for new homes, the relevant pre-retrofit assessment guides can be linked from the Retrofit tab, described below.

2.5 Climate Tab

Note climate-specific guidance related to the topic. Refer to the IECC climate zones and reference the IECC map as needed. Include climate-specific requirements, if any, from codes and standards and DOE programs such as ENERGY STAR and DOE Zero Energy Ready Home.

If there is no climate-specific information for the topic, state "No climate-specific information applies" after the Climate heading.

If implementation of a measure varies significantly based on the climate zone (e.g., vapor barriers), make these climate distinctions clear in the Description text as well.

2.6 Training Tab

Training materials consist of right and wrong images, presentations, and videos. This is a great place to include additional images you have that may not fit into the Description text. We also welcome presentations, recorded webinars, and videos that you or others have prepared on the topic.

Right and Wrong Images

Photographs showing the building concept applied correctly and incorrectly are great. Arrows or circles may be included on the image to draw attention to the specific problem or solution, but these details must be part of the image file. Insert the image in the Word file and follow with the file name, image title, and source (as noted above, if this image was used in a publication, please provide the publication info; if the image hasn't been used in a publication, just note unpublished). The image title should start with the word "Right -..." or "Wrong - …" and the title should clearly say what is right or wrong in the image. Please also provide the image file as a separate jpg, png, or gif file.

PowerPoint Presentations

Presentations should be publicly available from reputable sources where copyright and use will not be an issue or for which you have obtained permission. This could include ".gov" websites and presentations your team or others have produced with government funding.

In your Word document, please include the following information for each presentation:

- A url link to the presentation
- Title
- Authors
- Organization
- Publication or Presentation Date.

- If the presentation is not posted to an accessible internet site, please provide the presentation to NREL/PNNL as a PDF.

Videos and Webinars

Videos are a great addition to your content. Please provide us a YouTube or Vimeo link. The video should be your own or from a source where copyright and use will not be an issue. This could include federal, state, or city government websites, public universities, and video content your team or others have produced with government funding, or video from other sources such as industry associations from which you have obtained written permission to use the video or webinar. (There is a copyright permission form in Appendix A.)

In your Word document, please include the following information for each video:

- A link to the video
- Title
- Authors
- Organization
- Publication Date
- A transcript of the video (see below under 508 Compliance).

The best way to provide the video to NREL or PNNL is as a link (to the website or YouTube url for the video). If the video is not located at an accessible url, contact PNNL about providing the video file to us as an MP4 file.

508 Compliance - To meet Section 508 accessibility compliance requirements, all videos should be accompanied by a transcript file (TXT, DOC, or PDF formats are all acceptable). For new videos, closed captions should also be provided, synchronized with the soundtrack.

2.7 CAD Tab

For building assembly details, CAD files can be very helpful. For each CAD image, please provide the image in the following three file formats; all three should have the same file name but different extensions:

- a .DWG CAD file
- a PDF of the CAD image
- a JPG, PNG, or GIF image of the CAD file suitable for display in the Guide.

Insert a copy of the display image in the Guide document and add the following information after it:

- the image title
- the author of the image
- the organization
- the image source.

If the CAD file was not produced by you, or with government funding, please provide a completed permission form for its use. Please remove company names from the CAD image.

2.8 Compliance Tab

List codes, standards, and programs that have requirements relevant to the Guide topic. Include the name of the program, code, or standard and its version or edition year in the title. Include any applicable section titles and section numbers after the title.

Potentially relevant codes and programs include the International Energy Conservation Code, the International Residential Code, other applicable I Codes, other standards (e.g., ANSI, ASHRAE), and relevant program criteria from the DOE Zero Energy Ready Home program, ENERGY STAR Certified Homes, EPA Indoor airPLUS, etc. Please provide a url for the code or standard document. If the code or standard itself is available by purchase only, then provide a url for the organization.

If there are any codes or standards issues that would pose a barrier to the measure described in your guide, identify those barriers and any work-around solutions in the Compliance tab.

2.9 Retrofit Tab

This tab should appear on all full new home guides. The purpose is to describe any details that would differ when implementing the measure in an existing home rather than a new home. If there is little or no difference, simply state "The information in this guide applies to new and existing homes."

