Gable End Bracing

Retrofitting Gable Ends to Improve their Resistance to Hurricanes and High Winds

The section is intended for applications where the gable end wall framing is provided by a wood gable end wall truss or a conventionally framed rafter system. The retrofits are appropriate for wall studs oriented with their broad face parallel to or perpendicular to the gable end surface. Gable ends that require strengthening shall be permitted to be retrofitted using methods prescribed by provisions of this section. These prescriptive methods of retrofitting are intended to increase the resistance of existing gable end construction for out-of-plane wind loads resulting from high wind events.
Gable End Bracing

Introduction

Gable ends are the upper triangular walls that rest on rectangular walls. The triangles may be of various proportions and may have a section cutoff. Figures 1 through 6 show a variety of gable ends. The only gable ends for which retrofitting is addressed in this guide are those that have attic space for working. It does not address gable end walls where the room behind the wall has a cathedral or vaulted ceiling. Gable ends taller than 4’ are the ones that typically need to be retrofitted. Gable ends which exceed 16’ in height require retrofits designed by an engineer licensed in the State of South Carolina.

*Note: When performing gable end retrofits as part of the South Carolina Safe Home Grant Program, ALL gable ends on the home must be retrofitted in order to meet the intent of the program.*

*Note: These standards are similar to the requirements for the Institute of Business and Home Safety (IBHS), FORTIFIED Home standards.*

Additional information on retrofitting gable ends can be found in the 2015 South Carolina Existing Building Code, Appendix C – Guidelines for the Wind Retrofit of Existing Buildings [https://codes.icesafe.org/content/chapter/7321/](https://codes.icesafe.org/content/chapter/7321/)
Figure 1. House with large and small gable ends  Figure 2. Large gable at end wall

Figure 3. Gable end with attached chimney  Figure 4. Cut off gable over garage with covered entry to side

Figure 5. Gable end with intersecting shed roof  Figure 6. Gable end over garage and living area
Wind Forces on Gable Ends: Hurricanes push both (inward) and pull (outward) on houses when wind pressures are applied to the home. In fact, the outward acting, negative pressures are higher than inward acting, positive pressures.

Because hurricanes are large powerful storms, a house near the track of the storm may experience strong winds from several different directions. It is hard to know which gable end will experience the highest wind pressures and whether the pressures will be inward or outward acting. Consequently, it is prudent to retrofit all gable ends on a home.

Typical Traditional Construction Practices: Gable ends on older buildings were not designed with the wind forces in mind as those constructed now. Some older gable ends may not have any structural sheathing in place being only covered by the finished siding or stucco.

Types of Failures: There are three main points of failure of gable end walls.

1. First, the most common type of failure is loss of roof sheathing from the gable end that results in the gable wall losing its bracing along the top edge. This type of failure is shown in Figure 7.
2. The second most common type of gable end failure is at the connection where the gable section meets the wall below. See Figures 8 and 9.
3. The third weak link is the actual framing members that make up the gable end wall structure. In many houses, these members are the structural members of the end roof.
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.

Figure 8. The second most common type of gable end failure is at the connection between the rectangular and triangular walls – here the failure is just starting.
Figure 9. The most common result of wall connection failures is a missing gable end wall and the wall below.

*When is it Important?* The taller the gable end triangle, the greater the risk of damage in a hurricane. For gable ends that are less than 4-feet tall, the forces applied by a 140-mph wind gust along the top and bottom edges of the gable end wall will be less than 100 pounds per foot of gable width. Most nailed connections will withstand these forces. In addition, if the gable end is less than about 4-feet tall, it will be difficult for a worker to access the gable end to perform the necessary retrofit work from inside the attic.

