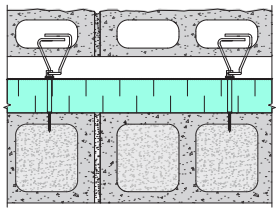
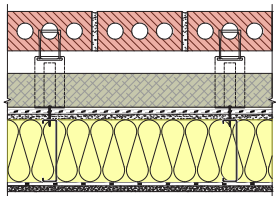
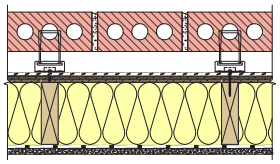
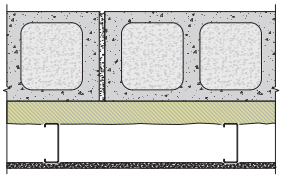
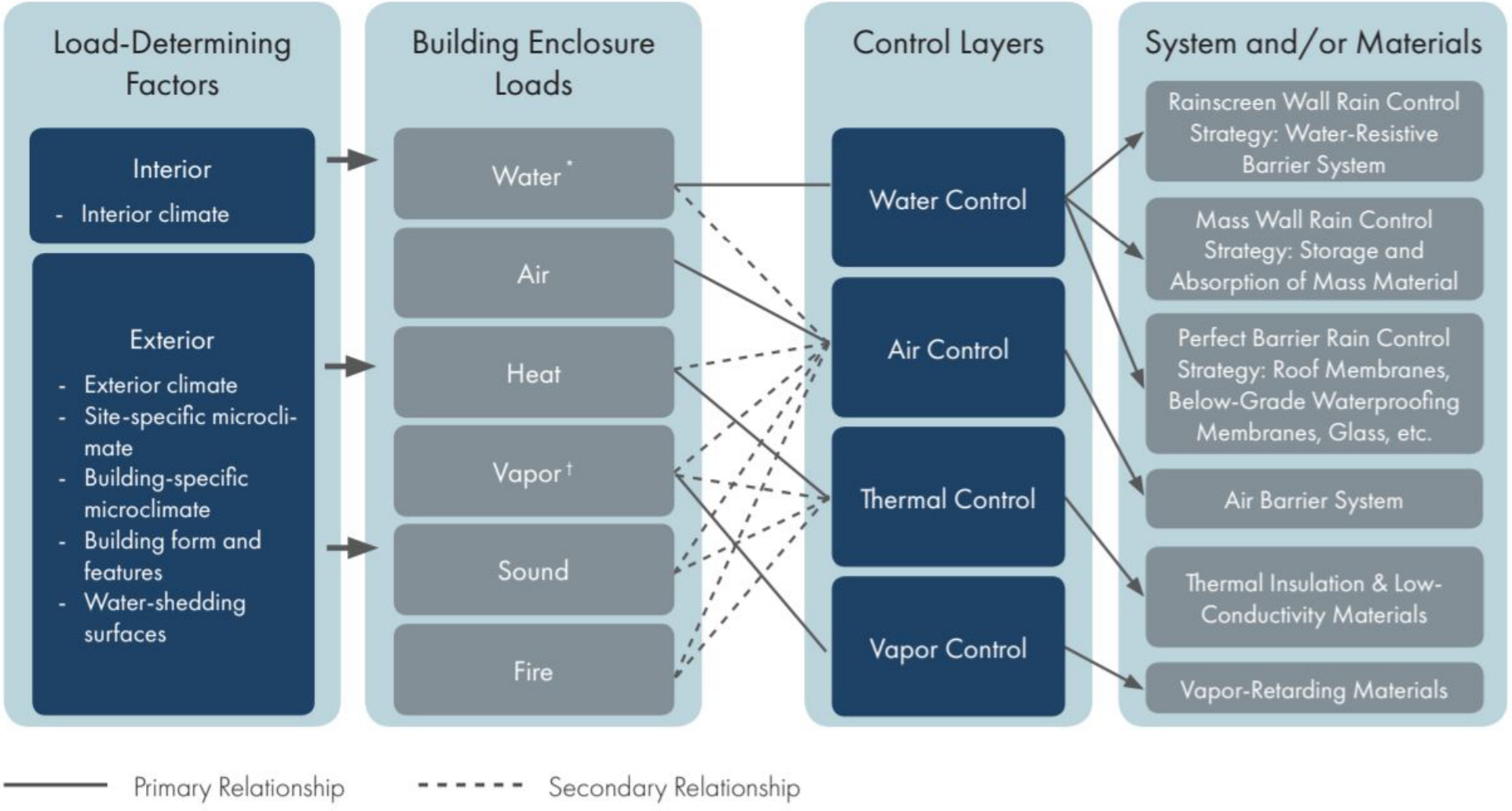
Table 2-1 System Comparison Matrix

Comparison Categories	Anchored Masonry Veneer Systems (See Chapter 6)			Single-Wythe CMU (See Chapter 7)
				
Backup Wall Structure	CMU or Concrete	Steel Stud-Framed	Wood-Framed	CMU
Maximum Building Height				
Insulation Strategy	Exterior of structure	In framed cavity and exterior of structure	In framed cavity; insulation exterior of structure optional	Interior of structure
Typical Assembly Thermal Performance	R-10 through R-20+ See page 138 for thermal performance information.	R-15 through R-20+ Exterior insulation typical to compensate for highly conductive steel framing. See page 141 for thermal performance information.	R-18 through R-20+ For a greater assembly effective R-value, exterior insulation may be added to this assembly. See page 147 for thermal performance information.	R-7 through R-20+ Interior continuous insulation unbridged by highly conductive steel framing provides the greatest effective R-value. See page 151 for thermal performance information.
Cladding Attachment (Lateral Loads)	Anchored Cavity depths are limited to 6 ⅝″ per TMS-402-16. [1] See page 71 for anchor options.	Anchored Cavity depths are limited to 6 ⅝″ per TMS 402-16. [1] See page 71 for anchor options.	Anchored Cavity depths are limited to 6 ⅝″ per TMS 402-16. [1] See page 71 for anchor options.	N/A Independent cladding design not applicable; wall structure provides cladding element.
Cladding Support (Gravity Loads)	Bearing Elements Requires TMS-402-16 [1] required bearing elements such as footings, shelf angles, and floor slabs.	Bearing Elements Requires TMS-402-16 [1] required bearing elements such as footings, shelf angles, and floor slabs.	Bearing Elements Requires TMS-402-16 [1] required bearing elements such as footings, shelf angles, and floor slabs.	Bearing Elements Single-wythe system is the cladding and is supported by footings and floor slabs.
Fire Resistance Rating				

Legend:

Maximum Building Height	**Low** ≤ 3 stories	**Mid** 4–8 stories	**High** ≥ 9 stories	Fire Resistance Rating	= 1 HOUR

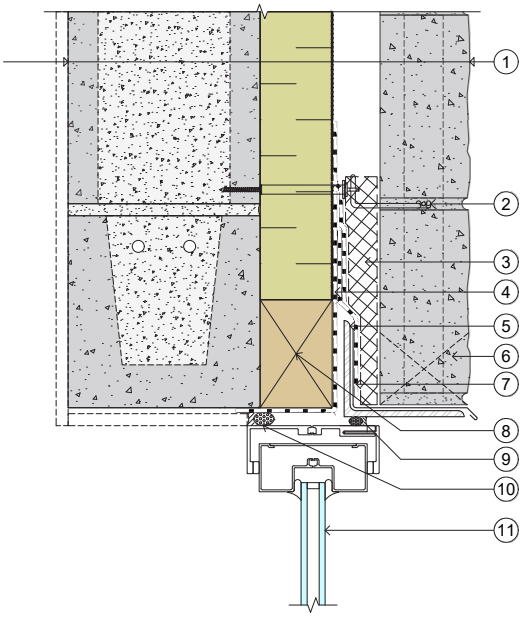


* Water is defined here as precipitation (rain, snow, hail, etc.) and groundwater as well as condensate moisture.
† Vapor is separately defined here as the water vapor in air.

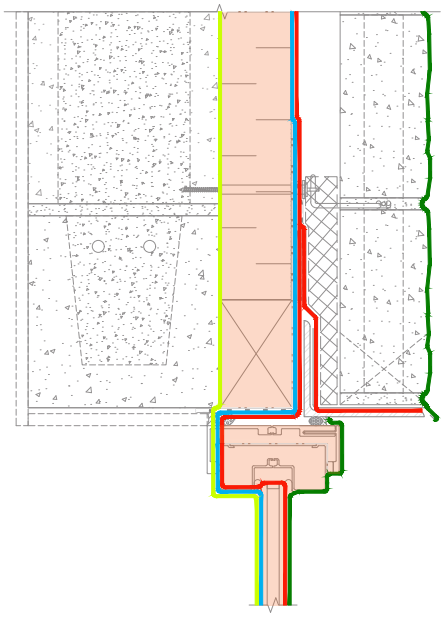
Table 5-1 Summary of Good, Better, Best options for the job site sample panel

	Good	Better	Best
Description	Sample panel is part of the final installation	Stand-alone sample panel	Freestanding, wall system mock-up
Typical Components	Brick and mortar + repellents, coatings, and sealants + masonry accessories and enclosure components limited to the installation location	Brick and mortar + repellents, coatings, and sealants + most typical masonry accessories	Brick and mortar + repellents, coatings, and sealants + typical masonry accessories + window and/or door installation + architectural components (e.g. canopy, balcony, and signage attachments; lighting penetration; etc.)
Location Requirements	On building	Stand-alone, on project site	Freestanding, in a highly visible and protected location on the project site, available for reference and training as needed
Panel Size	4'x4'	4'x4'	Typically, larger than 4'x4'
Specified/ Constructed In Accordance With	TMS 602-16[2]	TMS 602-16[2] + project specifications for supplementary coordination and aesthetic requirements	TMS 602-16[2] + project specification for supplementary coordination and aesthetic requirements + project specification for building enclosure performance requirements
Performance Requirements	Article 3.3 F in TMS 602-16[2] for site tolerances	Article 3.3 F in TMS 602-16[2] for site tolerances	Article 3.3 F in TMS 602-16[2] for site tolerances + qualitative or quantitative air infiltration testing per standardized test methods + water penetration resistance testing per standardized test methods
Aesthetic Requirements	Minimum industry standards (ASTM, ANSI, ACI)	Minimum industry standards (ASTM, ANSI, ACI)	Minimum industry standards (ASTM, ANSI, ACI) + project-specified supplementary requirements
Example Image	 *Fig. 5-8 On-building sample panel example*	 *Fig. 5-9 Standalone sample panel example*	 *Fig. 5-10 Freestanding mock-up example*

CMU BACKUP WALL: Window Head Detail



Detail 6-1 CMU Backup Wall: Window Head Detail



Water-Shedding Surface and Control Layers of Detail 6-1

Legend

1. Typical Assembly:
   - Single-wythe CMU wall
   - Faced rigid board insulation
   - Air cavity
   - Anchored masonry veneer
2. Masonry veneer anchor
3. Mortar collection mesh
4. Fluid-applied air barrier and WRB flashing membrane
5. Hot-dipped galvanized-steel loose lintel
6. Vent/weep at maximum 24 inches on-center
7. Self-adhered flashing lapping on a sheet metal flashing with end dams (beyond)
8. Continuous blocking anchored to structure for window support and attachment
9. Sealant over backer rod
10. Continuous air barrier sealant tied to continuous seal at window perimeter
11. Storefront window, align thermal break with rigid board insulation

Detail Discussion

The window in this series of details is aligned with the adjacent insulation to minimizing thermal bridging around the rough opening at the window-to-wall interface.

A self-adhered flashing membrane transitions from the face of the insulation to the sheet-metal flashing. This allows water at the face of the insulation (the water control layer) to drain to the exterior through the vent/weep. A self-adhered flashing is used in lieu of a sheet-metal flashing; a sheet-metal flashing would require additional blocking, and less insulation, at the rough opening head for attachment.

Water-Shedding Surface & Control Layers

Water-Shedding Surface

Control Layers:

Water

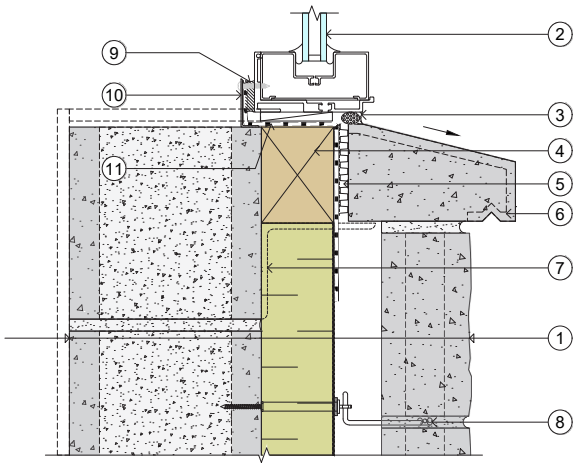
Air

Vapor

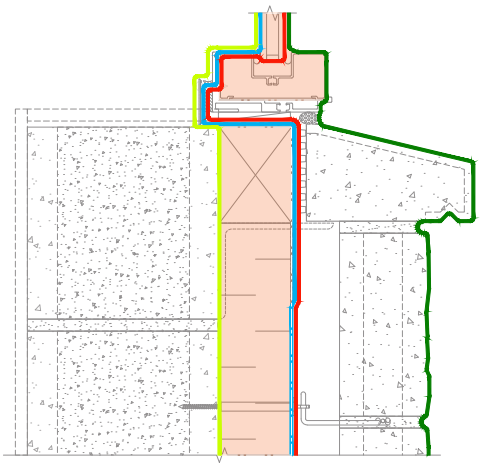
Thermal

Note: Control layers are shown for a Class I or II faced rigid insulation board product.

CMU BACKUP WALL: Window Sill Detail



Detail 6-2 CMU Backup Wall: Window Sill Detail



Water-Shedding Surface and Control Layers of Detail 6-2

Legend

1. Typical Assembly:
   - Single-wythe CMU wall
   - Faced rigid board insulation
   - Air cavity
   - Anchored masonry veneer
2. Storefront window, align thermal break with rigid board insulation
3. Sealant over backer rod
4. Continuous blocking anchored to structure for window support and attachment
5. Drainage matrix
6. Sloped precast sill with chamfered drip edge and sealant over backer rod at precast joints
7. Intermittent structural support for precast sill (beyond)
8. Masonry veneer anchor
9. Continuous air barrier sealant tied to continuous seal at window perimeter
10. Back dam angle at sill, minimum 1 inch tall, fasten window through back dam angle
11. Fluid-applied air barrier and WRB flashing membrane

Detail Discussion

Intermittent attachments back to the structure may be required to support the precast sill element. These attachments require detailing with a fluid-applied or self-adhered flashing membrane where they project through the insulation and facer. Intermittent attachments disrupt the insulation (thermal control layer) less than continuous attachments and are preferred.

The drainage matrix behind the precast sill element allows for a continuous pathway for water to drain from the window rough opening into the air cavity below where it can be redirected exterior of the masonry veneer. This allows for a backer rod and sealant joint at the window perimeter to maintain a continuous water-shedding surface.

Water-Shedding Surface & Control Layers

Water-Shedding Surface

Control Layers:

Water

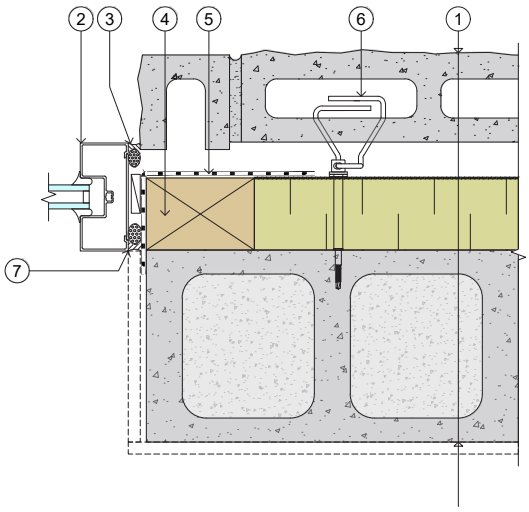
Air

Vapor

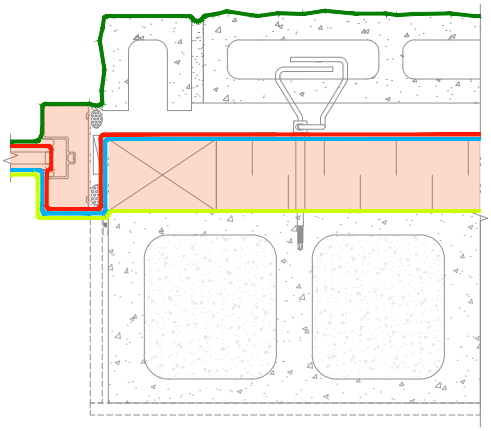
Thermal

Note: Control layers are shown for a Class I or II faced rigid insulation board product.

CMU BACKUP WALL: Window Jamb Detail



Detail 6-3 CMU Backup Wall: Window Jamb Detail



Water-Shedding Surface and Control Layers of Detail 6-3

Legend

1. Typical Assembly:
   - Single-wythe CMU wall
   - Faced rigid board insulation
   - Air cavity
   - Anchored masonry veneer
2. Storefront window, align thermal break with rigid board insulation
3. Sealant over backer rod
4. Continuous blocking anchored to structure for window support and attachment
5. Fluid-applied air barrier and WRB flashing membrane
6. Masonry veneer anchor
7. Continuous air barrier sealant tied to continuous seal at window perimeter

Detail Discussion

Wood blocking shown at the jamb serves as a nailer to attach the window. Air and water control layer continuity between the window and wall is provided by a continuous seal and the fluid applied flashing membrane at the window rough opening perimeter. A veneer return at the jamb may be needed to allow for the exterior backer rod and sealant to be installed. An air gap is to remain between the return brick and flashing membrane. It should not be packed with mortar.

Water-Shedding Surface & Control Layers

Water-Shedding Surface

Control Layers:

Water

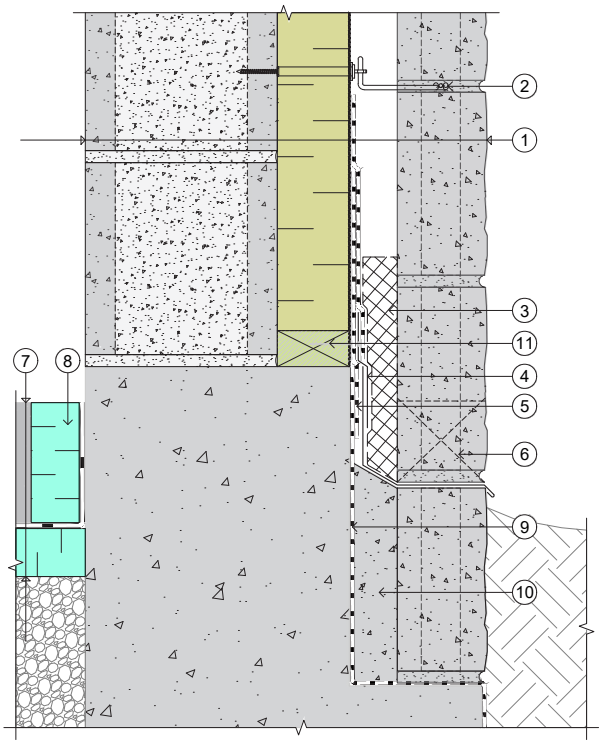
Air

Vapor

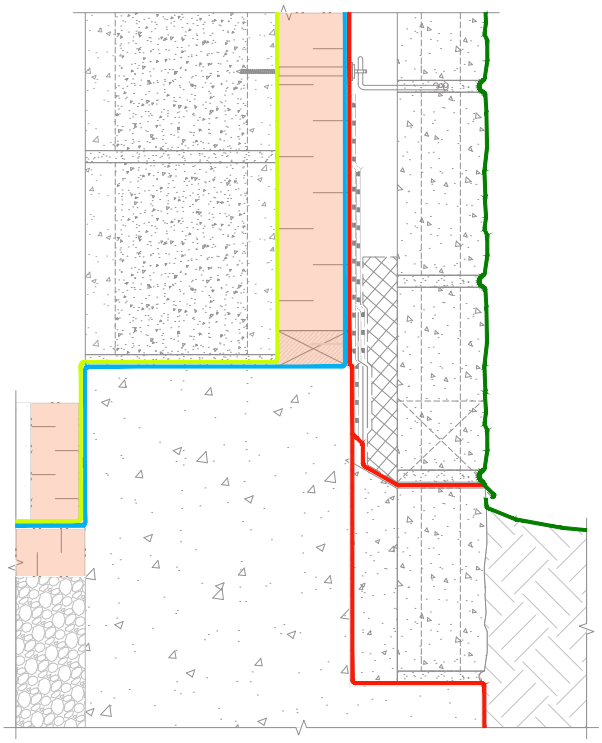
Thermal

Note: Control layers are shown for a Class I or II faced rigid insulation board product.

CMU BACKUP WALL: Base-of-Wall Detail



Detail 6-4 CMU Backup Wall: Base-of-Wall Detail



Water-Shedding Surface and Control Layers of Detail 6-4

Legend

1. Typical Assembly:
   - Single-wythe CMU wall
   - Faced rigid board insulation
   - Air cavity
   - Anchored masonry veneer
2. Masonry veneer anchor
3. Mortar collection mesh
4. Two-piece sheet-metal flashing with hemmed drip edge and end dams beyond, attached through the wood blocking
5. Fluid-applied air barrier and WRB flashing membrane
6. Vent/weep at maximum 24 inches on-center
7. Typical Assembly at Floor:
   - Concrete floor slab
   - Vapor barrier
   - Rigid XPS insulation
   - Capillary break
8. Rigid XPS insulation thermal break
9. Below-grade waterproofing or dampproofing with protection course where required
10. Continuous grout, sloped at top
11. Preservative treated wood blocking

Detail Discussion

In this detail, a thermal break is provided between the concrete floor slab and foundation element to minimize heat loss at the floor-to-wall interface.

The bottom courses of masonry are at or below-grade; continuous grout exists behind the veneer for support. The sheet-metal flashing shown drains the wall cavity above to the exterior and stops the transfer of any moisture between the above- and below-grade masonry.

Wood blocking shown serves as a nailer to attach the two-piece sheet-metal flashing.