If there is more extensive guidance, it can be arranged under subheadings (Scope, Description, Success, Climate, Training, CAD, Compliance, and More). Please link to the DOE Standard Work Specifications tool https://sws.nrel.gov/ if it contains any guidance specifically relevant to the topic.

Common health and safety issues have been addressed in seven information guides listed and linked below. You may link to any of these that are appropriate to the topic of your guide:

Pre-Retrofit Assessment of Attics, Ceilings, and Roofs

Pre-Retrofit Assessment of Walls, Windows, and Doors

Pre-Retrofit Assessment of Crawlspaces and Basements

Pre-Retrofit Assessment of Combustion Appliances

Pre-Retrofit Assessment of Hazardous Materials

Pre-Retrofit Assessment of Existing HVAC Systems

Pre-Retrofit Assessment of Ventilation Systems

For the retrofit Description subheading, there is no need to repeat all of the installation steps. Just note any differences from the original new home instructions, including changes in materials and sequencing, or additional steps. Note where the additional steps fall in relation to the original numbered steps, e.g., "Before step 1…" or "Between steps 1 and 2."

Under Training, include any additional videos or right/wrong images that are specific to retrofits.

2.10 More Tab

Contributors

Please list the name of your organization and the name of any other organizations who contributed significantly to the information in this guide. Include a url for each organization.

Case Studies and References and Resources

List case studies and references pertinent to the topic.

Case Studies

If you are citing case studies that are already in the Building America Solution Center, please include the full title and Solution Center URL.

Case studies by others should come from peer-reviewed, reputable sources. Please include the title and url.

Building America Teams: if you are developing a case study as part of work under a Building America contract, please work with your NREL research coordinator to have the case study peer reviewed and formatted before including it with your guide for uploading to the Solution Center.

2.11 References and Resources

List all references you wish to include as supplementary resources. Please include any references cited in text. Please include only published sources from reputable, preferably peer-reviewed, sources. References could include reports, journal articles, conference papers, web pages, etc. Please include the title, authors, organization, date, and url. For webpages, if no date is available, please include the date accessed.

Appendix A Copyright Permission Forms

All images in the Solution Center are available to the public for free download. A permission form (Appendix A) should be filled out for any figure or picture that was not created using federal government dollars. Stock images or images randomly pulled from the Internet cannot be used. If you would like to use an image that was produced by another nongovernment-funded source, please use the permission form to obtain permission from the image creator allowing DOE to use and share the image. To help save time, forms can be filled out with inclusive language to cover multiple images from the same source.

BASC Copyright Permission Form

Please use this form for all images that are not publicly available, or funded by the U.S. Government, and that are to be used in websites or documents produced by the U.S. Department of Energy's Building America and Building Technology Programs.

The undersigned, as owner of all rights, including, copyrights, in the work titled:
_____
_____ (the "work"), does hereby irrevocably grant permission to the U.S. Department of Energy and its contractors to use this work (including any photographs and graphic images) on websites or in documents, and hereby grants an irrevocable license to third-party entities public and private to view and use or modify the work for other uses (e.g., images and text are available for download into other applications for third-party use). To the best of your knowledge, this permission and the license granted herein do not infringe on any third-party rights.

Should the submitted material be used in a U.S. Department of Energy website or document, the Contributor agrees that it will not claim or imply any endorsement by DOE of any of its products or processes.

Permission and license granted:

By (signature): _____
Printed Name: _____
Title (if signing on behalf of a Company or Institution):
_____
Date: _____

Company/Institution Name (if Applicable) and Address:
_____
Telephone: _____Fax: _____
Email: _____
Requested Credit Line (if applicable; for example, "Courtesy of ABC Company"):
_____

Please scan or pdf and email this completed Copyright Permission Form to:

The Building America Solution Center Files

basc@pnnl.gov

Appendix B: Example Solution Center Guide Submission

This Appendix provides an example of how to format and submit content for each of the nine tabs within a Guide. Format the text in an MS Word file as you would like to see it in the Solution Center. See the finished product for reference in the Solution Center here: Lateral Bracing in Gable End Walls.