*Gable Ends Not Covered in this Guide:* Gable ends on rooms with vaulted or cathedral ceilings pose special problems for retrofitting. Unless care was taken in the design and construction of these walls to provide the kind of bracing they will need to stand up to strong winds, they are very likely to fail. The structural solutions usually involve beams that either span across the width of the wall or columns that span from floor to ceiling. Gable end walls adjacent to cathedral or vaulted ceilings require the retrofit designs of a structural engineer licensed in the State of South Carolina to develop a structural solution for retrofit.
Common Definitions Associated with Gable End Wall Retrofits

ADDED STUD - Studs installed in a gable end wall to provide the required minimum spacing between existing wall studs prior to adding any retrofit studs needed to brace or stiffen the gable end wall.

ANCHOR BLOCK - A nominal 2-in.-thick by at least 4-in.-wide piece of lumber secured to horizontal braces and filling the gap between existing framing members for the purpose of restraining horizontal braces from movement perpendicular to the framing members.

ATTIC-FRAMING MEMBERS - Structural members such as ceiling joists, rafters, and roof trusses that support ceiling diaphragms or roof decking.

BALLOON FRAMING - A type of wall framing where vertical wall framing members of the gable end wall and the rectangular wall below are continuous from the top of the gable end wall to the bottom of the rectangular wall below.

COMPRESSION BLOCK - A nominal 2-in.-thick by at least 4-in.-wide piece of lumber used to restrain in the compression mode (force directed towards the interior of the attic) an existing or retrofit stud. It is attached to a horizontal brace and bears directly against the existing or retrofit stud.

CONVENTIONALLY FRAMED GABLE END - A conventionally framed gable end with studs whose faces are perpendicular to the gable end wall.

EXISTING STUD - A stud in a gable end wall that already exists before the installation of added studs or conducting gable end bracing and stiffening using lateral braces or retrofit studs.

GABLE END WALL - The triangular wall segment at a gable end whose framing members may be conventionally framed, balloon framed, or framed with a truss.

GABLE END TRUSS - A roof truss at an exterior wall with lumber members oriented with their wide faces parallel to the plane of the wall.

GUSSET ANGLE BRACKET - Metal connectors intended by the manufacturer to connect materials at right angles to each other supplied by the manufacturer with fasteners.

HORIZONTAL BRACE - A nominal 2-in.-thick by at least 4-in.-wide piece of lumber used to restrain both compression and tension loads applied by a retrofit stud. It is typically installed horizontally on the top of floor framing members (truss bottom chords or ceiling joists) or on the bottom of pitched roof framing members (truss top chord or rafters).
LATERAL BRACE - A lumber member typically installed horizontally on the top of attic floor framing members or on the bottom of pitched roof framing members used to transfer both compression and tension loads applied by a gable wall existing, added or retrofit stud into either the ceiling or roof diaphragm.

NAIL PLATE - A manufactured metal plate made of galvanized steel with factory punched holes for fasteners. A nail plate may have the geometry of a strap.

PLATFORM FRAMING - A type of wall framing where structural framing members of the gable end wall terminate at or above the top plate on the rectangular wall below the gable end wall.

PRIMARY STUD - An existing or added stud as defined above. A vertical member installed against the gable end wall sheathing and connected to the top and bottom chords of the gable end framing that provides the required minimum spacing of structural members supporting the wall sheathing.

RETROFIT STUD - A nominal 2-in. lumber member used to structurally supplement an existing gable end wall stud.

RIGHT ANGLE GUSSET BRACKET - A 14 gauge or thicker metal right angle bracket with a minimum load capacity perpendicular to the plane of either face of 350 lb. when connected to wood or concrete with manufacturer-specified connectors.

STUD-TO-PLATE CONNECTOR - A manufactured metal connector designed to connect studs to plates with a minimum uplift capacity of 500 lb.

