One definition of inspect is “to examine closely and critically.” In building construction, the term inspections can imply other terms: completeness, code compliance, quality assurance, and as-specified are a few examples. For the purposes of this guide, inspection will be discussed as actions performed by a building owner, product manufacturer, code official, and others. Construction observations for quality assurance and assessment are typically performed by professional, credentialed construction observers and consultants, such as a Certified Mason Contractor (CMC) as recognized by the Washington State Conference of Mason Contractors; however, these services may be provided by individuals with extensive experience in design and construction of building enclosure components.

This guide has been compiled to provide assistance regarding the design, engineering, and construction of components of masonry building enclosure systems, including exterior walls, accessories, waterproofing, openings, and transition flashings. The guidelines included cover these systems during their design, specification, and initial construction. The purpose of this guide is to assist quality assurance observers and owners who may have limited knowledge and experience in the specifics of masonry system component installation or evaluation. This guide also serves as a procedural reference for experienced professionals who review masonry systems regularly.

During construction, quality assurance observers can review the masonry systems as they are installed to confirm that they comply with the project specifications, industry standards, and recognized guidelines for the work being performed. Following construction and throughout the service life of the system, visual assessments can determine if maintenance is required beyond cleaning debris from elements of a masonry system or replacing sealant or pointing that has aged to the point of failure. If more detailed and involved maintenance is required, a credentialed, professional building enclosure consultant experienced in masonry design and restoration or a Certified Mason Contractor should be engaged.

Resources for information contained in this guide may be found in the Resources Section near the end of this document.

This publication was created under the oversight of professional building envelope consultants, engineers, architects, experienced commercial masonry contractors, and other masonry specialists. Therefore, the information ultimately comes directly from consultants and contractors with decades of in-the-field masonry experience.
This guide should be considered as a supplement to other masonry industry publications as they describe many details and alternate construction methods and applications. Where project specifications may be inadequate, many of the details within the publications are subject to interpretation by professional building envelope consultants or the judgment and experience of a commercial mason contractor.

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**TABLE OF CONTENTS**

**INTRODUCTION**
- How to Use This Guide
- Guide Assemblies
- Assembly Comparison Matrix
- Pricing Analysis
- Online Availability
- Building Enclosure System
- Building Enclosure Loads

**Control Functions and Critical Barriers**
- Assembly Design Approaches
- Water-Shedding Surface (WSS)
- Water-Resistive Barrier (WRB)
- Air-Barrier System (AB)
- Thermal Envelope
- Vapor Retarder (VR)
- Building Form and Features
- Prescriptive Compliance Option
- Non-prescriptive Compliance Option
- Mass Wall Considerations
- Insulation Products
- Air Leakage

**Sheet-Metal Components**

**Movement Joints**
- Joint Locations
- Vertical Joint Placement
- Horizontal Joint Placement
- Joint Design
- Best Practices
- Architectural Considerations

**Cleaners, Repellents, and Coatings**
- Cleaning Methods
- Surface-Applied Clear Water Repellents
- Best Practices
- Elastomeric Coatings
- Best Practices
### CHAPTER 1: CMU WALL WITH ANCHORED MASONRY VENEER

<table>
<thead>
<tr>
<th>Building Enclosure Control Functions and Critical Barriers</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water-Shedding Surface (WSS)</td>
<td>2</td>
</tr>
<tr>
<td>Water-Resistive Barrier (WRB)</td>
<td>3</td>
</tr>
<tr>
<td>Air Barrier (AB)</td>
<td>4</td>
</tr>
<tr>
<td>Thermal Envelope</td>
<td>5</td>
</tr>
<tr>
<td>Vapor Retarder (VR)</td>
<td>6</td>
</tr>
<tr>
<td>Thermal Performance and Energy Code Compliance</td>
<td>7</td>
</tr>
<tr>
<td>Assembly Effective Thermal Performance</td>
<td>8</td>
</tr>
<tr>
<td>Drainage, Ventilation, and Water Deflection</td>
<td>9</td>
</tr>
<tr>
<td>Drainage and Ventilation</td>
<td>10</td>
</tr>
<tr>
<td>Sheet-Metal Components</td>
<td>11</td>
</tr>
<tr>
<td>Movement Joints</td>
<td>12</td>
</tr>
<tr>
<td>Structural Considerations</td>
<td>13</td>
</tr>
<tr>
<td>Masonry Ties</td>
<td>14</td>
</tr>
<tr>
<td>Vertical Support</td>
<td>15</td>
</tr>
<tr>
<td>Corrosion Resistance</td>
<td>16</td>
</tr>
<tr>
<td>Clear Water Repellants</td>
<td>17</td>
</tr>
<tr>
<td>Pricing Analysis</td>
<td>18</td>
</tr>
<tr>
<td>Online Availability</td>
<td>19</td>
</tr>
<tr>
<td>Assembly Details</td>
<td>20</td>
</tr>
</tbody>
</table>

### CHAPTER 2: STEEL-FRAMED WALL WITH ANCHORED MASONRY VENEER

<table>
<thead>
<tr>
<th>Building Enclosure Control Functions and Critical Barriers</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water-Shedding Surface (WSS)</td>
<td>2</td>
</tr>
<tr>
<td>Water-Resistive Barrier (WRB)</td>
<td>3</td>
</tr>
<tr>
<td>Air Barrier (AB)</td>
<td>4</td>
</tr>
<tr>
<td>Thermal Envelope</td>
<td>5</td>
</tr>
<tr>
<td>Vapor Retarder (VR)</td>
<td>6</td>
</tr>
<tr>
<td>Thermal Performance and Energy Code Compliance</td>
<td>7</td>
</tr>
<tr>
<td>Assembly Effective Thermal Performance</td>
<td>8</td>
</tr>
<tr>
<td>Sheathing Selection</td>
<td>9</td>
</tr>
<tr>
<td>Drainage, Ventilation, and Water Deflection</td>
<td>10</td>
</tr>
<tr>
<td>Drainage and Ventilation</td>
<td>11</td>
</tr>
<tr>
<td>Sheet-Metal Components</td>
<td>12</td>
</tr>
<tr>
<td>Movement Joints</td>
<td>13</td>
</tr>
<tr>
<td>Structural Considerations</td>
<td>14</td>
</tr>
<tr>
<td>Masonry Ties</td>
<td>15</td>
</tr>
<tr>
<td>Vertical Support</td>
<td>16</td>
</tr>
<tr>
<td>Corrosion Resistance</td>
<td>17</td>
</tr>
<tr>
<td>Clear Water Repellants</td>
<td>18</td>
</tr>
<tr>
<td>Pricing Analysis</td>
<td>19</td>
</tr>
<tr>
<td>Online Availability</td>
<td>20</td>
</tr>
<tr>
<td>Assembly Details</td>
<td>21</td>
</tr>
</tbody>
</table>

### CHAPTER 3: WOOD-FRAMED WALL WITH ANCHORED MASONRY VENEER

<table>
<thead>
<tr>
<th>Building Enclosure Control Functions and Critical Barriers</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water-Shedding Surface (WSS)</td>
<td>2</td>
</tr>
<tr>
<td>Water-Resistive Barrier (WRB)</td>
<td>3</td>
</tr>
<tr>
<td>Air Barrier (AB)</td>
<td>4</td>
</tr>
<tr>
<td>Thermal Envelope</td>
<td>5</td>
</tr>
<tr>
<td>Vapor Retarder (VR)</td>
<td>6</td>
</tr>
<tr>
<td>Thermal Performance and Energy Code Compliance</td>
<td>7</td>
</tr>
<tr>
<td>Assembly Effective Thermal Performance</td>
<td>8</td>
</tr>
<tr>
<td>Sheathing Selection</td>
<td>9</td>
</tr>
<tr>
<td>Drainage, Ventilation, and Water Deflection</td>
<td>10</td>
</tr>
<tr>
<td>Drainage and Ventilation</td>
<td>11</td>
</tr>
<tr>
<td>Sheet-Metal Components</td>
<td>12</td>
</tr>
<tr>
<td>Movement Joints</td>
<td>13</td>
</tr>
<tr>
<td>Structural Considerations</td>
<td>14</td>
</tr>
<tr>
<td>Masonry Ties</td>
<td>15</td>
</tr>
<tr>
<td>Vertical Support</td>
<td>16</td>
</tr>
<tr>
<td>Corrosion Resistance</td>
<td>17</td>
</tr>
<tr>
<td>Clear Water Repellants</td>
<td>18</td>
</tr>
<tr>
<td>Pricing Analysis</td>
<td>19</td>
</tr>
<tr>
<td>Online Availability</td>
<td>20</td>
</tr>
<tr>
<td>Assembly Details</td>
<td>21</td>
</tr>
</tbody>
</table>

### CHAPTER 4: INTEGRALLY INSULATED CMU WALL

<table>
<thead>
<tr>
<th>Building Enclosure Control Functions and Critical Barriers</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water-Shedding Surface (WSS)</td>
<td>2</td>
</tr>
<tr>
<td>Water-Resistive Barrier (WRB)</td>
<td>3</td>
</tr>
<tr>
<td>Air Barrier (AB)</td>
<td>4</td>
</tr>
<tr>
<td>Thermal Envelope</td>
<td>5</td>
</tr>
</tbody>
</table>

Vertical Support
Corrosion Resistance
Masonry Veneer
Clear Water Repellents
Pricing Analysis
Online Availability
Assembly Details
CHAPTER 5: INTERIOR-INSULATED CMU WALL
Building Enclosure Control Functions and Critical Barriers
Water-Shedding Surface (WSS) 2
Water-Resistive Barrier (WRB) 3
Air Barrier (AB) 4
Thermal Envelope 5
Vapor Retarder (VR) 7
Thermal Performance and Energy Code Compliance 7
Assembly Effective Thermal Performance 8
Movement Joints 10
Structural Considerations 12
CMU Wall 12
Corrosion Resistance 13
Water Repellents 13
Pricing Analysis 13
Online Availability 14
Assembly Details 16

CHAPTER 6: CMU WALL WITH ADHERED MASONRY VENEER
Building Enclosure Control Functions and Critical Barriers 1
Water-Shedding Surface (WSS) 2
Water-Resistive Barrier (WRB) 3
Air Barrier (AB) 4
Thermal Envelope 5
Vapor Retarder (VR) 6
Thermal Performance and Energy Code Compliance 6
Assembly Effective Thermal Performance 7

CHAPTER 7: STEEL-FRAMED WALL WITH ADHERED MASONRY VENEER
Building Enclosure Control Functions and Critical Barriers 1
Water-Shedding Surface (WSS) 2
Water-Resistive Barrier (WRB) 3
Air Barrier (AB) 5
Thermal Envelope 5
Vapor Retarder (VR) 6
Thermal Performance and Energy Code Compliance 6
Assembly Effective Thermal Performance 7
Drainage, Ventilation, and Water Deflection 12
Drainage and Ventilation 12
Sheet-Metal Components 13
Movement Joints 13
Structural Considerations 14
Corrosion Resistance 15
Cement Backer Board 17
Crack Isolation Membrane 17
Masonry Veneer 18
Clear Water Repellents 18
Pricing Analysis 18
Online Availability 18
Assembly Details 22
INTRODUCTION

Masonry has been used successfully in building construction in the Northwest region (Washington, Oregon, and Idaho) for many decades as both the primary structural system and as a cladding. Masonry has withstood the test of time not only because of its natural resistance to fire, water, impact, and organic growth, but also because of its design versatility.