New BASC Disaster Resistance Guide to Add

Lateral Bracing in Gable End Walls

Scope

Install lateral bracing in gable end walls to ensure the building will resist design wind pressures. This guide provides an overview of lateral bracing in gable end walls with a focus on applications in hurricane-prone regions or other high-wind areas.

- Determine if the house is in a hurricane-prone region or other high-wind area (See Climate Tab)
- Determine if bracing is required for gable end walls.
- Determine if additional sheathing on the gable end wall is required.
- Strengthen the gable end wall connection to the wall below.
- Brace gable end walls to resist wind forces by installing a framing assembly at each gable wall stud that is taller than three feet: the framing assembly incudes horizontal braces, vertical retrofit studs, and compression blocks.

See the Compliance Tab for related codes and standards requirements, and criteria to meet national programs such as DOE's Zero Energy Ready Home program, ENERGY STAR Certified Homes, and Indoor airPLUS.

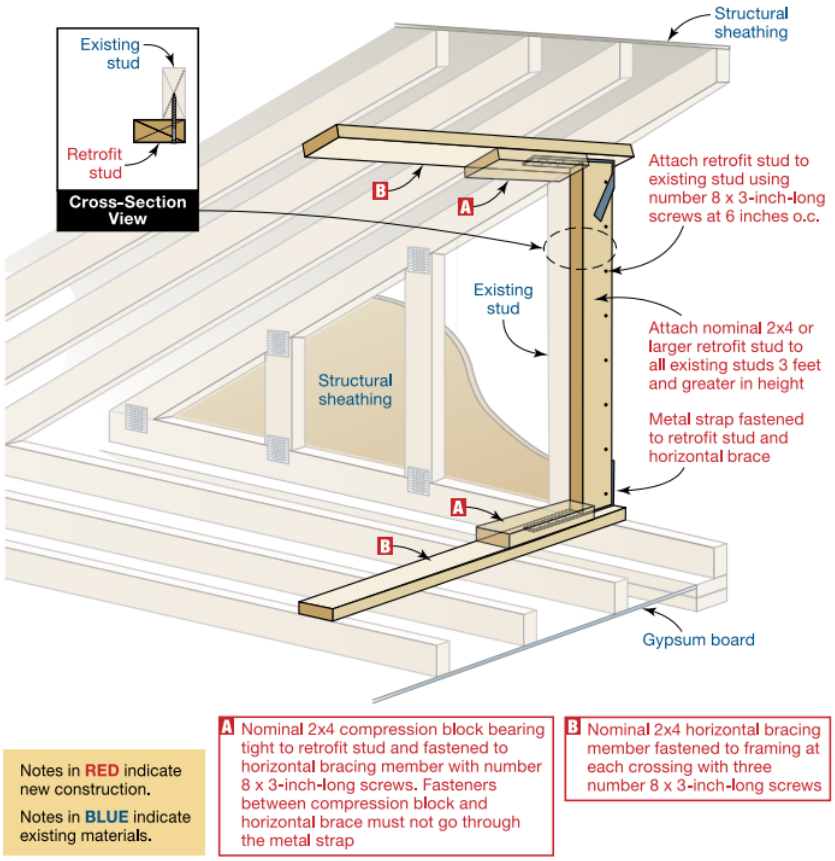


Figure S. Gable End Wall Bracing (Source: FEMA P-804 2010)
<Image is in BASC as "Right - Horizontal bracing is added to strengthen the gable end wall.
FileName: GableEndBrace-F1_LateralBrace-FEMA2013.jpg>

Description

Gable end walls are the triangular sections of wall that extend above the top plate at the gable ends of houses with gable roofs. Gable end walls that are inadequately braced or improperly anchored are vulnerable to collapse during high winds.

During a hurricane, tornado, or high winds, gable end walls can be damaged or detached from the rest of the structure, leading to severe damage to the roof and other structural members of the house (Figures 1 and 2). A compromised gable end wall can allow rainwater to enter the building causing severe damage, including saturation of insulation and ceiling drywall, potentially leading to collapsed ceilings and extensive damage to the interior of the home and its contents.