TRUSS GABLE END - An engineered factory-made truss or site-built truss that incorporates factory-installed or field-installed vertical studs with their faces parallel to the plane of the truss.
### Table E-1 Material Specifications for Gable End Retrofits

<table>
<thead>
<tr>
<th>Component</th>
<th>Minimum Size or Thickness</th>
<th>Minimum Material Grade or Type</th>
<th>Minimum Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>All lumber</td>
<td>2-inch nominal thickness minimum depth will vary according to application</td>
<td>#2 Spruce-Pine-Fir (S) or better</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Gusset angle bracket</td>
<td>14 gauge thickness</td>
<td>Galvanized sheet steel <em>approved</em> for connecting wood-to-wood, wood-to-CMU, or wood-to-concrete.</td>
<td>350 pounds uplift and lateral load</td>
</tr>
<tr>
<td>Stud-to-plate connector</td>
<td>14 gauge thickness</td>
<td>Galvanized sheet steel <em>approved</em> for connecting wood-to-wood.</td>
<td>500 pounds uplift</td>
</tr>
<tr>
<td>Metal connectors</td>
<td>20 gauge thickness</td>
<td>Galvanized sheet steel <em>approved</em> for connecting wood-to-wood, wood-to-CMU, or wood-to-concrete.</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Nail plates and straps</td>
<td>20 gauge thickness</td>
<td>Galvanized sheet steel <em>approved</em> for connecting wood-to-wood.</td>
<td>Not applicable</td>
</tr>
</tbody>
</table>
Table E-2 Nail and Screw Requirements

<table>
<thead>
<tr>
<th>Minimum Fastener Length (inches)</th>
<th>Fastener Type</th>
<th>Shank Diameter (Neglecting Galvanizing) Minimum and Maximum</th>
<th>Minimum Length of Thread (inches)</th>
<th>Minimum Head Diameter (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1(^1/4)</td>
<td>#8 screws</td>
<td>0.177 inches</td>
<td>1(^1/4)</td>
<td>0.28</td>
</tr>
<tr>
<td></td>
<td>8d common nails</td>
<td>0.131 inches</td>
<td>Not applicable</td>
<td>0.28</td>
</tr>
<tr>
<td>3</td>
<td>#8 screws</td>
<td>0.177 inches</td>
<td>1(^1/2)</td>
<td>0.28</td>
</tr>
<tr>
<td></td>
<td>10d common nails</td>
<td>0.148 inches</td>
<td>Not applicable</td>
<td>0.28</td>
</tr>
</tbody>
</table>

Overview of the Retrofit Process

Retrofitting gable ends to brace the walls entails **two specific activities**.

1. **Strengthening and bracing the gable end** which involves making the triangular shape end wall stronger and anchoring this wall to the roof and ceiling structure.

2. **Strengthening the wall-to-wall connection** which involves connecting the gable end wall to the exterior wall below.

**Strengthening and bracing the gable end:** Figure 10 illustrates the components involved in strengthening a gable end wall. Figure 11 is a photograph of a completed gable end.

**Strengthening the wall-to-wall connection:** This process connects the wall below to the reinforced gable end wall and involves installing straps, brackets, or screws between them to make a strong connection. Figures 19 and 20 detail the connections using various methods for both wood frame and concrete masonry walls.
Figure 10. Overall sketch showing the concept for strengthening and bracing a gable end wall
Figure 11. Photograph of completed gable end retrofit – the light-colored wood is the lumber added during the retrofit activity
Horizontal Braces

Horizontal braces shall be installed perpendicular to the top and bottom chords of the existing roof trusses or perpendicular to the rafters and ceiling joists at the location of each existing gable end wall stud greater than 4 ft in length. If the spacing of existing gable end studs is greater than 24 in. or no vertical gable end stud is present, a stud and horizontal braces shall be installed such that the maximum spacing between existing and added studs shall be 24 in. Additional gable end wall studs shall not be required at locations where their length would be 4 ft or less.