Historically, structural mass masonry wall assemblies were commonplace, primarily due to their superior fire resistance, durability, and weatherability. Over time, such assemblies have given way to alternate structural framing materials. By definition, mass structures inherently address the many above-grade wall functions, including control of water, air, heat, sound, and fire. Replacing the mass structure increases the complexity of the wall design as follows:

- Wall cavity and/or exterior insulation may be necessary for thermal and sound control.
- An air barrier is necessary to limit the uncontrolled exchange of air—and consequently the uncontrolled exchange of moisture (primarily vapor), heat, sound, and pollutants that move with air—between the interior and exterior environments.
- Moisture control is rethought to ensure that moisture-sensitive structural and insulation components are protected.

Traditional decorative and durable cornice and cornerstone elements and built-in drip edges at strategic locations were typical of mass masonry structures and responsible for deflecting much of the water cascading down the face of these buildings. These design elements have been either eliminated or traded for more modularized and economized veneer units that, while reminiscent of historic...
mass masonry construction detailing, do not have the same water-deflecting characteristics. Fortunately, most veneer assemblies are able to accommodate the added moisture ingress due to a concealed drainage cavity and flashings. The result is a similar material aesthetic, fire resistivity, and durability, yet a flatter and simpler appearance lacking the intrinsic ability to deflect water away from the masonry-clad wall face and away from areas most sensitive to water entry, e.g., wall penetrations such as vents, windows, and doors.

Though the evolution of the above-grade wall design has led to more complex overall assemblies, product selection, and code compliance than in previous years, it has also demonstrated the durable and accommodating nature of modern above-grade wall assemblies to the local climate conditions of the Northwest region.

As a result, the focus of this guide is to provide comprehensive design and construction detailing information for 8 primary above-grade wall assembly options successfully used in the Northwest climate that are composed of clay or concrete masonry as an adhered or anchored veneer or single-wythe CMU wall application. The focus for each assembly is to clarify the overall above-grade wall building enclosure design as it relates to managing heat, air, and moisture (both liquid water and vapor) transfer between the interior environment and exterior environment and to demonstrate the constructibility of these structures to ensure long-term durability. Cladding considerations including attachment and installation methods are also addressed. Each assembly within this guide is addressed specific to the Northwest region, including Washington, Oregon, and Idaho and considers local climate, codes, and building preferences and practices.

Fig. i-2 Modern masonry veneer structure, Wenatchee Valley College Music and Art Center, constructed in 2012

How to Use This Guide

This introductory chapter showcases the 8 primary above-grade wall assemblies that are the focus of this guide. This introduction also contains technical references and supporting information for general topics that apply to the featured above-grade wall assemblies.

Each subsequent chapter is dedicated to one of the primary above-grade wall assemblies and provides assembly-specific discussion, guidance, photos, and/or diagrammatic illustrations. Two- and three-dimensional details and cutaway wall sections are provided at the end of each chapter, summarizing the chapter content and illustrating its use in real-world applications.

The sections following the 8 assembly chapters contain additional information regarding thermal modeling parameters, published industry references, and product resources.

The information presented within this guide is not meant to be exhaustive of all assembly variations, product performance properties, or detailing approaches but rather represents a selection of the best practices and preferences used in the Northwest region.

Guide Assemblies

The 8 primary above-grade wall assemblies featured within this guide are shown in Fig. i-3 on page i-4, and are summarized in the Assembly Comparison Matrix, Table i-1 on page i-7.

- Chapter 1: CMU (or Concrete Alternate) Wall with Anchored Masonry Veneer
- Chapter 2: Steel-Framed Wall with Anchored Masonry Veneer
- Chapter 3: Wood-Framed Wall with Anchored Masonry Veneer
- Chapter 4: Integrally Insulated CMU Wall
- Chapter 5: Interior-Insulated CMU Wall
- Chapter 6: CMU Wall with Adhered Masonry Veneer
- Chapter 7: Steel-Framed Wall with Adhered Masonry Veneer
- Chapter 8: Wood-Framed Wall with Adhered Masonry Veneer (Thick or Thin Bed Method)
Assembly Comparison Matrix

The Table i-1 Assembly Comparison Matrix beginning on page i-7 is provided to assist designers with assembly selection. Comparison categories are those generally considered for both commercial and/or residential applications and include:

- Recommended Occupancy Type
- Building Enclosure Design Approach and Recommended Exposure
- Long-Term Wall Assembly Durability
- Typical Wall Thickness
- Typical Cladding Design Compliance
- Thermal Performance Considerations
- Special Construction Considerations
- Constructibility Ease with Limited/No Access to Exterior
- Fire Resistivity Considerations
- Maintenance Considerations
- Price Per Square Foot

Pricing Analysis

A pricing analysis is provided for each assembly within this guide and demonstrates the relative price per square foot. Pricing is for components outboard of the wall sheathing for framed or CMU backup wall assemblies. For exterior-exposed CMU wall systems, pricing includes all components except interior finishes and steel framing (where it occurs). Pricing is based on a 10,000- square-foot wall area and is valued for the 2015–2016 calendar year. Current pricing is also available at www.masonrysystemsguide.com.

Overall pricing is included within the Table i-1 Assembly Comparison Matrix beginning on page i-7. A pricing breakdown and additional related discussion is included in a summary table at the end of each assembly chapter.
Online Availability

The content of this guide and additional resources may be accessed online at www.masonrysystemsguide.com. Also available online are downloadable digital versions of two- and three-dimensional assembly details and cutaway sections as well as sample project specifications. Ongoing additions to references and resources included within this guide can also be accessed.

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<table>
<thead>
<tr>
<th>Assembly Comparison Category</th>
<th><strong>#1(A) and #1(B)</strong></th>
<th><strong>#2</strong></th>
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</thead>
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<tr>
<td><strong>Recommended Occupancy Type</strong></td>
<td>Residential OR Commercial</td>
<td>Residential OR Commercial</td>
</tr>
<tr>
<td><strong>Building Enclosure Design Approach and Recommended Exposure</strong></td>
<td>Rainscreen Design Approach, Low-to High-Rise Exposure</td>
<td>Rainscreen Design Approach, Low-to High-Rise Exposure</td>
</tr>
<tr>
<td><strong>Long-Term Wall Assembly Durability</strong></td>
<td>Resilient due to exterior insulation and rainscreen drainage cavity</td>
<td>Resilient due to rainscreen drainage cavity; effect of split insulation must be carefully considered</td>
</tr>
<tr>
<td><strong>Typical Wall Thickness</strong></td>
<td>CMU/concrete structure typically thicker than wood or steel (Chapters #2 and #3 Assemblies); continuous insulation increases thickness</td>
<td>Continuous insulation increases assembly thickness vs. typical assembly (Chapter #3 Assembly)</td>
</tr>
<tr>
<td><strong>Typical Cladding Design Compliance</strong></td>
<td>Precriptive cladding design allowed based on ACI-530 up to 4.5-inch cavity depth (face of backup wall to back of veneer)</td>
<td>Precriptive cladding design allowed based on ACI-530 up to 4.5-inch cavity depth (face of backup wall to back of veneer)</td>
</tr>
<tr>
<td><strong>Typical Thermal Performance</strong></td>
<td>CMU wall grouting requirements limit core insulation options; continuous exterior insulation typically required. Masonry tie penetrations through the insulation may need to be considered when determining thermal performance.</td>
<td>Continuous exterior insulation typically required to compensate for highly conductive steel framing. Masonry tie penetrations through the insulation may need to be considered when determining thermal performance.</td>
</tr>
<tr>
<td><strong>Special Construction Considerations</strong></td>
<td>Anchored systems require code compliant bearing elements</td>
<td>Anchored systems require code compliant bearing elements</td>
</tr>
<tr>
<td><strong>Construction Ease with Limited / No Exterior Access (property line applications)</strong></td>
<td>Requires exterior access</td>
<td>Requires exterior access</td>
</tr>
<tr>
<td><strong>Fire Resistivity Considerations</strong></td>
<td>Fire resistivity high. Type of exterior insulation may affect fire propagation requirements.</td>
<td>Fire resistivity moderate. Type of exterior insulation may affect fire propagation requirements.</td>
</tr>
<tr>
<td><strong>Maintenance Considerations</strong></td>
<td>Regular maintenance required; clear water repellent recommended. Consider flashings and other water-shedding features to reduce quantity of moisture on the face of the masonry.</td>
<td>Regular maintenance required; clear water repellent recommended. Consider flashings and other water-shedding features to reduce quantity of moisture on the face of the masonry.</td>
</tr>
<tr>
<td><strong>Price Per Square Foot</strong></td>
<td>Low and High Baseline Cost: $32.25 - $38.00</td>
<td>Low and High Baseline Cost: $32.25 - $40.00</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Assembly</th>
<th>#3 Wood-Framed Wall with Anchored Masonry Veneer</th>
<th>#4 Integrally Insulated CMU Wall</th>
<th>#5 Interior-Insulated CMU Wall</th>
<th>#6 CMU Wall with Adhered Masonry Veneer</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Assembly Comparison Category</strong></td>
<td><strong>Recommended Occupancy Type</strong></td>
<td><strong>Building Enclosure Design Approach and Recommended Exposure</strong></td>
<td><strong>Long-Term Wall Assembly Durability</strong></td>
<td><strong>Typical Wall Thickness</strong></td>
</tr>
<tr>
<td>Recommended Occupancy Type</td>
<td>Residential OR Commercial</td>
<td>Mass Wall Design Approach, Low-rise Exposure</td>
<td>Resilient due to rainscreen drainage cavity; effect of split insulation must be carefully considered if provided</td>
<td>Typical thickness for masonry veneer wall</td>
</tr>
<tr>
<td>Building Enclosure Design Approach and Recommended Exposure</td>
<td>Rainscreen Design Approach, Low- to Mid-rise Exposure</td>
<td>Structural durability high. Water repellents (admixture and surface applied) and/or opaque coatings provide water resistivity.</td>
<td>Prescriptive cladding design allowed based on ACI-530 up to 4.5-inch cavity depth (face of backup wall to back of veneer)</td>
<td>Prescriptive/Engineered</td>
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<tr>
<td>Long-Term Wall Assembly Durability</td>
<td></td>
<td>Core insulation provided to meet code compliance; may qualify for energy code compliance exceptions in some areas</td>
<td>Low-conductivity wood framing.</td>
<td>Typical Cladding Design Compliance</td>
</tr>
<tr>
<td>Typical Wall Thickness</td>
<td></td>
<td></td>
<td></td>
<td>Low and High Baseline Cost: $24.25 - $36.50</td>
</tr>
<tr>
<td>Typical Cladding Design Compliance</td>
<td></td>
<td></td>
<td>Typical Thermal Performance</td>
<td></td>
</tr>
<tr>
<td>Typical Thermal Performance</td>
<td></td>
<td></td>
<td>Interior closed-cell spray foam insulation provides highest R-value per inch</td>
<td></td>
</tr>
<tr>
<td>Special Construction Considerations</td>
<td></td>
<td>Special Construction Considerations</td>
<td>Multiple functions of interior spray foam reduces construction complexity; added measures for moisture control recommended</td>
<td></td>
</tr>
<tr>
<td>Construction Ease with Limited / No Exterior Access (property line applications)</td>
<td>Anchored systems require code compliant bearing elements</td>
<td>No exterior access required; however, installation of repellents or coatings is limited</td>
<td>No exterior access required; however, installation of repellents or coatings is limited</td>
<td>Requires exterior access</td>
</tr>
<tr>
<td>Fire Resistivity Considerations</td>
<td>Requires exterior access</td>
<td>Fire resistivity moderate. Exterior insulation where used may affect fire propagation requirements</td>
<td>Fire resistivity high.</td>
<td>Fire resistivity high. Exterior insulation may affect fire propagation requirements.</td>
</tr>
<tr>
<td>Maintenance Considerations</td>
<td>Regular maintenance required; clear water repellent recommended. Consider flashings and other water-shedding features to reduce quantity of moisture on the face of the masonry.</td>
<td>Regular maintenance required; clear water repellent recommended.</td>
<td>Regular maintenance required. Additional maintenance/review recommended to ensure adhered veneer integrity.</td>
<td>Regular maintenance required.</td>
</tr>
<tr>
<td>Price Per Square Foot</td>
<td>Low and High Baseline Cost: $30.50 - $37.25</td>
<td>Low and High Baseline Cost: $24.25 - $36.50</td>
<td>Low and High Baseline Cost: $27.75 - $34.25</td>
<td>Low and High Baseline Cost: $49.50 - $60.75</td>
</tr>
</tbody>
</table>
The remaining sections within this introduction serve as a reference for topics consistent among many of the chapter assemblies. These topics include building enclosure system and loads; identification of building enclosure control functions and critical barriers; assembly design approaches; thermal performance and energy code compliance; sheet-metal components; movement joints; as well as cleaning, repellents, and coatings. Additional references and resources for these topics may be found at the end pages of this guide.