Water-Shedding Surface & Control Layers

Water-Shedding Surface

Control Layers:

Water

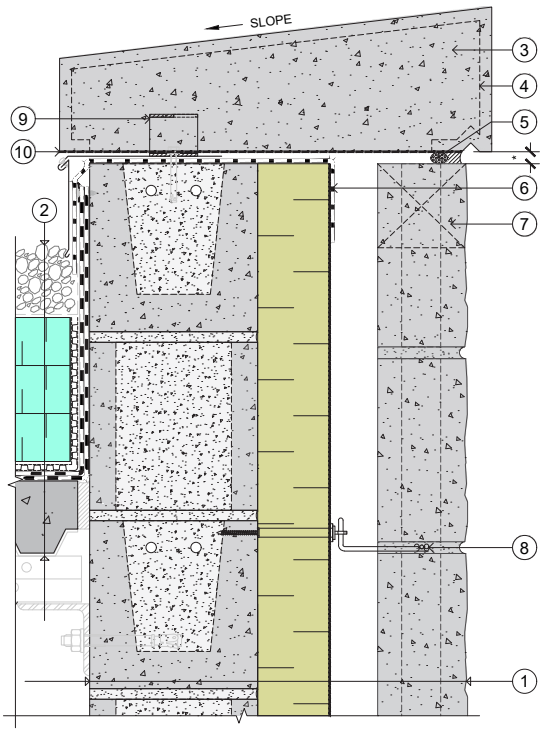
Air

Vapor

Thermal

Note: Control layers are shown for a Class I or II faced rigid insulation board product.

CMU BACKUP WALL: Roof Parapet Detail



Detail 6-5 CMU Backup Wall: Roof Parapet Detail

Water-Shedding Surface and Control Layers of Detail 6-5

Legend

1. Typical Assembly:
   - Single-wythe CMU wall
   - Faced rigid board insulation
   - Air cavity
   - Anchored masonry veneer
2. Inverted roof membrane assembly
3. Precast cornice with chamfered drip edge
4. Sealant over backer rod at precast joints beyond
5. Sealant over backer rod
6. Fully-reinforced fluid-applied roof flashing membrane
7. Vents at maximum 24 inches on-center (optional)
8. Masonry veneer anchor
9. Split-tail anchor
10. Cementitious-based waterproof coating

*Minimum 3/8-inch to allow for movement. Confirm dimension with Engineer of Record.

Detail Discussion

An application of cementitious-based waterproof coating is applied on the underside of the architectural precast concrete, cast stone, or limestone cap to minimize the migration of moisture below the cap area. This application can mitigate efflorescence in the wall below.

The drip edge at the underside of the parapet cap encourages water to shed away from the enclosure before it can run down the face of the masonry cladding. This application can minimize staining and efflorescence.

The thermal performance of this detail may be improved by framing and insulating the parapet as shown in Detail 6-13. The best approach for minimizing heat loss at the parapet is by insulating up and over the parapet structure.

Water-Shedding Surface & Control Layers

Water-Shedding Surface

Control Layers:

Water

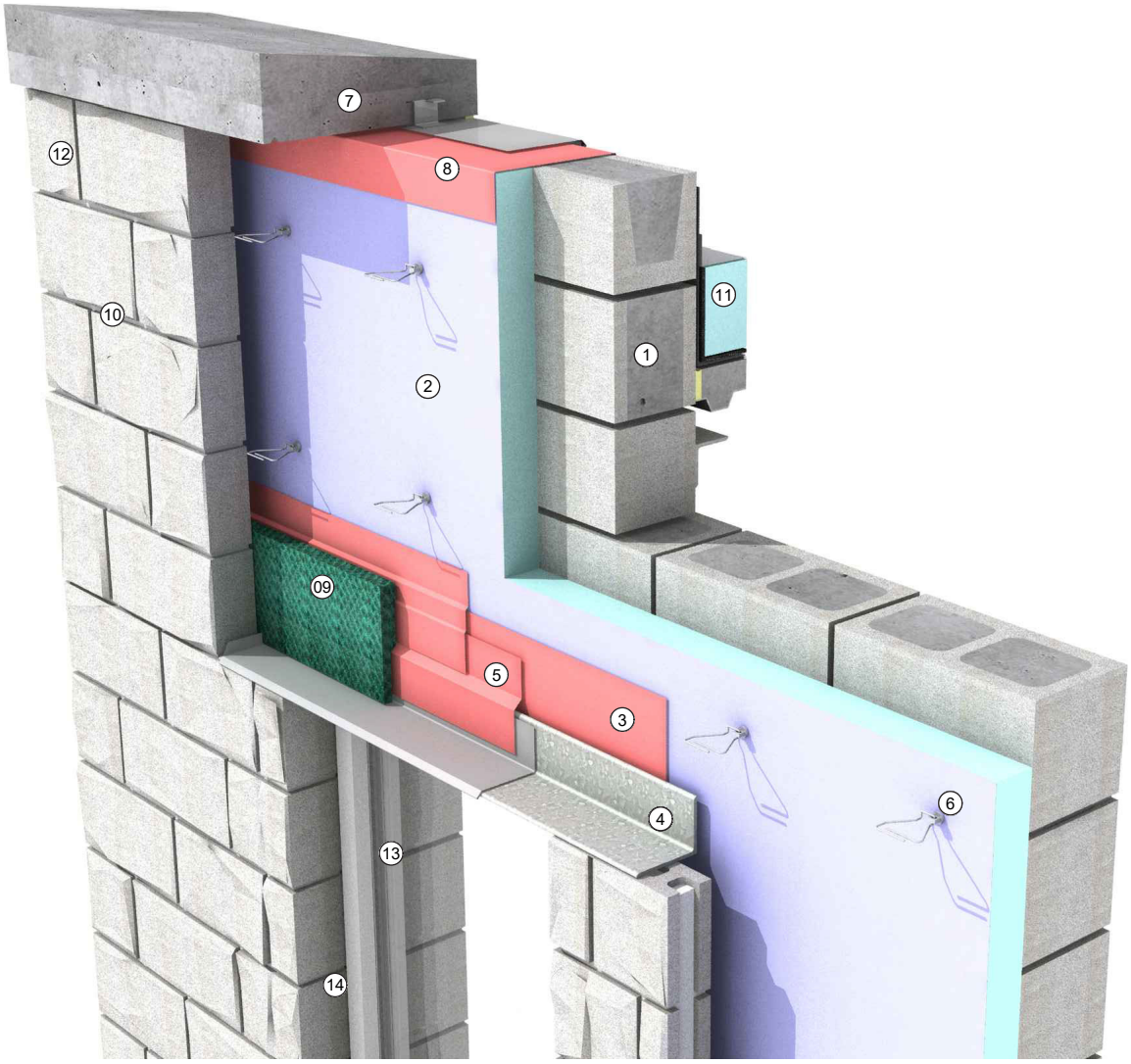
Air

Vapor

Thermal

Note: Control layers are shown for a Class I or II faced rigid insulation board product.

CMU BACKUP WALL: Roof Parapet 3D Detail



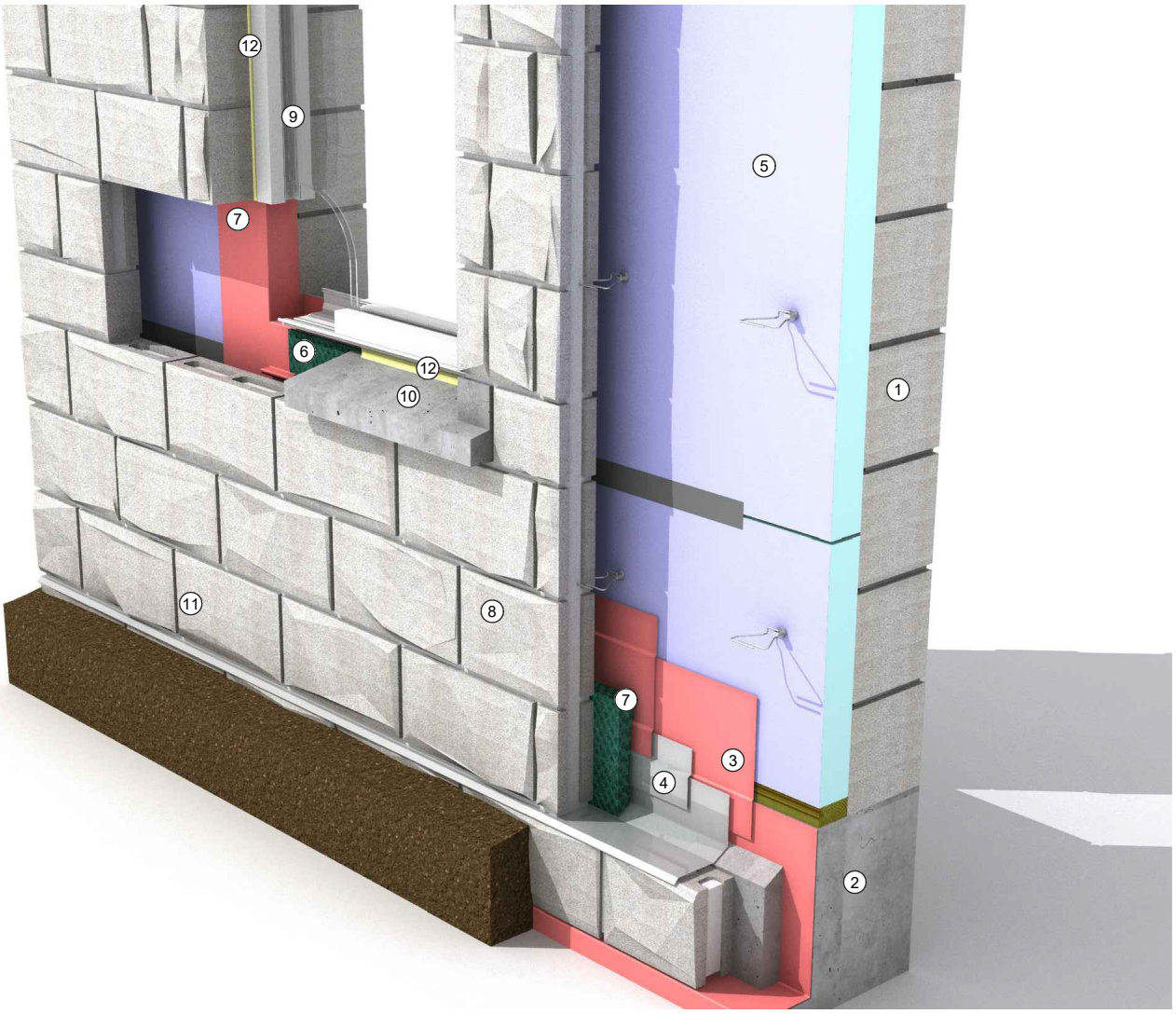
Detail 6-6 CMU Backup Wall: Roof Parapet 3D Detail

Legend

1. Single-wythe CMU wall
2. Faced rigid board insulation
3. Fluid-applied air barrier and WRB flashing membranes
4. Hot-dipped galvanized-steel loose lintel
5. Self-adhered flashing lapping on a sheet metal flashing with end dams (beyond)
6. Masonry veneer tie
7. Precast cornice with chamfered drip edge
8. High-temperature self-adhered membrane
9. Mortar collection mesh
10. Anchored masonry veneer
11. Inverted roof membrane assembly and roof structure
12. Vents at maximum 24-inches on-center (optional)
13. Storefront window
14. Sealant over backer rod

Refer to Detail 6-1, Detail 6-3, and Detail 6-5 for more information.

CMU BACKUP WALL: Base-of-Wall 3D Detail



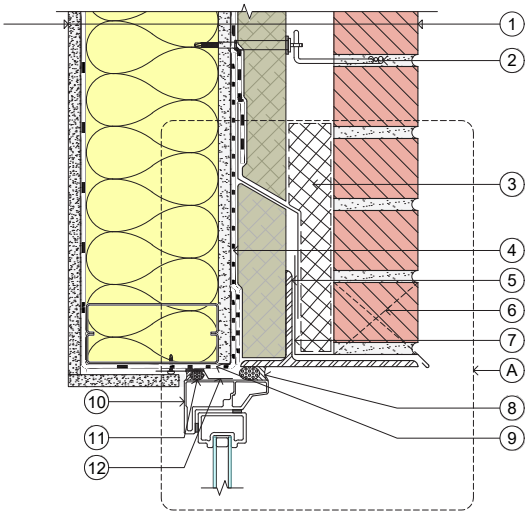
Detail 6-7 CMU Backup Wall: Base-of-Wall 3D Detail

Legend

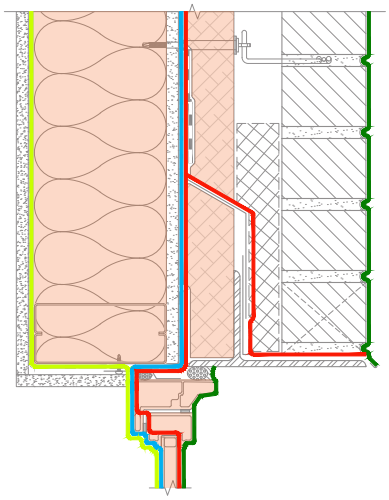
1. Single-wythe CMU wall
2. Concrete foundation element
3. Fluid-applied or self-adhered flashing membrane
4. Two-piece sheet-metal flashing with hemmed drip edge and end dams beyond, attached through the wood blocking
5. Faced rigid board insulation
6. Mortar collection mesh
7. Fluid-applied air barrier and WRB flashing membrane
8. Anchored masonry veneer
9. Storefront window
10. Sloped precast sill with chamfered drip edge and sealant over backer rod at precast joints
11. Vent/weep at maximum 24-inches on-center
12. Continuous sealant and backer rod

Refer to Detail 6-2, Detail 6-3, and Detail 6-4 for more information.

STEEL STUD-FRAMED BACKUP WALL: Window Head Detail



Detail 6-8 Steel Stud-Framed Backup Wall: Window Head Detail



Water-Shedding Surface and Control Layers of Detail 6-8

Legend

1. Typical Assembly:
   - Interior gypsum board
   - Vapor retarder
   - Steel stud-framed wall with batt insulation
   - Exterior sheathing
   - Self-adhered sheet- or fluid-applied air barrier and WRB field membrane
   - Semi-rigid exterior insulation
   - Air cavity
   - Anchored masonry veneer
2. Masonry veneer anchor
3. Mortar collection mesh
4. Self-adhered sheet- or fluid-applied air barrier and WRB field membrane
5. Hot-dipped galvanized-steel loose lintel
6. Vent/weep at maximum 24 inches on-center
7. Two-piece sheet-metal head flashing with hemmed drip edge and end dams (beyond)
8. Sealant over backer rod
9. Self-adhered sheet- or fluid-applied air barrier and WRB flashing membrane
10. Non-flanged window
11. Continuous air barrier sealant tied to continuous seal at window perimeter
12. Window strap anchor, bed in air barrier sealant at continuous air barrier sealant joint plane

A. See alternate shelf angle support detailing options on page 63

Detail Discussion

A non-flanged window is shown in the detail and facilitates future window replacement without the need to remove the anchored masonry veneer or window flanges.

The intermittent strap anchors used to attach the window to the structure are bed in sealant at the plane of the continuous air barrier sealant at the window perimeter. This allows the air and water control layer to be continuous between the window and rough opening flashing membrane behind strap anchors.

Water-Shedding Surface & Control Layers

Water-Shedding Surface

Control Layers:

Water

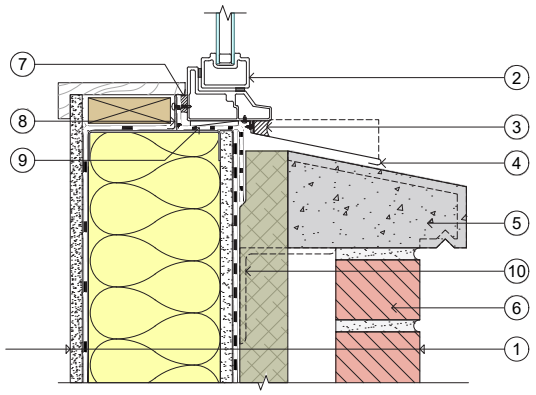
Air

Vapor

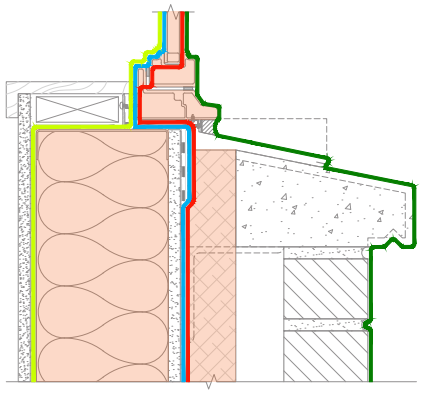
Thermal

Note: Control layers are shown for a Class IV permeance (and sometimes Class III permeance) air barrier and WRB field membrane and where a vapor retarder is located at the interior face of the framing.

STEEL STUD-FRAMED BACKUP WALL: Window Sill Detail



Detail 6-9 Steel Stud-Framed Backup Wall: Window Sill Detail



Water-Shedding Surface and Control Layers of Detail 6-9

Legend

1. Typical Assembly:
   - Interior gypsum board
   - Vapor retarder
   - Steel stud-framed wall with batt insulation
   - Exterior sheathing
   - Self-adhered sheet- or fluid-applied air barrier and WRB field membrane
   - Semi-rigid exterior insulation
   - Air cavity
   - Anchored masonry veneer
2. Non-flanged window on minimum ¼-inch thick intermittent plastic shims
3. Sealant over bond breaker
4. Sloped sheet-metal sill flashing with hemmed edge and end dams (beyond), attached to intermittent L-angle at window per window manufacturer recommendations
5. Sloped precast sill with chamfered drip edge and sealant over backer rod at precast joints
6. Anchored masonry veneer
7. Continuous air barrier sealant tied to continuous seal at window perimeter
8. Back dam angle at sill, minimum 1 inch tall, fasten window through back dam angle
9. Self-adhered sheet- or fluid-applied air barrier and WRB flashing membrane
10. Intermittent structural support for precast sill (beyond)

Detail Discussion

The sheet-metal sill flashing conceals the rainscreen cavity. End dams exist on the sheet-metal sill flashing and terminate within a bed joint of the brick return beyond. This provides continuity of the water-shedding surface at the jamb to sill interface, minimizing the opportunity for water to enter the air cavity behind the brick.

This guide recommends against placing a sheet-metal flashing below the precast sill. It can prematurely degrade the mortar bed beneath the precast sill.

A chamfer is shown in the underside of the precast sill to form a drip. This encourages water to shed from the sill before reaching the masonry veneer below.

Water-Shedding Surface & Control Layers

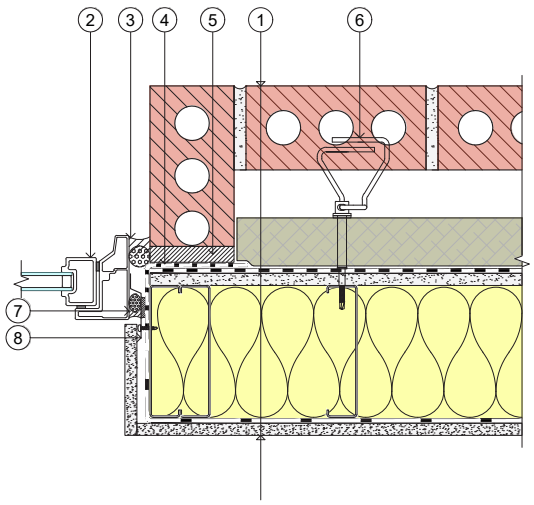
Water-Shedding Surface

Control Layers:

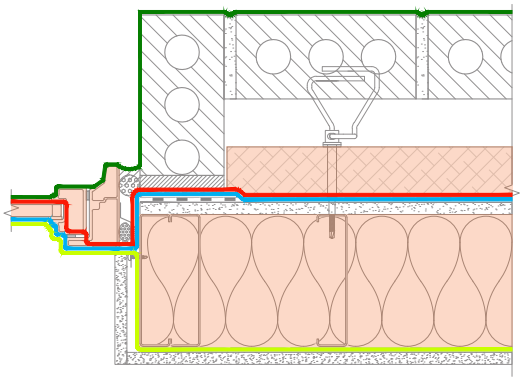
Water
Air
Vapor
Thermal

Note: Control layers are shown for a Class IV permeance (and sometimes Class III permeance) air barrier and WRB field membrane and where a vapor retarder is located at the interior face of the framing.

STEEL STUD-FRAMED BACKUP WALL: Window Jamb Detail



Detail 6-10 Steel Stud-Framed Backup Wall: Window Jamb Detail



Water-Shedding Surface and Control Layers of Detail 6-10

Legend

1. Typical Assembly:
   - Interior gypsum board
   - Vapor retarder
   - Steel stud-framed wall with batt insulation
   - Exterior sheathing
   - Self-adhered sheet- or fluid-applied air barrier and WRB field membrane
   - Semi-rigid exterior insulation
   - Air cavity
   - Anchored masonry veneer
2. Non-flanged window
3. Sealant over backer rod
4. Self-adhered sheet- or fluid-applied air barrier and WRB flashing membrane
5. Minimum ½-inch drainage path, fill with free draining compressible filler
6. Masonry veneer anchor
7. Continuous air barrier sealant tied to continuous seal at window perimeter
8. Window strap anchor, bed in air barrier sealant at continuous air barrier sealant joint plane

Detail Discussion

The backer rod and sealant joint at the interior side of the window provides air and water control layer continuity from the window to the air barrier and WRB flashing membrane at the rough opening. Strap anchors, which interrupt this sealant joint, are bed in sealant to maintain continuity of the air and water control layer.

In this detail the brick return at the jamb prevents the exterior insulation from extending up to the window. To improve the thermal performance of this interface, the exterior insulation can extend up to the window rough opening and a shallower brick return may be used. A sheet-metal jamb flashing (typically attached to the window with small clips) can be used to conceal the air cavity and insulation and provide continuity of the water-shedding surface.

