

APPENDIX C: Guidelines for the Wind Retrofit of Existing Buildings

CHAPTER C1

GABLE END RETROFIT FOR HIGH-WIND AREAS

Appendix C is not adopted by The City of Seattle.

SECTION C101 GENERAL

[B] C101.1 Intent and purpose. The provisions of this chapter provide prescriptive methods for selected structural retrofitting of existing buildings to increase their resistance to wind loads. Except as provided herein, other structural provisions of the *International Building Code* or the *International Residential Code* shall apply, as required.

[B] C101.2 Scope. The following prescriptive methods are intended for applications where the gable end wall framing is provided by a metal-plate-connected gable end frame or a conventionally framed gable end. The retrofits are appropriate for wall studs or webs spaced 24 inches (610 mm) on center maximum and oriented with the wide face either parallel or perpendicular to the surface of the gable end. Gable ends to be strengthened shall be permitted to be retrofitted using methods prescribed by provisions of this chapter.

SECTION C102 DEFINITIONS

The following words and terms shall, for the purposes of this chapter have the meanings shown herein.

[B] ANCHOR BLOCK. A 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.

[B] COMPRESSION BLOCK. A 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.

[B] CONVENTIONALLY FRAMED GABLE END. A gable end framed with studs whose faces are perpendicular to the gable end wall.

[B] GABLE END FRAME. A factory or site-fabricated frame, installed as a complete assembly that incorporates vertical webs with their faces parallel to the plane of the frame.

[B] HORIZONTAL BRACE. A 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 attic floor framing members (truss bottom chords or ceiling joists) or on the bottom of pitched roof framing members (truss top chord or rafters).

[B] HURRICANE TIES. Manufactured metal connectors designed to provide uplift and lateral restraint for roof framing members.

[B] 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.

[B] RETROFIT. The voluntary process of strengthening or improving buildings or structures, or individual components of buildings or structures for the purpose of making existing conditions better serve the purpose for which they were originally intended or the purpose that current building codes intend.

[B] RETROFIT STUD. A lumber member used to structurally supplement an existing gable end wall stud or gable end frame web.

[B] STUD-TO-PLATE CONNECTOR. A manufactured metal connector designed to connect studs to plates.

SECTION C103 MATERIALS OF CONSTRUCTION

[B] C103.1 Existing materials. All existing wood materials that will be part of the retrofitting work (trusses, rafters, ceiling joists, top plates, wall studs, etc.) shall be in sound condition and free from defects or damage that substantially reduces the load-carrying capacity of the member. Any wood materials found to be damaged or deteriorated shall be strengthened or replaced with new materials to provide a net dimension of sound wood equivalent to its undamaged original dimensions.

[B] C103.2 New materials. All new materials shall comply with the standards for those materials as specified in the *International Building Code* or the *International Residential Code*.

[B] C103.3. Material specifications for retrofits. Materials for retrofitting gable end walls shall comply with Table C103.3.

[B] C103.4 Twists in straps. Straps shall be permitted to be twisted or bent where they transition between framing members or connection points. Straps shall be bent only once at a given location though it is permissible that they be bent or twisted at multiple locations along their length.

[B] C103.5 Fasteners. Fasteners shall meet the requirements of Table C103.6, Sections C103.6.1 and C103.6.2, and shall be permitted to be screws or nails meeting the minimum length requirement shown in the figures and specified in the

tables of this appendix. Fastener spacing shall meet the requirements of Section C103.6.3.

[B] C103.5.1 Screws. Unless otherwise indicated in the appendix, screw sizes and lengths shall be in accordance with Table C103.6. Permissible screws include deck screws and wood screws. Screws shall have at least 1 inch (25 mm) of thread. Fine threaded screws or drywall screws shall not be permitted. Select the largest possible diameter screw such that the shank adjacent to the head fits through the hole in the strap.

[B] C103.5.2 Nails. Unless otherwise indicated in this appendix, nail sizes and lengths shall be in accordance with Table C103.6.

[B] C103.5.3 General fastener spacing. Fastener spacing for shear connections of lumber-to-lumber shall meet the requirements shown in Figure C103.6.3 and the following conditions.

[B] C103.5.3.1 General fastener spacing. Fastener spacing shall meet the following conditions except as provided for in Section C103.6.3.3.

The distance between fasteners and the edge of lumber that is less than $3\frac{1}{2}$ inches deep (89 mm) in the direction of the fastener length shall be a minimum of $\frac{3}{4}$ inch (19 mm).

1. The distance between fasteners and the edge of lumber that is more than 2 inches (51 mm) thick

**[B] TABLE C103.3
MATERIAL SPECIFICATIONS FOR RETROFITS**

COMPONENT	MINIMUM SIZE OR THICKNESS	MINIMUM MATERIAL GRADE	MINIMUM CAPACITY
Anchor blocks, compression blocks, and horizontal braces	2x4 nominal lumber	#2 Spruce-Pine-Fir or better	N/A
Nail plates	20 gauge thickness 8d minimum nail holes	Galvanized sheet steel	N/A
Retrofit studs	2x4 nominal lumber	#2 Spruce-Pine-Fir or better	N/A
Gusset angle	14 gage thickness	Galvanized sheet steel	350 pounds uplift and lateral load
Stud-to-plate connector	20 gage thickness	Galvanized sheet steel	500 pounds uplift
Metal plate connectors, straps, and anchors	20 gage thickness	Galvanized sheet steel	N/A

For SI: 1 pound = 4.4 N.

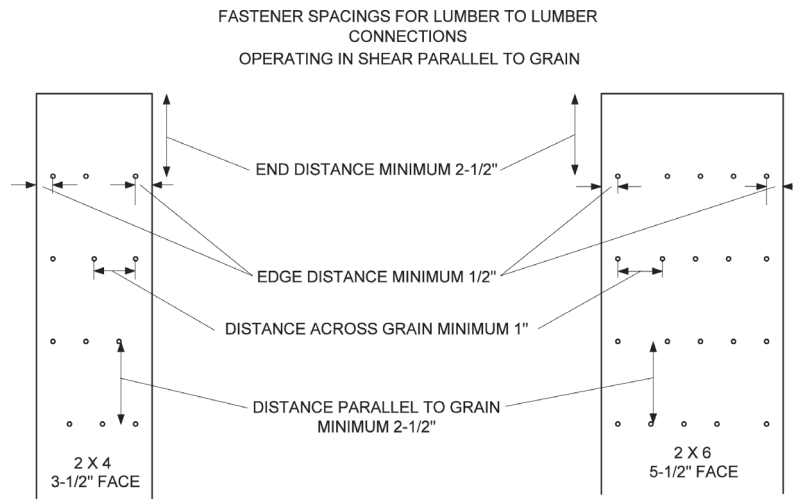
N/A = Not applicable

- a. Metal plate connectors, nail plates, stud-to-plate connectors, straps and anchors shall be products *approved* for connecting wood-to-wood or wood-to-concrete as appropriate.

**[B] TABLE C103.6
NAIL AND SCREW REQUIREMENTS**

FASTENER TYPE	MINIMUM SHANK DIAMETER	MINIMUM HEAD DIAMETER	MINIMUM FASTENER LENGTH
#8 screws	N/A	0.28 inches	1- $\frac{1}{4}$ inches
8d common nails	0.131 inches	0.28 inches	2- $\frac{1}{2}$ inches
10d common nails	0.148 inches	0.28 inches	3 inches

For SI: 1 inch = 25.4 mm.



For SI: 1 inch = 25.4 mm.

**[B] FIGURE C103.6.3
FASTENER SPACINGS FOR LUMBER-TO-LUMBER CONNECTIONS OPERATING IN SHEAR PARALLEL TO GRAIN**

in the direction of the fastener length shall be a minimum of $\frac{1}{2}$ inch (13 mm).

2. The distance between a fastener and the end of lumber shall be a minimum of $2\frac{1}{2}$ inches (64 mm).
3. The distance between fasteners parallel to the grain (center-to-center) shall be a minimum of $2\frac{1}{2}$ inches (64 mm).
4. The distance between fasteners perpendicular to the grain (center-to-center) in lumber that is less than $3\frac{1}{2}$ inches (89 mm) deep in the direction of the fastener length shall be 1 inch (25 mm).
5. The distance between fasteners perpendicular to the grain (center-to-center) in lumber that is more than 2 inches (51 mm) thick in the direction of the fastener length shall be $\frac{1}{2}$ inch (13 mm).

[B] C103.5.3.2 Wood-to-wood connections of two members each 2 inches or less in thickness. Wood-to-wood connections fastener spacing shall meet the following conditions.

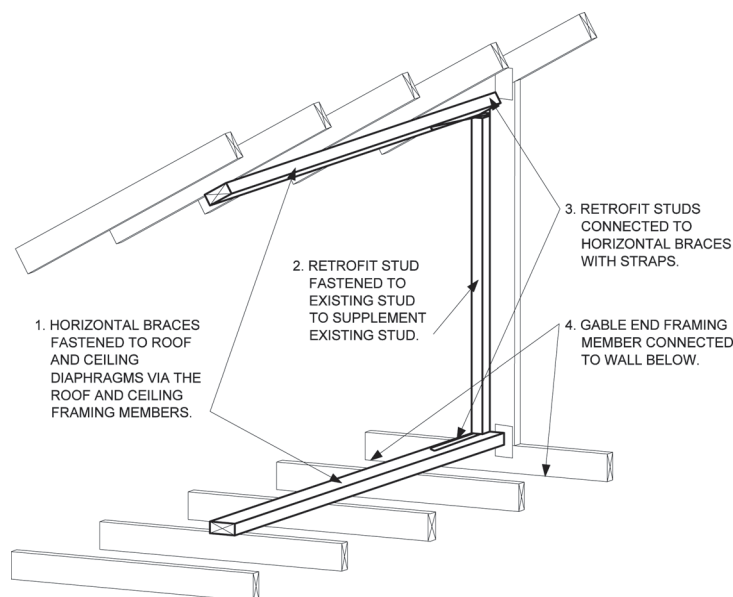
1. The distance between fasteners parallel to grain (center-to-center) shall be a minimum of $2\frac{1}{2}$ inches (64 mm).
2. The distance between fasteners across grain (center-to-center) shall be a minimum of 1 inch (25 mm).
3. For wood-to-wood connections of lumber at right angles, fasteners shall be spaced a minimum of $2\frac{1}{2}$ inches (64 mm) parallel to the grain and 1 inch (25 mm) perpendicular to the grain in any direction.

[B] C103.5.3.3 Metal connectors for wood-to-wood connections. Metal connectors for wood-to-wood connections shall meet the following conditions.

1. Fastener spacing to edge or ends of lumber shall be as dictated by the prefabricated holes in the connectors and the connectors shall be installed in a configuration that is similar to that shown by the connector manufacturer.
2. Fasteners in $1\frac{1}{4}$ -inch-wide (32 mm) metal straps that are installed on the narrow face of lumber shall be a minimum $\frac{1}{4}$ inch (6 mm) from either edge of the lumber. Consistent with Section C103.6.3.1, fasteners shall be permitted to be spaced according to the fastener holes fabricated into the strap.
3. Fasteners in metal nail plates shall be spaced a minimum of $\frac{1}{2}$ inch (13 mm) perpendicular to grain and a minimum of $1\frac{1}{2}$ inches (38 mm) parallel to grain.

SECTION C104 RETROFITTING GABLE END WALLS TO ENHANCE WIND RESISTANCE

[B] C104.1 General. 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. The ceiling diaphragm shall be comprised of minimum $\frac{1}{2}$ -inch-thick (13 mm) gypsum board, minimum nominal $\frac{3}{8}$ -inch-thick (10 mm) wood structural panels, or plaster. An overview isometric drawing of one type of gable end retrofit to improve wind resistance is shown in Figure C104.1.1.



THIS FIGURE SHOWS A TRUSS GABLE END.
THE METHODOLOGY FOR A CONVENTIONALLY FRAMED GABLE END IS SIMILAR.
THE NUMBERS INDICATE A TYPICAL SEQUENCE OF INSTALLATION.
IN ORDER TO SHOW STRAPS COMPRESSION BLOCKS ARE NOT SHOWN.