**Building Enclosure System**

The building enclosure (building envelope) is a system of materials, components, and assemblies physically separating the interior environment from the exterior environment(s). As an environmental separator, the building enclosure can be grouped into three subcategories: support, control, and finish. Support satisfies structural requirements whereas finish satisfies interior and exterior aesthetics.

As an environmental separator, the building enclosure controls heat, air, and moisture transfer and, along with the heating and ventilation systems, helps maintain a comfortable and healthy indoor environment.

The elements of the building enclosure include roofs, above- and below-grade walls, windows, doors, skylights, exposed floors, the basement/slab-on-grade floor, and all of the interfaces and details in between. Typical building enclosure elements are depicted in Fig. i-4. As the focus of this guide is specific to the 8 primary assemblies described in the previous sections, only design considerations

<table>
<thead>
<tr>
<th><strong>Assembly</strong></th>
<th><strong>#7</strong> Steel-Framed Wall with Adhered Masonry Veneer</th>
<th><strong>#8(A) and #8(B)</strong> Wood-Framed Wall with Adhered Masonry Veneer (Thick or Thin Bed Method)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Recommended Occupancy Type</strong></td>
<td>Residential OR Commercial</td>
<td>Residential OR Commercial</td>
</tr>
<tr>
<td><strong>Building Enclosure Design Approach and Recommended Exposure</strong></td>
<td>rainscreen Design Approach, Low- to Mid-Rise Exposure. Consider access for maintenance on high-rise applications.</td>
<td>rainscreen Design Approach, Low- to Mid-Rise Exposure. Consider access for maintenance on higher-rise applications.</td>
</tr>
<tr>
<td><strong>Long-Term Wall Assembly Durability</strong></td>
<td>Resilient due to rainscreen drainage cavity; effect of split insulation must be carefully considered</td>
<td>Resilient due to rainscreen drainage cavity; clear drainage cavity (Assembly #8(B)) higher performing</td>
</tr>
<tr>
<td><strong>Typical Wall Thickness</strong></td>
<td>Thinner than anchored (Chapter #2 Assembly); continuous insulation increases thickness</td>
<td>Typical thickness for anchored veneer wall; thinner than anchored (Chapter #3 Assembly)</td>
</tr>
<tr>
<td><strong>Typical Cladding Design Compliance</strong></td>
<td>Cladding system typically engineered. When proprietary cladding attachment systems are used, contact manufacturer.</td>
<td>Cladding system typically engineered. When proprietary cladding attachment systems are used, contact manufacturer.</td>
</tr>
<tr>
<td><strong>Typical Thermal Performance</strong></td>
<td>Continuous exterior insulation typically required to compensate for highly conductive steel framing. Cladding support penetrations through the exterior insulation may need to be considered when determining thermal performance.</td>
<td>Low-conductivity wood framing</td>
</tr>
<tr>
<td><strong>Special Construction Considerations</strong></td>
<td>Several cladding components and stages required</td>
<td>Several cladding components and stages required</td>
</tr>
<tr>
<td><strong>Construction Ease with Limited / No Exterior Access (property line applications)</strong></td>
<td>Requires exterior access</td>
<td>Requires exterior access</td>
</tr>
<tr>
<td><strong>Fire Resistivity Considerations</strong></td>
<td>Fire resistivity moderate. Exterior insulation may affect fire propagation requirements.</td>
<td>Fire resistivity moderate. Exterior insulation where used may affect fire propagation requirements.</td>
</tr>
<tr>
<td><strong>Maintenance Considerations</strong></td>
<td>Regular maintenance required. Additional maintenance/review recommended to ensure adhered veneer integrity.</td>
<td>Regular maintenance required. Additional maintenance/review recommended to ensure adhered veneer integrity.</td>
</tr>
<tr>
<td><strong>Price Per Square Foot</strong></td>
<td>Low and High Baseline Cost: $49.50 - $62.75</td>
<td>Low and High Baseline Cost: $38.75 - $55.25 (8A) $46.25 - $53.00 (8B)</td>
</tr>
</tbody>
</table>

Fig. i-4 Many building enclosure elements are visible in this photo, including a roof, above-grade walls, windows, doors, and floors (i.e., soffits).
zones impose a wide range of environmental loads, including rainfall as shown in Fig. i-6 and Fig. i-7. In the Northwest, rainfall loads span from areas of significant precipitation and cooler temperatures near the western Washington peninsula, the Oregon coast, and the higher elevations of Idaho; more extreme temperatures occur both in winter and summer months in dryer areas in eastern Washington and Oregon and southern Idaho.

Control Functions and Critical Barriers

A primary function of the building enclosure is to control (or rather appropriately manage) environmental loads. Various materials are used within enclosure assemblies and details to perform different control functions depending on their material properties and placement. The following control functions are typically considered: water (precipitation and ground), water vapor, air, heat, sound, fire, light, and contaminants. The interior and exterior finish can also be considered as part of the control function. For the purpose of this guide, the primary control functions of water, air, heat, and vapor are addressed in greater detail here. Where appropriate, detailing considerations are also discussed and included for roof, floor-line, and foundation assembly transitions as well as fenestration openings within the above-grade wall.
detail. Consideration of sound, fire, light, and contaminants may be related to the concepts discussed within this guide but are not covered in detail.

Applying the concept of control functions, the term critical barrier is commonly used to refer to materials and components that together perform an important function within the building enclosure. A critical barrier must be continuous for the enclosure to perform as designed. It has become common and referenced within building codes to define specific critical barriers within an enclosure assembly, such as a vapor retarder/barrier or an air barrier. Fig. i-8 depicts the link between the concept of control functions and the associated critical barrier. Fig. i-8 also describes primary and secondary relationships.

The use of critical barrier concepts to evaluate assemblies and details is consistent with industry best practices. The concepts are useful to assess specific assemblies and details being considered for a project. The application of the critical barrier concept will help all parties better understand the role and importance or functions of certain materials and details. As a result, the critical barriers of water-shedding surface (WSS), water-resistive barrier (WRB), air barrier (AB), thermal envelope (e.g. thermal insulation), and vapor retarder/barrier (VR) are demonstrated for each chapter assembly and their respective two-dimensional details throughout this guide. Building form and features are also important concepts for controlling water and are only addressed in this introductory chapter to provide general design guidance.

Throughout this guide, the critical barriers for each assembly and accompanying details will be included similar to those shown in Fig. i-9 and Fig. i-10 on page i-16. Placement and continuity of these critical barriers are also shown for each two-dimensional detail in the following chapters.

The next section introduces the two primary assembly design approaches that apply to the assemblies within this guide. Further discussion on each critical barrier and how each applies to the assembly design approaches is discussed in the following sections.

### Assembly Design Approaches

Assemblies within this guide provide the control functions as part of either a rainscreen design approach or mass wall design approach.

A rainscreen design approach is shown in Fig. i-9 on page i-16. This design approach assumes that moisture makes its way through the cladding plane while the building is in-service and provides a level of redundancy to protect against water ingress. A rainscreen assembly includes the following characteristics:

- A continuous WSS (the rainscreen)
- An air space behind the cladding that is vented and drained to the outside
- A WRB (drainage plane) such as a sheathing membrane inside of the drainage space (WSS and WRB are separated)
- Drain holes or gaps through the cladding so that water can leave the cavity, with a flashing at all penetrations and transitions (e.g., base-of-wall, doors, and windows, etc.) to direct draining water to the outside
- A continuous air-barrier system (AB) to improve the control of rainwater penetration

It is important to note that using rainscreen wall assemblies that exhibit good resistance to water penetration and that are fundamentally less sensitive to moisture ingress does not eliminate the need for implementing proper details and ensuring acceptable construction practices are followed. Improperly executed details are frequently sources of water entry, critically affecting the moisture performance of the assembly and contributing to premature weathering or
efflorescence on the masonry veneer system.

The assemblies in Chapters 1, 2, 3, 6, 7, and 8 are a rainscreen design approach.

A mass wall design approach is shown in Fig. i-10. It provides a WSS and WRB within the CMU structure. In recent years, the mass wall design approach has evolved to allow for thinner mass wall assemblies that control water through the use of clear surface-applied water-repellents and water-repellent admixtures.

The assemblies in Chapters 4 and 5 use a mass wall design approach.

**Water-Shedding Surface (WSS)**

In general, the water-shedding surface (WSS) is the outer surface of assemblies, interfaces, and details that will deflect and/or drain the vast majority of the exterior water from the assembly. In simplest terms, the WSS is the exterior surface of the building enclosure and the first line of defense against water ingress. The WSS reduces the rain load on the underlying elements of the assembly and serves as a solar control function to protect underlying components from ultraviolet (UV) exposure.

For the rainscreen design approach assemblies included within this guide, the WSS is the adhered or anchored masonry veneer. Because claddings can allow a significant amount of water behind the WSS, a means to drain this moisture out of the wall must be provided.

For the mass wall design approach assemblies included within this guide, the WSS is the single-wythe CMU wall structure, which contains surface-applied clear water repellent and water-repellent admixtures within the block and mortar.

For the additional details and transitions shown throughout this guide, the WSS also includes sheet-metal flashings, as well as the exterior face of fenestrations (e.g., windows), the roof membrane of a conventional roof assembly, and the top surface of the insulation of an inverted roof assembly.

Example details included at the end of each assembly chapter demonstrate the location of the WSS at typical wall transitions and a window penetration.

**Water-Resistive Barrier (WRB)**

The water-resistive barrier (WRB) is the second and last line of defense against water ingress. It is the surface within the wall assembly intended to prevent liquid water from traveling further into the assembly and is often relied upon for
A WRB system includes a WRB field membrane and accessory products such as flexible self-adhered flashing membranes, fluid-applied flashing membranes, sealants, tapes, and fasteners. These components, when combined, form the WRB system and may also perform as an AB system. When selecting a WRB system, the following properties should be considered:

- **Water Vapor Transmission (Vapor Permeance)** – A minimum of 10 perms should be designated for vapor-permeable membranes in the Northwest region and a maximum of 1 perm for vapor-impermeable membranes. Minimum water vapor permeance is demonstrated through ASTM E96 when tested with both water and desiccant methods.

- **Water Penetration Resistance** – A product that demonstrates no water leakage when tested to 15 psf to ASTM E331.

- **Durability** – A product should be resistant to tears and punctures that may occur during installation or wind gusts. The product must also be able to withstand ultraviolet (UV) exposure following installation and prior to cladding attachment.