Water-Shedding Surface & Control Layers

Water-Shedding Surface

Control Layers:

Water

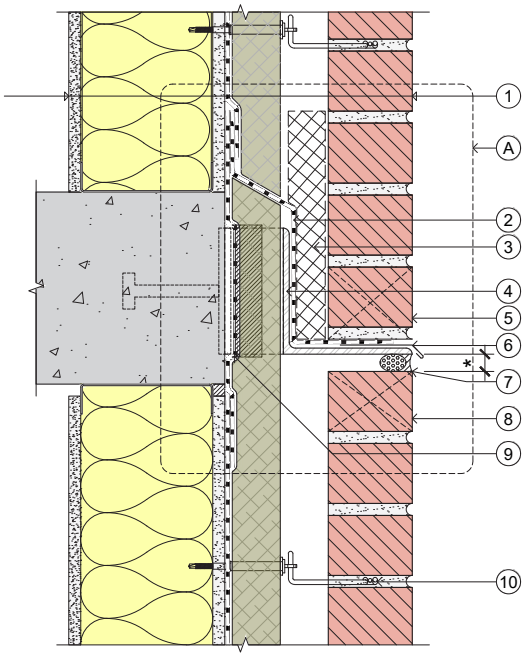
Air

Vapor

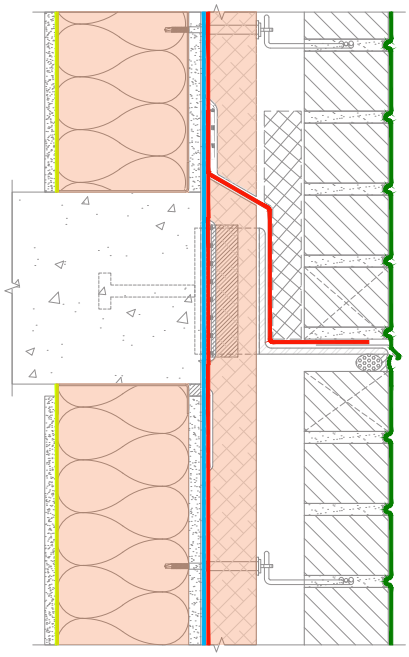
Thermal

Note: Control layers are shown for a Class IV permeance (and sometimes Class III permeance) air barrier and WRB field membrane and where a vapor retarder is located at the interior face of the framing.

STEEL STUD-FRAMED BACKUP WALL: Floor Line Detail



Detail 6-11 Steel Stud-Framed Backup Wall: Floor-Line Detail



Water-Shedding Surface and Control Layers of Detail 6-11

Legend

1. Typical Assembly:
   - Interior gypsum board
   - Vapor retarder
   - Steel stud-framed wall with batt insulation
   - Exterior sheathing
   - Self-adhered sheet- or fluid-applied air barrier and WRB field membrane
   - Semi-rigid exterior insulation
   - Air cavity
   - Anchored masonry veneer
2. Self-adhered flashing membrane
3. Mortar collection mesh
4. Hot-dipped galvanized-steel standoff shelf angle support anchored on intermittent structural support
5. Vent/weep at maximum 24 inches on-center
6. Sheet-metal flashing with hemmed drip edge
7. Sealant over backer rod
8. Vent at maximum 24 inches on-center (optional)
9. Self-adhered sheet- or fluid-applied air barrier and WRB flashing membrane, extend onto intermittent structural support
10. Masonry veneer anchor

A. See alternate shelf angle support detailing options on page 63

*Minimum ⅜-inch to allow for movement. Confirm dimension with Engineer of Record.

Detail Discussion

See Shelf Angle Flashing Options on page 63 and page 64 for alternative flashing solutions that may be used at the floor line.

The use of a standoff shelf angle to support the anchored masonry veneer allows insulation to run continuously across the floor line and minimize thermal bridging. This minimizes heat loss at the floor line and can improve thermal comfort; it is more thermally efficient than a continuous shelf angle support as discussed in Chapter 8.

Water-Shedding Surface & Control Layers

Water-Shedding Surface

Control Layers:

Water

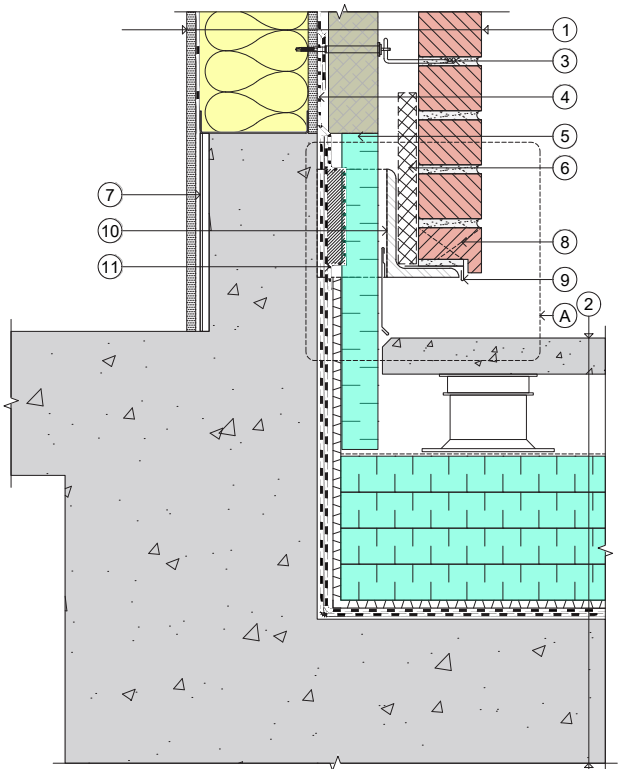
Air

Vapor

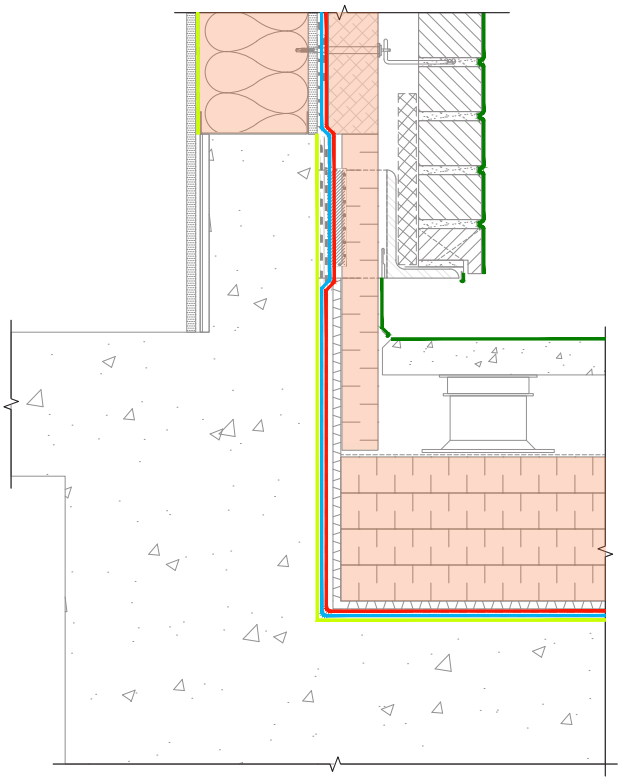
Thermal

Note: Control layers are shown for a Class IV permeance (and sometimes Class III permeance) air barrier and WRB field membrane and where a vapor retarder is located at the interior face of the framing.

STEEL STUD-FRAMED BACKUP WALL: Roof-to-Wall Detail



Detail 6-12 Steel Stud-Framed Backup Wall: Roof-to-Wall Detail



Water-Shedding Surface and Control Layers of Detail 6-12

Legend

1. Typical Assembly:
   - Interior gypsum board
   - Vapor retarder
   - Steel stud-framed wall with batt insulation
   - Exterior sheathing
   - Self-adhered sheet- or fluid-applied air barrier and WRB field membrane
   - Semi-rigid exterior insulation
   - Air cavity
   - Anchored masonry veneer
2. Inverted roof assembly
3. Masonry veneer anchor
4. Self-adhered sheet- or fluid-applied air barrier and WRB flashing membrane, lapped over roof membrane termination and roof penetration flashing membrane
5. Continuous rigid or semi-rigid exterior insulation over drainage composite
6. Mortar collection mesh
7. Interior furring for finish attachment
8. Vent/weep at maximum 24 inches on-center
9. Sheet-metal flashing with hemmed drip edge
10. Hot-dipped galvanized-steel standoff shelf angle support anchored on intermittent structural support
11. Roof penetration flashing membrane (per roof membrane manufacturer), extend onto structural support

A. See alternate shelf angle support detailing options on page 63

Detail Discussion

The standoff shelf angle support at this transition allows for continuous thermal insulation across the roof and wall assemblies.

Masonry wall system installation often precedes roof membrane installation and restricts future access for installation of the roof membrane and flashing components behind the standoff shelf angle. As a result, installation of a roof membrane prestrip and roof penetration flashing membrane at the concrete wall is needed prior to masonry wall system installation. The roof membrane manufacturer can provide recommended prestrip detailing.

Water-Shedding Surface & Control Layers

Water-Shedding Surface

Control Layers:

Water

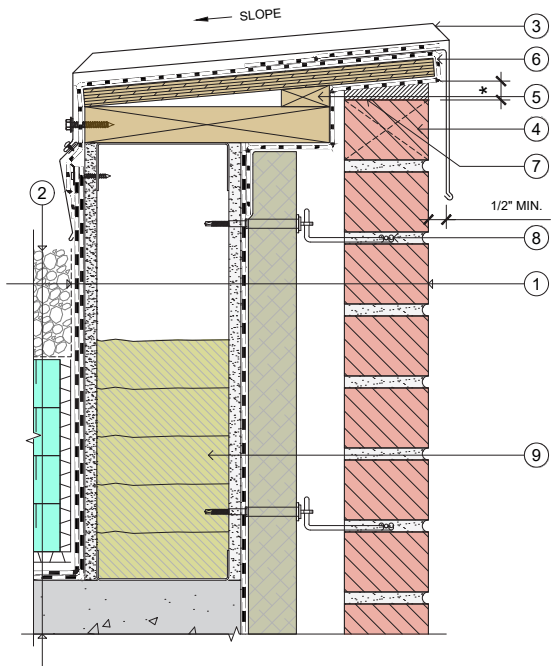
Air

Vapor

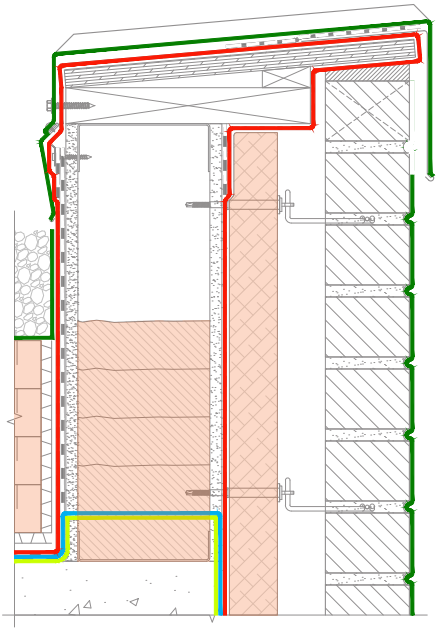
Thermal

Note: Control layers are shown for a Class IV permeance (and sometimes Class III permeance) air barrier and WRB field membrane and where a vapor retarder is located at the interior face of the framing.

STEEL STUD-FRAMED BACKUP WALL: Roof Parapet Detail



Detail 6-13 Steel Stud-Framed Backup Wall: Roof Parapet Detail



Water-Shedding Surface and Control Layers of Detail 6-13

Legend

1. Parapet Assembly:
   - Roof membrane
   - Exterior sheathing
   - Vented steel stud-framed wall
   - Exterior sheathing
   - Self-adhered sheet- or fluid-applied air barrier and WRB field membrane
   - Air cavity
   - Anchored masonry veneer
2. Inverted roof membrane assembly
3. Standing-seam sheet-metal coping with gasketed washer fasteners
4. Vent at maximum 24 inches on-center (optional)
5. Preservative-treated wood blocking
6. High-temperature self-adhered membrane
7. Compressible filler
8. Masonry veneer anchor
9. Closed-cell spray foam insulation

*Minimum ⅜-inch to allow for movement. Confirm dimension with Engineer of Record.

Detail Discussion

The vents shown in the top course of the anchored masonry veneer are optional and may be used to increase ventilation of air behind the brick cavity. As shown in this detail, the sheet-metal coping is held away from the face of the masonry so as not to block the vent.

A compressible filler is used between the masonry veneer and parapet blocking to allow for a separation between the blocking and anchor masonry veneer while preventing insects and debris from entering the cavity behind the masonry veneer.

Parapet cavity insulation provides continuity of the thermal control layer at the roof-to-wall transition.

Water-Shedding Surface & Control Layers

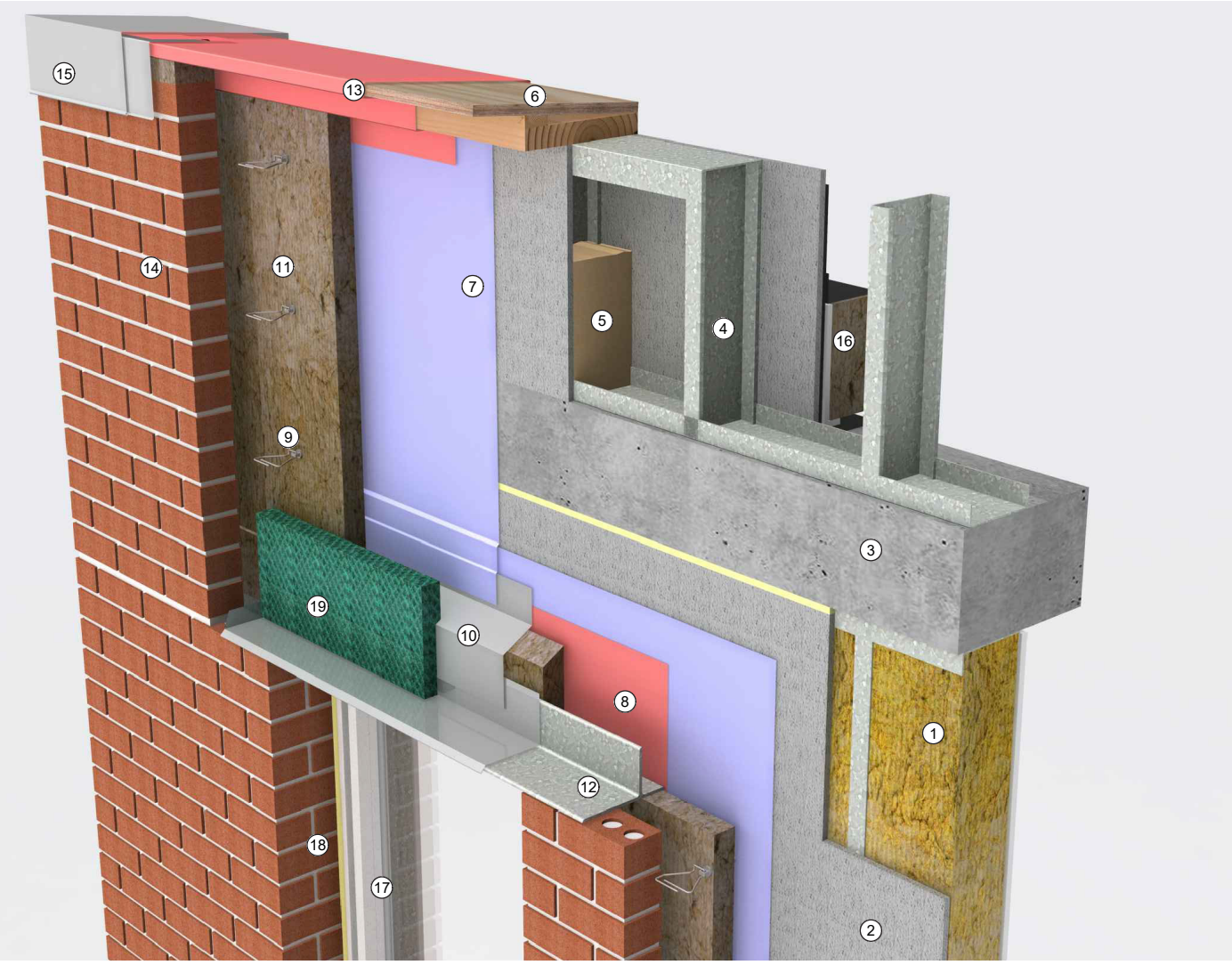
Water-Shedding Surface

Control Layers:

Water
Air
Vapor
Thermal

Note: Control layers are shown for a Class IV permeance (and sometimes Class III permeance) air barrier and WRB field membrane and where a vapor retarder is located at the interior face of the framing.

STEEL STUD-FRAMED BACKUP WALL: Parapet 3D Detail



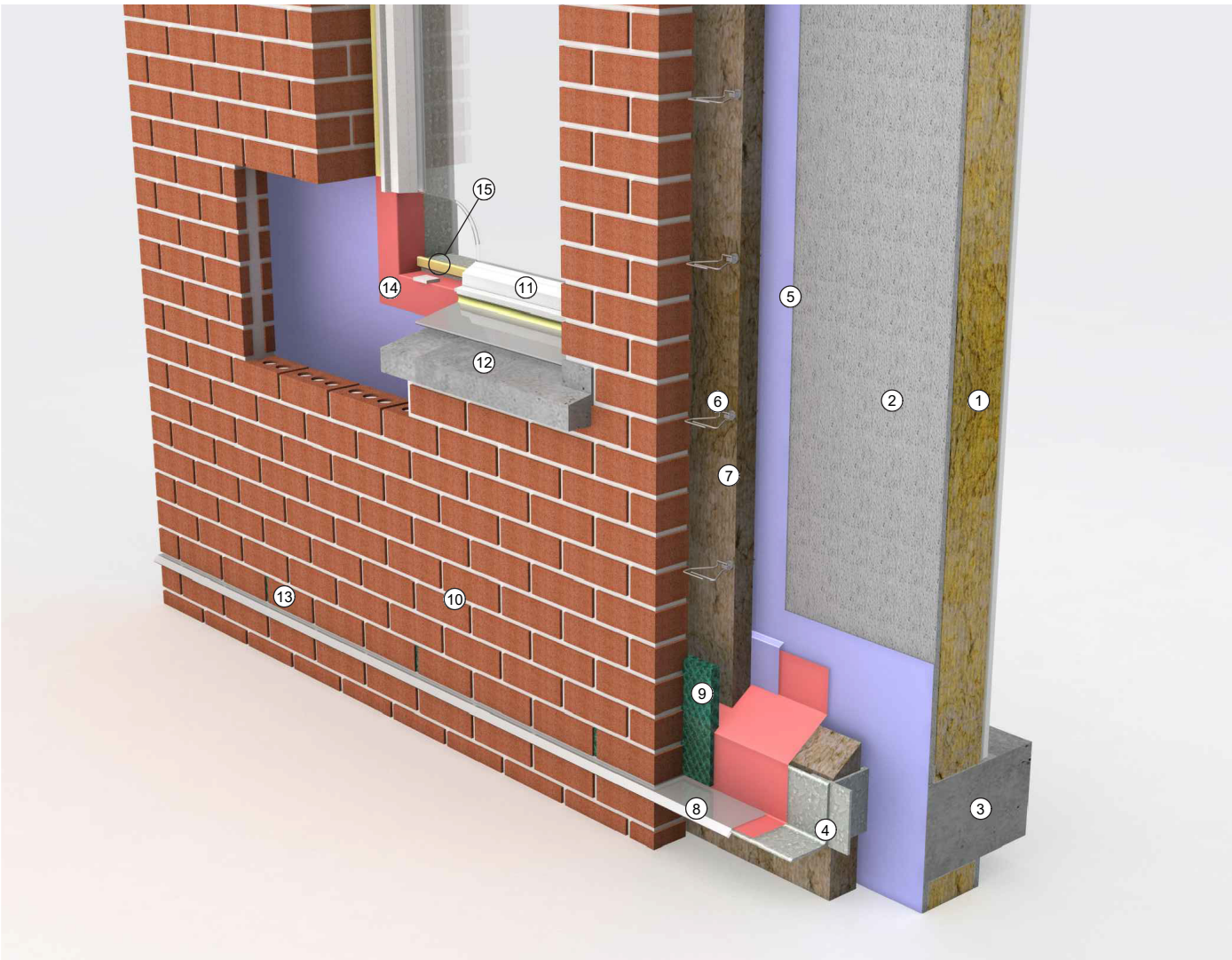
Detail 6-14 Steel Stud-Framed Backup Wall: Parapet 3D Detail

Legend

1. Steel stud-framed wall with batt insulation
2. Exterior sheathing
3. Concrete roof structure
4. Steel stud parapet framing
5. Closed-cell spray foam insulation plug
6. Sloped preservative-treated blocking
7. Self-adhered sheet- or fluid-applied air barrier and WRB field membrane
8. Self-adhered sheet- or fluid-applied air barrier and WRB flashing membranes
9. Masonry veneer anchor, fastened through air barrier sealant, fluid-applied flashing membrane, or self-adhered membrane patch per WRB system manufacturer recommendations
10. Two-piece sheet-metal head flashing with hemmed drip edge and end dams
11. Semi-rigid exterior insulation
12. Hot-dipped galvanized-steel loose lintel
13. High-temperature self-adhered membrane
14. Anchored masonry veneer
15. Sloped standing-seam sheet-metal coping with gasketed washer fasteners
16. Inverted roof membrane assembly
17. Non-flanged window
18. Anchored masonry veneer
19. Mortar collection mesh

Refer to Detail 6-8, Detail 6-10, and Detail 6-13 for more information.

STEEL STUD-FRAMED BACKUP WALL: Base-of-Wall 3D Detail



Detail 6-15 Steel Stud-Framed Backup Wall: Base-of-Wall 3D Detail

Legend

1. Steel stud-framed wall with batt insulation
2. Exterior sheathing
3. Concrete floor slab
4. Hot-dipped galvanized-steel standoff shelf angle support anchored on intermittent structural support
5. Self-adhered sheet- or fluid-applied air barrier and WRB field membrane
6. Masonry veneer anchor, fastened through air barrier sealant, fluid-applied flashing membrane, or self-adhered membrane patch per WRB system manufacturer recommendations
7. Semi-rigid exterior insulation
8. Sheet-metal flashing with hemmed drip edge
9. Mortar collection mesh
10. Anchored masonry veneer
11. Non-flanged window
12. Sloped precast concrete sill with sloped sheet-metal sill flashing
13. Vent/weep at maximum 24-inches on-center
14. Self-adhered sheet- or fluid-applied air barrier and WRB flashing membrane
15. Continuous air barrier sealant tied to continuous seal at window perimeter

Refer to Detail 6-9, Detail 6-10, and Detail 6-11 for more information.