Each required added stud shall be attached to the existing roofing framing members (truss top chord or rafter and truss bottom chord or ceiling joist) using a minimum of two (2) 3-in. toenail fasteners (#8 wood screws or 10d nails) and a metal connector or mending plate with a minimum of four (4) 1¼-in.-long fasteners (#8 wood screws or 8d nails) at each end. The horizontal brace shall be oriented with their long face across the top and bottom chords of the wood trusses (or rafters and ceiling joists) and extend a minimum of three framing spacings from the gable end wall plus 2½ in. beyond the last top chord or bottom chord member (rafter or ceiling joist) as shown in Figure 12. The horizontal brace shall be located no farther than ½ in. from the inside face of the gable end wall truss. Each horizontal brace shall be fastened to each existing framing member (top chord or rafter or bottom chord or ceiling joist) that it crosses using three (3) 3-in.-long fasteners (#8 wood screws or 10d nails).
Continuous Horizontal Braces secured with 3" long fasteners.

Braces to be centered on edge of existing stud where retrofit stud is to be added.

The Horizontal Brace is shown so the Retrofit Stud can be placed on the left.

Requirements:
- Horizontal braces shall be minimum 2x4 lumber.
- The number of horizontal braces must be as the table indicates.
- Horizontal braces must be at least 6’ long unless blocking or decking is used.
- Horizontal braces must be long enough so that fasteners at the far end are no closer to the end of the brace than 2-1/2”.
- Horizontal braces must be fastened to at least 3 framing members.
- 3 fasteners are required to secure brace to each framing member crossed.
- Fasteners must be 3” long 10d nails or #8 screws – longer fasteners are not recommended.
- Using screws on the bottom brace will reduce the risk of damaging ceiling textures compared to hammering nails. Longer fastener are not recommended.
- Spacings of fasteners on the braces is important. 1/2” from edge. Staggered.
- Fasten to as many framing members as possible.

Horizontal Braces

Figure 12 Horizontal Bracing
Figure 13. Installation of upper horizontal brace.
Retrofit Studs

The retrofit studs shall consist of the minimum size members for the height ranges of the existing vertical gable end wall studs. Retrofit studs shall be installed adjacent to the existing or added vertical gable end wall studs and extend from the top of the lower horizontal brace to the bottom of the upper horizontal brace. A maximum gap of ⅛ in. shall be permitted between the retrofit stud and the bottom horizontal brace. A maximum gap of ½ in. shall be permitted between the top edge of the retrofit stud closest to the upper horizontal brace and the horizontal brace surface. See Figure 14.

Retrofit Stud Fastening

Each retrofit stud shall be fastened to the top and bottom horizontal brace members with a minimum of a 20 gauge, 1¼-in.-wide flat metal strap with pre-punched fastener holes. Each top and bottom strap shall extend sufficient distance onto the vertical face of the retrofit stud and be fastened with the number of 1¼-in.-long fasteners (#8 wood screws or 8d nails). Each strap shall be fastened to the top and bottom horizontal brace members with the minimum number of 1¼-in.-long fasteners (#8 wood screws or 8d nails). The retrofit stud members shall also be fastened to the side of the existing vertical gable end wall studs with 3-in.-long fasteners (#8 wood screws or 10d nails) spaced at 6 in. o.c. as shown in Figure 14. Applying construction adhesive where the retrofit stud will contact the existing framing can help strengthen the connection. See Figure 15.
Figure 14. Installation of retrofit stud.
Figure 15. Applying construction adhesive where retrofit stud will make contact with the sheathing
Compression Blocks

Compression blocks shall be installed on the horizontal braces directly against either the existing vertical gable end wall stud or the retrofit stud. See Figure 10 and 17.

When the compression block is installed against the retrofit stud, the block shall be allowed to be placed on top of the strap. A maximum gap between the compression block and the existing vertical gable end wall stud member or retrofit stud of ⅛ in. shall be permitted. Compression blocks shall be fastened to the horizontal braces with the minimum number of 3-in.-long fasteners (#8 wood screws or 10d nails).

Fastening of compression blocks, retrofit stud and horizontal brace can been seen in Figure 18.
Figure 17. Installation of compression blocks.