Figure 1. This gable end wall failed because connectors were missing at the points of support (blue circles) and the outlookers were not connected to the end truss (yellow circle). (Source: FEMA P-2077 2020)
<In BASC as "Wrong – This gable end wall failed because connectors were missing at the points of support (blue circles) and the outlookers were not connected to the end truss (yellow circle)"
Filename: GableLateralBraceFailure-FEMA2020.jpg>

Figure 2. This roof structure failed during a hurricane due to inadequate bracing of the gable end trusses. (Source: FEMA, Building Performance: Hurricane Andrew in Florida, https://www.fema.gov/media-library-data/20130726-1611-20490-8788/fia22_sec2.pdf)
Image title: Wrong – This roof structure failed due to inadequate bracing.
Filename: RoofTrussFailLateralBrace-FEMA2020.jpg
<Intern, see if this fig is in BASC, if not add it, then add here. See if source is in BASC, if not add it, and link it here and on More tab>

How to Install Lateral Bracing in Gable End Walls

1. Strengthen the gable end wall, as required:
    - Minimum 3/8-inch structural wall sheathing over the entire gable end wall
    - Maximum 24-inch spacing between studs on gable end walls.
2. Strengthen the gable end wall connection to the wall below using metal bracket connectors and one of the following methods:
    - Attach the bottom chord of the gable end wall to the wall below using right angle gusset brackets consisting of 14-gauge or thicker material with a minimum load capacity of 350 pounds. Install the right-angle gusset brackets along the wall where the gable end wall height is greater than 3 feet at the spacing specified in Table 1 below. Use a minimum of two fasteners specified by the manufacturer to attach the angle gusset bracket.
    - For a conventionally framed gable end wall, attach each stud along the wall where the height of the wall is greater than 3 feet to the bottom plate using a stud-to-plate connector. Connect the bottom plate to the wall below using 4.5-inch, ¼-inch-diameter screws.

Table 1. Spacing of right-angle gusset brackets connecting the gable end wall to the wall below as recommended by the IBHS Fortified Home program
(Source: FORTIFIED Home High Wind Standard)

Exposure Category	Wind Speed, mph	Maximum Spacing of Right-Angle Gusset Brackets
	Maximum 3-Sec. Gust	
C	110	38 in.
C	120	32 in.
C	130	28 in.
C	140	24 in.
C	150	20 in.
B	110	48 in.
B	120	40 in.
B	130	36 in.
B	140	30 in.
B	150	26 in.

For steps 3 through 5, refer to Figure 3.

3. Install horizontal bracing, perpendicular to the gable wall, at the bottom chord or ceiling joist, and at the top chord or roof rafter, at each gable end wall stud greater than 3 feet high. Attach bracing using three #8 x 3-in. screws at each truss chord or rafter and joist.
4. Attach a vertical retrofit stud, between the upper and lower horizontal bracing, to each existing gable wall stud.

- Attach retrofit stud to upper and lower horizontal bracing using metal straps, minimum 20-gauge x 1-1/4-in. wide with pre-punched fastener holes, using #8 screws.
- Attach retrofit stud to existing stud using #8 x 3-in. screws at 6 inches on-center.
- The maximum allowable gap between the retrofit stud and bracing is 1/8-in. at the lower brace and 1/2-in. at the upper brace.

5. Install compression blocks on horizontal bracing bearing tightly against the vertical retrofit stud, to restrain horizontal movement. Attach compression blocks using three #8 x 3-in. screws; screws must not go through the strapping.