**[B] FIGURE C104.1.1
BASIC GABLE END RETROFIT METHODOLOGY**

[B] C104.2 Horizontal braces. Horizontal braces shall be installed perpendicular to the roof and ceiling framing members at the location of each existing gable end stud greater than 3 feet (91 cm) in length. Unless it is adjacent to an omitted horizontal brace location, horizontal braces shall be minimum 2x4 dimensional lumber as defined in Section C103.3. A single horizontal brace is required at the top and bottom of each gable end stud for Retrofit Configuration A, B, or C. Two horizontal braces are required at the top and bottom of each gable end stud for Retrofit Configuration D. Maximum heights of gable end wall studs and associated retrofit studs for each Retrofit Configuration shall not exceed the values listed in Table C104.2. Horizontal braces shall be oriented with their wide faces across the roof or ceiling framing members, be fastened to a minimum of three framing members, and extend at least 6 feet (183 cm) measured perpendicularly from the gable end plus 2½ inches (64 mm) beyond the last top chord or bottom chord member (rafter or ceiling joist) from the gable end as shown in Figures C104.2(1), C104.2(2), C104.2(3) and C104.2(4).

[B] C104.2.1 Existing gable end studs. If the spacing of existing vertical gable end studs is greater than 24 inches (64 mm), a new stud and corresponding horizontal braces shall be installed such that the maximum spacing between existing and added studs shall be no greater than 24 inches (64 mm). Additional gable end wall studs shall not be required at locations where their length would be 3 feet (91 cm) or less. Each end of each required new 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 3-inch (76 mm) toenail fasteners (#8 wood screws or 10d nails) and a metal connector with minimum uplift capacity of 175 pounds (778 N), or nail plates with a minimum of four 1¼-inch-long (32 mm) fasteners (#8 wood screws or 8d nails).

[B] C104.2.2 Main method of installation. Each horizontal brace shall be fastened to each existing roof or ceiling

member that it crosses using three 3-inch-long (76 mm) fasteners (#8 wood screws or 10d nails) as indicated in Figure C104.2(1) and Figure C104.2(3) for trusses and Figure C104.2(2) and Figure C104.2(4) for conventionally framed gable end walls. Alternative methods for providing horizontal bracing of the gable end studs as provided in Sections C104.2.3 through C104.2.9 shall be permitted.

[B] C104.2.3 Omitted horizontal brace. Where conditions exist that prevent installation in accordance with Section C104.2.2, horizontal braces shall be permitted to be omitted for height limitations corresponding to Retrofit Configurations A and B as defined in Table C104.2 provided installation is as indicated in Figure C104.2.3 and provided all of the following conditions are met. This method is not permitted for Retrofit Configurations C or D.

1. There shall be at least two horizontal braces on each side of an omitted horizontal brace or at least one horizontal brace if it is the end horizontal brace. Omitted horizontal braces must be separated by at least two horizontal braces even if that location is comprised of two retrofit studs and two horizontal braces.
2. Horizontal braces adjacent to the omitted horizontal brace shall be 2x6 lumber, shall butt against the existing studs, and shall be fastened to each existing roof or ceiling member crossed using three 3-inch-long (76 mm) fasteners (#8 wood screws or 10d nails). For Retrofit Configuration B, four fasteners shall be required on at least one of the connections between the horizontal brace and the existing roof and ceiling framing members. Fasteners shall be spaced a minimum of ¾ inch (19 mm) from the edges of the horizontal braces and a minimum of 1¾ inch (44 mm) from adjacent fasteners.

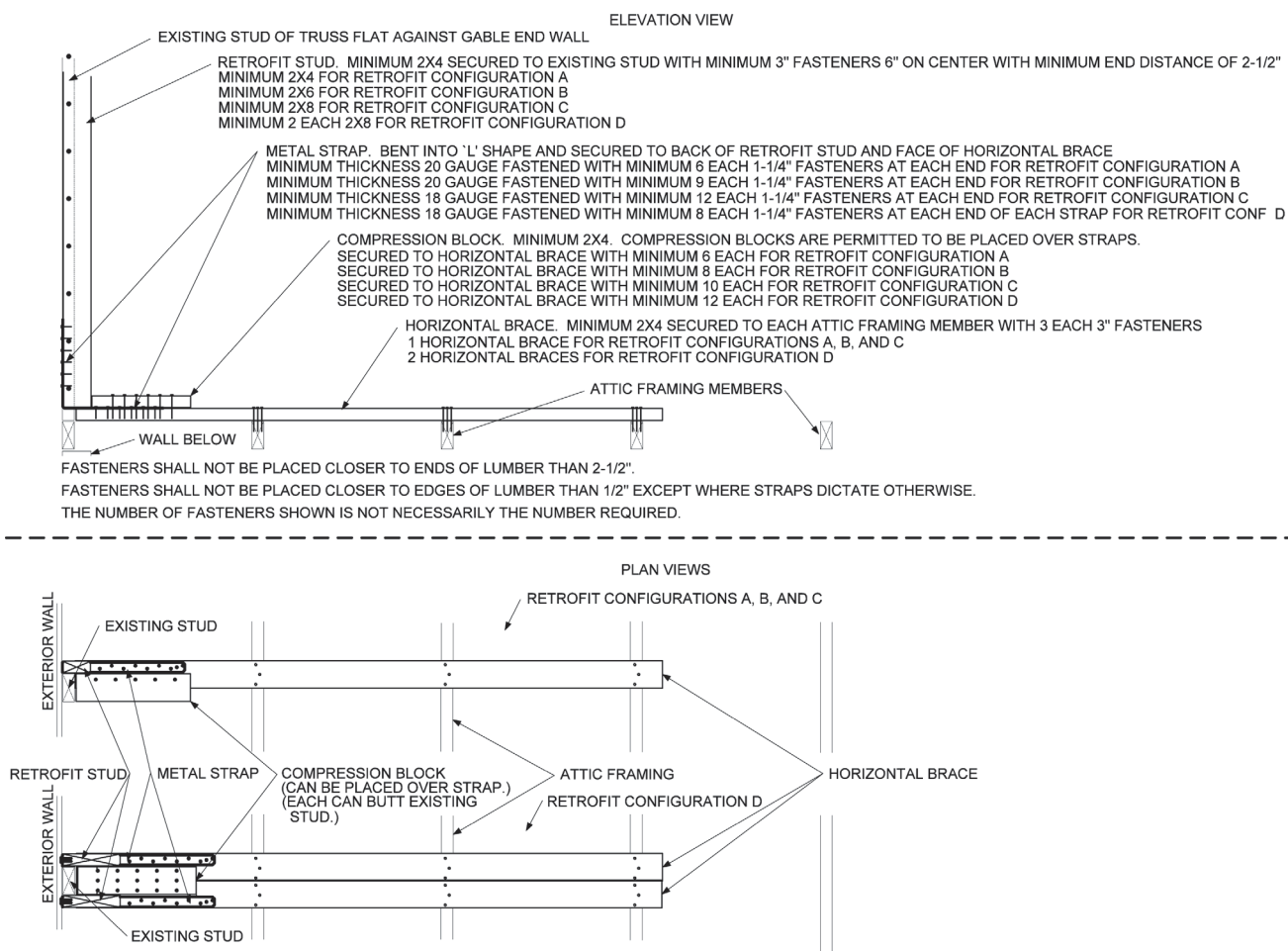
**[B] TABLE C104.2
STUD LENGTH LIMITATIONS BASED ON EXPOSURE AND DESIGN WIND SPEED**

EXPOSURE CATEGORY	MAXIMUM 3-SEC GUST BASIC WIND SPEED ^a	MAXIMUM HEIGHT OF GABLE END RETROFIT STUD ^b			
C	110	8'-0"	11'-3"	14'-9"	16'-0"
C	120	7'-6"	10'-6"	13'-6"	16'-0"
C	130	7'-0"	10'-0"	12'-3"	16'-0"
C	140	7'-0"	10'-0"	12'-3"	16'-0"
C	150	6'-6"	8'-9"	11'-0"	16'-0"
B	110	8'-0"	12'-3"	16'-0"	N/R ^c
B	120	8'-0"	11'-3"	14'-9"	16'-0"
B	130	8'-0"	11'-3"	14'-9"	16'-0"
B	140	7'-6"	10'-6"	13'-6"	16'-0"
B	150	7'-0"	10'-0"	12'-3"	16'-0"
Retrofit Configuration		A	B	C	D

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

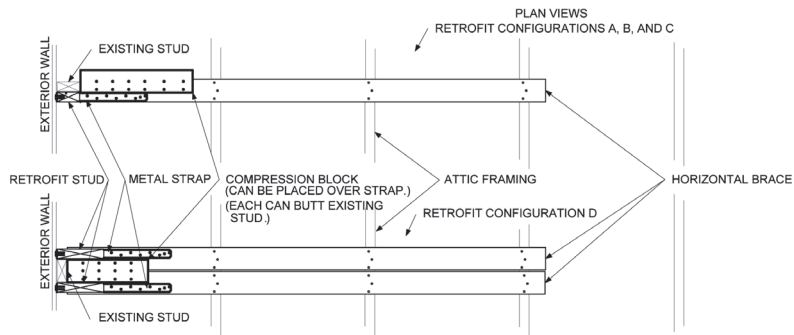
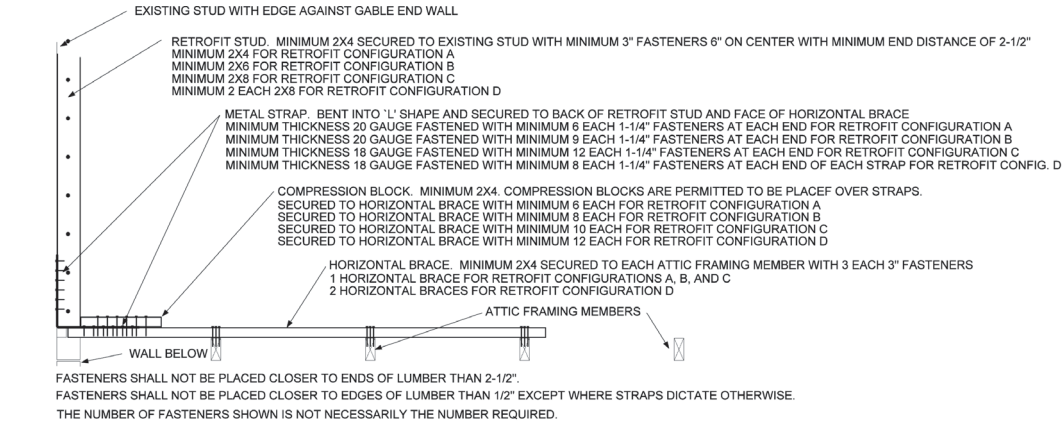
- a. Interpolation between given wind speeds is not permitted.
b. Existing gable end studs less than or equal to 3'-0" in height shall not require retrofitting.
c. N/R = Not Required. Configuration C is acceptable to 16'-0" maximum height.

3. Where the existing studs on each side of an omitted horizontal brace have their wide face perpendicular to the gable end wall, the retrofit studs at those locations and the retrofit stud at the omitted horizontal brace locations shall extend a minimum of $3\frac{3}{4}$ inches (95 mm) beyond the interior edge of the existing studs for both Retrofit Configurations A and B. The edges of the three retrofit studs facing towards the interior of the attic shall be aligned such that they are the same distance from the gable end wall.
4. Retrofit studs shall be fastened to existing studs in accordance with Section C104.3.
5. Retrofit studs adjacent to the omitted horizontal brace shall be fastened to the horizontal brace using straps in accordance with Table C104.4.1 consistent with the size of the retrofit stud. The method applicable to Table C104.4.2 is not permitted.
6. A strong back made of minimum of 2x8 lumber shall be placed parallel to the gable end and shall be located on and span between horizontal braces on the two sides of the omitted horizontal brace and shall extend beyond each horizontal brace by a minimum of $2\frac{1}{2}$ inches (64 mm). The strong back shall be butted to the three retrofit studs. The strong back shall be attached to each of the horizontal braces on which it rests with five 3-inch-long (76 mm) fasteners (#8 screws or 8d nails). The fasteners shall have a minimum $\frac{3}{4}$ -inch (19 mm) edge distance and a minimum $2\frac{1}{2}$ -inch (64 mm) spacing between fasteners. Additional compression blocks shall not be required at locations where a strong back butts against a retrofit stud.
7. The retrofit stud at the location of the omitted horizontal braces shall be fastened to the strong back using a connector with minimum uplift capacity of 800 pounds (3559 N) and installed such that this capacity is oriented in the direction perpendicular to the gable end wall.
8. The use of shortened horizontal braces using the alternative method of Section C104.2.5 is not permitted for horizontal braces adjacent to the omitted horizontal braces.
9. Horizontal braces shall be permitted to be interrupted in accordance with Section C104.2.8.