STEEL STUD-FRAMED BACKUP WALL: Saddle Flashing 3D Detail

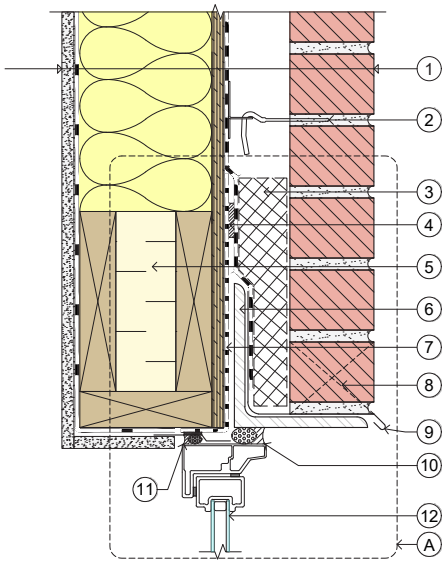
Detail 6-16 Steel Stud-Framed Backup Wall: Saddle Flashing 3D Detail

Legend

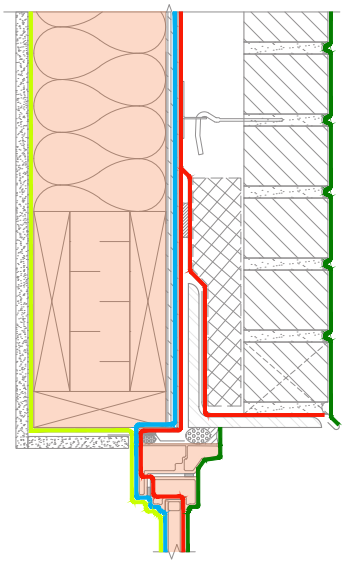
1. Inverted roof membrane assembly over concrete roof structure
2. Inverted roof membrane
3. Self-adhered or fluid-applied flashing membrane, lap over roof membrane termination, roof penetration flashing membrane, and parapet saddle flashing membrane
4. Self-adhered sheet- or fluid-applied air barrier and WRB field membrane
5. Parapet saddle flashing membrane, extend onto sloped parapet blocking beyond anchored masonry veneer wall face (above)
6. Semi-rigid mineral fiber exterior insulation
7. Hot-dipped galvanized-steel standoff shelf angle support on intermittent knife plates
8. Shelf angle knife plate support with roof penetration flashing membrane (per roof membrane manufacturer)
9. Mortar collection mesh
10. Sheet-metal flashing with hemmed drip edge
11. Anchored masonry veneer
12. High-temperature self-adhered membrane, lap membrane over parapet saddle flashing membrane and roof membrane termination
13. Exterior sheathing
14. Closed-cell spray foam insulation within framed parapet
15. Sloped standing-seam sheet-metal coping, end dam at anchored masonry veneer face beyond
16. Sheet-metal counterflashing with spring lock inserted into mortar bed beyond, seal with a sanded sealant over backer rod

Refer to Detail 6-12 and Detail 6-13 for more information.

WOOD-FRAMED BACKUP WALL: Window Head Detail



Detail 6-17 Wood-Framed Backup Wall: Window Head Detail



Water-Shedding Surface and Control Layers of Detail 6-17

Legend

1. Typical Assembly:
   - Interior gypsum board
   - Vapor retarder
   - Wood-framed wall with batt insulation
   - Exterior sheathing
   - Mechanically attached air barrier and WRB field membrane
   - Air cavity
   - Anchored masonry veneer
2. Masonry veneer anchor
3. Mortar collection mesh
4. Continuous air barrier sealant
5. Insulated window header
6. Hot-dipped galvanized-steel loose lintel
7. Self-adhered sheet- or fluid-applied air barrier and WRB flashing membrane
8. Vent/weep at maximum 24 inches on-center
9. Sheet-metal head flashing with hemmed drip edge and end dams (beyond)
10. Sealant over backer rod
11. Continuous air barrier sealant tied to continuous seal at window perimeter
12. Non-flanged window

A. See alternate shelf angle support detailing options on page 63

Detail Discussion

A loose lintel is depicted in this detail; however, the structure support for the anchored masonry above the window could also be a shelf angle support attached back to the wood-framed structure. In this case, the shelf angle would be detailed similar to Detail 6-20.

A continuous bead of air barrier sealant exists between the rough opening flashing and the mechanically attached air barrier and WRB field membrane to maintain air control layer continuity.

Water-Shedding Surface & Control Layers

Water-Shedding Surface

Control Layers:

Water

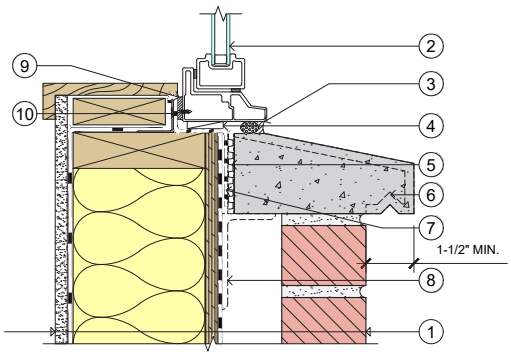
Air

Vapor

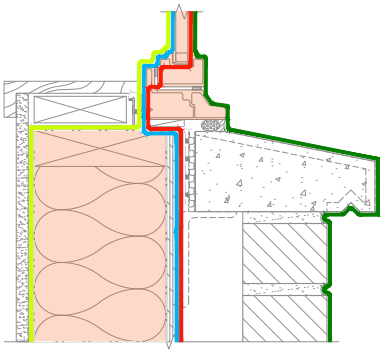
Thermal

Note: Control layers are shown for a Class IV permeance (and sometimes Class III permeance) air barrier and WRB field membrane and where a vapor retarder is located at the interior face of the framing.

WOOD-FRAMED BACKUP WALL: Window Sill Detail



Detail 6-18 Wood-Framed Backup Wall: Window Sill Detail



Water-Shedding Surface and Control Layers of Detail 6-18

Legend

1. Typical Assembly:
   - Interior gypsum board
   - Vapor retarder
   - Wood-framed wall with batt insulation
   - Exterior sheathing
   - Mechanically attached air barrier and WRB field membrane
   - Air cavity
   - Anchored masonry veneer
2. Non-flanged window on minimum ¼-inch thick intermittent plastic shims
3. Sealant over backer rod
4. Minimum ⅛-inch thick intermittent shims behind sill flange for drainage
5. Drainage matrix behind precast sill for drainage
6. Sloped precast sill with chamfered drip edge and sealant over backer rod at precast joints
7. Self-adhered sheet- or fluid-applied air barrier and WRB flashing membrane
8. Intermittent structural support for precast sill (beyond), detail anchor through air barrier and WRB membrane per membrane manufacturer requirements
9. Continuous air barrier sealant tied to continuous seal at window perimeter
10. Back dam angle at sill, minimum 1 inch tall, fasten window through back dam angle

Detail Discussion

This guide recommends that a sheet-metal flashing is not placed below the precast sill. It can prematurely degrade the mortar bed beneath the precast sill.

Air and water control layer continuity in this detail is achieved by sealing the window frame against the flashing membrane at the sill back dam. The flashing membrane is adhered to the field membrane.

Intermittent structural supports may be needed to support the sloped precast sill. Air and water control layer continuity should be considered at these supports; additional sealant and/or flashing membranes may be required.

Water-Shedding Surface & Control Layers

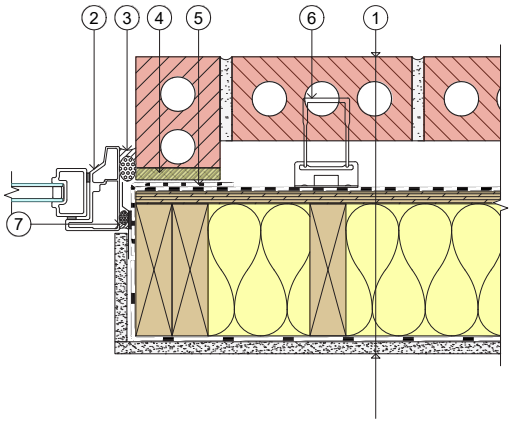
Water-Shedding Surface

Control Layers:

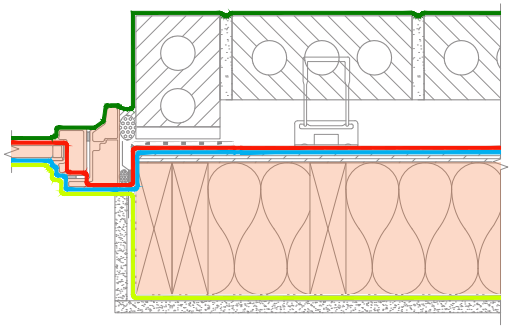
Water
Air
Vapor
Thermal

Note: Control layers are shown for a Class IV permeance (and sometimes Class III permeance) air barrier and WRB field membrane and where a vapor retarder is located at the interior face of the framing.

WOOD-FRAMED BACKUP WALL: Window Jamb Detail



Detail 6-19 Wood-Framed Backup Wall: Window Jamb Detail



Water-Shedding Surface and Control Layers of Detail 6-19

Legend

1. Typical Assembly:
   - Interior gypsum board
   - Vapor retarder
   - Wood-framed wall with batt insulation
   - Exterior sheathing
   - Mechanically attached air barrier and WRB field membrane
   - Air cavity
   - Anchored masonry veneer
2. Non-flanged window
3. Sealant over backer rod
4. Minimum ½-inch drainage path, fill with free-draining compressible filler
5. Self-adhered sheet- or fluid-applied air barrier and WRB flashing membrane
6. Masonry veneer anchor
7. Continuous air barrier sealant tied to continuous seal at window perimeter

Detail Discussion

A drainage pathway is maintained between the brick return and the flashing membrane at the rough opening. This pathway may be filled with a free-draining material such as semi-rigid mineral fiber insulation or drainage matrix. Avoid packing this cavity with mortar, which can transfer moisture from the masonry veneer to the flashing membrane and possibly the sheathing beneath.

A non-flanged window is depicted in this set of details. Flanged windows may be used with masonry veneer but non-flanged window are often considered for the ease of future window removal and replacement.

Where exterior insulation is used with a wood-framed backup wall condition, refer to the steel stud-framed details for similar detailing.

Water-Shedding Surface & Control Layers

Water-Shedding Surface

Control Layers:

Water

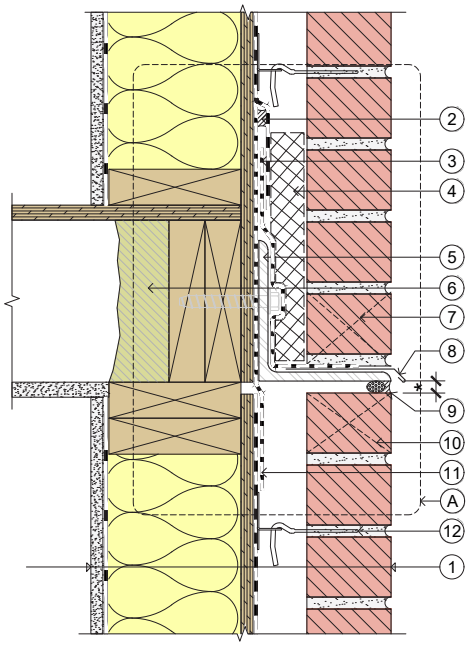
Air

Vapor

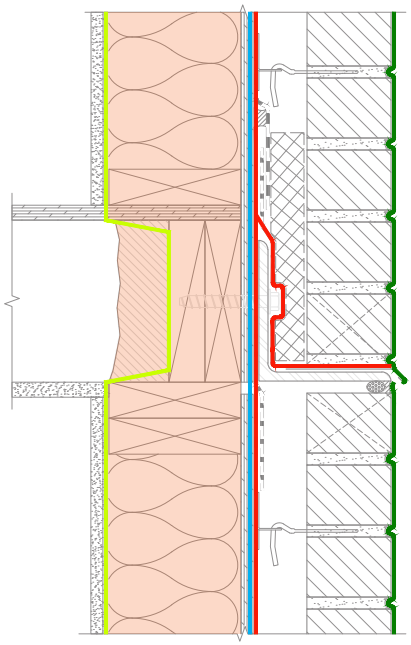
Thermal

Note: Control layers are shown for a Class IV permeance (and sometimes Class III permeance) air barrier and WRB field membrane and where a vapor retarder is located at the interior face of the framing.

WOOD-FRAMED BACKUP WALL: Floor Line Detail



Detail 6-20 Wood-Framed Backup Wall: Floor Line Detail



Water-Shedding Surface and Control Layers of Detail 6-20

Legend

1. Typical Assembly:
   - Interior gypsum board
   - Vapor retarder
   - Wood-framed wall with batt insulation
   - Exterior sheathing
   - Mechanically attached air barrier and WRB field membrane
   - Air cavity
   - Anchored masonry veneer
2. Continuous air barrier sealant
3. Self-adhered sheet- or fluid-applied air barrier and WRB flashing membrane
4. Mortar collection mesh
5. Hot-dipped galvanized-steel standoff shelf angle
6. Closed-cell spray foam insulation
7. Vent/weep at maximum 24 inches on-center
8. Sheet-metal flashing with hemmed drip edge
9. Sealant over backer rod
10. Vent/weep at maximum 24 inches on-center (optional)
11. Self-adhered sheet- or fluid-applied air barrier and WRB flashing membrane
12. Masonry veneer anchor

A. See alternate shelf angle support detailing options on page 63

*Minimum ⅜-inch to allow for movement. Confirm dimension with Engineer of Record.

Detail Discussion

See Shelf Angle Flashing Options on page 63 for alternative flashing that may be used at the window head condition.

A continuous bead of air barrier sealant exists between the flashing membrane and the mechanically attached air barrier and WRB field membrane to maintain air control layer continuity.

Water-Shedding Surface & Control Layers

Water-Shedding Surface

Control Layers:

Water

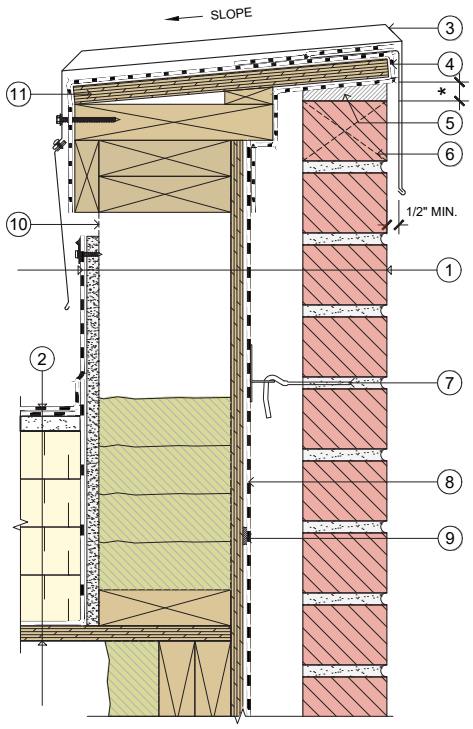
Air

Vapor

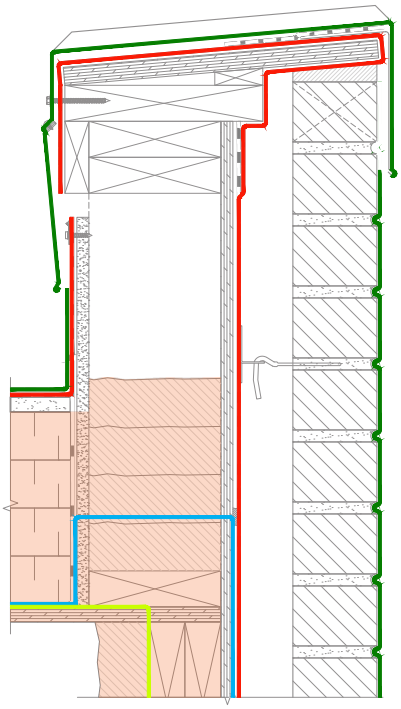
Thermal

Note: Control layers are shown for a Class IV permeance (and sometimes Class III permeance) air barrier and WRB field membrane and where a vapor retarder is located at the interior face of the framing.

WOOD-FRAMED BACKUP WALL: Parapet Detail



Detail 6-21 Wood-Framed Backup Wall: Parapet Detail



Water-Shedding Surface and Control Layers of Detail 6-21

Legend

1. Parapet Assembly:
   - Roof membrane
   - Exterior sheathing
   - Vented wood-framed parapet
   - Exterior sheathing
   - Mechanically attached air barrier and WRB field membrane
   - Air cavity
   - Anchored masonry veneer
2. Conventional roof assembly
3. Standing-seam sheet-metal coping with gasketed washer fasteners
4. High-temperature self-adhered membrane
5. Compressible filler
6. Vents at maximum 24 inches on-center (optional)
7. Masonry veneer anchor
8. Closed-cell spray foam insulation
9. Continuous air-barrier sealant between sheathing and mechanically attached air barrier and WRB field membrane
10. Insect screen
11. Preservative-treated wood blocking

*Minimum ⅜-inch to allow for movement. Confirm dimension with Engineer of Record.

Detail Discussion

At the roof parapet transition, the closed-cell spray foam insulation and the continuous bead of air barrier sealant provide continuity of the air control layer. Additionally, the closed-cell spray foam assists with vapor control at this transition. An alternative to the use of closed-cell spray foam insulation within the parapet is to provide a prestrip membrane below the parapet framing to transition the air control layer from the wall to the roof assembly. This requires the exterior sheathing to be broken at the parapet and the membrane installation to be coordinated with framing.

A compressible filler is used between the masonry veneer and parapet blocking to allow for differential movement between the backup wall and masonry veneer while preventing insects and debris from entering the cavity behind the masonry veneer.

Water-Shedding Surface & Control Layers

Water-Shedding Surface

Control Layers:

Water
Air
Vapor
Thermal

Note: Control layers are shown for a Class IV permeance (and sometimes Class III permeance) air barrier and WRB field membrane and where a vapor retarder is located at the interior face of the framing.

WOOD-FRAMED BACKUP WALL: Parapet 3D Detail

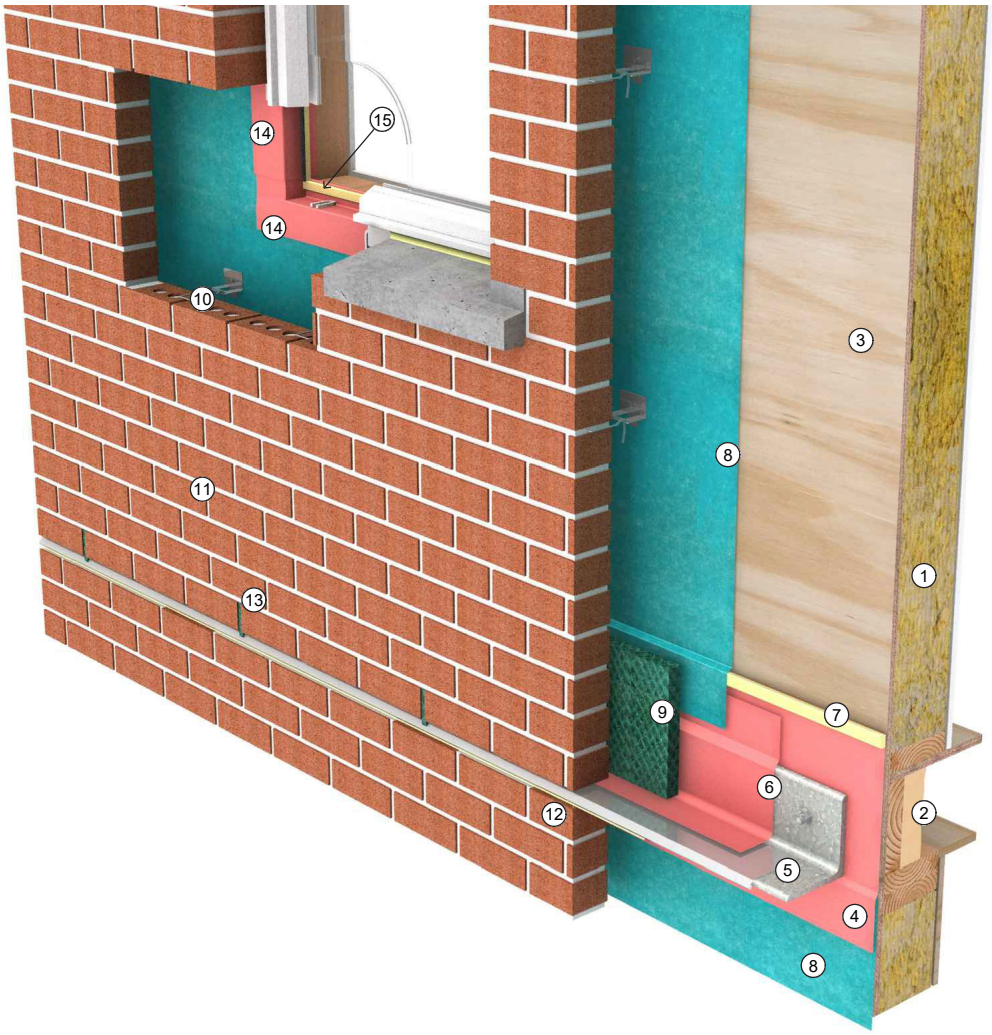
Detail 6-22 Wood-Framed Backup Wall: Parapet 3D Detail

Legend

1. Wood-framed wall with batt insulation
2. Exterior sheathing
3. Vented wood-framed parapet
4. Closed-cell spray foam insulation
5. Sloped preservative-treated blocking
6. Mechanically attached air barrier and WRB field membrane
7. Sheet-applied or fluid-applied air barrier and WRB flashing membrane
8. Masonry veneer anchor, fastened through air barrier sealant, fluid-applied flashing membrane, or self-adhered membrane patch per WRB system manufacturer recommendations
9. Anchored masonry veneer
10. Hot-dipped galvanized-steel loose lintel
11. Sheet-metal head flashing with hemmed drip edge and end dams beyond
12. Continuous air barrier sealant
13. Conventional roof assembly
14. High-temperature self-adhered membrane
15. Sloped standing-seam sheet-metal coping with gasketed washer fasteners
16. Closed-cell spray foam insulation
17. Flanged window

Refer to Detail 6-17, Detail 6-19, and Detail 6-21 for more information.