Requirements
- The number of fasteners shall be as specified on the table.
- Compression blocks shall be lumber no smaller than 2x4.
- The compression block must be long enough to accommodate the number of fasteners specified in the table.
- Fasteners must be a minimum of 2-1/2” apart along the length of the compression block.
- Fasteners must be a minimum of 1” apart from each other side to side.
- Fasteners must be a minimum of 1/2" from the edge of the compression block and the horizontal brace.
- Fasteners must be nails 10d in diameter or #8 screws.
- Fasteners must be no closer to the ends of the compression block than 2-1/2”
Figure 18. Layout of fasteners on horizontal brace for connection to framing members as well as connections of retrofit stud strap and one option for attachment of compression block.
Connection of gable end wall to wall below

The bottom chords or bottom members of wood framed gable end walls shall be attached to the wall below. The particular method chosen shall correspond to the framing system and type of wall construction encountered. See Figures 19 and 20.

Note: Due to access considerations, this retrofit may need to be performed before any of the other gable end retrofit activities.

Figure 19. Gable end walls over conventionally framed wood walls.
Truss gable end wall

The bottom chords of the gable end wall shall be attached to the wall below using right angle gusset brackets consisting of 14 gauge or thicker material with a minimum load capacity of 350 lb. perpendicular to the plane of either face of the connector. The right-angle gusset brackets shall be installed throughout the portion of the gable end where the gable end wall height is greater than 4 ft in height. Brackets shall be spaced 36” apart. A minimum of two (2) of the fasteners specified by the manufacturer shall engage the body of the bottom chord.
Figure 22 Right Angle Gusset Bracket

Conventionally framed gable end wall

Each stud in a conventionally framed gable end wall, throughout the length of the gable end wall where the wall height is greater than 4 ft, shall be attached to the bottom or sill plate using a stud-to-plate connector. The bottom or sill plate shall then be connected to the wall below following the manufacturer’s installation instructions for the metal connector being used.
Appendix A

Appendix A contains various details of gable ends, bracing connections, and fastening specifications. As previously mentioned, each gable even on the same home can differ, so preparation should be made to address each individual gable accordingly.

These details as well as those found in the 2015 South Carolina Existing Building Code, Appendix C – Guidelines for the Wind Retrofit of Existing Buildings [https://codes.iccsafe.org/content/chapter/7321/](https://codes.iccsafe.org/content/chapter/7321/) can assist in determining the exact procedure for varying situations that might be encountered in the field.
Appendix A

Engineering Drawings Showing Gable End Retrofit Components and Connections

![Diagram of gable end retrofit components and connections]

FIGURE A-1  SECTION VIEW OF GABLE END RETROFIT (TRUSS WALL)
FIGURE A-2  DETAILS OF STRAP & COMPRESSION BLOCK INSTALLATION – 2x4 RETROFIT STUD

EXISTING TRUSS GABLE END WALL

EXISTING STUD

MIN. (6) 1/4" LONG FASTENERS Ø FLAT STRAP ANCHOR WRAP

MAX. GAP TO GABLE END

2x4 RETROFIT STUD – ATTACH TO EXISTING STUD W/ MIN. 3" LONG FASTENERS Ø 6" O.C.

2 x 4 COMPRESSION BLOCK
(MIN. 1 1/2" LONG) – ATTACH TO HORIZONTAL BRACE W/ (6) 3" LONG FASTENERS

FLAT 2x4 HORIZONTAL BRACE

2" STACKER

MIN. (3) 3" LONG FASTENERS Ø HORIZONTAL BRACE CONNECTION TO EACH TRUSS

EXISTING FRAMING MEMBER

PLAN VIEW
FIGURE A-3 DETAILS OF STRAP & COMPRESSION BLOCK INSTALLATION - 2x6 RETROFIT STUD
Figure A-4: Details of Strap & Compression Block Installation – 2x8 Retrofit Stud