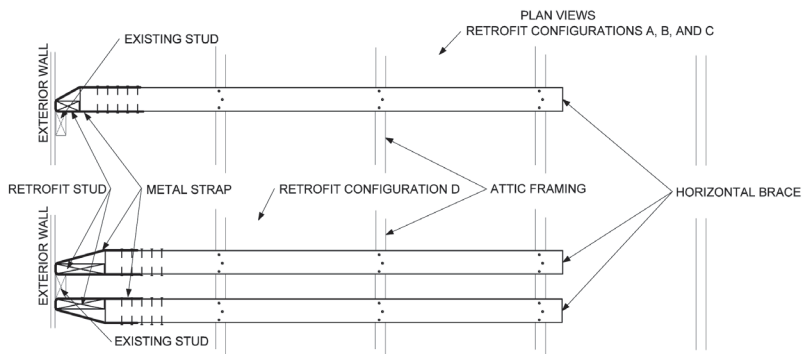
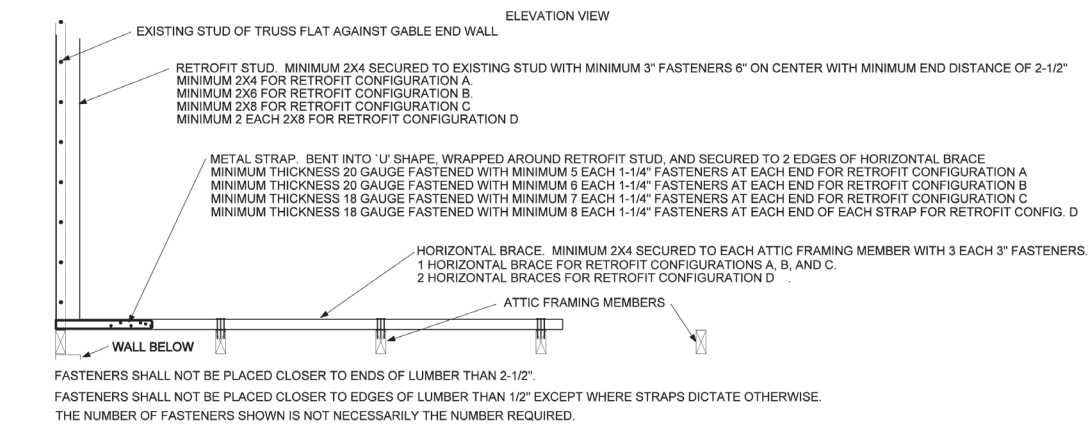
For SI: 1 inch = 25.4 mm.

[B] FIGURE C104.2(1)
TRUSS FRAMED GABLE END



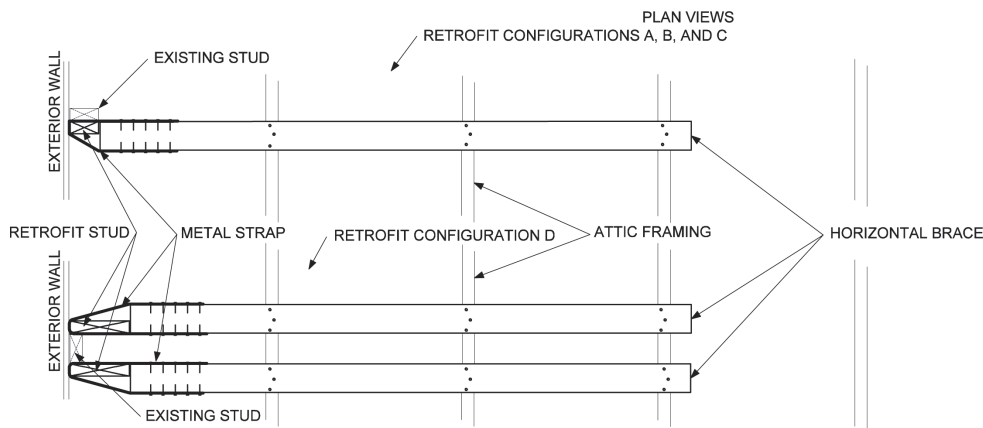
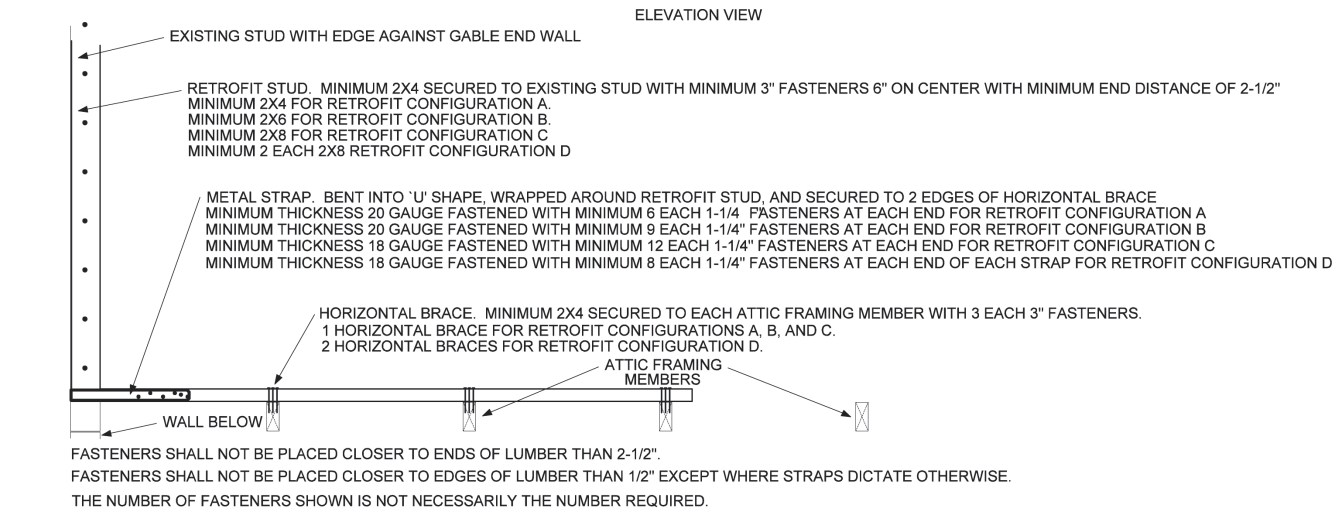
For SI: 1 inch = 25.4 mm.

[B] FIGURE C104.2(2)
CONVENTIONALLY FRAMED GABLE END L-BENT STRAP



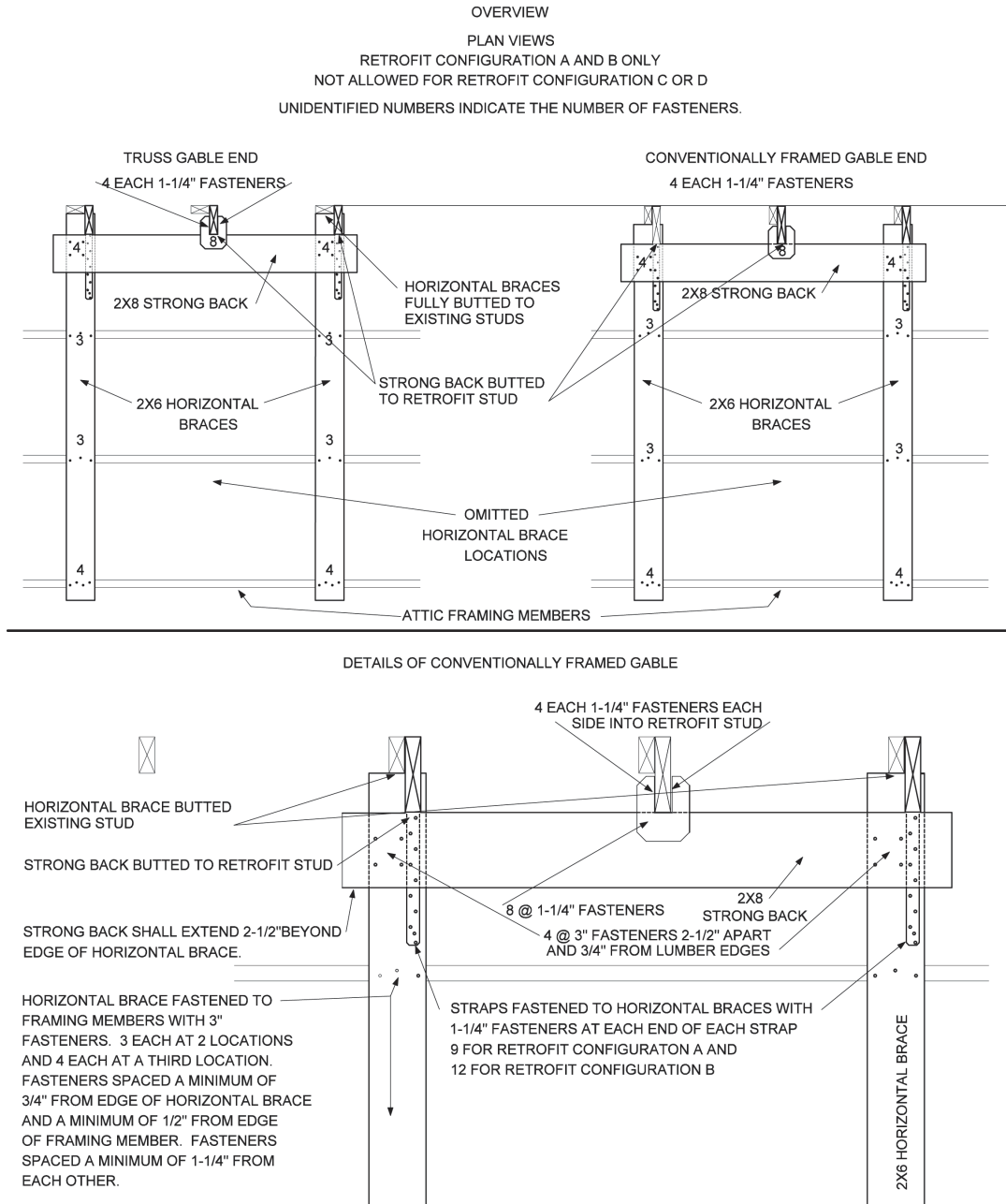
For SI: 1 inch = 25.4 mm.

[B] FIGURE C104.2(3)
TRUSS FRAMED GABLE END U-BENT STRAP



For SI: 1 inch = 25.4 mm.

[B] FIGURE C104.2(4)
CONVENTIONALLY FRAMED GABLE END U-BENT STRAP



For SI: 1 inch = 25.4 mm.

**[B] FIGURE C104.2.3
OMITTED HORIZONTAL BRACE**

[B] C104.2.4 Omitted horizontal brace and retrofit stud. Where conditions exist that prevent installation in accordance with Section C104.2.2 or Section C104.2.3, then retrofit studs and horizontal braces shall be permitted to be omitted from those locations by installation of ladder assemblies for Retrofit Configurations A and B as defined in Table C104.2 provided all of the following conditions are met. This method is not permitted for Retrofit Configurations C or D.

1. No more than two ladder assemblies are permitted on a single gable end.

2. There shall be at least two retrofit studs and horizontal brace assemblies on either side of the locations where the retrofit studs and horizontal bracing members are omitted (no two ladder braces bearing on a single retrofit stud).
3. Where the existing studs on each side of an omitted horizontal brace have their wide face parallel to the gable end wall the retrofit studs at those locations and the retrofit stud at the omitted horizontal brace locations shall be 2x6 lumber for Retrofit Configuration A and 2x8 lumber for Retrofit Configuration B.

4. Horizontal braces adjacent to the omitted horizontal brace shall be 2x6 lumber and be fastened to each existing roof or ceiling member crossed using three 3-inch-long (76 mm) fasteners (#8 wood screws or 10d nails) as indicated in Figure C104.2(1) and Figure C104.2(3) for gable end frames and Figure C104.2(2) and Figure C104.2(4) for conventionally framed gable end walls. For Retrofit Configuration B, four fasteners shall be required on at least one of the connections between the horizontal brace and the existing roof and ceiling framing members.
5. Ladder rungs shall be provided across the location of the omitted retrofit studs as indicated in Figure C104.2.4(1) for gable end frames and Figure C104.2.4(2) for conventionally framed gable end walls.
6. Ladder rungs shall be minimum 2x4 lumber oriented with their wide face horizontal and spaced a maximum of 16 inches (41 cm) on center vertically.
7. Where ladder rungs cross wall framing members they shall be connected to the wall framing members with a metal connector with a minimum capacity of 175 pounds (778 N) in the direction perpendicular to the gable end wall.
8. Notching of the ladder rungs shall not be permitted unless the net depth of the framing member is a minimum of 3¹/₂ inches (89 mm).