WOOD-FRAMED BACKUP WALL: Base-of-Wall 3D Detail



Detail 6-23 Wood-Framed Backup Wall: Base-of-Wall 3D Detail

Legend

1. Wood-framed wall with batt insulation
2. Closed-cell spray foam insulation
3. Exterior sheathing
4. Self-adhered or fluid-applied flashing membrane
5. Sheet-metal flashing with hemmed drip edge over hot-dipped galvanized-steel angle
6. Self-adhered or fluid-applied flashing membrane
7. Continuous air barrier sealant
8. Mechanically attached air barrier and WRB field membrane
9. Mortar collection mesh
10. Masonry veneer anchor, fastened through air barrier sealant, fluid-applied flashing membrane or self-adhered membrane patch per WRB system manufacturer recommendations
11. Anchored masonry veneer
12. Sealant over backer rod
13. Weep/vent at maximum 24-inches on-center
14. Self-adhered sheet- or fluid-applied air barrier and WRB flashing membrane
15. Continuous air barrier sealant tied to continuous seal at window perimeter

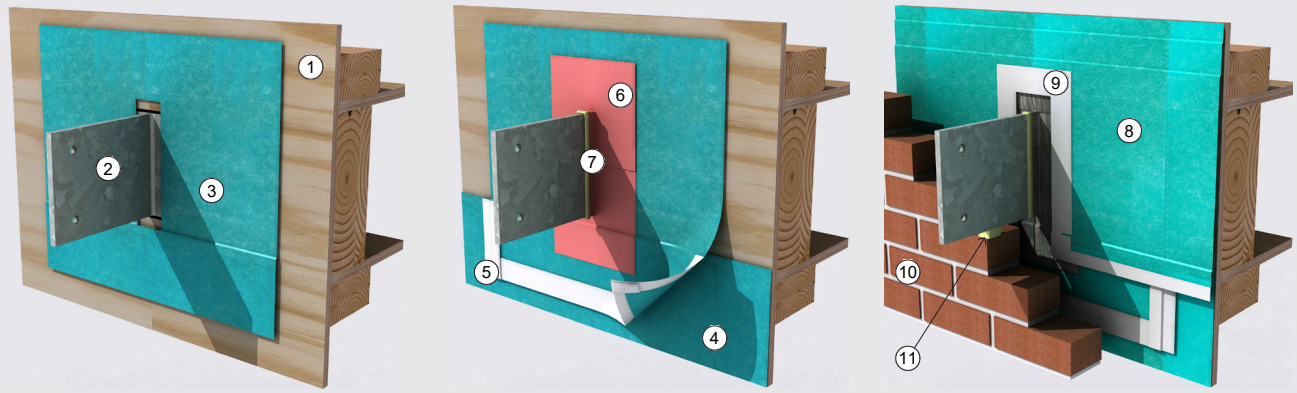


Fig. 6-11 Sheet-applied membrane flashing sequence

Sheet-Applied Air Barrier and WRB System – Flashing Sequence

1. Framed wall sheathing (shown) or backup wall structure face (e.g., CMU)
2. Hot-dipped galvanized knife plate (shown) or other penetration secured to structure
3. Air barrier and WRB target sheet, notched around penetration
4. Air barrier and WRB field membrane, lapped below target sheet
5. Air barrier and WRB tape (typically not required with self-adhered air barrier and WRB systems)
6. Self-adhered flashing membrane, fit tightly onto penetration
7. Continuous sealant at flashing membrane leading edges around penetration
8. Air barrier and WRB field membrane
9. Continuous air barrier and WRB tape (typically not required with self-adhered air and WRB systems)
10. Masonry veneer
11. Continuous sealant over backer rod around penetration, size joint for project specific movement

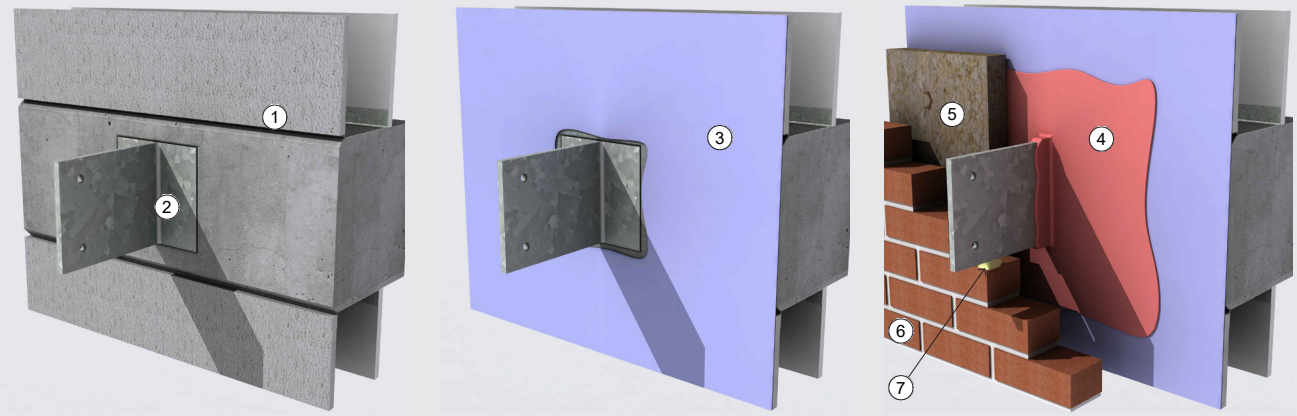


Fig. 6-12 Fluid-applied membrane flashing sequence

Fluid-Applied Air Barrier and WRB System – Flashing Sequence

1. Framed wall sheathing (shown) or backup wall structure face (e.g., CMU)
2. Hot-dipped galvanized knife plate (shown), or other penetration, secured to structure
3. Air barrier and WRB field membrane
4. Air barrier and WRB flashing membrane over field membrane and onto penetration
5. Exterior insulation, tight to penetration
6. Masonry veneer
7. Continuous sealant over backer rod around penetration, size joint for project specific movement

Table 6-1 Anchored masonry veneer wall assembly components and water-shedding surface and control layer summary

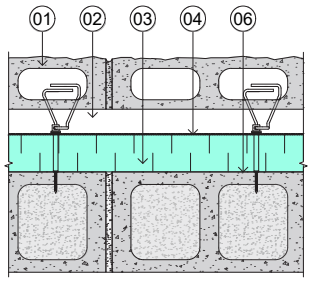
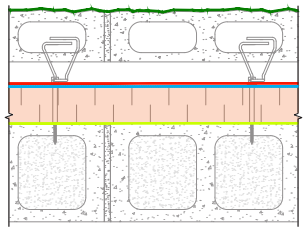
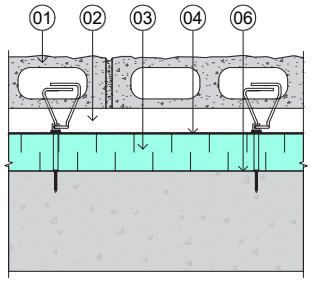
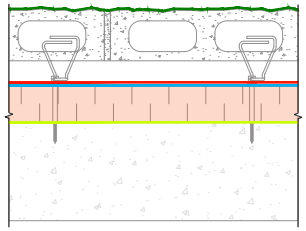
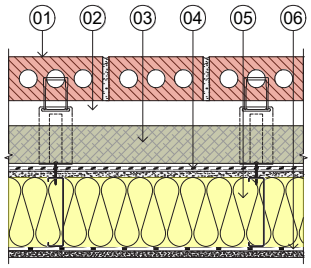
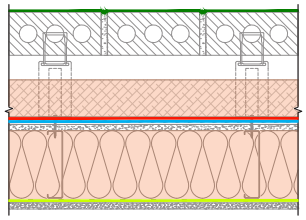
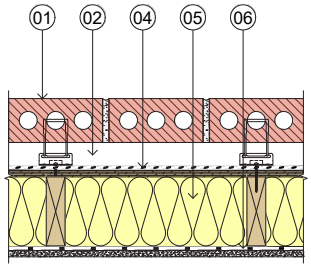
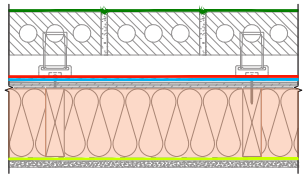
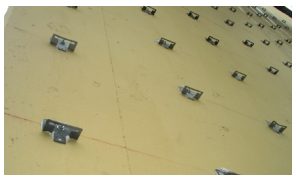
Backup Wall Structure	Masonry Veneer Assembly	Water Shedding-Surface and Control Layers
CMU		
Concrete		
Steel Stud-Framed		
Wood-Framed		
LEGEND	1. Anchored masonry veneer (fired clay brick or CMU) 2. Air cavity 3. Exterior insulation 4. Air barrier and water-resistive barrier 5. Batt insulation 6. Vapor control membrane	Water-Shedding Surface Control Layers: Water Air Vapor Thermal

Table 6-2 Air barrier and/or water-resistive barrier systems common in Colorado and southern Wyoming

Air Barrier & WRB System	Description	Typical Accessories at Transitions/Penetrations / Common Typical Backup Wall Structures	Typical Primary Control Layer Function**			
			Vapor	Thermal	Air	Water
MECHANICALLY ATTACHED SHEET						
	Loose-laid sheet mechanically attached to the exterior sheathing and/or framing with washer head fasteners, staples, cladding supports/masonry anchors, etc.	Self-adhered or fluid-applied flashing membranes / WOOD-FRAMED	✓*		✓	✓
SELF-ADHERED MEMBRANE						
	Sheet membrane with adhesive backing, continuously bonded to the backup wall sheathing or structure	Self-adhered or fluid-applied flashing membranes / CMU, CONCRETE, STEEL STUD-FRAMED, WOOD-FRAMED	✓*		✓	✓
FLUID-APPLIED MEMBRANE						
	Fluid-applied membrane, continuously bonded to the backup wall structure following membrane cure	Self-adhered or fluid-applied flashing membranes / CMU, CONCRETE, STEEL STUD-FRAMED, WOOD-FRAMED	✓*		✓	✓
INSULATED SHEATHING						
	Exterior rigid board insulation (i.e., XPS or faced EPS/polyisocyanurate) with board seams sealed and/or taped	Self-adhered or fluid-applied flashing membranes / CMU, CONCRETE, STEEL STUD-FRAMED, WOOD-FRAMED	✓	✓	✓	✓
SEALED SHEATHING						
	Exterior gypsum board or plywood sheathing with sealed seams (either joint sealant, fluid-applied membrane, or tape)	Self-adhered or fluid-applied flashing membranes / CMU, CONCRETE, STEEL STUD-FRAMED, WOOD-FRAMED			✓	
CLOSED-CELL SPRAY POLYURETHANE FOAM (CCSPF)						
	Spray foam insulation is spray-applied and bonds to the backup wall sheathing or structure	Self-adhered or fluid-applied flashing membranes / CMU, CONCRETE, STEEL STUD-FRAMED, WOOD-FRAMED	✓	✓	✓	✓

*Sheathing membrane products (i.e., loose-laid sheets, self-adhered membrane, and fluid-applied membrane) are available in a range of permeance classes. In Colorado and southern Wyoming, typically these air and water control layers function as the vapor control layer when the membrane is a Class 1 or Class 2 vapor permeance. In this instance, these membranes should typically only be used when ½ of the wall's total R-value of insulation is located outboard of this membrane.

**Refer to page 21 for the properties of each control layer. Systems listed can only perform as the control layer indicated when these properties are met.

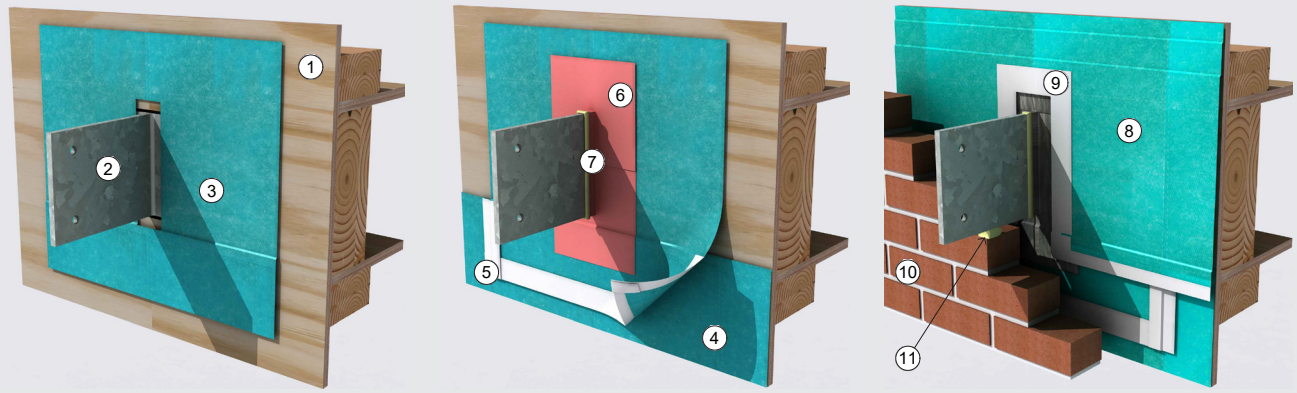


Fig. 6-11 Sheet-applied membrane flashing sequence

Sheet-Applied Air Barrier and WRB System – Flashing Sequence

1. Framed wall sheathing (shown) or backup wall structure face (e.g., CMU)
2. Hot-dipped galvanized knife plate (shown) or other penetration secured to structure
3. Air barrier and WRB target sheet, notched around penetration
4. Air barrier and WRB field membrane, lapped below target sheet
5. Air barrier and WRB tape (typically not required with self-adhered air barrier and WRB systems)
6. Self-adhered flashing membrane, fit tightly onto penetration
7. Continuous sealant at flashing membrane leading edges around penetration
8. Air barrier and WRB field membrane
9. Continuous air barrier and WRB tape (typically not required with self-adhered air and WRB systems)
10. Masonry veneer
11. Continuous sealant over backer rod around penetration, size joint for project specific movement

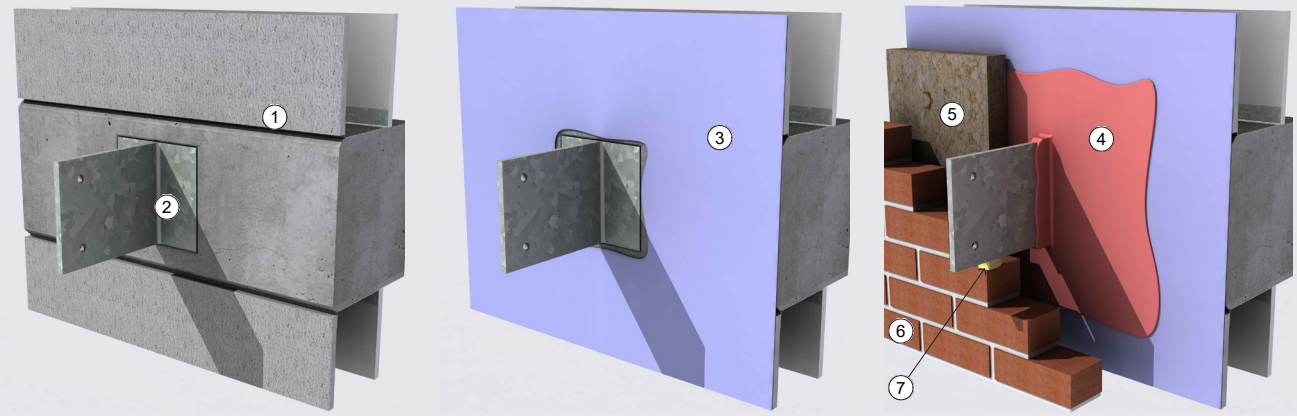


Fig. 6-12 Fluid-applied membrane flashing sequence

Fluid-Applied Air Barrier and WRB System – Flashing Sequence

1. Framed wall sheathing (shown) or backup wall structure face (e.g., CMU)
2. Hot-dipped galvanized knife plate (shown), or other penetration, secured to structure
3. Air barrier and WRB field membrane
4. Air barrier and WRB flashing membrane over field membrane and onto penetration
5. Exterior insulation, tight to penetration
6. Masonry veneer
7. Continuous sealant over backer rod around penetration, size joint for project specific movement

Table 6-3 Summary of TMS 402-16[3] provisions for adjustable anchors

Prescriptive Spacing for Adjustable Two-Piece Masonry Veneer Ties			
Spacing Designation	Requirement Category (use more stringent spacing requirements where applies)		
	General	Seismic Design Categories D, E, and F*	High Wind†
Maximum Wall Area per Anchor	2.67 ft^2	2.00 ft^2 (75% of General Requirement Max.)	1.87 ft^2 (70% of General Requirement Max.)
Maximum Horizontal Spacing	32-inches	32-inches	18-inches
Maximum Vertical Spacing	25-inches	25-inches	18-inches
Maximum Spacing at Opening‡	36-inches	36-inches	24-inches
Maximum Distance from Openings	12-inches	12-inches	12-inches

* Seismic design categories as determined by ASCE 7

† High wind includes wind velocity pressures between 40 psf and 55 psf as determined by ASCE 7 and when the building's mean roof height is less than or equal to 60 ft

‡ For openings larger than 16-inches in either dimension

Table 6-4 Summary of TMS 402-16[3] provisions for adjustable and non adjustable masonry anchors. Photos courtesy of Hohmann & Barnard, Inc.

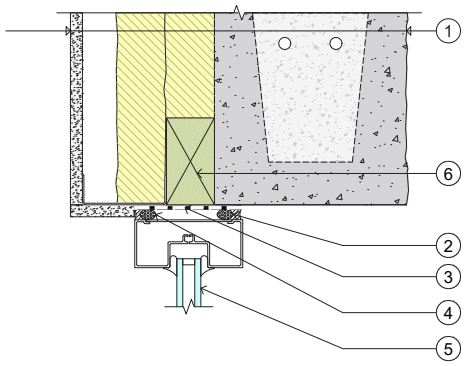
	Common Anchor Types					
	ADJUSTABLE ANCHOR TYPE				NON ADJUSTABLE ANCHOR TYPE	
						
	Plate Anchor	Embedded Joint Reinforcement Anchor	Screw Anchor	L-Bracket Anchor	Surface-Mounted Anchor	Corrugated Metal Anchor
CMU Backup		Offers less adjustability due to fixed placement of reinforcing in block bed joints.		See general notes below.	TMS 402-16[3] requires an adjustable tie.	TMS 402-16[3] requires an adjustable anchor.
Concrete Backup		Anchor not constructible with backup wall structure.		See general notes below.	TMS 402-16[3] requires an adjustable anchor. Anchor may be paired with a dove tail slot to provide adjustability; however, the slot is difficult to waterproof and is typically avoided.	TMS 402-16[3] requires an adjustable anchor.
Steel Stud-Framed Backup		Anchor not constructible with backup wall structure.		See general notes below.		
Wood-Framed Backup		Anchor not constructible with backup wall structure.		See general notes below.	Adjustable anchors are preferred when possible.	Anchor has poor corrosion resistance and is typically avoided.
General Notes		Consider air barrier and WRB system detailing requirements around wires.	Thermally improved anchor option; see Chapter 8 for more discussion.	May not be preferred by some installers as it requires vertical installation of some insulation boards.		

Permitted by TMS 402-16[3]

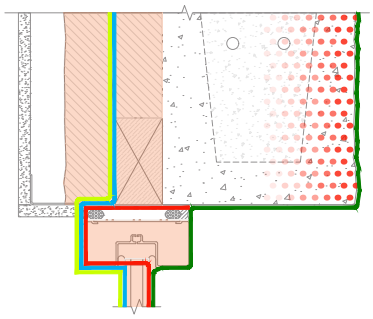
Permitted by TMS 402-16;[3] however, see additional table discussion/notes

Not permitted by TMS 402-16[3]

SINGLE-WYTHE CMU WALL: Window Head Detail



Detail 7-1 Single-Wythe CMU Wall: Window Head Detail



Water-Shedding Surface and Control Layers of Detail 7-1

Legend

1. Typical Assembly:
   - Interior gypsum board
   - Steel stud-framed wall
   - Closed-cell spray foam (CCSPF) insulation between studs (optional) and min. 2 inches continuous CCSPF
   - Single-wythe CMU wall with water-repellent admixture at block and mortar
   - Clear water-repellent
2. Sealant over backer rod
3. Fluid-applied air barrier and WRB flashing membrane
4. Continuous air barrier sealant tied to continuous seal at window perimeter
5. Storefront window
6. Preservative treated wood blocking

Detail Discussion

The flashing membrane extends from the interior framing to the CMU rough opening. The flashing membrane and the continuous air barrier sealant joint provide air and water control layer continuity from the window to the CMU wall.

Blocking at the window perimeter provides a low-conductivity solution for mechanically attaching the window as required by the window manufacturer.

Water-Shedding Surface & Control Layers

Water-Shedding Surface

Control Layers:

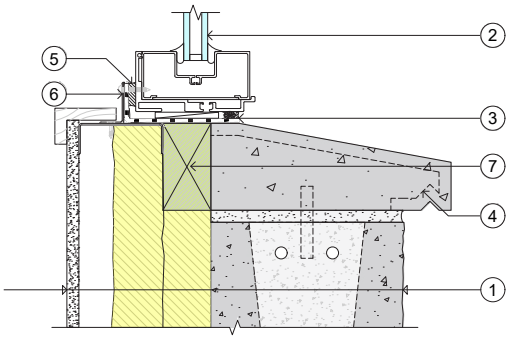
Water

Air

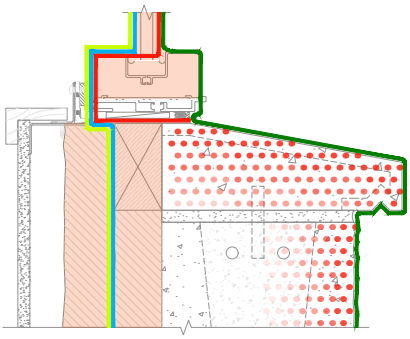
Vapor

Thermal

SINGLE-WYTHE CMU WALL: Window Sill Detail



Detail 7-2 Single-Wythe CMU Wall: Window Sill Detail



Water-Shedding Surface and Control Layers of Detail 7-2

Legend

1. Typical Assembly:
   - Interior gypsum board
   - Steel stud-framed wall
   - Closed-cell spray foam (CCSPF) insulation between studs (optional) and min. 2 inches continuous CCSPF
   - Single-wythe CMU wall with water-repellent admixture at block and mortar
   - Clear water-repellent
2. Storefront window on minimum ¼-inch thick intermittent shims
3. Sealant joint over backer rod (weep at quarter points)
4. Sloped precast sill with chamfered drip edge, with sealant over backer rod at precast joints
5. Continuous air barrier sealant tied to continuous seal at window perimeter
6. Continuous back dam angle at rough opening perimeter, minimum 1-inch tall, with window fastened through the back dam angle per window manufacturer recommendations
7. Preservative treated wood blocking

Detail Discussion

The slope at the precast sill encourages water to drain away from the window rough opening. A chamfer is shown in the underside of the precast sill to form a drip. This encourages water to shed from the sill before reaching the masonry veneer below.