- **Compatibility** – The product selected should have known compatibility with all accessory products such as self-adhered membranes, liquid-applied membranes, sealants, and tapes.

- **Air Barrier Performance** – Where the WRB also forms the AB, the performance properties of the AB should also be demonstrated. (Refer to the Thermal Performance and Energy Code Compliance section of this chapter for more discussion).

In the mass wall design assemblies included within this guide, the WRB is the single-wythe CMU wall structure that contains surface-applied clear water repellent and water-repellent admixtures within the block and mortar. Example details, two-dimensional details, and three-dimensional wall sections
included at the end of each assembly chapter demonstrate the general installation of the WRB.

**Air-Barrier System (AB)**

The air-barrier is a system of materials that controls flow of air through the building enclosure, either inward or outward. Air flow is significant with respect to heat flow (space conditioning), interstitial vapor condensation (water vapor transported by bulk air flow), and rain penetration control. AB systems should be impermeable to air flow, continuous across the building envelope, able to withstand the forces that act upon them (e.g., mechanical pressures, wind pressures, and stack effect), and durable over the life expectancy of the building enclosure.

For a rainscreen design approach, there are many types of AB products and systems available on the market today. A typical practice within the Northwest is to use a dual-function field membrane that has the performance properties of both an AB and a WRB. When this membrane is paired with accessory products (e.g., self-adhered flexible flashings, fluid-applied flashings, sealants, and/or tapes) and is detailed for airtightness, an AB system is provided.

Where the AB system is provided through the use of a mechanically attached sheet, it is attached to the structure with furring strips, masonry ties, cladding support clips, or washer head fasteners as recommended by the air barrier membrane manufacturer. Attachment provides long-term resistance to the pillowing effects of air pressure differentials. Where a self-adhered sheet membrane or fluid-applied membrane is used, the membrane bonds directly to the exterior sheathing or substrate for continuous support.

Other types of AB systems include:

- **Sealed Sheathing:** This option includes exterior gypsum board or plywood with sealed seams (either joint sealant or tape) to provide the AB field membrane. The AB at the sheathing is transferred to window rough openings, penetrations, and across shelf-angle attachments with flexible self-adhered flashing membrane or liquid-applied flashings. A separate WRB field membrane is required for use with this AB system.

- **Closed-Cell Spray Polyurethane Foam (CCSPF):** Spray foam insulation may be installed over the exterior wall sheathing to form the AB system. This system relies on flexible self-adhered membrane flashings at rough openings and transitions to complete the AB system. Use of an exterior CCSPF insulation also provides the WRB, thermal envelope, and VR critical barriers.

- **Rigid Exterior Insulation:** This option includes exterior rigid board insulation such as extruded polystyrene (XPS) insulation or foil-faced expanded polystyrene (EPS) or polyisocyanurate. Board seams are sealed and/or taped to form the AB system as well as the WRB. Fluid-applied or self-adhered membrane flashings are used to complete the AB and WRB system at transitions. This system also provides the thermal envelope and VR critical barriers.

- **Airtight Drywall Approach (ADA):** This option relies on interior gypsum board and additional air-sealing strategies to form an AB system at the interior plane of the enclosure. This approach is traditionally a single-family residential air-sealing strategy and can be difficult to execute successfully at transitions such a wall-to-roof lines, complex framing structures, partition walls, and service penetrations. Air-sealing strategies for this approach are typically concealed, making quality control review and system repair difficult. This approach is not recommend for the commercial structures or multifamily structures to which this guide applies.

For the mass wall design approach assemblies within this guide, the single-wythe CMU wall structure may provide the AB system.

Performance requirements for air barrier materials and air barrier systems specific to both rainscreen design approach and mass wall design approach assemblies are further discussed in the Thermal Performance and Energy Code Compliance section of this introductory chapter.

Example details included at the end of each assembly chapter demonstrate the location of a continuous air barrier at typical wall transitions and a window penetration.

**Thermal Envelope**

Placement and continuity of thermal insulation is an important factor of a thermally efficient building enclosure. While not typically considered a critical barrier but more of a control function, the thermal insulation materials and line
provides VR requirements for Northwest Climate Zones 5, 6, and Marine 4.

Vapor diffusion control is not to be confused with bulk air flow control (air barrier). Continuity and sealing of air barrier details is very important; if the same material is being used to control both vapor diffusion and air flow material continuity and air sealing is critical.

Common VR types used within above-grade wall structures in the Northwest region:

- **Polyvinyl Acetate (PVA) Vapor-Retarding Primer:** This applied coating requires a substrate for application. It is typically applied to the face of interior gypsum board prior to the finish paint.

- **Asphalt-Coated Kraft Paper:** This sheet good is typically a facer to the wall cavity batt insulation and is located behind the interior gypsum board.

- **Polyamide Film:** This sheet good product is located behind the interior gypsum board. It is installed after wall cavity batt installation.

**Building Form and Features**

Building form and features including roof overhangs, balconies, canopies, and other protruding elements, etc., also play a critical barrier function whereby these elements deflect rain and provide shading from the sun and buffering from wind as shown similar in Fig. i-15 on page i-24. The protection provided by these components may allow for alternative water control strategies to be utilized at protected areas. For this reason, deflection elements can be considered as part of the critical barrier analysis. Conversely, balconies and other exterior architectural elements can also act as water-trapping features, unless carefully designed to prevent trapping water. The criticality of building form also depends on climate, and on rainfall in particular; therefore, building form and features are more critical in regions of greater rainfall (refer to Fig. i-7 on page i-13). Building form and features are not addressed within above-grade wall assemblies included within
the remaining chapters of this guide but are important design components that should be considered on a project-specific basis.

Thermal Performance and Energy Code Compliance

The energy performance of buildings in the Northwest is governed by:

- **State of Oregon** – *2014 Oregon Energy Efficiency Specialty Code (OEESC)*, based on the 2009 IECC with amendments, effective July 1, 2014

In general, these energy codes address the *minimum* requirements for both the thermal envelope and air barrier system critical barriers of the opaque above-grade wall assemblies included within this guide.

Within this guide, discussions related to the energy code focus on the above-listed codes and their **commercial energy code compliance** provisions; residential provisions are not explicitly addressed. Definitions of residential and commercial buildings may be found within the Definitions chapter of each of the codes listed above.

The energy codes that govern in the Northwest define the prescriptive thermal performance of above-grade walls that form the thermal envelope. Under commercial provisions, prescriptive performance requirements for opaque above-grade walls are differentiated in the IECC based codes by:

- **Climate zone** (Zone Marine 4, Zone 5, or Zone 6), as shown in Fig. i-16
- **Occupancy** (All Other or Group R)
- **Classification** (i.e., mass, metal building, metal-framed, or wood-framed and other).

Table i-2 on page i-28 summarizes the prescriptive above-grade wall thermal envelope requirements as they apply to the assemblies of this guide. Requirements include both minimum R-value (located above each U-factor) and maximum U-factor. Minimum R-value requirements are for nominal insulation and include continuous insulation (ci), which is discussed in the Continuous Insulation section of this chapter. U-factors define the maximum thermal transmittance of the assembly when insulation and other bridging elements that are required to be

![Fig. i-15 ICHS Shoreline Medical and Dental Clinic, constructed in 2014, features large roof overhangs and canopies above entrances to deflect rain away from the above-grade enclosure components and shade the interior environment from the sun.](image)

![Fig. i-16 Northwest region (Washington, Oregon, and Idaho Climate zones including Zone Marine 4, Zone 5, and Zone 6.](image)
Discussion and numerous tables are available within Northwest energy codes and ASHRAE 90.1 to assist with determining the U-factors of above-grade wall assemblies. Where assemblies are not represented within these resources, various methods are available for calculating the effective thermal performance of the wall and are listed below. Appropriate calculation methods should be confirmed with the local jurisdiction as not all of these methods may be accepted:

- **Parallel Path and Isothermal Planes** (refer to the ASHRAE Handbook of Fundamentals): Typically used for assemblies with low-conductivity materials. Where material conductivity varies minimally, a parallel path method is typically used, such as with a wood-framed wall. When material conductivities within the assembly vary moderately, such as in a CMU wall, the isothermal planes method is typically used. These methods should not be relied upon for assemblies with highly conductive materials (e.g., steel studs) or intermittent components such as fasteners or ties through exterior insulation.

- **Zone Method and Modified Zone Method** (refer to the ASHRAE Handbook of Fundamentals): Typically used for assemblies with highly conductive elements such as steel studs. These methods are not recommended for determining the performance of assemblies with intermittent fasteners or ties through exterior insulation.

- **Two-Dimensional Computer Modeling**: Programs such as Lawrence Berkeley National Laboratory’s THERM calculate two-dimensional heat transfer. This method may be used for most above-grade wall assemblies; however, it is not appropriate for assemblies where intermittent fasteners, ties, or cladding supports bridge exterior insulation. An example of a two-dimensional thermal image is shown in Fig. i-18 on page i-30.

- **Three-Dimensional Computer Modeling**: Programs such as HEAT3 (buildingphysics.com) calculate three-dimensional heat transfer. This method may be used for all above-grade assemblies, including those

**Non-prescriptive Compliance Option**

Refer to Fig. i-17 on page i-29, which identifies the non-prescriptive compliance option (e.g., a trade-off strategy or whole-building modeling strategy). When a project seeks this compliance option, an above-grade wall assembly’s thermal performance is determined as a U-factor; however, it may or may not be required to meet the prescriptive values shown in Table i-2.

An exception to the compliance strategies is denoted in the footnotes of Fig. i-17 on page i-29. Refer to the Chapter 4 discussion for more information regarding this exception.

**Prescriptive Compliance Option**

Refer to Fig. i-17 on page i-29, which identifies the prescriptive compliance option for energy code compliance. Where a project seeks this compliance option, the above-grade wall assembly must meet one of the following:

- **R-value Compliance Strategy**: The minimum nominal insulation R-value(s) listed in Table i-2 are to be met. As an example, for an R-value compliance strategy, a wood-framed wall (such as in Assemblies 3 and 8) in a multifamily residential (Group R) application in the City of Seattle must have a nominal R-21 wall cavity insulation to meet code compliance. This same wall on a Group R building in Oregon may comply with the energy code with a nominal R-21 wall cavity insulation or with R-13 wall cavity insulation plus a nominal R-3.8 continuous insulation.

- **U-Factor Alternative Compliance Strategy**: The maximum assembly U-factor listed in Table i-2 is to be met. For this strategy, the project-specific assembly U-factor will need to be determined. Determining this U-factor is further discussed in the Non-prescriptive Compliance Option section of this chapter.

An exception to the compliance strategies is denoted in the footnotes of Fig. i-17 on page i-29. Refer to the Chapter 4 discussion for more information regarding this exception.

Project-specific thermal performance values for opaque above-grade wall assemblies should be used for energy code compliance and should be determined from a source that is approved by the local governing jurisdiction. Sources may include the Appendices of the WSEC and SEC, ASHRAE 90.1, COMcheck, thermal modeling, or other industry resources.
Table i-2 Northwest energy codes - prescriptive compliance values for opaque above-grade wall assemblies within this guide.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Climate Zone</td>
<td>S and Marine 4, 5, 6, and Marine 4</td>
<td>S and Marine 4</td>
<td>S and Marine 4</td>
<td>S and Marine 4, 5, 6, and Marine 4</td>
</tr>
</tbody>
</table>

Step 1: Determine Governing Energy Code:
- 2012 WSEC, 2012 SEC, 2014 OEESC, or 2012 IECC

Step 2: Determine Project Climate Zone:
- Zone Marine 4, Zone 5, or Zone 6

Step 3: Select a Strategy

Step 4: Determine Assembly
- Provide insulation that meets or exceeds the R-values listed in Table i-2.