[B] C104.2.5 Short horizontal brace. Where conditions exist that prevent installation in accordance with Sections C104.2.2, C104.2.3 or C104.2.4 the horizontal braces shall be permitted to be shortened provided installation is as indicated in Figure C104.2.5 and all of the following conditions are met.

1. The horizontal brace shall be installed across a minimum of two framing spaces, extend a minimum of 4 feet (122 cm) from the gable end wall plus 2¹/₂ inches (64 mm) beyond the farthest roof or ceiling framing member from the gable end, and be fastened to each existing framing member with three 3-inch-long (76 mm) fasteners (#8 wood screws or 10d nails)
2. An anchor block shall be fastened to the side of the horizontal brace in the second framing space from the gable end wall as shown in Figure C104.2.5. The anchor block lumber shall have a minimum edge thickness of 1¹/₂ inches (38 mm) and the depth shall be as a minimum the depth of the existing roof or ceiling framing member. Six 3-inch-long (76 mm) fasteners (#8 wood screws or 10d nails) shall be used to fasten the anchor block to the side of the horizontal brace.
3. The anchor block shall extend into the space between the roof or ceiling framing members a minimum of one-half the depth of the existing framing members at the location where the anchor

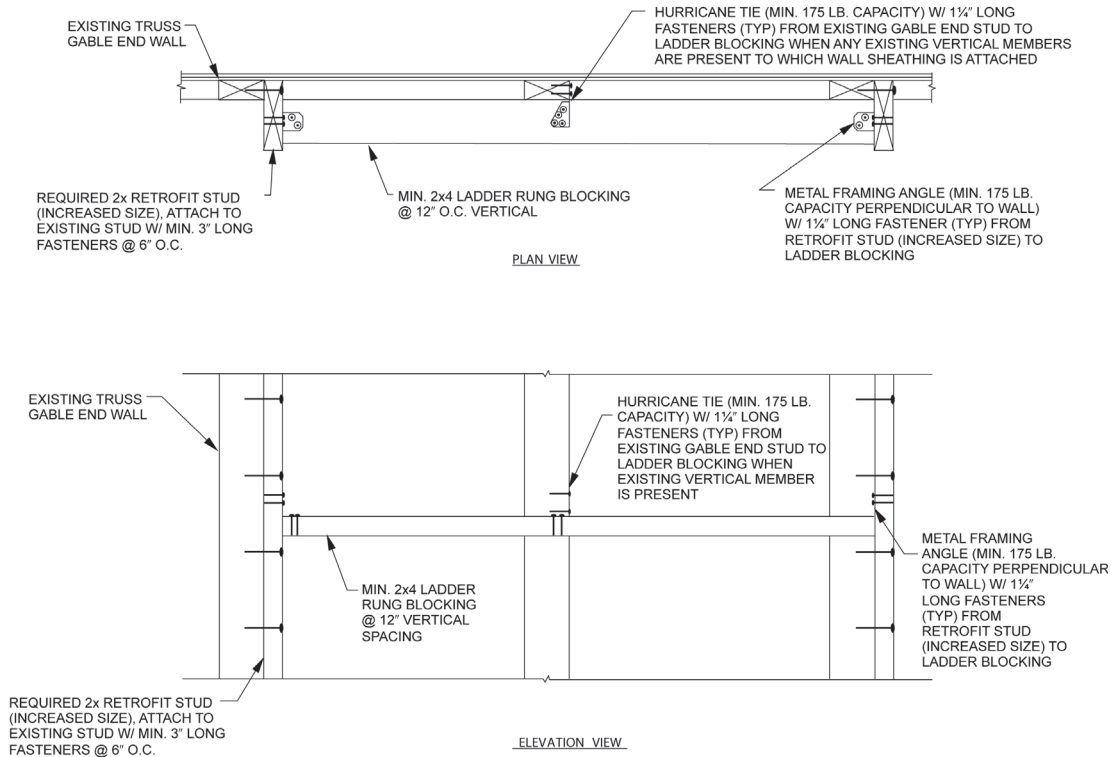
block is installed. The anchor block shall be installed tightly between the existing framing members such that the gap at either end shall not exceed ¹/₈ inch (3 mm).

4. The use of omitted horizontal braces using the method of Section C104.2.3 adjacent to a short horizontal brace as defined in this section is not permitted.

[B] C104.2.6 Installation of horizontal braces onto webs of trusses. Where existing conditions preclude installation of horizontal braces on truss top or bottom chords they shall be permitted to be installed on truss webs provided all of the following conditions are met.

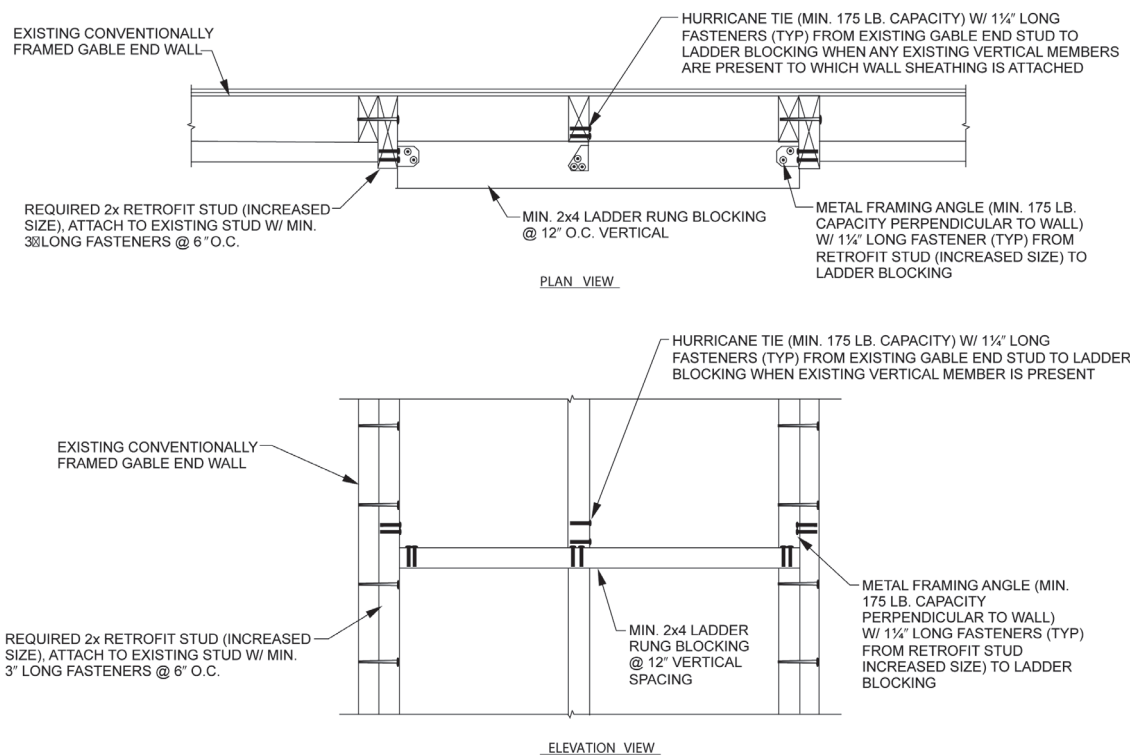
1. Horizontal braces shall be installed as close to the top or bottom chords as practical without altering the truss or any of its components and not more than three times the depth of the truss member to which it would ordinarily be attached.
2. A racking block, comprised of an anchor block meeting the definition of anchor block of Section C102 or comprised of minimum ¹⁵/₃₂-inch (12 mm) plywood or ⁷/₁₆-inch (11 mm) Oriented Strand Board (OSB), shall be fastened to the horizontal brace in the second framing space from the gable end wall. The racking block shall extend toward the roof or ceiling diaphragm so that the edge of the racking block closest to the diaphragm is within ¹/₂ the depth of the existing framing member from the diaphragm surface. The racking block shall be attached to horizontal braces using six fasteners (#8 wood screws or 10d nails) of sufficient length to provide 1¹/₂ inches (38 mm) of penetration into the horizontal brace.
3. Racking blocks shall be permitted to be fastened to any face or edge of horizontal braces between each web or truss vertical posts to which a horizontal brace is attached. Racking blocks shall be permitted to be on alternate sides of horizontal braces. Racking blocks shall be installed tightly between the lumber of truss members or truss plates such that the gap at either end shall be a maximum of ¹/₈ inch (3 mm).

[B] C104.2.7 Alternative method of installation of horizontal braces at truss ridges. Where conditions exist that limit or restrict installation of horizontal braces near the peak of the roof, ridge ties shall be added to provide support for the required horizontal brace. The top of additional ridge tie members shall be installed a maximum of 16 inches below the existing ridge line or 4 inches below impediments. A minimum 2x4 member shall be used for each ridge tie and fastening shall consist of two 3-inch (76 mm) long wood screws, four 3-inch-long (76 mm) 10d nails or two 3¹/₂-inch-long (89 mm) 16d nails driven through and clinched at each top chord or web member intersected by the ridge tie as illustrated in Figure C104.2.7.