Attachment of the window is shown through a structural back dam angle in lieu of down through the sill membrane. This minimizes the risk for water intrusion into the wall cavity below should water exist within the window rough opening. Intermittent shims below the window encourage drainage of the rough opening. Water that may exist within the rough opening can exit through weeps in the exterior sealant joint.

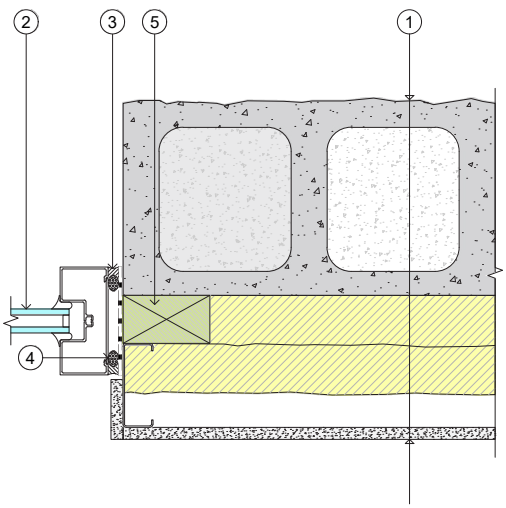
Water-Shedding Surface & Control Layers

Water-Shedding Surface

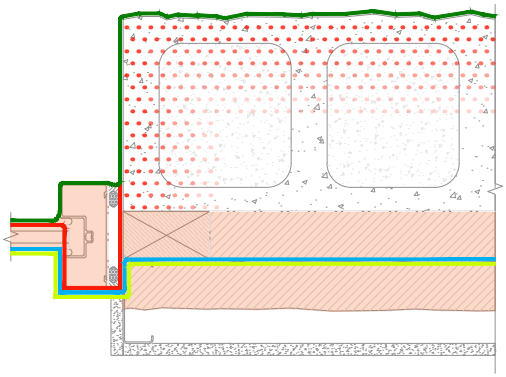
Control Layers:

Water
Air
Vapor
Thermal

SINGLE-WYTHE CMU WALL: Window Jamb Detail



Detail 7-3 Single-Wythe CMU Wall: Window Jamb Detail



Water-Shedding Surface and Control Layers of Detail 7-3

Legend

1. Typical Assembly:
   - Interior gypsum board
   - Steel stud-framed wall
   - Closed-cell spray foam (CCSPF) insulation between studs (optional) and min. 2 inches continuous CCSPF
   - Single-wythe CMU wall with water-repellent admixture at block and mortar
   - Clear water-repellent
2. Storefront window
3. Sealant joint over backer rod
4. Continuous air barrier sealant tied to continuous seal at window perimeter
5. Preservative treated wood blocking

Detail Discussion

The window is aligned with the rough opening blocking and insulation, rather than with the CMU wall, to provide better continuity of the thermal control layer. The continuous air barrier sealant joint, along with the flashing membrane, provide continuity of the air and water control layer.

Water-Shedding Surface & Control Layers

Water-Shedding Surface

Control Layers:

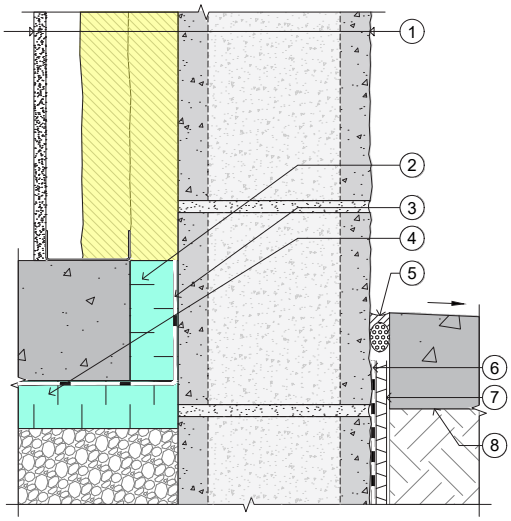
Water

Air

Vapor

Thermal

SINGLE-WYTHE CMU WALL: Base-of-Wall Detail



Detail 7-4 Single-Wythe CMU Wall: Base-of-Wall Detail

Water-Shedding Surface and Control Layers of Detail 7-4

Legend

1. Typical Assembly:
   - Interior gypsum board
   - Steel stud-framed wall
   - Closed-cell spray foam (CCSPF) insulation between studs (optional) and min. 2 inches continuous CCSPF
   - Single-wythe CMU wall with water-repellent admixture at block and mortar
   - Clear water-repellent
2. Rigid XPS insulation
3. Underslab vapor barrier
4. Rigid XPS underslab insulation
5. Hardscape sealant joint
6. Damp-proofing (optional)
7. Drainage composite or gravel backfill
8. Hardscape

Detail Discussion

The XPS insulation provides a thermal break between the concrete floor slab and the single-wythe CMU wall. This allows for thermal continuity between the underslab insulation and wall insulation.

Water-Shedding Surface & Control Layers

Water-Shedding Surface

Control Layers:

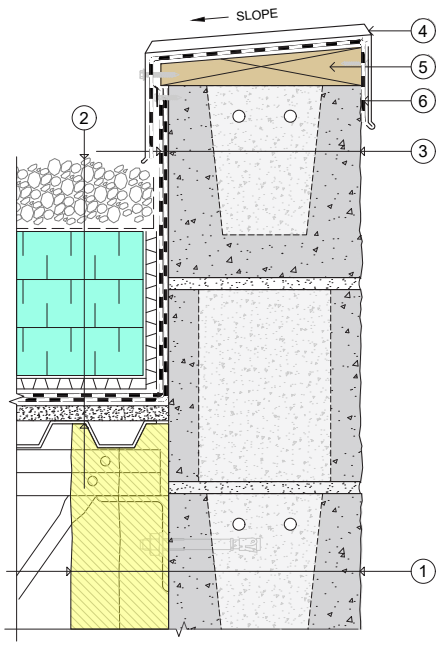
Water

Air

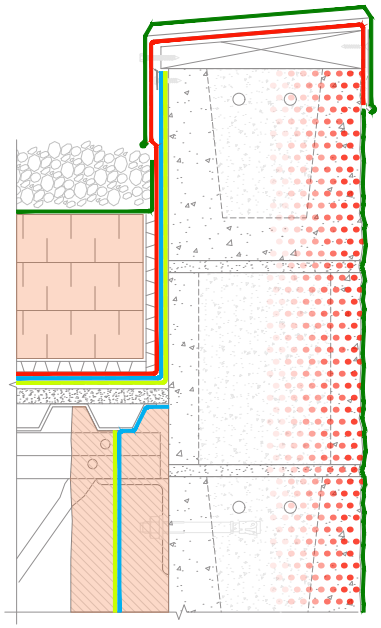
Vapor

Thermal

SINGLE-WYTHE CMU WALL: Roof Parapet Detail



Detail 7-5 Single-Wythe CMU Wall: Roof Parapet Detail



Water-Shedding Surface and Control Layers of Detail 7-5

Legend

1. Typical Assembly:
   - Interior gypsum board
   - Steel-framed wall
   - Closed-cell spray foam (CCSPF) insulation between studs, min. 2 inches continuous CCSPF
   - Single-wythe CMU wall with water-repellent admixture at block and mortar
   - Clear water-repellent
2. Inverted roof membrane assembly
3. Typical Parapet Assembly:
   - Inverted roof membrane
   - Single-wythe CMU wall with water-repellent admixture at block and mortar
   - Clear water repellent
4. Standing-seam sheet-metal coping with gasketed washer fasteners
5. Preservative-treated wood blocking
6. High-temperature self-adhered membrane

Detail Discussion

The sheet-metal coping with hemmed drip edge sheds water away from the wall top and CMU wall face below. It is recommended that the sheet-metal coping counterflash the top course of block by a minimum of 3 inches.

The CCSPF extends tight up to the underside of the deck and around roof structure and anchor elements. This reduces the opportunity for warm, moisture-laden interior air to contact the deck and CMU wall where it's coldest.

Water-Shedding Surface & Control Layers

Water-Shedding Surface

Control Layers:

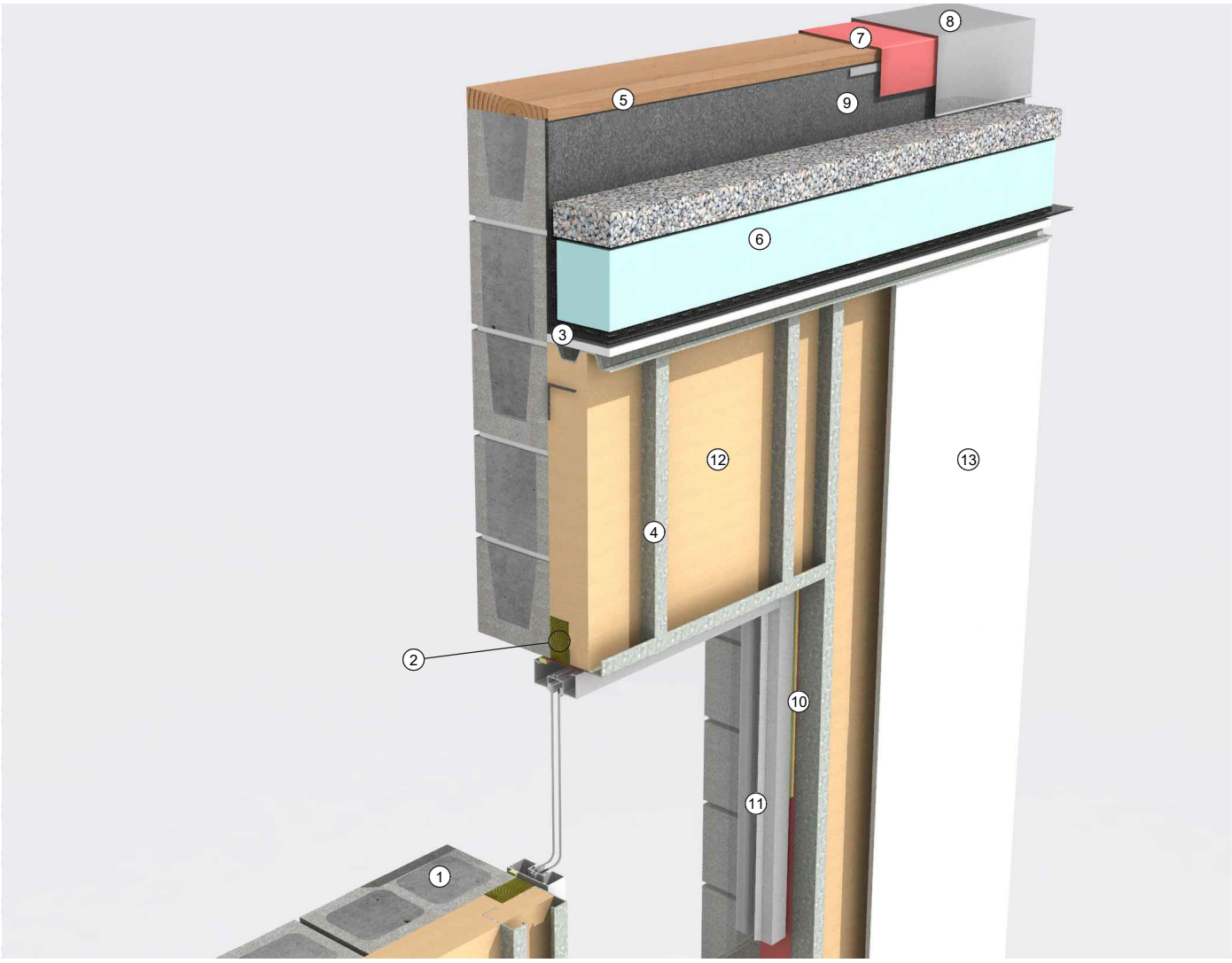
Water

Air

Vapor

Thermal

SINGLE-WYTHE CMU WALL: Roof Parapet 3D Detail

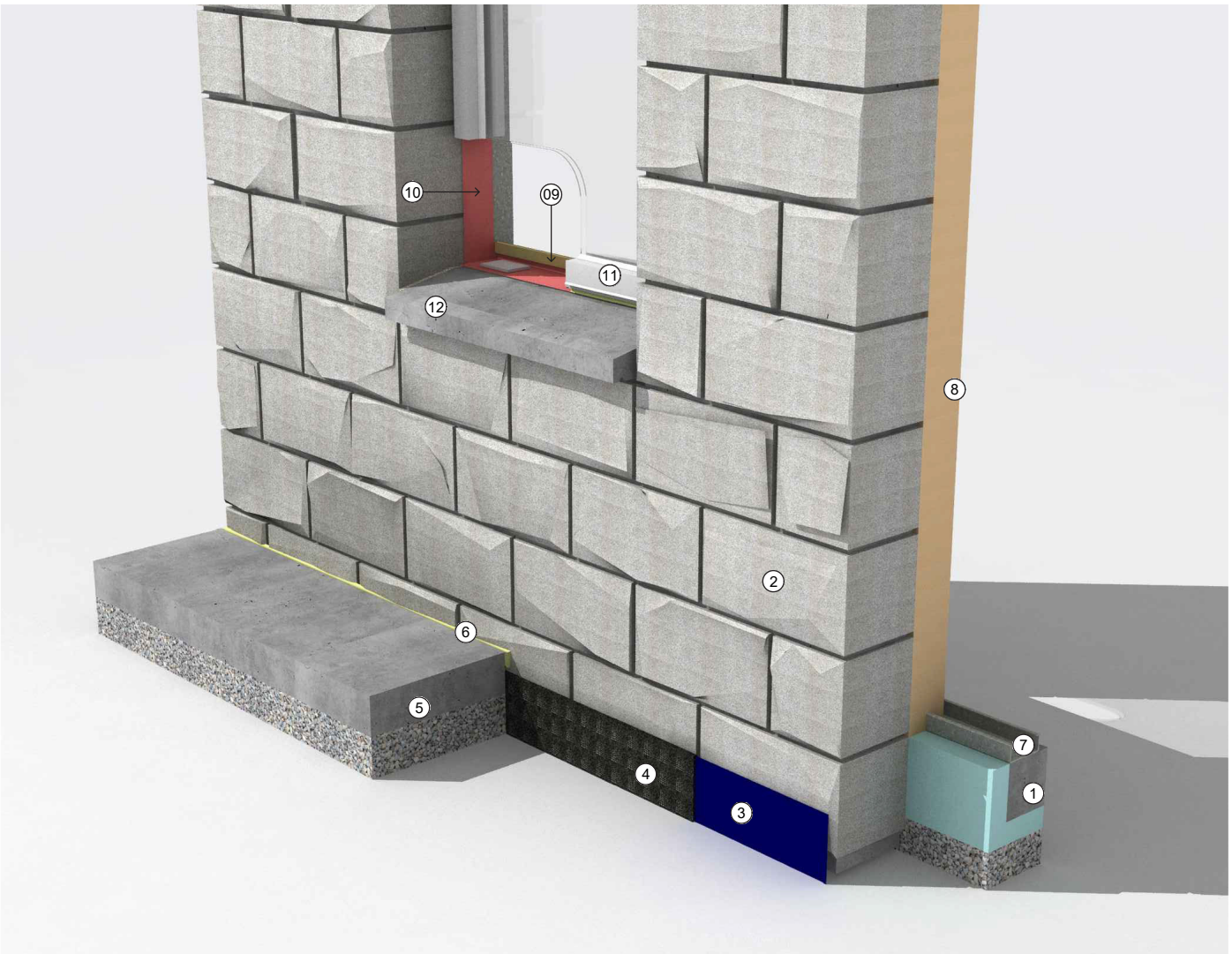


Detail 7-6 Single-Wythe CMU Wall: Roof Parapet 3D Detail

Legend

1. Single-wythe CMU wall with water-repellent admixture
2. Preservative-treated wood blocking
3. Roof structure
4. Steel stud-framed wall
5. Sloped, preservative-treated wood blocking
6. Inverted roof membrane assembly
7. High-temperature self-adhered membrane
8. Sloped standing-seam sheet-metal coping with gasketed washer fasteners
9. Roof membrane termination
10. Continuous air barrier sealant, tied to continuous seal at window perimeter.
11. Storefront window
12. Closed-cell spray foam (CCSPF) insulation between studs
13. Interior gypsum board

SINGLE-WYTHE CMU WALL: Base-of-Wall 3D Detail

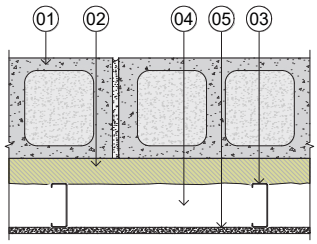
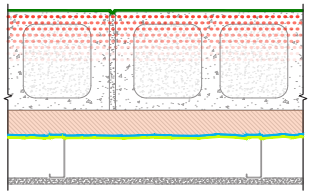
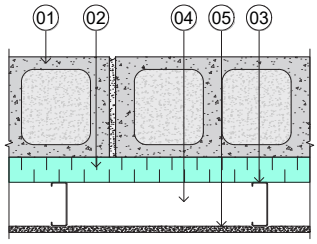
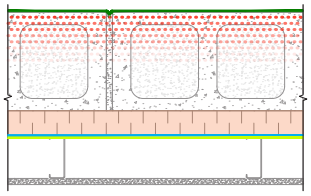


Detail 7-7 Single-Wythe CMU Wall: Base-of-Wall 3D Detail

Legend

1. Concrete floor slab over XPS insulation and vapor barrier
2. Single-wythe CMU wall with water-repellent admixture
3. Damp-proofing
4. Drainage composite or gravel backfill
5. Hardscape, sloped away from structure
6. Hardscape sealant joint between hardscape and CMU wall
7. Steel stud-framed wall
8. Closed-cell spray foam (CCSPF) insulation between studs
9. Continuous air barrier sealant tied to continuous seal at window perimeter
10. Fluid-applied flashing membrane
11. Storefront window
12. Sloped precast concrete sill

Table 7-1 Single-wythe CMU wall assembly components and water-shedding surface and control layer summary

Insulation Option	Single-Wythe CMU Wall	Water Shedding-Surface and Control Layers
Closed-Cell Spray Foam Insulation		EXTERIOR  INTERIOR
Vapor-Impermeable Board Insulation*		EXTERIOR  INTERIOR
LEGEND	1. Single-wythe CMU wall with water-repellent admixture and surface-applied clear water repellent 2. Continuous insulation 3. Steel stud-framed wall 4. Air cavity w/services (optional) 5. Interior gypsum board * With fully tapered/sealed joints, terminations, and penetrations	Water-Shedding Surface Control Layers: Water Air Vapor Thermal

options listed in Table 7-1. Elastomeric coatings are further discussed in Chapter 4.

Air Control Layer

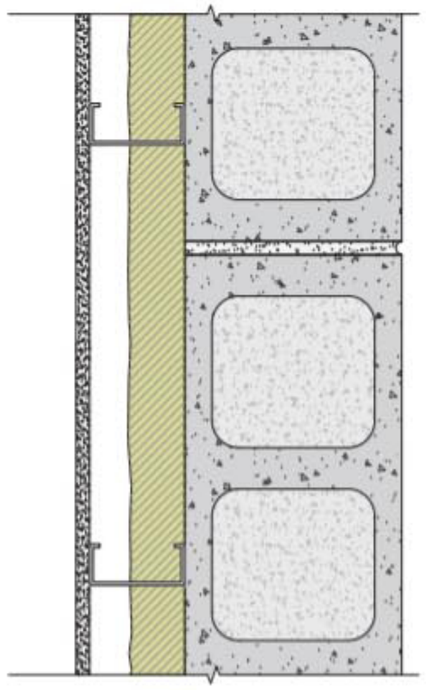
The air control layer comprises the air barrier system and is responsible for controlling the flow of air through the building enclosure, either inward or outward. Air flow is significant because it impacts heat flow (space conditioning), water vapor transport, and rain penetration control. Refer to Chapter 3 for a discussion regarding the air control layer and properties of the air barrier system.

For the single-wythe wall system shown in Table 7-1, the air barrier system is either:

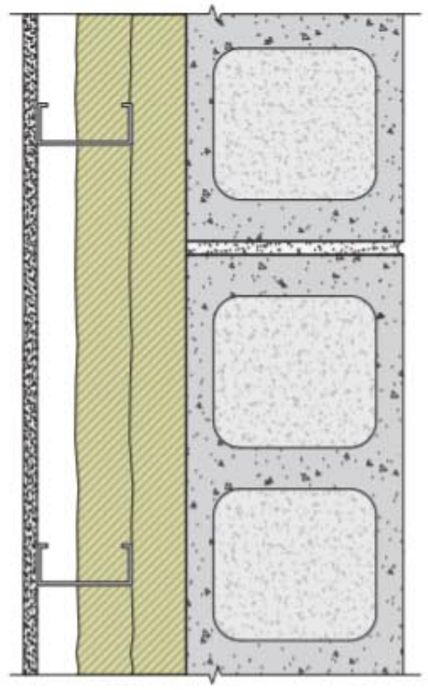
- The CCSPF interior of the CMU wall structure.
- XPS insulation when fully taped and/or sealed at all joints, terminations, and penetrations.
- The foil facer of board insulation products when the facer is fully taped and/or sealed at all joints, terminations, and penetrations.