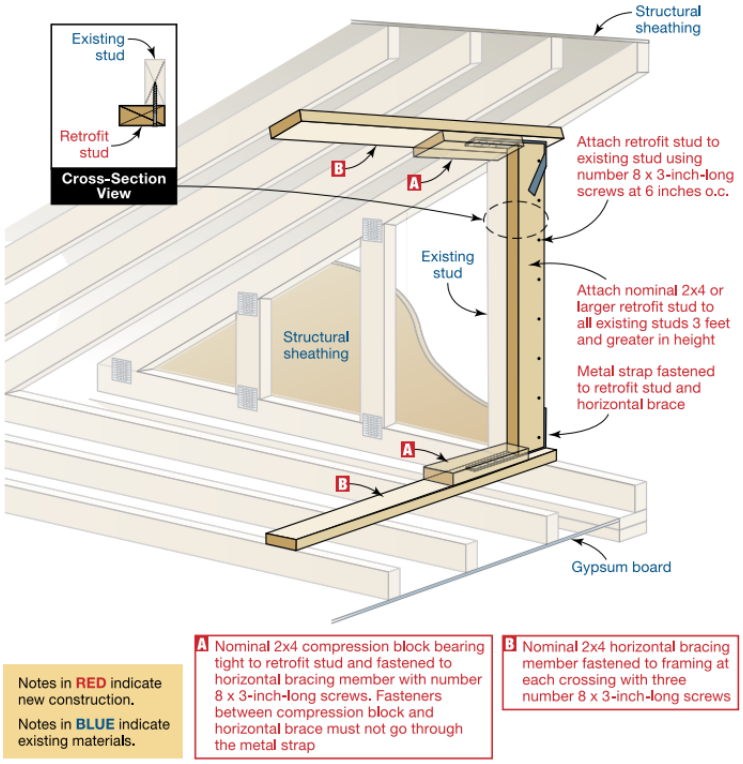


Figure 3. Horizontal bracing is added to strengthen a gable end wall (Source: FEMA P-804 2010)
<Image is in BASC as "Right - Horizontal bracing is added to strengthen the gable end wall. FileName: GableEndBrace-F1_LateralBrace-FEMA2013.jpg>

Success

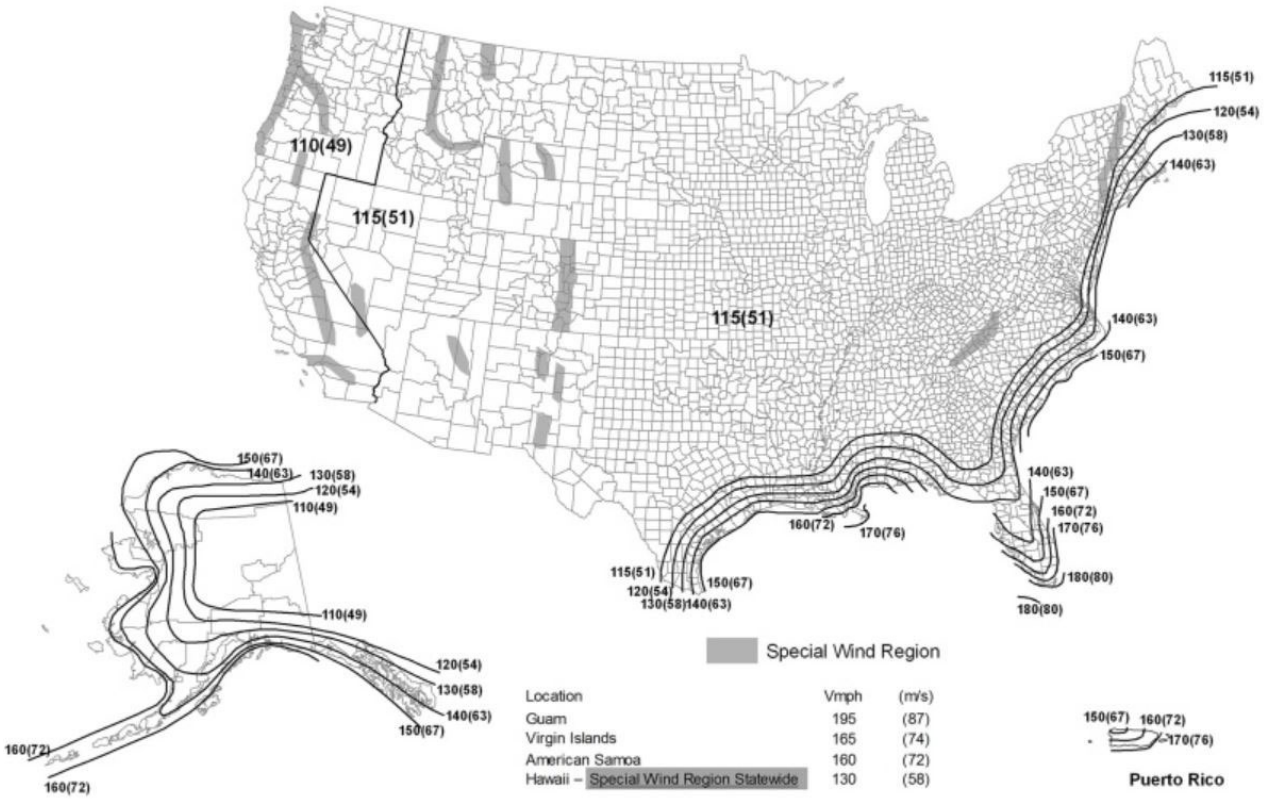
Dimensional lumber used for braces, studs, and blocking should conform to applicable standards or grading rules. Metal plate connectors, straps, and anchors should have product approval and should be approved for connecting wood to wood. Straps and tie plates should be manufactured from galvanized steel with a minimum thickness provided by 20 gauge and have holes sized for 8d nails.