- **Existing Truss Cable End Wall**
- **Existing Stud**
- **Min. (12) 1/4" Long Fasteners + Flat Strap Anchor Wrap**
- **Compression Block Tight Against Existing Stud (Max Gap 1/8")**
- **2x4 Compression Block – Min. 16" Long – Attach to Horizontal Brace w/ (10) 3" Long Fasteners**
- **2x8 Retrofit Stud – Attach to Existing Stud w/ Min. 3" Long Fasteners @ 6" O.C.**
- **Flat Strap Anchor – Attach to Horizontal Brace w/ Min. (12) 1/4" Long Fasteners**
- **Flat 2x4 Horizontal Brace**
- **1/2" Min.**
- **Existing Framing Member**
- **Min. (3) 3" Long Fasteners @ Horizontal Brace Connection to Each Truss**
- **1/4" Stagger**

**Plan View**
FIGURE A-6  SECTION VIEW OF GABLE END RETROFIT (CONVENTIONAL FRAMED)
FIGURE A-7  DETAILS OF STRAP & COMPRESSION BLOCK INSTALLATION – 2x4 RETROFIT STUD
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FIGURE A-8 DETAILS OF STRAP & COMPRESSION BLOCK INSTALLATION – 2x6 RETROFIT STUD
**Figure A.10** Details of Strap & Compression Block Installation – (2) 2x8 Retrofit Stud

- **Existing Framed Gable End Wall**
- **Existing Stud**
- **Min. (8) 1\(\frac{1}{4}\)" Long Fasteners @ Flat Strap Anchor Wrap**
- **(2) 2x8 Retrofit Stud – Attach to existing stud w/ min. 3" Long Fasteners @ 6" O.C.**
- **Compression Block Tight Against Retrofit Stud (Max Gap 3\(\frac{1}{8}\)"")**
- **(2) 2x4 Composition Block (Min. 17\(\frac{1}{8}\)" Long) – Attach to Horizontal Brace w/ (6) 3" Long Fasteners Each Block**
- **\(\frac{1}{4}\)" Min.**
- **\(\frac{3}{8}\)" Stagger**
- **Min. (3) 3" Long Fasteners @ Horizontal Brace Connection to Each Truss**
- **Flat (2) 2x4 Horizontal Brace**

**Legend:**
- **Existing Framing Member**
- **Plan View**
- **Max. Gap Horizontal to Gable End**
- **Min. 2\(\frac{1}{8}\)""
FIGURE A-11  DETAIL OF ANCHOR BLOCK INSTALLATION
Figure A-12 Detail of Retrofit Stud Splice

- Required Flat Strap Anchor
- Existing Gable End Stud
- Required 2x Retrofit Stud w/ 3" Long Fasteners @ 6" O.C.
- 50" Long Splice Member
  - Match size of Retrofit Stud
  - Center on splice location
- Install minimum (27) 3" Long Fasteners from Splice Member to Retrofit Stud (each side of splice location)
- Required Flat Strap Anchor

NOTE:
Splice location may be required at top of gable end stud if height > 11'-0" to 12'-0"
Figure A-13: Detail of ladder bracing for omitted retrofit stud (truss gable end)
Figure A-14 Detail of ladder bracing for omitted retrofit stud (conventional framing)
Figure A-15: Detail of Retrofit Ridge Tie Installation

- Required 2" retrofit stud – attach to existing stud w/ min. 3" long fasteners @ 6" O.C.
- 2" x 4" compression block of required length – attach to horizontal brace w/ required number of 3" long fasteners
- Install 2" x 4" compression blocking (tight fit) between center existing gable end stud or retrofit stud (top and bottom)
- Center flat 2" x 4" horizontal braces @ side of center existing gable end stud and in line with retrofit stud
- Gable end studs ≤ 3'-0" (but ≤ 16'-0") – no retrofits required per Table 1804.2
- Gable end studs > 3'-0" – required size fasteners per Table 1804.2
- Flat 2" x 4" horizontal braces
- When additional supports are needed for horizontal brace near ridge: min. 2" rafter tie – attach to each intersecting member per section