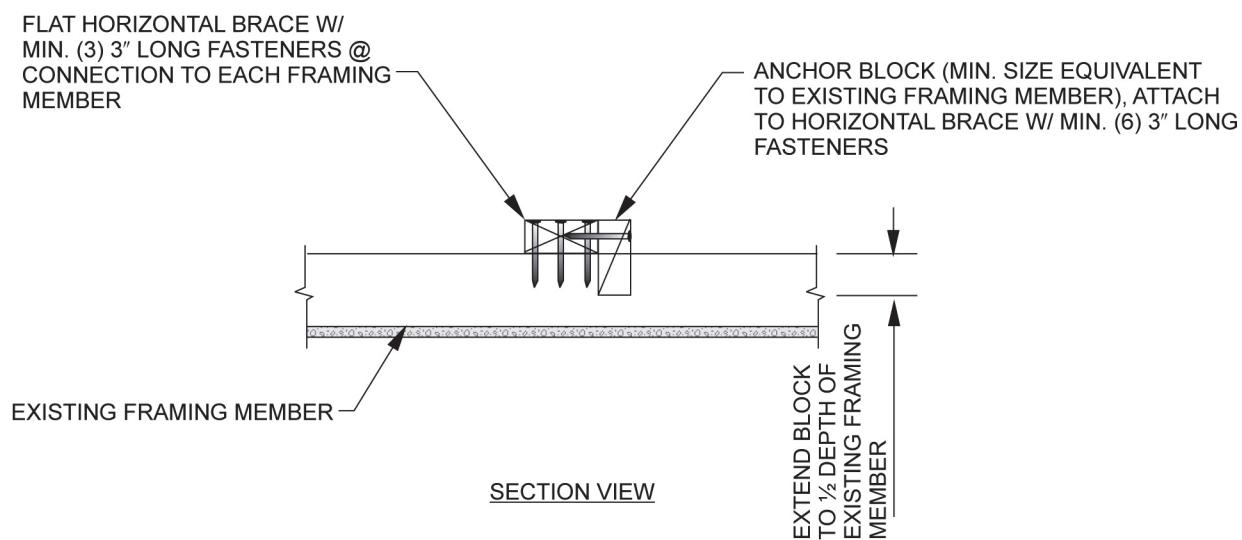
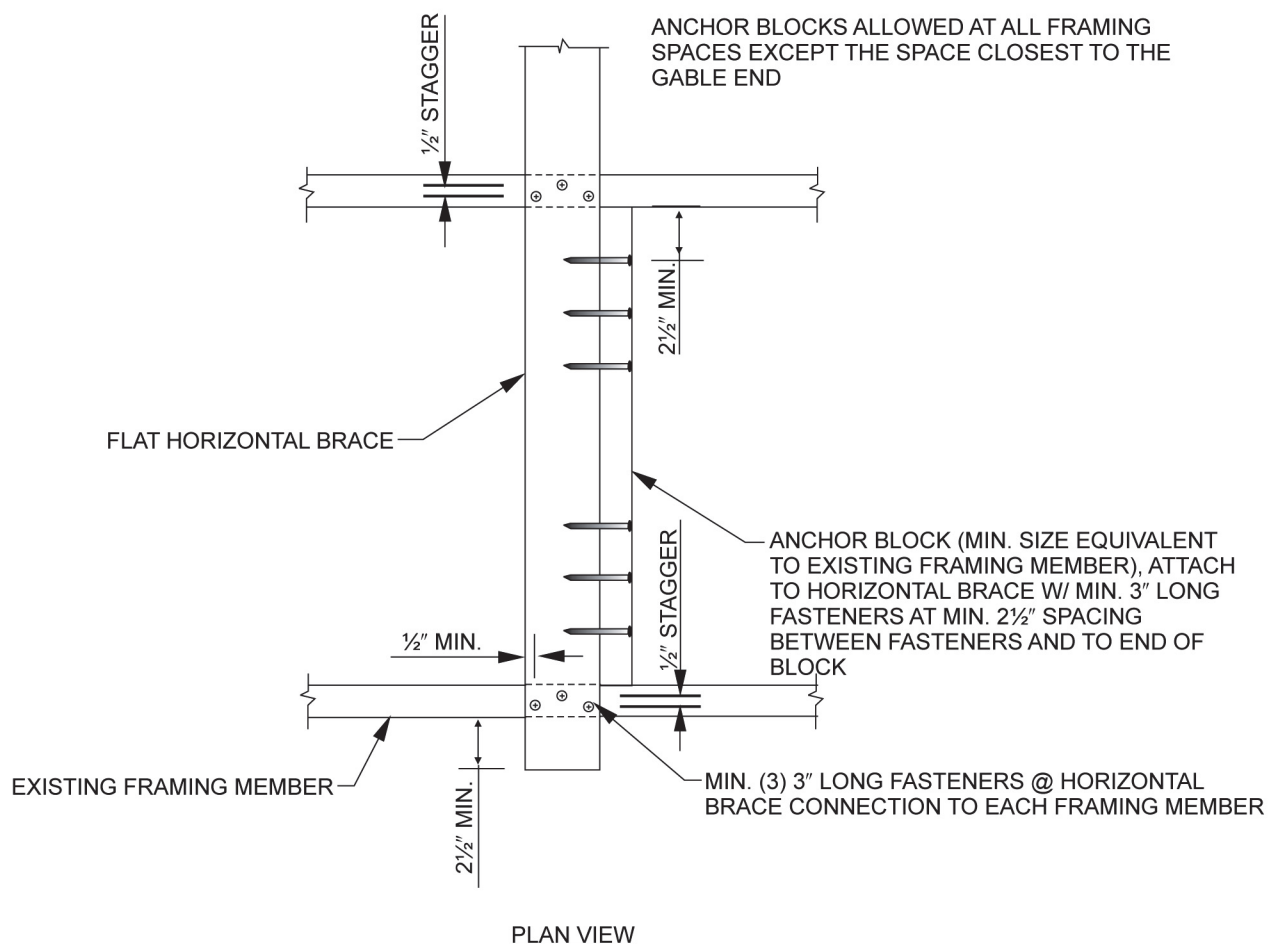
For SI: 1 inch = 25.4 mm; 1 pound = 4.4 N.

[B] FIGURE C104.2.4(1)
LADDER BRACING FOR OMITTED RETROFIT STUD (GABLE END FRAME)



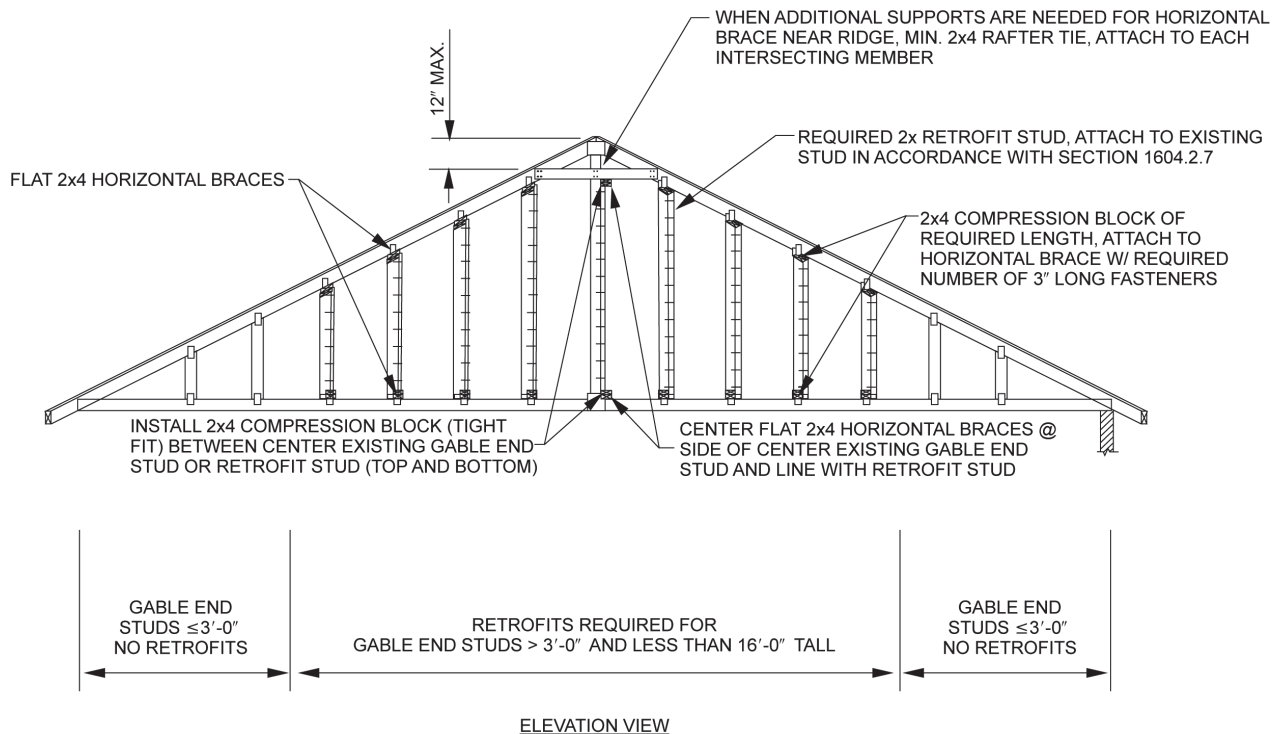
For SI: 1 inch = 25.4 mm; 1 pound = 4.4 N.

[B] FIGURE C104.2.4(2)
LADDER BRACING FOR OMITTED RETROFIT STUD (CONVENTIONALLY FRAMED GABLE END)



For SI: 1 inch = 25.4 mm.

**[B] FIGURE C104.2.5
ANCHOR BLOCK INSTALLATION**



For SI: 1 inch = 25.4 mm; 1 foot = 304.8 mm.

[B] FIGURE C104.2.7
DETAIL OF RETROFIT TIE INSTALLATION

[B] C104.2.8 Interrupted horizontal braces. Where conditions exist that prevent the installation of a continuous horizontal brace then horizontal braces shall be permitted to be interrupted using the methods shown in Figure C104.2.8(1), Figure C104.2.8(2), and Figure C104.2.8(3). For interruptions that occur in the attic framing space closest to the gable end, nine 3-inch (76 mm) fasteners shall be used to connect each section of the interrupted horizontal braces. For interruptions that occur in the second attic space from the gable end, six 3-inch (76 mm) fasteners shall be used to connect each section of the interrupted horizontal braces. For interruptions that occur in the attic framing space farthest from the gable end, three 3-inch (76 mm) fasteners shall be used to connect each section of the interrupted horizontal braces. Horizontal braces shall be continued far enough to allow connections to three existing roof framing members as shown in Figures C104.2.8(1), C104.2.8(2) or C104.2.8(3). Fasteners shall be spaced in accordance with Section C103.6.3. Horizontal braces shall be the same width and depth as required for an uninterrupted member.

[B] C104.2.9 Piggyback gable end frames. Piggyback gable end frames (gable end frames built in two sections one above the other) shall be permitted to be retrofitted if either of the following cases is true.

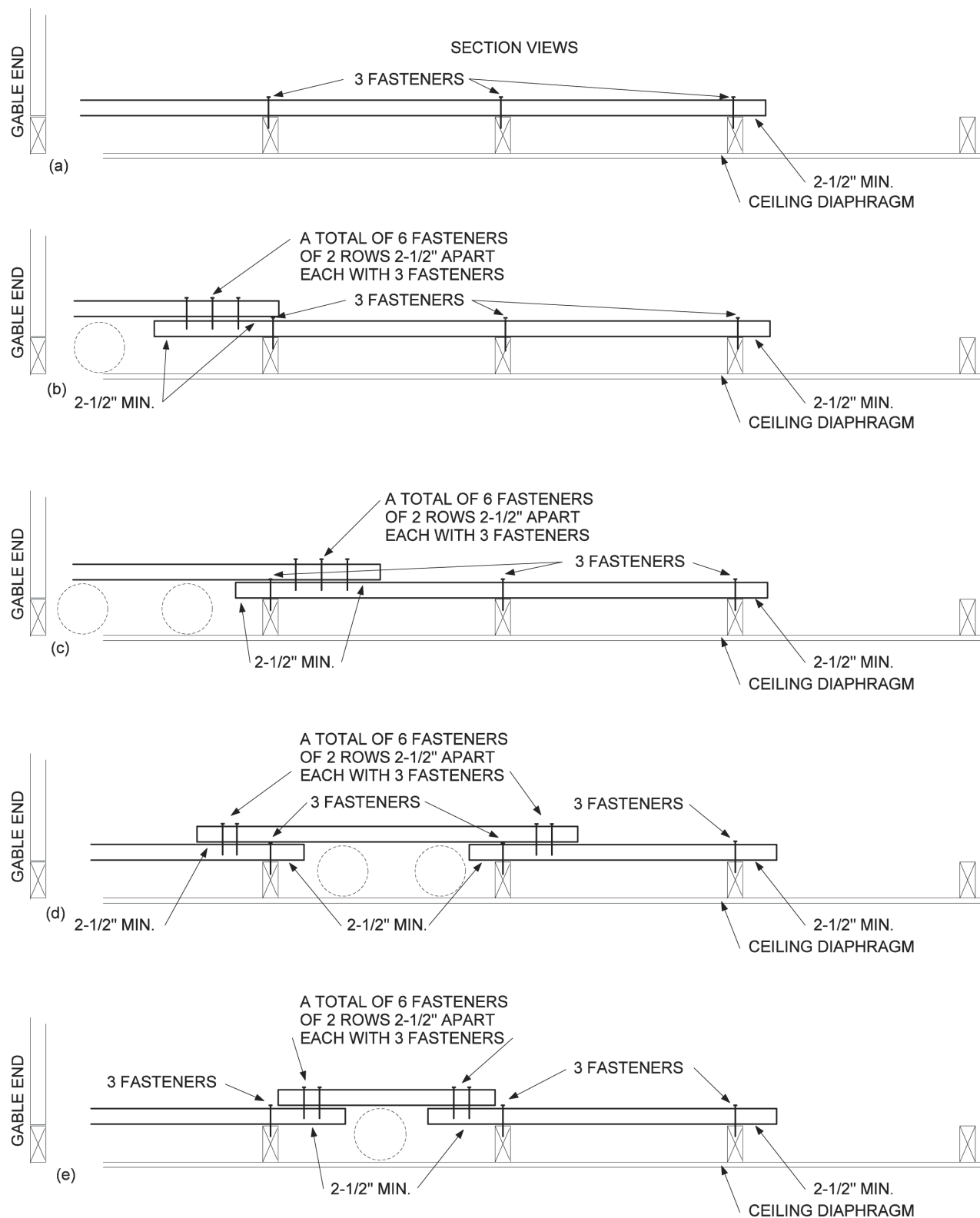
1. The existing studs in both the upper gable end frames and the lower gable end frames to which wall sheathing, panel siding, or other wall covering are attached are sufficiently in line that retrofit

studs can be installed and connections made between the two with retrofit stud(s).

2. Existing studs in the upper frame are not sufficiently in line with the studs in the frame below and the existing studs in the upper frame are 3 feet (91 cm) or shorter.