See if local building codes have specific requirements or ask the local building department. For disaster resistance, comply with the roofing requirements defined by the IBHS Fortified Home Program.

Climate

The International Residential Code (2018) does not have specific requirements for gable end wall bracing but general requirements for wood wall framing are provided in Section R602.

Homes located in coastal high-wind areas including hurricane-prone regions (Figure 1) generally require enhanced attachment that can withstand greater wind speeds than the rest of the country. The IRC defines hurricane-prone regions as areas along the Atlantic and Gulf Coasts where wind velocity is >115 mph, and Hawaii, Puerto Rico, Guam, the Virgin Islands, and American Samoa.



Wind Region Terminology
Hurricane-Prone Regions: Areas along the Atlantic and Gulf coasts where wind velocity is >115 mph, and Hawaii, Puerto Rico, Guam, Virgin Islands, and American Samoa.
High-Wind Areas (not code defined): Generally where wind velocity is >115 mph, including portions of Alaska

Figure 1. U.S. Wind Regions as identified in the International Residential Code (Source: Figure R301.2(5)A Excerpted from the 2018 International Residential Code) <figure in BASC>

The Insurance Institute for Business and Home Safety® (IBHS) offers guidance, best practices, and voluntary construction standards and programs for building in disaster-prone areas including hurricane

and other high-wind zones. The IBHS FORTIFIED Roof™ program includes guidance on sealed roof decks, flashing, and shingle attachment.

Training

Right and Wrong Images

Figure 7-14.
Improperly braced gable walls. The ceiling diaphragm (i.e., the bottom chords of the scissor truss) is located several feet above the top of the end wall top plate and no wall-to-truss bracing is provided. (Source: FEMA 549)

Image Title: Wrong – This house under construction is lacking wall-to-truss bracing and the bottom chord of the scissor trusses is several feet above the top of the end wall top plate.
NoBrace-F6-LateralBrace-FEMA2020.jpg

Figure 7. The most common gable end failure is one where the wall loses support along its top edge because sheathing is blown off. The wall may fold outward or be blown inward.

Source: Fortified Home Hurricane Standards
Wrong – The roof sheathing was inadequately fastened and gave way causing the gable end wall to fail.
Filename: RoofSheathFail-F7-LateralBrace-FEMA2020.jpg