Whole-Building Modeling Strategy

Use when enclosure components that exceed prescriptive R-value and U-factor requirements will be used to offset those that do not meet prescriptive R-value and U-factor requirements. This strategy is typically not successful when a project exceeds maximum glazing area percentages set by the energy code.

For Chapters 1 through 3 and 5 through 8 assemblies, use thermal modeling results tables and figures within each chapter to estimate the insulation thickness and tie or cladding support clip material/type of the assembly.

Provide opaque above-grade wall insulations with an R-value equivalent to or greater than set forth in Table i-2.

Table i-2: Opaque Above-Grade Wall - thermal envelope requirements

For Chapters 1 through 3 and 5 through 8 assemblies, use thermal modeling results tables and figures within each chapter to estimate the insulation thickness and tie or cladding support clip material/type of the assembly. Results are depicted in effective R-values and can be compared to the equivalent R-value shown in parenthesis in Table i-2. Also see the Modeling Results section of each chapter for additional information on optimizing performance.
with exterior insulation bridged by fasteners. An example of a 3-dimensional thermal image is shown in Fig. i-19.

Within this guide, three-dimensional computer modeling was employed for Chapters 1 through 3 and 5 through 8 assemblies to demonstrate how typical thermal bridges—like masonry ties, shelf angles, and cladding support systems of various types—contribute to the effective thermal performance of each assembly. Based on modeling results, insulation thicknesses and types as well as cladding support materials and types may be estimated for project-specific assemblies. Through evaluation of the results, numerous options for thermally optimizing each assembly are discussed. Modeling results and discussion are demonstrated in each chapter as an effective R-value but may be converted to a U-factor by dividing 1 by the R-value. Modeling does not account for the impact of thermal mass.

Thermal modeling was undertaken using HEAT3 (buildingphysics.com). Modeling specifics and additional information used to complete the modeling within this guide is provided in Appendix A.

Continuous Insulation

Continuous insulation is referenced in the prescriptive requirements for many assemblies within this guide. Where continuous insulation is required or used to meet code compliance, the definitions of continuous insulation must be carefully considered; definitions vary by jurisdiction within the Northwest region and include:

- **2012 IECC:** No definition is provided. This guide recommends referring to ASHRAE 90.1-2010 and confirming local requirements with the governing jurisdiction.

- **2012 WSEC and 2012 SEC:** “Insulation that is continuous across all structural members without thermal bridges other than service openings and penetrations by metal fasteners with a cross-sectional area, as measured in the plane of the surface, of less than 0.04% of the opaque surface area of the assembly. It is installed on the interior or exterior or is integral to any opaque surface of the building envelope.”

- **2014 OEESC:** “Insulation that is continuous across all structural members without thermal bridges other than fasteners and service openings. It is installed on the interior or exterior or is integral to any opaque surface of the building.”

- **ASHRAE 90.1-2010:** “Insulation that is continuous across all structural members without thermal bridges other than fasteners and service openings. It is installed on the interior or exterior or is integral to any opaque surface of the building envelope.”

Based on the above definitions:

- ✔ Continuous insulation can be interior, exterior, or integral to the building envelope, for example, continuous insulation interior of a CMU wall as shown in Chapter 5.

- ✔ Insulation bridged by structural members (e.g., framing or anchored veneer shelf angles) may not be considered continuous and therefore should be clarified with the governing jurisdiction on a project-specific basis.

- ✔ Service openings (e.g., doors, ducts, etc.) have no impact on whether insulation is classified as continuous or not.

- ✔ Fasteners or metal fasteners may need to be considered, as discussed in the next section.

Metal Fasteners

The thermal performance of exterior insulation is reduced when penetrated by fasteners (metal or otherwise). Continuous insulation with no fasteners will perform near its nominal R-value. However, when fasteners—especially metal fasteners, which are highly conductive—penetrate the insulation, the nominal R-value is reduced.

The term “thermal bridging” is not defined by the energy codes that govern the Northwest region (Washington, Oregon, and Idaho). However, the 2013 ASHRAE Handbook of Fundamentals recognizes thermal bridging as “passing highly conductive materials through insulation layers.”
For this reason, metal fasteners (including masonry ties and cladding support clips) may need to be considered for energy code compliance.

The definition of a fastener or metal fastener may vary by code and jurisdiction. Continuous insulation is also not directly defined by the IECC. As a result, the local governing jurisdiction should be contacted for determining when fasteners are to be considered. Below, some general clarifications are provided for assistance.

- Under the 2012 WSEC and 2012 SEC, the fasteners’ cross-sectional area of penetration (as measured in the plane of the surface) and as calculated as a percentage of opaque wall area, must be considered. Where this area of penetration exceeds 0.04%, the penetrated insulation is not considered continuous. For example, if exterior insulation is bridged by a 2-inch-wide double eye and pintle masonry tie at 24 inches on-center vertically and 16 inches on-center horizontally, the cross-sectional penetration area as a percentage is:
  - 0.04% for a 14-gauge backup plate: meets 0.04% and the exterior insulation is considered continuous.
  - 0.06% for a 12-gauge backup plate: exceeds 0.04% and the exterior insulation is not considered continuous, unless (1) an alternative nominal R-value as found for metal penetrations between 0.04% and 0.08% can be selected from Table C402.2, Footnote f, or (2) the effective thermal performance of the wall is calculated and designated as a U-factor to meet the prescriptive U-factor requirements.

Note that if the tie spacing was reduced to 16 inches on-center vertically and 16 inches on-center horizontally, the cross-section penetration area (as a percentage) of 14-gauge backup plate tie would be greater than 0.04%. In this case, guidance provided for the 0.06% case above should be considered.

- Under the 2014 OEESC, fasteners that penetrate continuous insulation have no impact on whether exterior insulation is considered continuous or not.

- When complying under the 2012 IECC, contact the local governing jurisdiction to confirm metal fastener and continuous insulation requirements.

Mass Wall Considerations

A mass wall has the ability to store thermal energy (i.e., heat) that can be released at a later time, reducing peak heating and cooling loads and increasing occupant thermal comfort. The benefit of thermal mass varies with climate zone and is more beneficial in warmer climates; however, thermal mass can still provide some benefit in cooler climates. Energy codes within the Northwest region take into consideration thermal mass properties by allowing mass wall assemblies to meet lesser prescriptive R-values (greater U-factors) than framed wall types. When complying with the energy code through a whole-building modeling approach, the benefits of thermal mass are directly considered within the building model.

The 2012 IECC, WSEC, and SEC and the 2014 OEESC define a mass wall as “weighing not less than 35 psf of wall area; or not less than 25 psf of wall area if the material weight is not more than 120 pcf.” Under this definition, 6-inch or larger lightweight (103 pcf) CMU or heavier block qualifies as a mass wall, as does a typical concrete backup wall. The classification of a “mass wall” typically encompasses the backup wall structure; veneer inclusions should be confirmed with the local governing jurisdiction. Chapters 1, 4, 5, and 6 assemblies with CMU backup wall structure typically qualify as mass walls.

In the states of Oregon and Washington (excluding the City of Seattle), integrally insulated CMU walls such as the Chapter 4 assembly are exempt from prescriptive performance R-value and U-factors when the following two conditions are met:

1. “At least 50% of block cores are filled with perlite or equivalent fill insulation.” An alternate to perlite is a phenolic resin core foam insulation as shown in Fig. i-20.
2. “Space use includes warehouse (storage and retail), gymnasium, auditorium, church chapel, arena, kennel, manufacturing plant, indoor swimming pool, pump station, water and waste water treatment facility, storage facility, restroom/concessions, mechanical/electric structures, storage area, and motor vehicle service facility.” In Washington only, “Where additional uses not listed (such as office, retail, etc.) are contained within the building, the exterior walls that enclose these areas may not utilize this exception and must comply with the appropriate mass wall R-value [from the prescriptive compliance table].”

![Fig. i-20 Foam-in-place CMU core insulation](image)
Insulation Products

A variety of insulation products exist on the market today for wall cavities, integral insulation, and continuous (interior or exterior) insulation.

For wall cavities, unfaced fiberglass or mineral fiber batts are most common. High-density versions of either batt can be found and assist with achieving a greater assembly effective R-value without increasing wall depth, especially in wood-framed wall assemblies. Due to the significant reduction in effective thermal performance for steel-framed wall assemblies (typically 40 to 60%), a high-density batt provides little benefit over lower-density batt products. Batt insulation widths and thicknesses range in size to accommodate most standard wood and steel framing depths. Wall cavity insulation may also include sprayed polyurethane foam insulation, which is available in both open- and closed-cell varieties and varies in thermal resistance and vapor permeance.

Where split insulation occurs (e.g., both wall cavity and exterior insulation) it is important to consider the air- and vapor-permeability of the both the selected insulating materials and WRB field membrane. These considerations are discussed in each assembly chapter.

Where continuous insulation is required, several types of board insulation products are available.

- **Semi-Rigid Mineral Fiber (R-4.2/inch):** Hydrophobic, tolerates moisture, and has free draining capabilities. This insulation is vapor-permeable, which allows it to be acceptable for use exterior of both vapor-permeable and vapor-impermeable air and water-resistant barrier membranes. The semi-rigid properties of this insulation facilitate a snug fit at board joints and around metal penetrations such as masonry ties and cladding support clips without requiring notching. The density of the semi-rigid insulation should be considered for cladding attachment designs where insulation compression is necessary to support cladding attachment.

- **Rigid Extruded Polystyrene (XPS) (R-5 per inch):** Moisture-resistant and suitable for wet environments. XPS has a vapor permeance less than 1.0 and is a Class II vapor retarder. As a result, XPS may be used where cavity insulation does not exist or when the cavity stud insulation nominal R-value is 1/2 to 1/3 of the total nominal insulation R-value of the assembly. Rigid board insulation may require notching around intermittent cladding supports or ties to create a snug fit. An example of this insulation product type is shown in Fig. i-22.

- **Rigid Polyisocyanurate (R-5.0 to 5.7 per inch):** When used as continuous exterior insulation, typically includes a foil facer or moisture-tolerant facing to protect the insulation core. Faced polyisocyanurate insulation has a vapor permeance of approximately 0.01 and is a Class II vapor retarder. As a result, polyisocyanurate may be used where cavity insulation does not exist or when the cavity stud insulation nominal R-value is 1/2 to 1/3 of the total nominal insulation R-value of the assembly. Rigid board insulation may require notching around intermittent cladding supports or ties to create a snug fit.

- **Closed-cell Spray Foam Insulation (R-5.5 to R-6 per inch):** may be used as exterior or interior insulation and eliminates the need for a separate air and vapor barrier. This insulation option should be installed after all wall penetrations and cladding supports are in place. To avoid excessive heat buildup during installation, closely follow the manufacturer’s installation instructions. Closed-cell spray foam insulation has a vapor permeance less than 1.0 at 2-inch or greater thicknesses and provides a Class II vapor retarder. As a result, closed-cell spray foam insulation may be used where cavity insulation does not exist or when the cavity stud insulation nominal R-value is 1/2 to 1/3 of the total nominal insulation R-value of the assembly.

Integral insulation, which may be used within the assemblies of this guide, may be loose-fill such as perlite but is commonly provided by a expanding...
Air barrier compliance options. The remaining two options require that materials or assemblies meet specific air permeance performance and meet specific installation requirements.

The following checklist items can increase the success rate for the design and installation of a continuous air barrier in all jurisdictions.