For Condition 1 both the lower stud and the upper stud shall be retrofitted using the methods of Section C104.2. For Condition 2 the retrofit stud shall be connected to the lower studs using the methods of Section C104.2 and be continuous from the bottom horizontal brace to the top horizontal brace. No connection is required between the retrofit stud and the upper stud. In both conditions the bottom chord of the piggyback truss section shall be fastened to each retrofit stud using a connector with minimum axial capacity of 175 pounds (778 N).

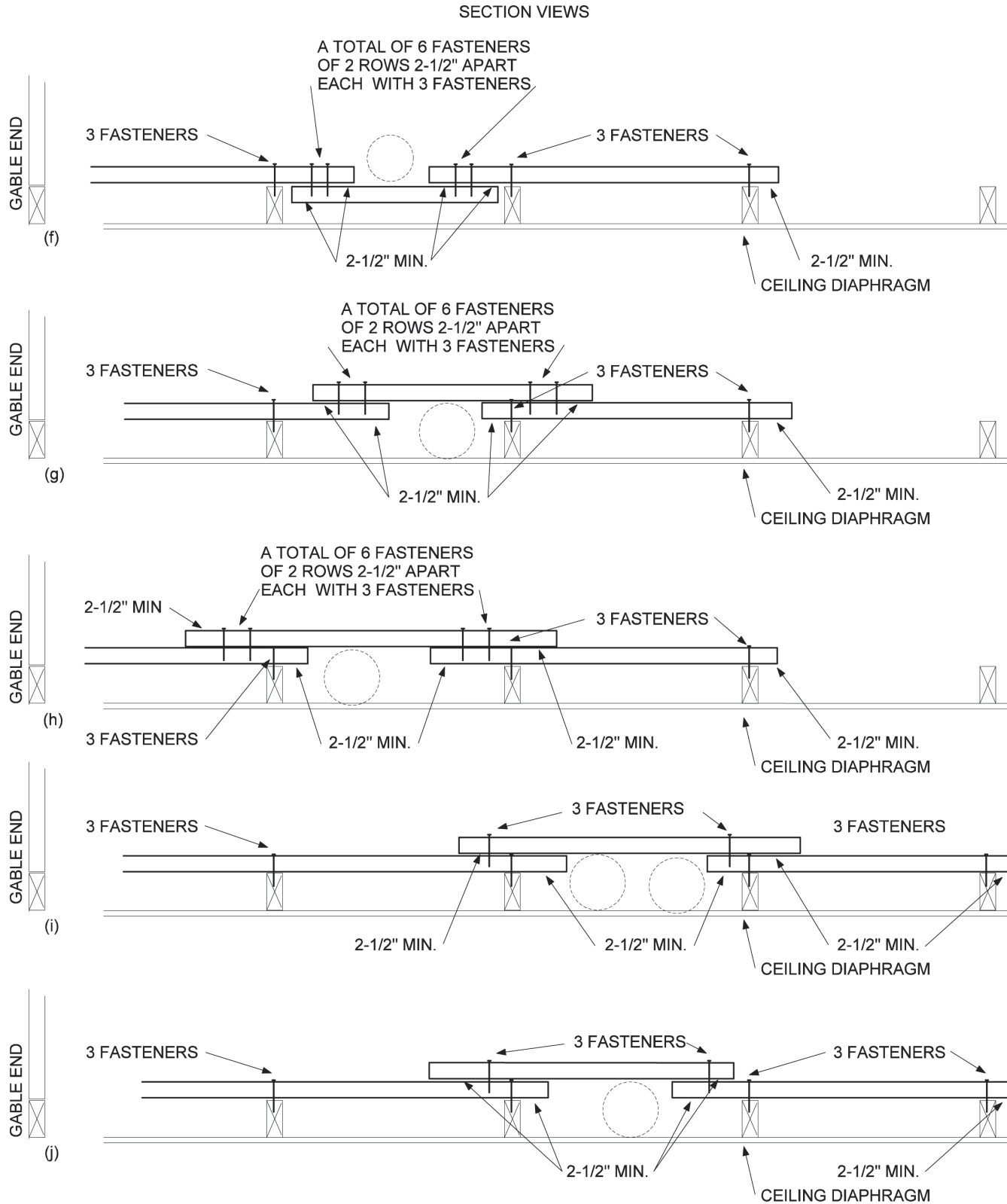
[B] C104.3 Retrofit studs. Retrofit studs shall be installed in accordance with Section C104.3.1 using one of the five methods of Sections C104.3.2, C104.3.3, C104.3.4, C104.3.5, or C104.3.6. Figure C104.3 shows these methods of installation. For the Retrofit Configuration obtained from Table C104.2, the size of retrofit studs shall be as indicated in Table C104.4.1 or Table C104.4.2. Retrofit studs shall extend from the top of the lower horizontal brace to the bottom of the upper horizontal brace except that a maximum gap of $\frac{1}{8}$ inch (3 mm) is permitted at the bottom and $\frac{1}{2}$ inch (13 mm) at the top. Where wall sheathing, panel siding, or other wall covering is fastened to a conventionally framed gable end, retrofit studs shall be applied in accordance with Section C104.2.1.



ALL FASTENERS 3"

For SI: 1 inch = 25.4 mm.

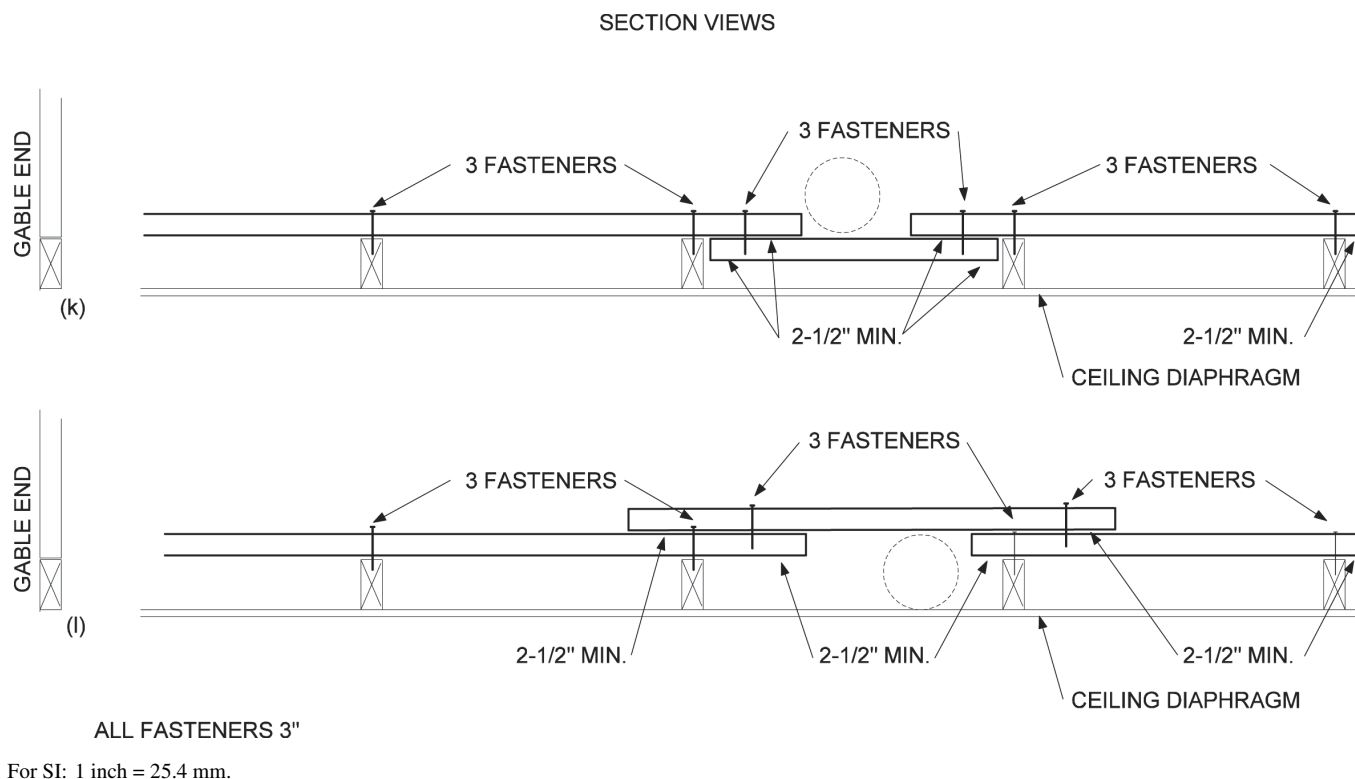
**[B] FIGURE C104.2.8(1)
SPliced HORIZONTAL BRACES**



ALL FASTENERS 3"

For SI: 1 inch = 25.4 mm.

[B] FIGURE C104.2.8(2)
SPLICED HORIZONTAL BRACES



[B] FIGURE C104.2.8(3)
SPliced HORIZONTAL BRACES

[B] C104.3.1 Fastening. Where nail plates are not used, retrofit studs shall be attached to existing studs using 3-inch (76 mm) fasteners at a maximum of 6 inches (152 mm) on center but no closer than $2\frac{1}{2}$ inches (64 mm) on center with fasteners no closer to ends of members than $2\frac{1}{2}$ inches (64 mm).

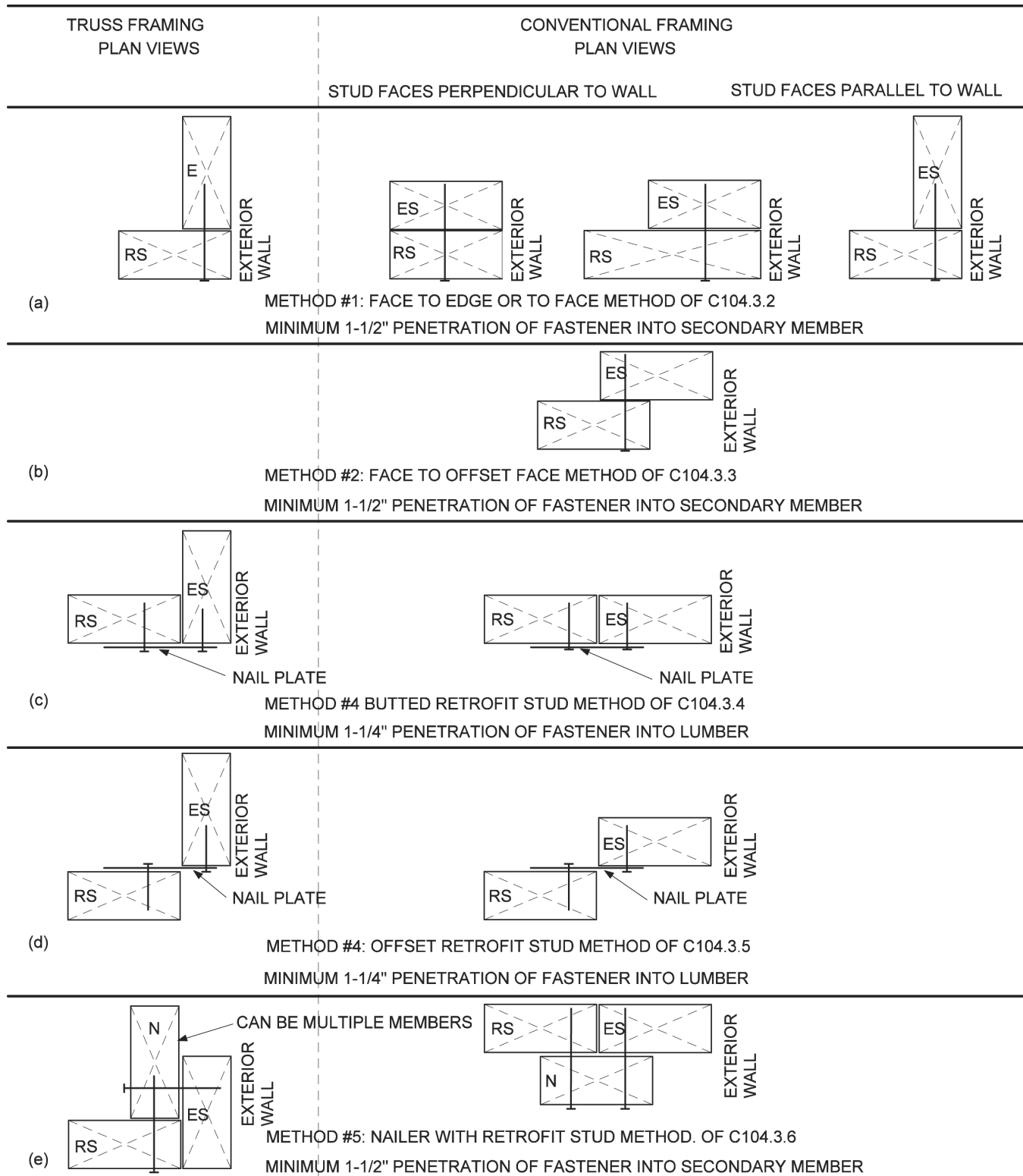
[B] C104.3.2 Method #1: Face-to-edge or face-to-face method. Retrofit studs shall be installed immediately adjacent to existing gable end wall studs as indicated in Figure C104.3(a). The retrofit studs shall overlap the edge or side of the existing stud by a minimum of $1\frac{1}{4}$ inches (32 mm). Fasteners shall be installed as specified in Section C104.3.1.