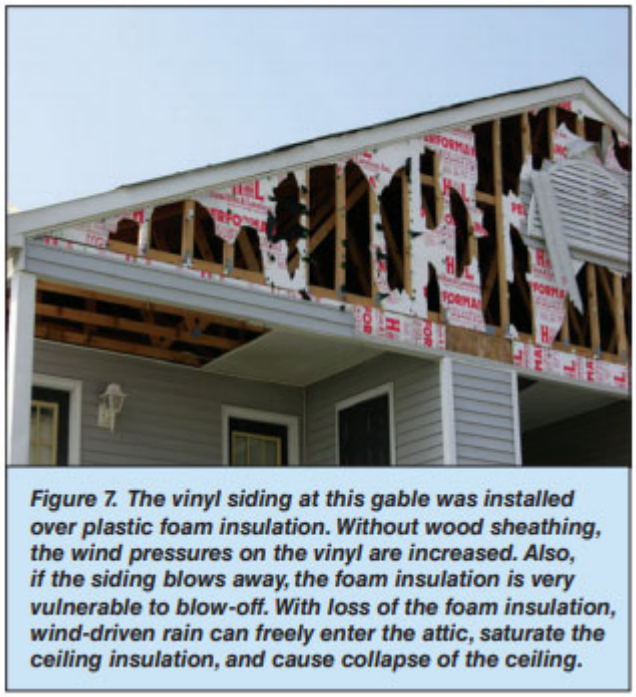


Figure 7. The vinyl siding at this gable was installed over plastic foam insulation. Without wood sheathing, the wind pressures on the vinyl are increased. Also, if the siding blows away, the foam insulation is very vulnerable to blow-off. With loss of the foam insulation, wind-driven rain can freely enter the attic, saturate the ceiling insulation, and cause collapse of the ceiling.

Figure: Wrong – The gable end wall failed because the rigid foam sheathing was not backed up by plywood or OSB.
Source: FEMA P-499 Home Builder's Guide to Coastal Construction, Technical Fact Sheet No. 5.3

Presentations

None Available

Videos

FORTIFIED Animation: Hurricane & HWH - Gables <in BASC>

IBHS' Guide to Gable End Bracing <in BASC>

CAD

None Available

Compliance

International Residential Code (2012-2021)

R802.10.3 Bracing. Trusses shall be braced to prevent rotation and provide lateral stability in accordance with the requirements specified in the construction documents for the building and on the individual truss design drawings.

Table R802.11 provides rafter or truss uplift connection forces from wind.

R802.11.1 Uplift resistance.

R803.2.3. Installation. Wood structural panel used as roof sheathing shall not cantilever more than 9 inches (229 mm) beyond the gable end wall unless supported by gable overhang framing.

IBHS FORTIFIED Home High Wind Standard (2019)

"Gable end walls must have structural wall sheathing (minimum of 3/8-in. plywood or OSB or equivalent)."

"Gable end walls need to be braced."

Section A103.6.1 Screws.

Section A103.6.2 Nails.

Section A103.7 Fastener Spacing

A104.2 Horizontal Braces.

A104.6 Connection of gable end wall to wall below.

More

FEMA P-2077, Mitigation Assessment Team Report Hurricane Michael in Florida Building Performance Observations, Recommendations, and Technical Guidance

<in BASC 2020>

IBHS FORTIFIED Home Hurricane Standard

<In BASC 2019>

IBHS FORTIFIED Home High Wind Standard

<in BASC 2019>

FEMA P-804, Wind Retrofit Guide for Residential Buildings

<in BASC>

Hurricane Retrofit Guide
<In BASC 2010>

Contributors to this Guide

Home Innovation Research Labs

Retrofit

The FEMA Wind Retrofit Guide for Residential Buildings (FEMA P- 804) has information for retrofitting existing gable end walls in residential buildings.

1. Check the stud spacing and wall connections for the existing gable end walls.

- Conventionally framed gable end walls can be strengthened by using straps or right-angle brackets to anchor each stud longer than 3 feet to the upper and lower framing members (frequently existing studs are only toe-nailed).

2. Vertical framing members can be strengthened by installing retrofit studs that are adjacent to the gable end wall stud and extend from the top of the lower horizontal brace to the bottom of the upper horizontal brace.
   - The retrofit stud is a nominal 2-inch lumber member used to structurally supplement an existing gable end wall. A maximum gap of 1/8 inch is permitted between the retrofit stud and the bottom horizontal brace and ½ inch is permitted between the top edge of the retrofit stud and the horizontal brace.
   - Fasten each retrofit stud to the top and bottom horizontal brace members with a minimum of a 20-gauge, 1 ¼ inch wide flat metal strap with pre-punched fastener holes. The strap should be fastened using #8 wood screws or 8d nails. They should also be fastened to the side of the vertical gable end wall studs with #8 wood screws or 10d nails spaced at 6 inches o.c.

Step 3: Follow the steps in the Description Tab to install lateral bracing as required.

Step 4: Ensure the sheathing thickness is at least 3/8 inch and re-nail sheathing if required.