**Design Checklist**

☑ Select appropriate air barrier materials and systems. An air barrier material has an air permeance less than 0.004 cfm/ft² at 1.57 psf (75 Pa) when tested to ASTM E2178. An air barrier assembly has an air permeance of less than 0.04 cfm/ft² at 1.57 psf (75 Pa) when tested to ASTM E2357 and ASTM E283. Section C402.4 of the 2012 IECC, WSEC, and SEC and Section 502.4 of the 2014 OEESC include a number of materials and assemblies that meet these requirements. The Air Barrier Association of American (ABAA) also lists several commercially available compliant air barrier membranes and systems online at www.airbarrier.org.

☑ Ensure that a continuous line representing the plane of airtightness can be drawn across all assemblies, details, and transitions between assemblies. Details included within this guide demonstrate this practice; an example is shown in Fig. i-11 on page i-18.

☑ Clearly delineate the air barrier 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. i-24 on page i-38. This delineation is required by the 2012 SEC for compliance.

☑ Identify air barrier installation, testing, and installer qualification requirements in the project manual. Include general air barrier system requirements in a Division 1 section. Also include air barrier requirements in related Division 7 sections. Air barrier master specifications related to Division 1 and 7 are available online from ABAA.

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**Air Leakage**

Energy codes within the Northwest have mandatory air leakage requirements. Requirements include a continuous air barrier throughout the building thermal envelope (i.e., surrounding conditioned and semi-heated spaces). The air barrier must be continuously sealed and supported by the structure (e.g., with fasteners or adhered to the sheathing). Air barrier compliance options for each Northwest code are provided below. All members of the design and construction team should be familiar with the air barrier requirements specific to their jurisdiction.

- **Under the 2012 WSEC and 2012 SEC**, once the whole-building air barrier system is complete, the rate of air leakage must be determined by performing a whole-building air leakage test such as that shown in Fig. i-23. The maximum allowable air leakage rate is 0.40 cfm/ft² at 0.3 in-H₂O (75 Pa) when tested to ASTM E779. Failure to comply with the maximum leakage rate requires a visual inspection and repair of the discontinuous air barrier areas to the extent practicable under 2012 code provisions. Industry research has demonstrated this code-maximum air leakage target is not prohibitively difficult to meet.

- **Under the 2012 IECC and 2014 OEESC**, air leakage testing is one of three

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**For above-grade wall assemblies in the Northwest, vapor-impermeable exterior insulation and vapor-impermeable air and water-resistive barrier membranes may be used when the assembly insulation is located exterior of the air and water-resistive barrier or when the exterior insulation is 1/2 to 2/3 of the total nominal insulation R-value in the assembly. This reduces the risk of condensation development within the wall cavity. Vapor-impermeable products and greater insulation R-value splits may be considered but should be carefully evaluated based on project-specific characteristics.**

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**Although masonry is defined as a noncombustible cladding material, the use of a combustible air and water-resistive barrier or foam plastic insulation within a wall cavity can trigger fire propagation considerations and requirements. Depending on the local jurisdiction, IBC Section 1403.5 regarding vertical and lateral flame propagation as it relates to a combustible water-resistive barrier may require acceptance criteria for NFPA 285. The use of foam plastic insulation within a wall cavity should also be addressed for IBC Chapter 26 provisions.**
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 between roof-to-wall and roof-to-foundation detailing.

☑ 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.

Sheet-Metal Components

Sheet-metal components deflect liquid water and are used in both rainscreen and mass wall design approaches and typically occur above and below wall penetrations, as parapet caps, and as counterflashing elements to protect flashing membranes. In a rainscreen design approach, cross-cavity sheet-metal flashings deflect water within the rainscreen cavity back to the exterior environment while still allowing cavity ventilation.

Design Considerations

The location of sheet metal flashings should be carefully planned for each project but, at minimum, should be located:

- Above and below wall penetrations such as windows, doors, electrical outlets, fixtures, and pipe penetrations. This applies to both rainscreen design approach assemblies and where practicable in mass wall design approach assemblies.

- At perpendicular wall interfaces such as parapet-to-wall or roof-to-wall saddle conditions and at parapet tops. This applies to both rainscreen and mass wall design approaches.

- For a rainscreen design approach, at every floor line for buildings three stories or greater in height. Regardless of building height, it is best practice to locate sheet metal flashings at every floorline. Examples are depicted in Fig. i-26 and Fig. i-27.

- At vertical support elements of anchored masonry veneer assemblies and at movement joints designed to accommodate vertical differential movement in a rainscreen design approach.

Sheet-metal flashing profiles should include a projected hemmed drip edge and...
positive slope. For cross cavity sheet metal flashings, a minimum 4-inch-tall back leg should be provided and should be shingle lapped into the WRB system. Where serving as a counterflashing, the sheet metal should counterflash cladding a minimum of 1.5 inches (where possible) and project a minimum of half an inch beyond the cladding face to avoid blocking ventilation. The vertical location of the sheet-metal flashing in relation to the masonry veneer must be considered. Adequate spacing between the sheet metal and veneer above and below will ensure building movement does not affect the sheet-metal flashing profile or its function.

In a rainscreen design approach, folded end dams assist with deflecting water away from the rainscreen cavity and should be provided at all flashing terminations (e.g., at the ends of a window head flashing).

Where sheet-metal laps occur, laps should either be fully sealed with a high-quality silicone or butyl-based sealant or may be soldered. Laps within sheet-metal parapet coping should be standing-seam.

It is a best practice to construct masonry veneer sheet-metal flashings from stainless steel. Stainless steel is relatively inert to the corrosiveness of mortar and provides a similar level of durability and longevity as the masonry veneer. Prefinished galvanized sheet-metal products may be used in masonry veneer applications; however, they may require replacement before the masonry veneer does.

Cross-Cavity Alternate

Where exterior insulation is used, cross-cavity sheet-metal flashings create a thermal bridge. An alternate to a sheet-metal flashing at anchored veneer assemblies is to provide a flexible self-adhered flashing membrane that is fully supported by the insulation and lapped into the WRB as shown in Fig. i-27. This flexible membrane is shingle-lapped over the bearing element (typically a standoff shelf angle) and onto a sheet-metal drip flashing.

Movement Joints

Over time, volumetric changes will occur within any above-grade wall assembly and can be the result of changes in temperature, moisture, elastic deformation, settlement, and creep. The amount of movement that occurs will depend on the building materials used within the wall assembly as well as on the intensity of the influencing mechanism (e.g., temperature change). In general, wood frame members, concrete, CMU, and stone will shrink, whereas clay masonry will expand. If steel studs or a CMU backup wall are used and are properly protected, minimal volume change is expected.

Different materials within each above-grade wall assembly may also move differently in relation to one another as shown by the example in Fig. i-29 on page i-42. If not properly designed for, differential movement can cause unwanted cracking, spalling, buckling, settlement, or separation within the building structure or veneer.

For the purpose of this guide, discussion and design of movement joints are considered as they relate to differential movement between the veneer and wall structure and also include control and expansion joints. The consideration for locating and sizing building expansion joints that occur within the wall structure is beyond the scope of this guide but must be appropriately designed for and integrated into the above-grade wall system where they occur.
The discussion of building movement in this guide is meant to be a general reference; it is the responsibility of the Designer of Record to appropriately design for building movement.

Joint Locations

This section identifies general rules for locating movement, expansion, and control joints as they relate to the 8 primary wall assemblies in this guide.

- For adhered veneers, joint location recommendations vary throughout the industry and should be confirmed with the veneer unit manufacturer for the project specific application. In general, this guide recommends that joints be provided such that each panel of adhered masonry does not exceed 144 square feet. A maximum height/width or width/height ratio of 2.5 to 1 should be maintained. Spacing between joints should not exceed 15 feet in any direction. Refer to Brick Industry Association (BIA) Technical Note 28C and the Latricrete Direct-Adhered Ceramic Tile, Stone, and Thin Brick Facades Technical Design Manual (1998) for additional information. An example of adhered veneer joint locations is shown in Fig. i-28.

- For anchored clay masonry veneer, provide expansion joints such that long wall sections do not exceed 25 feet apart at occupied space and 15 feet apart at parapet conditions. Joint locations may be reduced to 20 feet at wall sections that have openings. Additional guidance on brick veneer expansion joints may be referenced from BIA Technical Notes 18 and 18A. An example of anchored masonry veneer joint locations is shown in Fig. i-30.

- For anchored concrete masonry veneer, provide control joints such that long wall sections do not exceed a length to height ratio of 1.5. The maximum wall length between control joints is 26 feet. Additional guidance on concrete masonry veneer control joints may be referenced from Northwest Concrete Masonry Association (NWCMA) Tek Note on Design of Concrete Masonry Veneer for Crack Control.

- For CMU wall structures, control joints should be spaced every 40 feet or where needed to minimize wall sections to a 3:1 ratio of length to height, whichever is less. Additional guidance on control joints may be referenced from NWCMA Tek Note on Control Joints for Concrete Masonry Crack Control. An example of CMU control joint locations is shown in Fig. i-31 on page i-44.

Fig. i-28 Example of adhered masonry veneer horizontal and vertical movement joints located at floor lines and in alignment with window jambs.

Fig. i-29 Cross-cavity sheet-metal flashing displacement as a result of wood-framed wall shrinkage and brick anchored veneer expansion

Fig. i-30 Example of anchored brick veneer movement joint locations.
There is no single set of recommendations for the placement and design of movement joints that will work for all projects. Additionally, joints may be added more frequently than is necessary for aesthetic purposes. In general, the following locations for movement joints within a masonry veneer or structure should be considered in addition to the above.

**Vertical Joint Placement**

- Throughout long walls with no openings as described in the previous section
- At wall offsets and setbacks
- At or within 10 feet of corners
- Around openings such as windows and doors
- At intersections and junctions (at intersections of walls that serve different functions or are different heights/thicknesses or cladding types)
- At parapets, align with joint placement at the wall area below
- Where framing methods or materials change (e.g., where a concrete meets steel-framed backup wall)

**Horizontal Joint Placement**

- At floor lines, aligned with the top-of-wall and floor interface.
- Below structural support elements such as shelf angles
- Between cladding material changes

Note that placement of horizontal joints are also recommended at various locations for a rainscreen design approach to allow for cavity drainage and ventilation. These locations are further discussed and identified within each chapter and with an asterisk (*) in chapter details.

**Joint Design**

Joints that accommodate vertical movement should either include a sheet metal flashing or a backer rod and sealant joint. Joints that accommodate horizontal movement should receive a backer rod and sealant joint. Movement joints should be designed and constructed to accommodate 3 to 4 times the amount of anticipated movement and should be no narrower than 3/8 of an inch. Movement joints should be free of debris, reinforcing, or other elements that may inhibit movement over the life of the building.

Joint sealants are a critical component of a movement joint and allow the joint to open and close uninhibited while providing a continuous water-shedding surface. Sealant products ideal for use at masonry movement joints have the following properties:

- **Movement Capabilities:** A low-modulus (highly elastic) sealant will allow for expansion or compression of the sealant joint without permanent deformation. The sealant product selected should have joint movement capabilities of a minimum 100% extension and 50% compression when tested to ASTM C719.

- **Adhesion to Substrate:** The sealant selected should have demonstrated adhesion to porous substrates such as masonry and concrete. Where differing substrates occur at either side of the movement joint (e.g., at metal panel–to-masonry veneer interfaces), the sealant should have acceptable adhesion to both substrates. Sealant adhesion testing prior to and during field installation is highly recommended and should result in cohesive sealant failure (rather than adhesive failure to the substrate).