Additional measures that can improve the wall systems air control include:

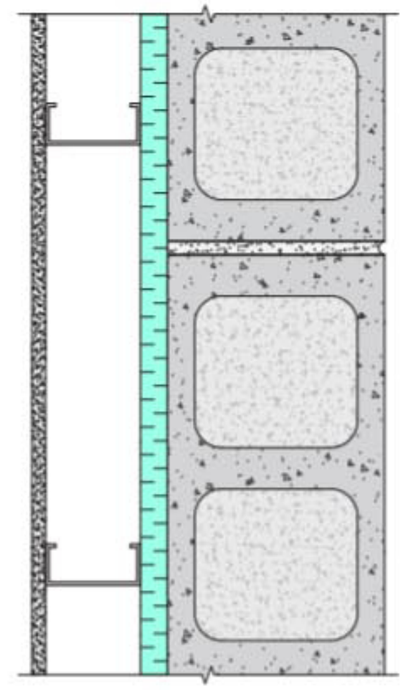
- A fluid-applied air barrier and WRB membrane where used on the interior face of the CMU wall structure.
- An elastomeric coating where used on the exterior face of the CMU wall structure.



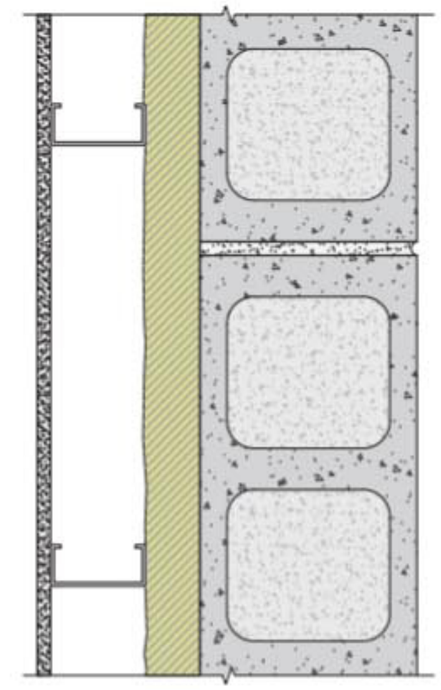
Option 1
R-12 Cavity Insulation



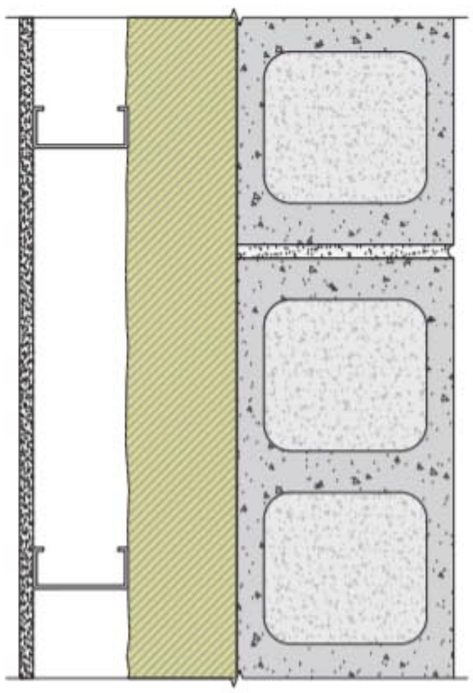
Option 2
R-12 Cavity Insulation with
R-12 Continuous Insulation



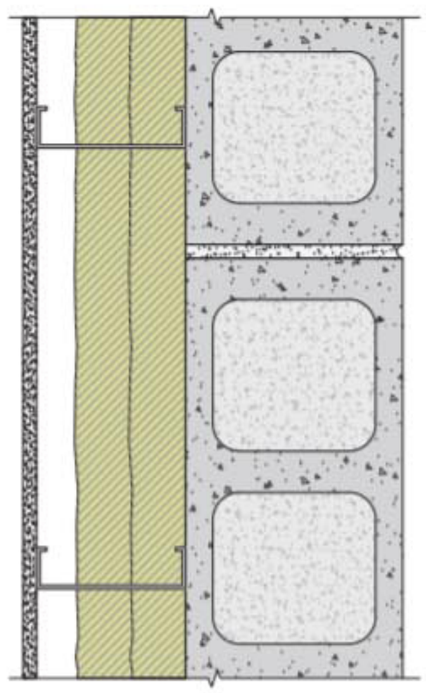
Option 3
R-5 Continuous Insulation



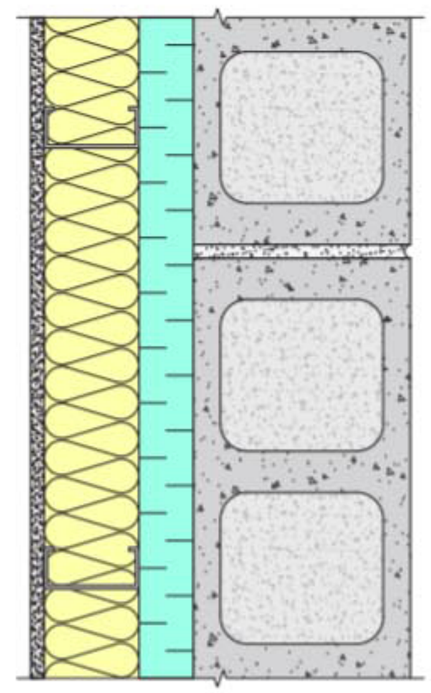
Option 4
R-12 Continuous Insulation



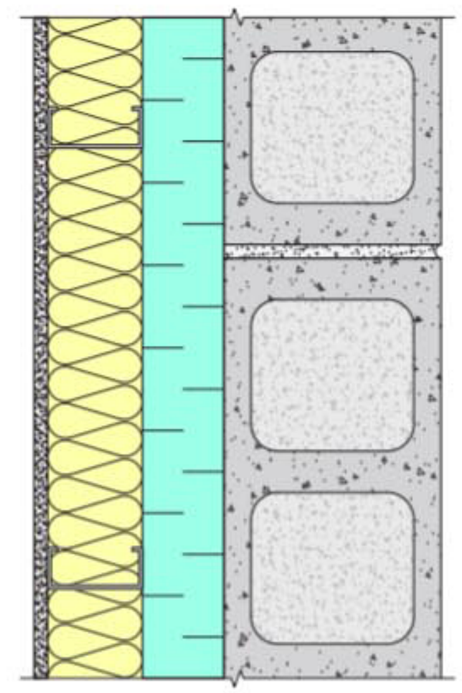
Option 5
R-24 Continuous Insulation



Option 6
R-24 Cavity Insulation



Option 7
R-15 Cavity Insulation
R-10 Continuous Insulation



Option 8
R-15 Cavity Insulation
R-15 Continuous Insulation

Step 1: *Determine*	Determine Governing Energy Code IECC version and local amendments →	Determine Project Climate Zone Zone 4B, Zone 5B, Zone 6B, or Zone 7B. →		Determine Project Occupancy Group R or All Other
Step 2: *Select an Option*	Prescriptive Compliance Options: Use when a whole-building energy model will not be performed to demonstrate energy code compliance. Typically, whole-building energy modeling methods are required when assembly R-values or U-factors cannot meet code requirements, when the U-factor component performance alternative cannot be used to demonstrate compliance, or when glazing areas exceed the maximum glazing area percentages set by the energy code.			Non-prescriptive Compliance Option: Use when prescriptive compliance options cannot be used to demonstrate energy code compliance.
Step 3: *Select a Strategy*	R-Value–Based Method Provide opaque above-grade wall insulation with an R-value equivalent to or greater than that described in Table 8-4. This is the least flexible strategy.	U-Factor–Based Method/ U-Factor Provide an opaque above-grade wall assembly with an assembly U-factor less than or equal to that described in Table 8-4. U-factors should consider all instances of thermal bridging required by the governing jurisdiction.	Component Performance Alternative/ U-Factor–Based Method/Building Envelope Trade-Off Option Provide an area-weighted calculation of assembly and component U-factors for comparison with the prescriptive target. Use when overpreforming assemblies can offset underpreforming assemblies and components. This strategy is typically not successful when a project exceeds maximum glazing area percentages set by the energy code.	Total Building Performance/ Energy Cost Budget Method Perform a whole-building energy model using approved software. Use when enclosure components, lighting, and HVAC performance will be traded off to meet energy code compliance. This strategy is typically used when a project will exceed maximum glazing area ratios set by the energy code.
Step 4: *Determine System*	Provide insulation that meets or exceeds the R-values listed in Table 8-4.	Provide assembly U-Factors from calculations, modeling, ASHRAE 90.1 [31] Appendix A tables, or other approved sources. Refer to modeling results presented at the end of this chapter to assist with determining appropriate insulation thickness.		

Design Checklist

- ✓ Select appropriate air barrier system materials and assemblies. Refer to Table 8-2 for air barrier system materials and assembly properties. The Air Barrier Association of American (ABAA) also lists several commercially available compliant air barrier membrane products and systems at www.airbarrier.org.[29]

- ✓ Ensure that a continuous line representing the plane of airtightness can be drawn across all wall assemblies, details, and transitions between assemblies. This includes in both plan and section perspectives. Details included within this guide demonstrate this practice; an example is shown in Fig. 8-3.

- ✓ Clearly delineate the air barrier system boundary on the construction documents. This practice is typically performed on the floor plans for each building level and on each building section as shown in Fig. 8-4. This delineation is required by the City of Fort Collins energy code (local amendments to the 2015 IECC) for compliance,[11] in addition to the calculation of the air barrier pressure boundary surface area.

- ✓ Identify air barrier system installation, testing, and installer qualification requirements in Divisions 1 and 7 of the project manual. Air barrier master specifications related to Divisions 1 and 7 are available from the ABAA's website and may be modified to meet local code and project-specific requirements.

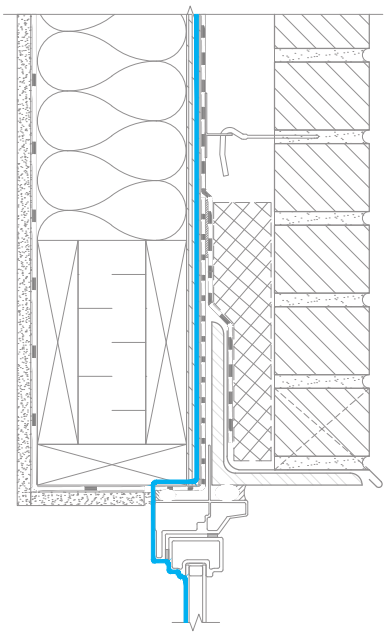


Fig. 8-3 Typical window head detail and wood stud–framed backup wall. The plane of airtightness (i.e., the air control layer) is denoted in blue.

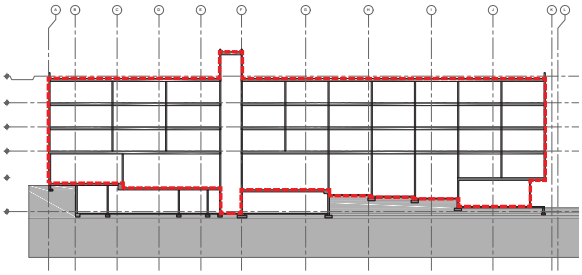


Fig. 8-4 Whole-building section with the continuous air barrier system pressure boundary denoted in red.

Adapted from the National Masonry Systems Guide: Northwest Edition

Construction/Installation Checklist

- ✓ Prior to the installation of air barrier system components, coordinate an air barrier system preconstruction meeting with the general contractor, designer(s), and the trade/subcontractor responsible for the installation of the air barrier system as well as all additional trades whose work may interface or penetrate the air barrier system (e.g., window installers, framers, siders, mechanical, etc.). Clarify the responsibilities of all parties involved with the air barrier system installation and review installation requirements and limitations of the system as well as any details/installations that will require significant coordination efforts to implement.

- ✓ Use installers who are experienced with the specific air barrier system installation to perform the installation of air barrier components. For example, if the primary air barrier strategy is a sealed sheathing approach, using an installer with experience installing sealed sheathing can increase the likelihood for quality air barrier installation.

- ✓ Designate an air barrier system/building enclosure supervisor or superintendent from the construction team to oversee all trades involved in installation related to the air barrier system.

- ✓ Build freestanding mock-ups of all project-specific typical and unique air barrier system details. Retain building mock-ups for training and reference purposes throughout construction.

- ✓ Perform qualitative diagnostic air leakage testing of mock-up installations to identify deficiencies. Correct deficiencies and retest to demonstrate that deficiencies have been resolved. Refer to ASTM E1186[23] for air leakage site detection practices.

- ✓ Implement a quality control program. Develop a checklist of items that need to be reviewed before the air barrier system is covered with additional elements such as exterior insulation and cladding.

- ✓ Provide third-party quality assurance reviews of installed air barrier detailing and provide periodic diagnostic air leakage testing to ensure airtight transitions, especially at roof-to-wall and wall-to-foundation transitions and at the floor line and window perimeter details.

- ✓ Execute whole-building air leakage testing prior to covering, when possible. This limits the need to remove building elements (such as cladding) to correct deficiencies.

Adapted from the National Masonry Systems Guide: Northwest Edition

Air and thermal control layers manage heat flow across the building enclosure, influencing the amount of energy and fuel required to heat and cool a building and affecting occupant thermal comfort and condensation risk. Chapter 3 discusses the basic function of the air and thermal control layers.

In Colorado and southern Wyoming, air control layer performance requirements and the thermal performance of opaque above-grade wall assemblies (e.g., masonry wall systems) is governed by locally adopted energy codes. Thus, this chapter discusses basic the air and thermal control layer in the context of energy code compliance requirements for whole-building air leakage and thermal performance, specifically conductive heat flow, of masonry wall systems. At the end of this chapter are design tables that may be used to estimate the thermal performance of typical masonry systems and their components.

Governing Energy Codes

In Colorado and southern Wyoming, building codes are adopted and enforced at the local level. While there is no statewide energy code, legislation passed in Colorado in 2007[1] set the 2003 International Energy Conservation Code (IECC)[2] as the minimum-required energy code for all jurisdictions in the state that have adopted building codes. In jurisdictions where no building codes have been adopted, the state requires that hotels, motels, and multifamily buildings[3] conform to the 2015 IECC.[4] In addition, factory-built structures[5] are required to conform to the minimum requirements of the 2009 IECC[6] where the locally adopted code is less stringent than the 2012 IECC.[7] Public buildings are required to conform to the 2015 IECC[4] statewide.

Most larger jurisdictions within Colorado have adopted the 2009,[6] 2012,[7] or 2015 IECC,[4] and several of these jurisdictions have enacted local amendments to the governing version of the IECC. This guide addresses some of these amendments; however, the Designer of Record is responsible to refer to code amendments of the authority having jurisdiction on a project-specific basis. Additionally, this guide references general 2018 IECC requirements, which have not yet been enacted by any jurisdiction at the time of publication.

Table 8-1 summarizes the governing energy codes for various jurisdictions within Colorado and southern Wyoming at the time of publication. Refer to the Colorado Department of Local Affairs website for the current IECC adoptions by county.[9] In general, these energy codes address the *minimum* requirements for both the air and thermal control layers of the opaque above-grade wall systems.

Table 8-1 Summary of governing energy codes for jurisdictions in Colorado and southern Wyoming

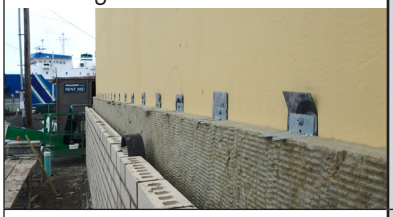
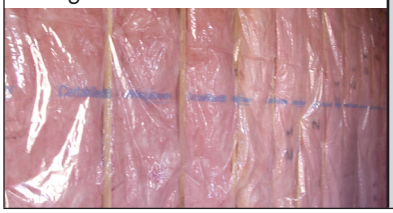
Jurisdiction	Governing Energy Code
City and County of Denver	2016 Denver Building and Fire Code based on the 2015 IECC with amendments[10]
City of Fort Collins	2015 IECC with amendments[11]
County of Boulder	2015 Boulder County Building Code Amendments based on the 2015 IECC with amendments[12]
City of Boulder	2017 City of Boulder Energy Conservation Code (COBECC), based on 2012 IECC with amendments[13]
County of Arapahoe	Energy Conservation Code of Arapahoe based on 2009 IECC with amendments[14]
City of Arvada	Code of the City of Arvada, Colorado based on 2015 IECC with amendments[15]
City of Aurora	City Code of Aurora, Colorado based on 2015 IECC with amendments[16]
County of Jefferson	The 2015 Jefferson County Building Code Supplement based on 2015 IECC without amendments[17]
City of Lakewood	Lakewood Building Code based on 2015 IECC with amendments[18]
County of Larimer	County of Larimer, Colorado Amendments to the 2015 IECC with amendments[19]
City of Cheyenne	2009 IECC[6]
City of Laramie	2012 IECC[7]

Table 8-2 Summary of IECC Air Leakage Requirements for Above-Grade Walls

Energy Code	Seals required at openings, penetrations, and joints?	Maximum air leakage rate requirement for fenestration assemblies?	Maximum air permeability requirement for materials?	Maximum air leakage requirement for assemblies?	Maximum whole-building air leakage requirement?*
2003/2009 IECC[2, 6]	Yes	Yes	No	No	No
2012 IECC[7]	Yes	Yes	A continuous air barrier must comply with one of the following options: 1. The air permeability of materials shall not exceed 0.004 cfm/ft^2 under a pressure differential of 0.3 inch water gauge when tested in accordance with ASTM E 2178.[25] 2. The average air leakage of assemblies of materials and components shall not exceed 0.04 cfm/ft^2 under a pressure differential of 0.3 inch water gauge when tested in accordance with ASTM E 2357,[26] ASTM E 1677,[27] or ASTM E 283.[28] 3. The air leakage rate of the completed building shall not exceed 0.4 cfm/ft^2 under a pressure differential of 0.3 inch water gauge when tested in compliance with ASTM E 779[20] (or an equivalent method approved by the code official).		
2015/2018 IECC[4, 8]	Yes, if not pursuing the whole-building air leakage test compliance option.	Yes, if not pursuing the whole-building air leakage test compliance option.	The air barrier must comply with one of the following options if not pursuing the whole-building air leakage test compliance option: 1. The air permeability of materials shall not exceed 0.004 cfm/ft^2 under a pressure differential of 0.3 inch water gauge when tested in accordance with ASTM E 2178.[25] 2. The average air leakage of assemblies of materials and components shall not exceed 0.04 cfm/ft^2 under a pressure differential of 0.3 inch water gauge when tested in accordance with ASTM E 2357,[26] ASTM E 1677,[27] or ASTM E 283.[28]		Compliance may be demonstrated by performing a whole-building air leakage test in compliance with ASTM E 779[20] (or an equivalent method approved by the code official) with a final result that does not exceed 0.40 cfm/ft^2 at 0.3 inch water gauge in lieu of the prescriptive requirements for seals, materials, and assemblies.*

*Local amendments in the cities of Fort Collins and Boulder include mandatory whole-building air leakage testing.

Table 8-3 Typical insulation types used in masonry wall systems

Insulation Product	Typical R-Value / Use in Wall Assembly	Air Permeance / Vapor Permanence	Moisture Tolerance	Installation Notes
Semi-Rigid Mineral Fiber 	approx. R-4.2 per inch / Cavity (Wood Stud–Framed) & Exterior	Air-Permeable / Class IV	Hydrophobic, tolerates moisture, and has free-draining capabilities.	The semi-rigid properties of this insulation facilitate a snug fit at board joints and around penetrations such as masonry anchors without requiring notching.
Rigid Extruded Polystyrene (XPS) 	R-5 per inch / Interior & Exterior	Air-Impermeable* / Class II	Moisture-resistant and suitable for wet environments.	Rigid board insulation may require notching around masonry anchors or other supports to create a snug fit. When multiple board layers are used, stagger board joints.
Rigid Polyisocyanurate 	R-5 to R-5.6 per inch / Interior, Exterior, or Cavity	Air-Impermeable* / Class I-Class III depending on the facer	Typically includes a foil or moisture-resistant facer. Uses a compatible tape at faced board joints to protect the insulation core from incidental moisture.	Rigid board insulation may require notching around masonry anchors or other supports to create a snug fit. When multiple board layers are used, stagger board joints.
Closed Cell Spray Foam 	R-5.5 to R-6.5 per inch / Interior, Exterior, or Cavity	Air-Impermeable / Class II at 2-inch thickness	Spray foam product should be rated for exterior use where used within the anchored masonry veneer air cavity.	Spray in place after framing, wall penetrations, and masonry anchors are in place.
Fiberglass Batt 	R-3.3 to R-3.7 per inch / Cavity	Air-Permeable / Class IV	Not moisture-tolerant; use in dry cavities only.	Size batt to fit snug in framing cavities and around penetration and building services. Do not compress batt.