[B] C104.3.3 Method #2: Face-to-face offset method. Retrofit studs shall be installed against the face of existing studs as indicated in Figure C104.3(b) such that the faces overlap a minimum of $1\frac{1}{2}$ inches (38 mm) and the edge distance to fasteners is no less than $\frac{3}{4}$ inch (19 mm). Fasteners shall be installed as specified in Section C104.3.1.

[B] C104.3.4 Method #3: Butted retrofit stud method. Provided that all of the following fastening conditions are met, retrofit studs shall be permitted to be butted by their edge to existing studs with the addition of nail plates as indicated in Figure C104.3(c) and Figure C104.3.4.

1. The narrow edge of retrofit studs shall be installed against the narrow or the wide face of existing studs.

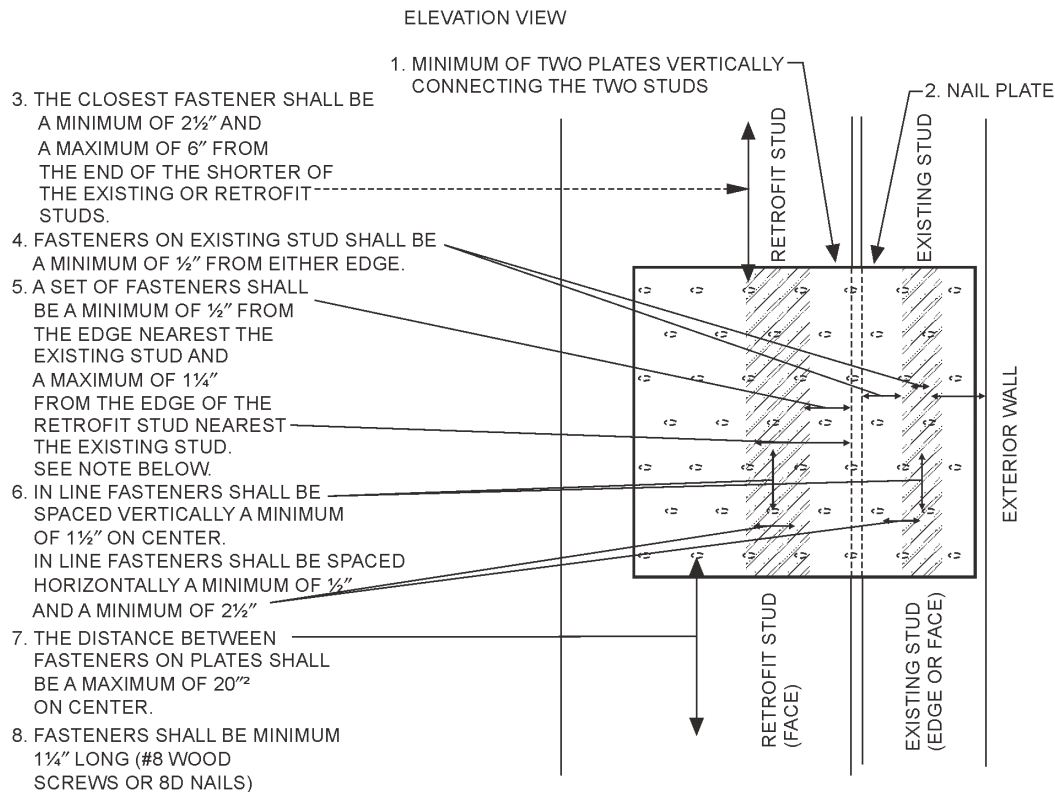
2. A minimum of two nail plates shall be used.
3. Fasteners used to secure nail plates to studs shall be a minimum $1\frac{1}{4}$ inches (32 mm) long (#8 wood screws or 8d nails).
4. Fasteners placed in nail plates shall have a minimum end distance of $2\frac{1}{2}$ inches (64 mm) for both studs and a maximum end distance of 6 inches (152 mm) from the ends of the shorter stud.
5. Fasteners shall have a minimum $\frac{1}{2}$ -inch (13 mm) edge distance. Fasteners shall be placed a maximum of $1\frac{1}{2}$ inches (38 mm) from the abutting vertical edges of existing studs and retrofit studs.
6. There shall be at least three fasteners through nail plates into all existing and retrofit studs to which the nail plate is attached.
7. Nail plates with three fasteners onto a single existing or retrofit stud shall be spaced a maximum of 15 inches (38 cm) on center.
8. Nail plates with more than three fasteners onto a single existing or retrofit stud shall be spaced a maximum of 20 inches (51 cm) on center.
9. Fasteners used to secure nail plates shall be spaced vertically a minimum of $1\frac{1}{2}$ inches (38 mm) on center. Staggered fasteners used to secure nail plates shall be spaced horizontally a minimum of $\frac{1}{2}$ inch (13 mm).



THE FIGURES DO NOT REFLECT THE NUMBER OF REQUIRED FASTENERS OR SHOW HORIZONTAL BRACES OR STRAPS. FASTENERS SHALL BE PLACED MAXIMUM 6" ON CENTER AND A MINIMUM OF 2-1/2" FROM ENDS. 3" FASTENERS CAN BE INSTALLED FROM EITHER SIDE OF LUMBER AS LONG AS THERE IS 1-1/2" FASTENER PENETRATION. ES INDICATES AN EXISTING STUD. RS INDICATES A RETROFIT STUD. N INDICATES A NAILER.

For SI: 1 inch = 25.4 mm.

[B] Figure C104.3
METHOD OF INSTALLING RETROFIT STUDS



For SI: 1 inch = 25.4 mm.

**[B] FIGURE C104.3.4
NAIL PLATE FASTENING**

[B] C104.3.5 Method #4: Offset retrofit stud method. Retrofit studs may be offset from existing studs by use of nail plates as shown in Figure C104.3(d) such that the vertical corner of a retrofit stud shall align with the vertical corner of an existing stud as indicated in Figure C104.3(d) and Figure C104.3.4, and the fastening conditions of Section C104.3.4 are met.

[B] C104.3.6 Method #5: Nailer with retrofit stud method. Retrofit studs and existing studs shall be permitted to be connected using noncontinuous 2x4 nailers as indicated in Figure C104.3(e) provided the following conditions are met.

- Both the existing stud and the retrofit stud shall be butted to nailers and both shall be fastened to the nailer with 3-inch-long (76 mm) fasteners (#8 wood screws or 8d nails). Fasteners connecting each stud to the nailer shall be spaced 6 inches (152 mm) o.c.
- Fasteners into nailers from any direction shall be offset vertically by a minimum of $2\frac{1}{2}$ inches (64 mm).
- Fasteners into nailers shall be a minimum of $2\frac{1}{2}$ inches (64 mm) but not more than 6 inches (152

mm) from the end of the shorter of the existing stud and retrofit stud to which they are fastened.

[B] C104.3.7 Reduced depth of retrofit studs. Retrofit studs may be reduced in depth by notching, tapering, or other methods at any number of locations along their length provided that all of the following conditions are met.

- Retrofit studs to be reduced in depth shall be sized such that the remaining minimum depth of member at the location of the notch (including cross-cut kerfs) shall not be less than that required by Table C104.4.1 or Table C104.4.2.
- Reduced in-depth retrofit stud shall not be spliced within 12 inches (30 cm) of the location of notches. Splice members shall not be notched.
- The vertical extent of notches shall not exceed 12 inches (30 cm) as measured at the depth of location of reduced depth.
- A reduced in-depth retrofit stud member shall be fastened to the side of the existing gable end wall studs in accordance with Section C104.3.1. Two additional 3-inch (76 mm) fasteners (#8 wood

screws or 10d nails) shall be installed on each side of notches in addition to those required by Section C104.3.1.

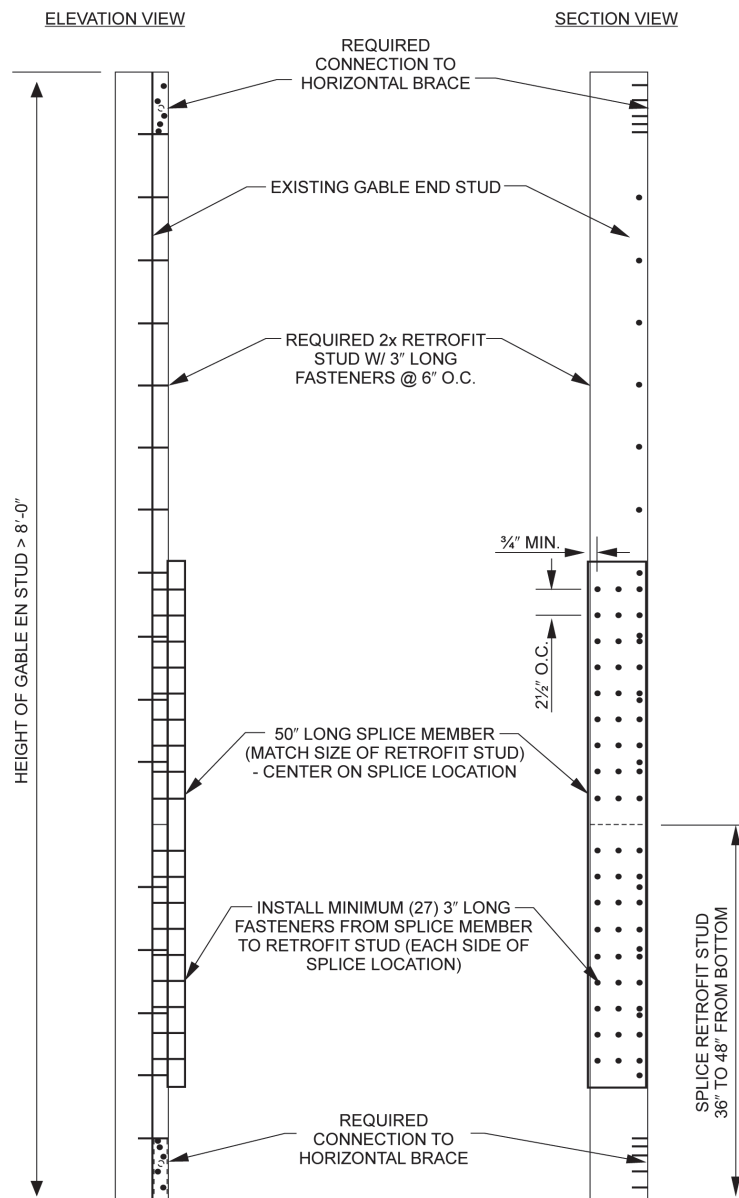
[B] C104.3.8 Retrofit stud splices. Retrofit studs greater than 8 feet (244 cm) in height may be field spliced in accordance with Figure C104.3.8.

[B] C104.4 Connection between horizontal braces and retrofit studs. Connections between horizontal braces and retrofit studs shall comply with Section C104.4.1 or Section C104.4.2. Each retrofit stud shall be connected to the top and bottom horizontal brace members with a minimum 20-gauge 1¹/₄-inch-wide (32 mm) flat or coil metal strap with pre-

punched holes for fasteners. Straps shall be fastened with 1¹/₄-inch-long (32 mm) fasteners (#8 wood screws or 8d nails) with the number of fasteners as indicated in Table C104.4.1 and Table C104.4.2. Fasteners shall be no closer to the end of lumber than 2¹/₂ inches (64 mm).

[B] C104.4.1 L-bent strap method. Retrofit studs shall be connected to horizontal braces or to strong backs in accordance with Figures C104.2(1), C104.2(2) or C104.2.3, and shall comply with the following conditions.

1. A strap shall be applied to the edges of a retrofit stud nearest the gable end wall and to the face of horizontal braces using at each end of the strap the



NOTE:
SPLICE LOCATION MAY BE REQUIRED AT TOP OF GABLE END STUD IF HEIGHT > 11'-0" TO 12'-0"

For SI: 1 inch = 25.4 mm; 1 foot = 304.8 mm.