- **Durability:** Movement joints at cladding should be UV-stable as well as durable when exposed to water and temperature fluctuations.

- **Longevity:** Masonry is a long-lasting cladding option and will likely outlive the movement sealant joint. To match the durability of the masonry cladding and reduce the replacement frequency of the joint, use a quality silicone sealant. When properly installed, silicone sealants will exhibit 20+ years of acceptable performance. Other sealant options such as hybrid or polyurethane sealants may provide acceptable performance for 10+ years before replacement is required.
Best Practices

The following joint design best practices will ensure long-term performance of a movement joint:

☑ Select a quality sealant based on the criteria described in the previous section of this guide.

☑ Follow industry-standard best practices for sealant joint installation. This includes joint design and substrate cleaning and priming. As a useful resource, refer to Dow Corning Americas Technical Manual as well as the joint dimensioning described in Fig. i-32.

☑ Provide an annual review and repair of joints one year after installation and biannual review thereafter. Areas of adhesive failure or damage should be repaired.

Architectural Considerations

Where there is a desire to minimize the visual appearance of masonry veneer movement joints, the following may be considered:

☑ Select a sealant joint color that is similar to the anchored veneer mortar or adhered veneer grout color.

Cleaners, Repellents, and Coatings

In the Northwest region, surface-applied clear water repellents are commonly applied to the surface of masonry veneer claddings and exposed CMU walls for the assemblies featured within this guide. Elastomeric coatings may also be used in targeted applications. The success of a clear water repellent or elastomeric coating is reliant on appropriate product selection, cleaning procedures, and application methods. Although the use of these products provides a number of purposes, as described below, these products do not make up for poor masonry workmanship or detailing. This guide section covers cleaning and best practices for selection and application of clear water sealers and elastomeric coatings.
Cleaning Methods

Debris and contaminants, including oil, grease, dirt, ash, and hydrocarbons, need to be cleaned from new masonry products prior to clear water repellent or elastomeric coating application. A number of cleaning methods are available, including hand, water, or chemical cleaning and abrasion.

Select cleaning procedures based on masonry and mortar colors, texture, and the type of existing debris or contaminants. In general, select the least aggressive cleaning method necessary to remove debris and contaminates. Over-cleaning masonry products or using excessive abrasion can alter the appearance of the masonry veneer or CMU and can encourage premature weathering.

For all cleaning methods, test-clean an inconspicuous area of the wall to confirm the effectiveness and acceptability of the cleaning method. Water clean only when temperatures exceed 40°F; even warmer temperatures may be required for applications of chemical cleaning products that rely on a chemical reaction to be effective.

ASTM D5703 and BIA Technical Note 20 are helpful resources for determining appropriate cleaning procedures for clay masonry units, whereas NCMA TEK 8-4A provides helpful discussion on cleaning CMU block of various types and finishes. Also consult the masonry unit or CMU manufacturer and cleaning product manufacturer (where applicable) prior to cleaning.

Surface-Applied Clear Water Repellents

A surface-applied clear water repellent is recommended for the assemblies in this guide that include adhered or anchored unglazed clay masonry veneer or exterior-exposed CMU. Application of a clear water repellent can reduce water absorption of masonry veneer and CMU, as demonstrated in Fig. i-36, while preserving or enhancing natural appearance. By reducing how much water the masonry cladding absorbs, less frequent wetting/drying and freezing/thawing cycles are expected to occur, reducing the likelihood of premature weathering and water-related damage and staining.

There are two primary types of repellents: penetrating or film-forming.

- Penetrating repellents have the ability to penetrate into the pores of the masonry while still allowing water vapor to diffuse through the masonry veneer. Common penetrating repellents include silicone resins, silanes, and siloxanes.
- Film-forming repellents, such as acrylics, stearates, and urethanes, form a thin film on the surface of the masonry face and across smaller pores. As a result, film-forming repellents can reduce the drying ability of the masonry cladding.

Of the two repellent types, penetrating repellents are recommended for use within the Northwest.

For unglazed clay masonry and CMU in the Northwest, use a silane/siloxane blend clear water repellent.

- Silanes penetrate deep into the pores of clay masonry.
- Siloxanes are deposited closer to the masonry surface.

Both silanes and siloxanes chemically bond to clay masonry, CMU, and mortar in the presence of moisture and alkalinity; as a result, silane/siloxane-based repellents can provide 5 to 10 years of protection, making such blends a durable and relatively longer-lasting water repellent option.

A penetrating silicone-based repellent may also be considered and may provide greater anti-graffiti properties than a silane/siloxane blend. Silicone-based repellents have less chemical bonding ability to clay masonry, mortar, and CMU than silane/siloxane blends have; thus, silicone-based repellents need to be reapplied more frequently than silane/siloxane-based products.

Clear water repellent application to glazed masonry veneers is not recommended. Glazed surfaces reduce the penetrating ability of clear water repellent products, limiting the effectiveness of the application.

When selecting a clear water repellent, the following characteristics/properties
are desirable for long-term performance:

- **Suitability for Substrate/Finish:** Products selected should be suited for vertical above-grade wall applications and project-specific masonry cladding types. Manufacturer-published literature should indicate that the product is acceptable for the type of masonry substrate and finish (e.g., split-faced CMU, fired clay brick, etc.).

- **High Vapor Permeance:** Water repellence test results should indicate 90% or more of the untreated masonry product vapor permeance is retained when tested to ASTM E96.

- **Effective Water Penetration Resistance:** ASTM E514 results should indicate an 85% reduction in maximum leakage rate when compared to an untreated wall.

- **Block and Mortar Water-Repellent Admixture Compatibility:** Where a clear water repellent is applied over CMU and mortar containing a water-repellent admixture, use a clear water repellent that is compatible with the admixture. Incompatible sealers may be less durable.

Where anti-graffiti repellent properties are desired, use a vapor-permeable silicone-based repellent with penetrating properties. The anti-graffiti repellent should provide similar vapor permeance and water penetration resistance to that listed above. The effectiveness of anti-graffiti properties is demonstrated through ASTM D7089 results, which may be used to compare the ease of graffiti removal. Clear water repellents should not be used as a replacement for a water-resistive barrier or air barrier within a masonry assembly. Water repellents are also not effective at bridging cracks or filling voids that result from poor joint design/installation or from long-term building movement. Although clear water repellents will increase the masonry’s ability to shed water, a repellent will not prevent efflorescence as a result of water intrusion behind a masonry veneer and will require reapplication to be effective over the long-term service life of the building.

**Best Practices**

The following general procedures and considerations are the best practices for clear water repellent application:

- Complete cladding sealant joints (such as around window and door perimeters and at expansion/control joints) prior to application. Provide a minimum 28-day cure on sealant joints prior to cleaning and application.

- Clean masonry substrates to remove debris and surface contaminates prior to water repellent application.

- Protect areas that are not to receive water repellent. Prevent contact between clear water repellents and non-masonry products such as asphalt-based products, window glazing, and landscaping.

- Avoid sealer application when rain threatens, when windy, and when minimum water repellent application temperatures are not met.

- Perform a mock-up to demonstrate protection, cleaning, and water repellent application procedures and for review of final masonry appearance.

- Plan application extents to determine start and stop application locations; avoid overlap.

- Apply water repellent in accordance with the repellent manufacturer installation instructions, including application rate. General application requirements may include the following:
  - Begin water repellent application on a dry substrate at lower surfaces, working upward as shown in Fig. i-37 on page i-51. Fully saturate brushes and rollers and provide a continuous stream for spray application. Brush away drips and runs.
  - Allow individual coats to penetrate a minimum of 5 to 15 minutes prior to reapplication where wet-on-wet application is required by some manufacturers.
  - Schedule reapplication of clear water repellent as prescribed by the manufacturer. Perform reapplication with the same or similarly formulated clear water repellent.
Elastomeric Coatings

Elastomeric coatings reduce the amount of water absorbed by masonry substrates and also provide crack-bridging properties that help reduce water leaks. Elastomeric coatings are typically installed where additional water penetration resistance is desired and where a painted surface is visually acceptable. An example of an elastomeric-coated CMU wall is shown in Fig. i-38. Elastomeric coatings can serve as a water-shedding surface, water-resistive barrier, and air barrier on the exterior face of a masonry substrate when a UV-stable coating is used.

A vapor-permeable silicone or acrylic elastomeric coating with UV resistance and high elongation properties is recommended for a good coating. A vapor-permeable coating will allow the masonry substrate to dry and reduces the likelihood of salt buildup and blistering of the coating.

When selecting an elastomeric coating, the following characteristics/properties are desirable for long-term performance:

- **Product Suitability**: Products suited for vertical above-grade wall applications with UV resistance
- **Water Penetration Resistance**: Resistance to wind-driven rain when tested to ASTM D6904 should result in no leaks.
- **Vapor Permeance**: A minimum vapor permeance of 8 perms when measured per by ASTM E96 wet cup method at the manufacturer-recommended dry film thickness.
- **Higher Solids Content**: Solids content by volume greater than 50% are commercially available and are determined through ASTM D2697 testing.
- **High Elongation Properties**: Elongation properties are determined per ASTM D412 and should exceed 300%.

**Fig. i-38 Exposed CMU wall coated with elastomeric coating**

- **Crack-Bridging Ability**: No cracking should occur when tested to ASTM C1305.
- **Validation**: Consider products that include an “SWR Institute Validation Program” label on the product data sheet. This label validates performance properties and can be helpful for comparing product options with the program label.

Elastomeric coatings can exhibit staining and may be difficult to clean. Surface staining is largely attributed to surface wetting below horizontal surfaces and penetrations including flashings, windows, and parapets. Therefore, staining can largely be reduced by reducing the amount of water that runs off onto the wall from these dirt-collecting surfaces. The use of sheet-metal drip edges (such as at window and door sills) is recommended to deflect water away from the surface of the masonry coating to help reduce staining.

**Best Practices**

The following general application procedures and considerations are the best practices for elastomeric coating application:

- Include consideration for water-shedding and deflection in above-grade wall design. Use minimum 1/2-inch projected drip edges to minimize coating staining and runoff.
- Provide a minimum 28-day cure for masonry grouts and adjacent concrete surfaces prior to application.
- Seal all cracks and cladding joints as recommended by the coating manufacturer. Use appropriate joint design and backing where movement joints occur. Typically, cracks or holes 1/16 of an inch wide or greater require treatment.
- Use block filler when required by the manufacturer. Some manufacturers may allow an additional application of coating in lieu of block filler.
- Test the coating adhesion to confirm cleaning procedures and priming requirements to the masonry substrate and joint sealants. Use a mock-up for coating review prior to full-scale application.

The remaining chapters within this guide address assembly-specific considerations for the 8 primary above grade wall assemblies.
CHAPTER 1:
CMU WALL WITH ANCHORED MASONRY VENEER

The Chapter 1 assembly is a rainscreen design approach with CMU or concrete wall structure and anchored masonry veneer. The components of this assembly, from interior to exterior, are described in Fig. 1-1. This assembly is appropriate for many applications including low-, mid-, or high-rise residential or commercial structures. An example application of this assembly is shown in Fig. 1-2 on page 1-3. Benefits and special considerations for this assembly are discussed in Table 1-1 on page 1-2.

This assembly with a concrete backup wall alternate is also depicted in Fig. 1-3 on page 1-3 and contains similar typical components to that described in Fig. 1-1.

Building Enclosure Control Functions and Critical Barriers

As noted in the Introduction, an above-grade wall assembly should provide control of water, air, heat, vapor, sound, and fire to serve as an effective and durable environmental separator. Control of these elements is provided by critical barriers such as a water-shedding surface (WSS), water-resistive barrier (WRB),

**Fig. 1-1 Typical Assembly 1 components from interior to exterior.**
Table 1-1 Assembly 1 comparison matrix excerpt from the Introduction Chapter.