* With all rigid board joints and edges taped/sealed

Table 8-4 Colorado and southern Wyoming – prescriptive energy code compliance values for opaque above-grade wall systems within this guide

Opaque Above-Grade Wall – Thermal Envelope Requirements														
		Energy Code	2012 IECC										2015 IECC	
		Climate Zone	4B		5B		6B		7B		8B		4B	
Guide Assembly Type		Classification	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R
Anchored Masonry Veneer	CMU (or Concrete) Wall	Mass	R-9.5ci	R-11.4ci	R-11.4ci	R-13.3ci	R-13.3ci	R-15.2ci	R-15.2ci	R-15.2ci	R-25ci	R-25ci	R-9.5ci	R-11.4ci
			U-0.104 (R-9.6)	U-0.090 (R-11.1)	U-0.078 (R-12.8)	U-0.078 (R-12.8)	U-0.078 (R-12.8)	U-0.071 (R-14.1)	U-0.061 (R-16.4)	U-0.061 (R-16.4)	U-0.061 (R-16.4)	U-0.061 (R-16.4)	U-0.104 (R-9.6)	U-0.090 (R-11.1)
	Steel Stud-Framed Wall	Metal-Framed	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-15.6ci	R-13 + R-7.5ci	R-13 + R-17.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci
			U-0.064 (R-15.6)	U-0.064 (R-15.6)	U-0.064 (R-15.6)	U-0.064 (R-15.6)	U-0.064 (R-15.6)	U-0.057 (R-17.5)	U-0.064 (R-15.6)	U-0.052 (R-19.2)	U-0.045 (R-22.2)	U-0.045 (R-22.2)	U-0.064 (R-15.6)	U-0.064 (R-15.6)
	Wood-Framed Wall	Wood-Framed & Other	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-15.6ci or R-20 + R-10ci	R-13 + R-15.6ci or R-20 + R-10ci	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20
			U-0.064 (R-15.6)	U-0.064 (R-15.6)	U-0.064 (R-15.6)	U-0.064 (R-15.6)	U-0.051 (R-19.6)	U-0.051 (R-19.6)	U-0.051 (R-19.6)	U-0.051 (R-19.6)	U-0.036 (R-27.8)	U-0.036 (R-27.8)	U-0.064 (R-15.6)	U-0.064 (R-15.6)
Single-Wythe CMU	Interior-Insulated	Mass	R-9.5ci	R-11.4ci	R-11.4ci	R-13.3ci	R-13.3ci	R-15.2ci	R-15.2ci	R-15.2ci	R-25ci	R-25ci	R-9.5ci	R-11.4ci
			U-0.104 (R-9.6)	U-0.090 (R-11.1)	U-0.078 (R-12.8)	U-0.078 (R-12.8)	U-0.078 (R-12.8)	U-0.071 (R-14.1)	U-0.061 (R-16.4)	U-0.061 (R-16.4)	U-0.061 (R-16.4)	U-0.061 (R-16.4)	U-0.104 (R-9.6)	U-0.090 (R-11.1)

ci= continuous insulation

Opaque Above-Grade Wall – Thermal Envelope Requirements *(continued)*																	
2015 IECC *(continued)*								2018 IECC									
5B		6B		7B		8B		4B		5B		6B		7B		8B	
All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R
R-11.4ci	R-13.3ci	R-13.3ci	R-15.2ci	R-15.2ci	R-15.2ci	R-25ci	R-25ci	R-9.5ci	R-11.4ci	R-11.4ci	R-13.3ci	R-13.3ci	R-15.2ci	R-15.2ci	R-15.2ci	R-25ci	R-25ci
U-0.090 (R-11.1)	U-0.080 (R-12.5)	U-0.080 (R-12.5)	U-0.071 (R-14.1)	U-0.071 (R-14.1)	U-0.061 (R-16.4)	U-0.061 (R-16.4)	U-0.061 (R-16.4)	U-0.104 (R-9.6)	U-0.090 (R-11.1)	U-0.090 (R-11.1)	U-0.080 (R-12.5)	U-0.080 (R-12.5)	U-0.071 (R-14.1)	U-0.071 (R-14.1)	U-0.071 (R-14.1)	U-0.061 (R-16.4)	U-0.061 (R-16.4)
R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-15.6ci	R-13 + R-7.5ci	R-13 + R-17.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-15.6ci	R-13 + R-7.5ci	R-13 + R-17.5ci
U-0.064 (R-15.6)	U-0.064 (R-15.6)	U-0.064 (R-15.6)	U-0.057 (R-17.5)	U-0.064 (R-15.6)	U-0.052 (R-19.2)	U-0.045 (R-22.2)	U-0.045 (R-22.2)	U-0.064 (R-15.6)	U-0.064 (R-15.6)	U-0.064 (R-15.6)	U-0.064 (R-15.6)	U-0.064 (R-15.6)	U-0.064 (R-15.6)	U-0.064 (R-15.6)	U-0.052 (R-19.2)	U-0.064 (R-15.6)	U-0.045 (R-22.2)
R-13 + R-3.8ci or R-20	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-15.6ci or R-20 + R-10ci	R-13 + R-15.6ci or R-20 + R-10ci	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-15.6ci or R-20 + R-10ci	R-13 + R-15.6ci or R-20 + R-10ci
U-0.064 (R-15.6)	U-0.064 (R-15.6)	U-0.051 (R-19.6)	U-0.051 (R-19.6)	U-0.051 (R-19.6)	U-0.051 (R-19.6)	U-0.036 (R-27.8)	U-0.036 (R-27.8)	U-0.064 (R-15.6)	U-0.064 (R-15.6)	U-0.064 (R-15.6)	U-0.064 (R-15.6)	U-0.051 (R-19.6)	U-0.051 (R-19.6)	U-0.051 (R-19.6)	U-0.051 (R-19.6)	U-0.036 (R-27.8)	U-0.036 (R-27.8)
R-11.4ci	R-13.3ci	R-13.3ci	R-15.2ci	R-15.2ci	R-15.2ci	R-25ci	R-25ci	R-9.5ci	R-11.4ci	R-11.4ci	R-13.3ci	R-13.3ci	R-15.2ci	R-15.2ci	R-15.2ci	R-25ci	R-25ci
U-0.090 (R-11.1)	U-0.080 (R-12.5)	U-0.080 (R-12.5)	U-0.071 (R-14.1)	U-0.071 (R-14.1)	U-0.061 (R-16.4)	U-0.061 (R-16.4)	U-0.061 (R-16.4)	U-0.104 (R-9.6)	U-0.090 (R-11.1)	U-0.090 (R-11.1)	U-0.080 (R-12.5)	U-0.080 (R-12.5)	U-0.071 (R-14.1)	U-0.071 (R-14.1)	U-0.071 (R-14.1)	U-0.061 (R-16.4)	U-0.061 (R-16.4)

Table 8-5 CMU backup wall with anchored masonry veneer: tabulated thermal modeling results

8" CMU Wall with Anchored Masonry Veneer, R-4.2/in - R-6/in Exterior Insulation						
Tie Type	Exterior Insulation Thickness	Nominal Insulation R-value	3D Thermal Modeling Effective R-Value of System (ft²·°F·hr/Btu)			
			Without Penetrations (Through Exterior Insulation)	With Masonry Anchor Penetrations @ 16" x 16" o.c.		
				Ties Only	Anchors + Standoff Shelf Angle	Anchors + Continuous Shelf Angle
Embedded Wire Tie (e.g., ladder style) – Stainless Steel	3"	12.6–18.0	15.9–21.3	14.9–19.3	13.1–16.2	9.5–10.9
	4"	16.8–24 .0	20.2–27.5	18.7–24.6	16.0–19.9	11.0–12.5
	5"	21.0–30.0	24.4–33.4	22.4–29.7	18.8–23.4	12.3–13.9
Embedded Wire Tie (e.g., ladder style) – Galvanized Steel	3"	12.6–18.0	15.9–21.3	13.2–16.4	11.8–14.1	8.8–9.9
	4"	16.8–24.0	20.2–27.5	16.3–20.4	14.2–17.1	10.1–11.3
	5"	21.0–30.0	24.4–33.4	19.3–24.2	16.5–19.8	11.3–12.6
Thermally Optimized Screw Tie – Stainless-Steel Hook	3"	12.6–18.0	15.9–21.3	14.1–17.9	12.4–15.2	9.2–10.4
	4"	16.8–24.0	20.2–27.5	17.4–22.2	15.1–18.4	10.5–11.9
	5"	21.0–30.0	24.4–33.4	20.6–26.3	17.4–21.2	11.7–13.1
Thermally Optimized Screw Tie – Galvanized Steel Hook	3"	12.6–18.0	15.9–21.3	14.0–17.8	12.4–15.1	9.2–10.4
	4"	16.8–24.0	20.2–27.5	17.4–22.1	15.0–18.3	10.5–11.9
	5"	21.0–30.0	24.4–33.4	20.5–26.2	17.4–21.2	11.7–13.1
Plate Tie (14 ga) – Stainless Steel	3"	12.6–18.0	15.9–21.3	14.1–18.0	12.5–15.3	9.2–10.5
	4"	16.8–24 .0	20.2–27.5	17.7–22.8	15.3–18.7	10.7–12.0
	5"	21.0–30.0	24.4–33.4	21.1–27.2	17.8–21.8	11.9–13.3
Plate Tie (14 ga) – Galvanized Steel	3"	12.6–18.0	15.9–21.3	12.2–14.8	11.0–12.9	8.4–9.3
	4"	16.8–24.0	20.2–27.5	14.8–17.9	13.0–15.3	9.5–10.5
	5"	21.0–30.0	24.4–33.4	17.1–20.7	14.9–17.4	10.5–11.6

Table 8-6 3 5/8-inch steel stud-framed wall thermal modeling results

3 5/8″ Steel Stud-Framed Wall with Anchored Masonry Veneer, R-15 Batt Insulation, R-4.2/in - R-6/in Exterior Insulation					
Tie Type	Exterior Insulation Thickness	Nominal Insulation R-value (Cavity + Exterior Insulation)	3D Thermal Modeling Effective R-Value of System (ft²·°F·hr/Btu)		
			Without Penetrations (Through Exterior Insulation)	With Masonry Tie Penetrations @ 16″ x 16″ o.c.	
				Stainless-Steel Tie and/or Hook	Galvanized-Steel Tie and/or Hook
Plate Tie (14ga)	2″	15.0 + 8.4–12.0	19.4–22.9	17.7–20.3	15.7–17.4
	3″	15.0 + 12.6–18.0	23.4–29.0	20.9–24.9	18.0–20.6
	4″	15.0 + 16.8–24.0	27.7–35.2	24.4–29.6	20.6–23.7
Thermally Optimized Screw Tie	2″	15.0 + 8.4–12.0	19.4–22.9	17.0–19.3	16.9–19.2
	3″	15.0 + 12.6–18.0	23.4–29.0	19.9–23.4	19.8–23.3
	4″	15.0 + 16.8–24.0	27.7–35.2	23.1–27.5	23.0–27.4

Table 8-7 Concrete floor line thermal modeling results with 3 5/8-inch steel stud-framed wall above and below

Concrete Slab Edge with Anchored Masonry				
Exterior Insulation Thickness	Nominal Exterior Insulation R-Value	3D Thermal Modeling Effective R-Value of System (ft²·°F·hr/Btu)		
		Exterior Insulation (Without Penetrations)	Standoff Shelf Angle	Continuous Shelf Angle
2"	8.4 – 12.0	12.4–16.2	6.6–6.8	2.8
3"	12.6–18.0	16.8–22.3	7.2–7.3	2.9
4"	16.8–24.0	21.3–28.7	7.6–8.2	3.1

Table 8-8 6-inch steel stud-framed wall thermal modeling results

6″ Steel Stud-Framed Wall with Anchored Masonry Veneer, R-21 Batt Insulation, R-4.2/in - R-6/in Exterior Insulation					
Tie Type	Exterior Insulation Thickness	System Nominal Insulation R-value (Cavity + Exterior Insulation)	3D Thermal Modeling Effective R-Value of System (ft²·°F·hr/Btu)		
			Without Penetrations (Through Exterior Insulation)	With Masonry Tie Penetrations @ 16″ x 16″ o.c.	
				Stainless-Steel Tie and/or Hook	Galvanized-Steel Tie and/or Hook
Plate Tie (14ga)	2″	21.0 + 8.4–12	20.4–24.4	18.7–21.6	16.7–18.7
	3″	21.0 + 12.6–18	24.7–30.4	22.3–26.3	19.3–21.8
	4″	21.0 + 16.8–24	29.1–36.6	25.8–31.0	21.8–24.9
Thermally Optimized Screw Tie	2″	21.0 + 8.4–12.0	20.4–24.4	18.0–20.6	17.9–20.5
	3″	21.0 + 12.6–18.0	24.7–30.4	21.2–24.7	21.1–24.6
	4″	21.0 + 16.8–24.0	29.1–36.6	24.4–28.9	24.3–28.7

Table 8-9 Concrete floor line thermal modeling results with 6-inch steel stud-framed wall above and below

Concrete Slab Edge with Anchored Masonry				
Exterior Insulation Depth	System Nominal Exterior Insulation R-Value	3D Thermal Modeling Effective R-Value of System (ft²·°F·hr/Btu)		
		Cavity + Exterior Insulation (Without Penetrations)	Standoff Shelf Angle	Continuous Shelf Angle
2"	8.4 – 12.0	12.8–16.6	5.9–6.4	3.9–4.1
3"	12.6–18.0	17.2–22.7	6.8–7.3	4.0–4.3
4"	16.8–24.0	21.7–29.1	7.6–8.2	4.2–4.5

Table 8-10 Wood-framed backup wall with anchored masonry veneer: tabulated thermal modeling results

Wood-Framed Wall with Anchored Masonry Veneer, 23% Framing Factor						
2x6 Framing, R-21 Batt Insulation, R-4.2/in - R-6/in Exterior Insulation						
Tie Type	Exterior Insulation Thickness	System Nominal Insulation R-value (Cavity + Exterior Insulation)	3D Thermal Modeling Effective R-Value of System (ft²·°F·hr/Btu)			
			Without Penetrations (Through Exterior Insulation)	With Masonry Tie Penetrations Considered @ 16″ x 16″ o.c.		
				Ties Only	Ties + Standoff Shelf Angle	Ties + Continuous Shelf Angle
Thermally Optimized Screw Tie – Stainless-Steel Hook	0″	21.0 + 0.0	18.3	18.2	–	18.1
	1″	21.0 + 4.2–6	22.6–24.4	22.2–23.8	22.0–23.6	21.6–23.0
	2″	21.0 + 8.4–12.0	26.9–30.6	26.0–29.1	25.7–28.7	24.6–27.0
	3″	21.0 +12.6–18.0	31.1–36.5	29.6–34.0	29.1–33.2	27.3–30.4
Thermally Optimized Screw Tie – Galvanized-Steel Hook	0″	21.0 + 0.0	18.3	18.2	–	18.1
	1″	21.0 + 4.2–6.0	22.6–24.4	22.1–23.7	22.0–23.5	21.6–23.0
	2″	21.0 + 8.4–12.0	26.9–30.6	26.0–29.1	25.7–28.6	24.6–26.9
	3″	21.0 + 12.6–18.0	31.1–36.5	29.5–33.9	29.1–33.2	27.3–30.4
Plate Tie (14 ga) – Stainless Steel	0″	21.0 + 0.0	18.3	18.2	–	18.1
	1″	21.0 + 4.2–6.0	22.6–24.4	22.2–23.8	22.0–23.6	21.6–23.0
	2″	21.0 + 8.4–12.0	26.9–30.6	26.0–29.1	25.7–28.7	24.7–27.0
	3″	21.0 +12.6–18.0	31.1–36.5	29.6–34.0	29.2–33.3	27.4–30.4
Plate Tie (14 ga) – Galvanized Steel	0″	21.0 + 0.0	18.3	18.1	–	18.1
	1″	21.0 + 4.2–6.0	22.6–24.4	21.9–23.4	21.7–23.2	21.4–22.6
	2″	21.0 + 8.4–12.0	26.9–30.6	25.4–28.2	25.1–27.8	24.1–26.2
	3″	21.0 +12.6–18.0	31.1–36.5	28.6–32.3	28.1–31.7	26.5–29.1
2x8 Framing, R-30 Batts, No Exterior Insulation						
Plate Tie (14 ga) – Galvanized Steel	0″	30	22.8	22.6	–	22.5

Thermal Modeling Results: Interior-Insulated Single-Wythe CMU

The modeled system includes an 8-inch medium-weight CMU block and eight configurations of interior insulation as depicted graphically in Fig. 8-23. Interior wall framing is provided by galvanized steel studs at 16-inches on-center, including a top and bottom track. Options 1, 3, and 4 were modeled with the wall framing offset from the CMU wall structure to allow clearance for a continuous insulation layer. The remaining options were modeled with wall framing tight to the CMU wall structure. Cavity insulation is either R-15 batt insulation or R-6/inch insulation, such as CCSPF. Continuous insulation is either R-5 or R-6/inch, typical R-values for either rigid XPS or CCSPF insulation respectively.

Table 8-11 Interior-insulated single-wythe CMU wall thermal modeling results

CMU Wall with Interior Insulation			
Insulation Option	Interior Insulation Thickness	Nominal Insulation R-Value*	3D Thermal Modeling Effective R-Value of System ($ft^2 \cdot °F \cdot hr/Btu$)
1	2"	12 cavity	7.2
2	4"	12 cavity + 12 ci	23.4
3	1"	5 ci	8.1
4	2"	12 ci	15.2
5	4"	24 ci	27.2
6	4"	24 cavity	9.1
7	2"	15 cavity + 10 ci	22.2
8	3"	15 cavity + 15 ci	27.3

**ci = continuous insulation*

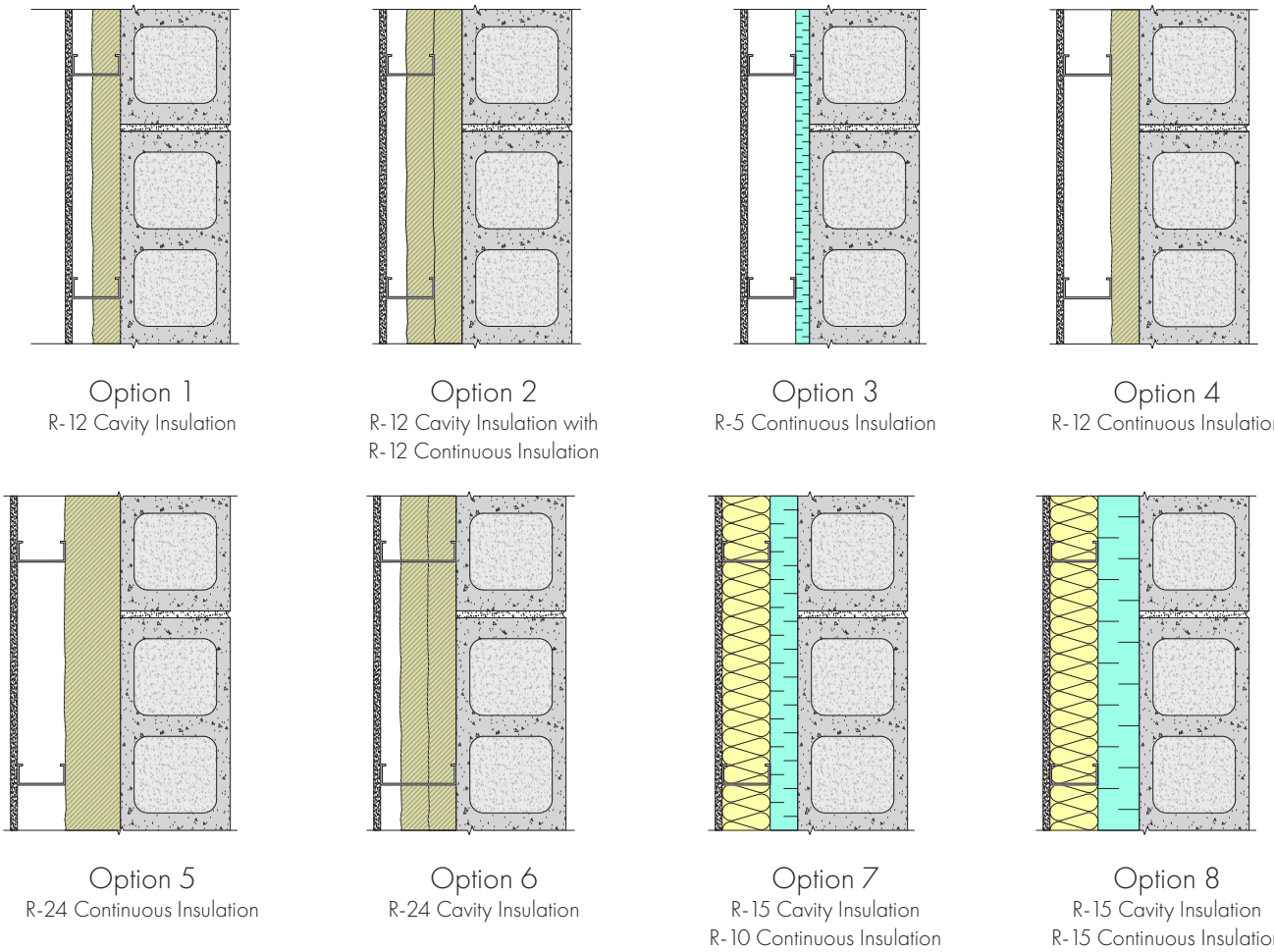


Fig. 8-23 Modeled insulation options for the interior insulated single-wythe CMU

Appendix: Thermal Modeling

Thermal modeling for this guide was undertaken using HEAT3.1.[1] HEAT3 is a three-dimensional finite-element thermal analysis software tool commonly used by the building industry to analyze building enclosure assemblies in three dimensions, which two-dimensional analysis tools (such as THERM) cannot accurately analyze. It allows for a more detailed analysis of building enclosure assemblies, including the impact of fasteners, masonry ties and discrete clips, and other construction realities. Modeling can determine effective R-values/U-factors from the heat flow measured through the building enclosure assembly.

The boundary conditions used for this guide's modeling are industry standard ASHRAE winter exterior and interior boundary conditions with temperatures of 0°F and 70°F and surface films 0.17 $ft^2 \cdot °F \cdot hr/Btu$ and 0.68 $ft^2 \cdot °F \cdot hr/Btu$ respectively. The material conductivities used for the modeling are provided in Table A-1.

Table A-1 Material conductivities used for thermal modeling

Material	Thermal Conductivity Btu·in/hr·ft·°F (W/m·K)
Masonry veneer	5.5 (0.79)
Mortar	5.0 (0.72)
Cement Board	1.73 (0.25)
¾-inch grout with metal lathe	32.6 (4.7)
Air cavities at varying thicknesses	Varies*
Polypropylene (in ½-inch drain mat)	1.53 (0.22)
High density polyethylene	3.5 (0.5)
EPDM	1.73 (0.25)
Galvanized sheet steel (studs, girts, ties)	430 (62)
Stainless steel (clips, ties, fasteners)	118 (17)
Mild steel (fasteners/angles)	314 (45.3)
Brass (masonry tie bolt sleeve)	832 (120)
Fiberglass frame (clip)	2.1 (0.3)
Exterior mineral wool insulation (R-4.2/in)	0.24 (0.0343)
Closed cell spray foam (R-6/in)	0.17 (0.0240)
½-inch Exterior gypsum	0.90 (0.13)
½-inch Plywood – Douglas Fir	0.65 (0.093)
Wood 2x SPF	0.83 (0.12)
Fiberglass batts 5.5-inch R-21	0.26 (0.0379)
Fiberglass batts 7.2-inch R-30	0.24 (0.0348)
Fiberglass batts 3.625-inch R-15	0.24 (0.0348)
Fiberglass batts 6-inch R-21	0.29 (0.0411)
½-inch Interior gypsum	1.1 (0.16)
Concrete (including reinforcing)	13.9 (2)
8-inch concrete masonry unit empty, including grout	8.0 (1.153)

* All air spaces assigned R-values based on values given for plane air spaces in the ASHRAE Handbook – Fundamentals.