**[B] FIGURE C104.3.8
RETROFIT STUD SPLICES**

number of fasteners specified in Table C104.4.1. Straps shall be long enough so that each strap extends sufficient distance onto the vertical face of the retrofit stud that the fastener closest to the ends of the studs is a minimum of $2\frac{1}{2}$ inches (64 mm) from the end of the stud. Straps shall be permitted to be twisted to accommodate the transition between the tops of retrofit studs and horizontal bracings following roof pitches.

2. Compression blocks shall be installed on the horizontal braces directly against either the existing vertical gable end wall stud or the retrofit stud. Figure C104.2(1) (trusses) and Figure C104.2(2) (conventionally framed) show the installation of the compression block against the existing vertical gable end wall stud with the strap from the retrofit stud running beside the compression block. Compression blocks shall be permitted to be placed over straps. Compression blocks shall be fastened to the horizontal braces with at least the minimum number of 3-inch-long (76 mm) fasteners (#8 wood screws or 10d nails) specified in Table C104.4.1. End and edge distances for fasteners shall be in accordance with Section C103.6.3.

[B] C104.4.2 U-bent strap method. Retrofit studs shall be connected to horizontal braces in accordance with Figure C104.2(3) or Figure C104.2(4), shall be limited to Retrofit Configurations A and B as defined in Table C104.2, and shall comply with the following conditions.

1. Straps of sufficient length to meet the requirements for the number of fasteners in accordance with Table C104.4.2 and meet the end distance require-

ments of Section C103.6.3 shall be shaped around retrofit studs and fastened to the edges of horizontal braces. Straps shall wrap the back edge of the retrofit stud snugly with a maximum gap of $\frac{1}{4}$ inch (6 mm). Rounded bends of straps shall be permitted. One fastener shall be installed that connects each strap to the side of the associated retrofit stud.

2. The horizontal brace shall butt snugly against the retrofit stud with a maximum gap of $\frac{1}{4}$ inch (6 mm).
3. Straps shall be permitted to be twisted to accommodate the transition between the tops of retrofit studs and horizontal braces that follow the roof pitch.

[B] C104.5 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 using one of the methods prescribed in Sections C104.5.1 or C104.5.2. The particular method chosen shall correspond to the framing system and type of wall construction encountered.

[B] C104.5.1 Gable end frame. The bottom chords of the gable end frame shall be attached to the wall below using gusset angles. A minimum of two fasteners shall be installed into the bottom chord. The gusset angles shall be installed throughout the portion of the gable end where the gable end wall height is greater than 3 feet (91 cm) at the spacing specified in Table C104.5.1. Connection to the wall below shall be by one of the methods listed below:

1. For a wood-frame wall below, a minimum of two fasteners shall be installed. The fasteners shall be of the same diameter and style specified by the gusset angle manufacturer and sufficient length to

**[B] TABLE C104.4.1
ELEMENT SIZING AND SPACING FOR L-BENT RETROFIT METHOD**

RETROFIT ELEMENTS	RETROFIT CONFIGURATION			
	A	B	C	D
Minimum size and number of Horizontal Braces	2 x 4	2 x 4	2 x 4	2 each 2 x 4
Minimum size and number of Retrofit Studs	2 x 4	2 x 6	2 x 8	2 each 2 x 8
Minimum number of fasteners connecting each end of straps to Retrofit Studs or to Horizontal Braces #8 screws or 10d nails $1\frac{1}{4}$ " long	6	9	12	8 on each strap
Minimum number of fasteners to connect Compression Blocks to Horizontal Braces #8 screws or 10d nails 3" long	6	8	10	12

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

**[B] TABLE C104.4.2
ELEMENT SIZING AND SPACING FOR U-BENT RETROFIT METHOD**

RETROFIT ELEMENTS	RETROFIT CONFIGURATION			
	A	B	C	D
Minimum size and number of Horizontal Braces	2 x 4	2 x 4	2 x 4	2 each 2 x 4
Minimum size and number of Retrofit Studs	2 x 4	2 x 6	2 x 8	2 each 2 x 8
Minimum number of fasteners connecting Straps to each edge of Horizontal Braces #8 screws or 10d nails $1\frac{1}{4}$ " long	6	7	7	6 on each side of strap

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

extend through the double top plate of the wall below.

2. For a concrete or masonry wall below without a sill plate, the type and number of fasteners into the wall shall be consistent with the gusset angle manufacturer's specifications for fasteners installed in concrete or masonry.
3. For a concrete or masonry wall below with a 2x sill plate, the fasteners into the wall below shall be of the diameter and style specified by the gusset angle manufacturer for concrete or masonry connections; but, long enough to pass through the wood sill plate and provide the required embedment into the concrete or masonry below. Alternatively, the gusset angle can be anchored to the sill plate using four each 1 $\frac{1}{2}$ -inch-long (38 mm) fasteners of the same type as specified by the gusset angle manufacturer for wood connections, provided that the sill plate is anchored to the wall on each side of the gusset angle by a $\frac{1}{4}$ -inch-diameter (6 mm) masonry screw with 2 $\frac{3}{4}$ inches (70 mm) of embedment into the concrete or masonry wall. A $\frac{1}{4}$ -inch (6 mm) washer shall be placed under the heads of the masonry screws.

[B] C104.5.2 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 3 feet (91 cm), shall be attached to the bottom or sill plate using a stud to plate connector with minimum uplift capacity of 175 pounds (778 N). The bottom or sill plate shall then be connected to the wall below using one of the methods listed below:

1. For a wood frame wall below, the sill or bottom plate shall be connected to the top plate of the wall below using $\frac{1}{4}$ -inch-diameter (6 mm) lag bolt fasteners of sufficient length to penetrate the bottom plate of the upper gable end wall and extend through the bottom top plate of the wall below. A washer sized for the diameter of the lag bolt shall be placed under the head of each lag bolt. The fasteners shall be installed at the spacing indicated in Table C104.5.2.
2. For a concrete or masonry wall below, the sill or bottom plate shall be connected to the concrete or masonry wall below using $\frac{1}{4}$ -inch-diameter (6 mm) concrete or masonry screws of sufficient length to provide 2 $\frac{3}{4}$ inches (70 mm) of embedment into the top of the concrete or masonry wall. A washer sized for the diameter of the lag bolt shall be placed under the head of each lag bolt. The fasteners shall be installed at the spacing indicated in Table C104.5.2.

**[B] TABLE C104.5.1
SPACING OF GUSSET ANGLES**

EXPOSURE CATEGORY	BASIC WIND SPEED (mph)	SPACING OF GUSSET ANGLES (inches)
C	110	38
C	120	32
C	130	28
C	140	24
C	150	20
B	110	48
B	120	40
B	130	36
B	140	30
B	150	26

For SI: 1 inch = 25.4 mm, 1 mile per hour = 0.45 m/s.

**[B] TABLE C104.5.2
SPACING OF LAG OR MASONRY SCREWS USED TO CONNECT SILL PLATE OF GABLE END WALL TO TOP OF THE WALL BELOW**

EXPOSURE CATEGORY	BASIC WIND SPEED (mph)	SPACING OF LAG OR MASONRY SCREWS (inches)
C	110	19
C	120	16
C	130	14
C	140	14
C	150	10
B	110	24
B	120	20
B	130	18
B	140	15
B	150	13

For SI: 1 inch = 25.4 mm.

CHAPTER C2

ROOF DECK FASTENING FOR HIGH-WIND AREAS

Appendix C is not adopted by The City of Seattle.

SECTION C201 GENERAL

[B] C201.1 Intent and purpose. The provisions of this chapter provide prescriptive methods for selected structural retrofitting of existing buildings. Compliance with these provisions will not always meet the requirements for new construction in the *International Building Code* or the *International Residential Code*. The provisions of this chapter are intended to provide methods for strengthening existing buildings to increase resistance to wind loads.

[B] C201.2 Scope. The provisions of this chapter are a prescriptive alternative for one- and two-family dwellings located where the wind speed according to Section 1609 of the *International Building Code* exceeds 100 mph (44.7 m/s) to achieve compliance with Section 706.3 of the *International Existing Building Code*.

SECTION C202 ROOF DECK ATTACHMENT FOR WOOD ROOFS

[B] C202.1 Roof decking attachment for one- and two-family dwellings. For one- and two-family dwellings, fastening shall be in accordance with Section C202.1.1 or C202.1.2 as appropriate for the existing construction. The diameter of 8d nails shall be a minimum of 0.131 inch (3 mm) and the length shall be a minimum of 2¹/₄ inches (57 mm) to qualify for the provisions of this section for existing nails regardless of head shape or head diameter.

[B] C202.1.1 Sawn lumber or wood plank roofs. Roof decking consisting of sawn lumber or wood planks up to 12 inches (30 cm) wide and secured with at least two nails (minimum size 8d) to each roof framing member it crosses shall be deemed to be sufficiently connected. Sawn lumber or wood plank decking secured with smaller fasteners than 8d nails or with fewer than two nails (minimum size 8d) to each framing member it crosses shall be deemed sufficiently connected if fasteners are added such that two clipped head, round head, or ring shank nails (minimum size 8d) are in place on each framing member the nail crosses.

[B] C202.1.2 Wood structural panel roofs. For roof decking consisting of wood structural panels, fasteners and spacings required in Table C202.1.2 are deemed to comply with the requirements of Section 706.3 of the *International Existing Building Code*.

Supplemental fasteners as required by Table C202.1.2 shall be 8d ring shank nails with round heads and the following minimum dimensions:

1. 0.113-inch-nominal (3 mm) shank diameter.

2. Ring diameter a minimum of 0.012 inch (0.3 mm) greater than shank diameter.
3. 16 to 20 rings per inch.
4. A minimum 0.280-inch (7 mm) full round head diameter.
5. Ring shank to extend a minimum of 1¹/₂ inches (38 mm) from the tip of the nail.
6. Minimum 2¹/₄-inch (57 mm) nail length.

**[B] TABLE C202.1.2
SUPPLEMENT FASTENERS AT PANEL EDGES AND INTERMEDIATE FRAMING**

EXISTING FASTENERS	EXISTING FASTENER SPACING (EDGE OR INTERMEDIATE SUPPORTS)	MAXIMUM SUPPLEMENTAL FASTENER SPACING FOR WIND SPEEDS GREATER THAN 100 MPH BUT LESS THAN OR EQUAL TO 110 MPH	MAXIMUM SUPPLEMENTAL FASTENER SPACING FOR INTERIOR ZONE ^c LOCATIONS FOR WIND SPEEDS EXCEEDING 110 MPH AND EDGE ZONES NOT COVERED BY THE COLUMN TO RIGHT	EDGE ZONE ^d FOR WIND SPEED GREATER THAN 120 MPH AND EXPOSURE C, OR WIND SPEED GREATER THAN 140 MPH AND EXPOSURE B
Staples or 6d	Any	6" o.c. ^b	6" o.c. ^b	4" o.c. ^b at panel edges and 4" o.c. ^b at intermediate supports
8d clipped head or round head smooth shank	6" o.c. or less	None necessary	None necessary along edges of panels but 6" o.c. ^b at intermediate supports of panel	4" o.c. ^a at panel edges and 4" o.c. ^a at intermediate supports
8d clipped head or round head ring shank	6" o.c. or less	None necessary	None necessary	4" o.c. ^a at panel edges and 4" o.c. ^a at intermediate supports
8d clipped head or round head smooth shank	Greater than 6" o.c.	6" o.c. ^a	6" o.c. ^a along panel edges and 6" o.c. ^b at intermediate supports of panel	4" o.c. ^a at panel edges and 4" o.c. ^a at intermediate supports
8d clipped head or round head ring shank	Greater than 6" o.c.	6" o.c. ^a	6" o.c. ^a	4" o.c. ^a at panel edges and 4" o.c. ^a at intermediate supports

For SI: 1 inch = 25.4 mm; 1 mile per hour = 0.447 m/s.

- a. Maximum spacing determined based on existing fasteners and supplemental fasteners.
- b. Maximum spacing determined based on supplemental fasteners only.
- c. Interior zone = sheathing that is not located within 4 feet of the perimeter edge of the roof or within 4 feet of each side of a ridge.
- d. Edge zone = sheathing that is located within 4 feet of the perimeter edge of the roof and within 4 feet of each side of a ridge.