<table>
<thead>
<tr>
<th>Assembly Comparison Category</th>
<th>#1(A) and #1(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recommended Occupancy Type</td>
<td>Residential OR Commercial</td>
</tr>
<tr>
<td>Building Enclosure Design Approach and Recommended Exposure</td>
<td>Rainscreen Design Approach, Low- to High-Rise Exposure</td>
</tr>
<tr>
<td>Long-Term Wall Assembly Durability</td>
<td>Resilient due to exterior insulation and rainscreen drainage cavity</td>
</tr>
<tr>
<td>Typical Wall Thickness</td>
<td>CMU/concrete structure typically thicker than wood or steel (Chapters #2 and #3 Assemblies); continuous insulation increases thickness</td>
</tr>
<tr>
<td>Typical Cladding Design Compliance</td>
<td>Prescriptive cladding design allowed based on ACI-530 up to 4.5-inch cavity depth (face of backup wall to back of veneer)</td>
</tr>
<tr>
<td>Typical Thermal Performance</td>
<td>CMU wall grouting requirements limit core insulation options; continuous exterior insulation typically required. Masonry tie penetrations through the insulation may need to be considered when determining thermal performance.</td>
</tr>
<tr>
<td>Special Construction Considerations</td>
<td>Anchored systems require code compliant bearing elements</td>
</tr>
<tr>
<td>Construction Ease with Limited / No Exterior Access (property line applications)</td>
<td>Requires exterior access</td>
</tr>
<tr>
<td>Fire Resistivity Considerations</td>
<td>Fire resistivity high. Type of exterior insulation may affect fire propagation requirements</td>
</tr>
<tr>
<td>Maintenance Considerations</td>
<td>Regular maintenance required; clear water repellent recommended. Consider flashings and other water-shedding features to reduce quantity of moisture on the face of the masonry</td>
</tr>
<tr>
<td>Price Per Square Foot</td>
<td>Low and High Baseline Cost: $32.25 - $38.00</td>
</tr>
</tbody>
</table>

Air barrier system (AB), thermal envelope, and vapor retarder (VR). Refer to Fig. 1-8 on page i-15 of the introductory chapter for a list of primary building enclosure control functions and associated critical barriers.

Fig. 1-4 illustrates the critical barrier locations for this assembly when a CMU backup wall is used. The critical barriers for typical Chapter 1 assembly CMU details are also provided adjacent to each detail at the end of this chapter.

As shown in Fig. 1-4, the WSS critical barrier occurs at the anchored masonry veneer with most water-shedding occurring at the wall face, while some water will be stored within the masonry veneer to be released at a later time. The WRB, AB, and VR critical barriers are all depicted at the same location at the exterior face of the CMU wall structure. As a result, a single membrane is used to serve as the WRB and AB (and may serve as the VR); this membrane is commonly referred to in this chapter as the air and water-resistive barrier (AB/WRB). The thermal envelope barrier includes the exterior insulation between the wall structure and masonry veneer.

The following sections provide more information and discuss best practices for the specific critical barriers of this assembly.

Water-Shedding Surface (WSS)

The WSS is a critical barrier which controls water.

The anchored masonry veneer cladding, including both mortar joints and masonry veneer units, is the primary WSS of this assembly. Additional components include sheet-metal flashings and drip edges, sealant joints, and fenestration systems as shown on the details included at the end of this assembly chapter.

To promote water shedding at the masonry veneer face, joints between masonry units should be appropriately installed with a tooled concave (preferred) or “V” shape.

When finished, the WSS critical barrier should be free of gaps except where providing drainage and/or ventilation. Movement joints and joints around fenestrations and penetrations should be continuously sealed with backer rod and sealant or counterflashed with a sheet-metal flashing to deflect wind-driven rain and shed water away from the rainscreen cavity.
**Water-Resistive Barrier (WRB)**

The WRB is a critical barrier that controls water.

In this assembly, the WRB critical barrier is primarily a self-adhered sheet or fluid-applied membrane that also functions as the AB system and may function as a VR; thus, it referred to as the AB/WRB membrane. A fluid-applied or self-adhered sheet AB/WRB field membrane are depicted in the details at the end of this chapter. An example of a fluid-applied AB/WRB membrane is shown in Fig. 1-5 on a concrete backup wall alternate. This membrane may be either a vapor-permeable or vapor-impermeable product because it is located interior of the assembly’s thermal envelope. Physical properties, such as vapor permeability of WRB products are discussed in detail in the Water-Resistive Barrier (WRB) section of the Introduction. The AB/WRB layer must be continuous across the wall face to serve as an effective critical barrier. In addition to the AB/WRB field membrane, the WRB critical barrier also includes fluid-applied or flexible flashing membranes, sealants, sheet-metal flashings, and interfaces with fenestration systems (e.g., windows and doors) as shown in the detail drawings that follow this chapter discussion. Where sheet-metal flashing components occur, the back leg of the sheet-metal flashing is lapped into the AB/WRB field membrane to encourage water at the WRB layer to drain toward the building exterior.

Masonry veneer ties in this assembly will penetrate the AB/WRB critical barrier and should be detailed based on the membrane manufacturer’s installation requirements. Typically, plate ties are bed in a compatible sealant or fluid-applied flashing product or are attached through a self-adhered membrane patch, whereas screw ties with gasketing washers typically do not require any detailing at the WRB plane.

Where a ladder eye-wire masonry veneer attachment method is used, a fluid-applied AB/WRB membrane is recommended; each wire penetration through the AB/WRB membrane should be sealed with a sealant or fluid-applied flashing material as recommended by the fluid-applied AB/WRB manufacturer.

**Air Barrier (AB)**

The AB system is a critical barrier that primarily controls air, heat, and vapor. The AB system also controls water, sounds, and fire.

In this assembly, the AB system critical barrier is the same self-adhered sheet or fluid-applied field membrane that also serves as the WRB critical barrier. The components described in the above Water-Resistive Barrier (WRB) section are also part of the AB layer, except sheet-metal flashings.

**Thermal Envelope**

The thermal envelope is a critical barrier that controls heat and assists with controlling vapor, sound, and fire.

In this wall assembly, the exterior insulation provides the thermal envelope. At transition details, the thermal envelope includes exterior insulation across bond beams, peripheral floor lines, and roof assembly insulation as well as slab and foundation insulation. Windows and doors that penetrate this wall are also part of the thermal envelope.

Exterior insulation provides the following benefits:

1. It allows for exterior insulation across floor lines (which are typically required to meet similar energy code compliance values as this wall assembly).
2. It keeps the structure warm (which reduces the risk that condensation may form interior face of the WRB).
3. It protects the AB/WRB from both extreme temperature fluctuations and damage during veneer installation.

The CMU (or concrete) in this assembly is also a thermal mass; thus, may provide thermal mass benefits as discussed in the introductory chapter.

Additional thermal envelope discussion is provided in the Thermal Performance and Energy Code Compliance section of this chapter and the introductory chapter.
Insulation Selection

For this assembly’s exterior insulation, semi-rigid mineral fiber board insulation or moisture-tolerant rigid board insulation products (e.g., polyisocyanurate or XPS as shown in Fig. 1-6) may be used. Refer to the Introduction for a discussion on various insulation types and considerations.

Vapor Retarder (VR)

The VR critical barrier is a layer that retards or greatly reduces (e.g., vapor barrier) the flow of water vapor due to vapor pressure differences across enclosure assemblies. Unlike the other critical barriers presented in this guide, the VR is not always necessary or required to be continuous.

For this assembly, a VR is not necessary. The risk of condensation development or damage to the structure due to outward vapor drive and condensation is unlikely due to all of the assembly’s insulation being located exterior of the wall structure and the AB/WRB barrier.

Note that Fig. 1-4 on page 1-3 identifies the VR at the exterior face of the CMU wall. This represents the exterior-most plane of the CMU wall structure, which has some vapor resistance. It would also represent the location of a VR if a relatively impermeable AB/WRB membrane is used.

Thermal Performance and Energy Code Compliance

This assembly is typically classified as a “mass” above-grade wall for energy code compliance purposes. Prescriptive energy code compliance values for this assembly are summarized in Table 1-3 on page 1-13 and describe:

- Minimum insulation R-values for a prescriptive R-value compliance strategy.
- Maximum assembly U-factors for a prescriptive U-factor alternative compliance strategy. Note, the equivalent assembly effective R-value of this maximum U-factor has been calculated and is denoted in parenthesis ( ) for easy comparison to thermal modeling results included within this chapter.
- Footnote (2) for compliance by exception. The ability to use this option depends on the jurisdiction, building’s occupancy type, and availability of CMU cores to be filled with insulation. If this exception is to be used, refer to the Chapter 4 Thermal Performance and Energy Code Compliance section.

When a non-prescriptive compliance option (e.g., a trade-off strategy or whole-building modeling strategy) is used for energy code compliance, this assembly’s effective thermal performance will need to be calculated; however, it may or may not be required to meet the prescriptive values shown in Table 1-3.

Fig. i-17 on page i-29 of the introductory chapter describes the typical process of navigating energy code compliance strategies and options. Thermal modeling results demonstrated within this chapter may be used to assist with estimating insulation and tie selection to achieve a project specific wall assembly thermal performance value. Options for thermally optimizing this assembly, as determined through the modeling results, are also provided.

Assembly Effective Thermal Performance

Masonry ties and floorline shelf angles penetrate the exterior insulation in this assembly and create areas of thermal bridging; thermal bridging reduces the assembly’s actual thermal performance.

Examples of thermal bridging are described by Fig. 1-8 through Fig. 1-13 on page 1-9. Where shown in Fig. 1-9, Fig. 1-11, and Fig. 1-13, the lighter blue thermal gradient color at the attachment locations describes a warmer temperature than the adjacent darker blue insulation face—an indicator of heat loss at the penetration through the insulation. This thermal bridging reduces the assembly’s effective thermal performance.

Although masonry is defined as a noncombustible cladding material, the use of a combustible air and water-resistant barrier or foam plastic insulation within a wall cavity can trigger fire propagation considerations and requirements. Depending on the local jurisdiction, IBC Section 1403.5 regarding vertical and lateral flame propagation as it relates to a combustible water-resistant barrier may require acceptance criteria for NFPA 285. The use of foam plastic insulation within a wall cavity should also be addressed for IBC Chapter 26 provisions.

Project-specific thermal performance values for the opaque above-grade wall assembly of this chapter should be used for energy code compliance and should be determined from a source that is approved by the local governing jurisdiction. Sources may include the Appendices of the WSEC and SEC, ASHRAE 90.1, COMcheck, thermal modeling, or other industry resources.
Three-dimensional thermal modeling demonstrates this assembly’s effective thermal performance with various insulation thicknesses, insulation R-values, masonry veneer anchors, and standoff shelf angle options. A discussion on the modeling performed for this guide is included in the Introduction Chapter and the Appendix.

Thermal Modeling: Variables

The following are modeling variables specific to this assembly—CMU wall with anchored masonry veneer:

- **Wall Structure** – An 8-inch, medium-weight block. Modeling results are not presented for a concrete backup wall structure; however, similar results would be expected for this alternate backup wall type as the overall performance is driven by the insulation and thermal bridging. Modeling results consider a concrete slab bypass condition with and without a shelf angle.

- **Masonry Ties** – Various tie types are considered at 16 inches by 16 inches spacing. Tie types are shown in Fig. 1-7 and include:
  - Ladder eye-wire tie (3/16-inch diameter) with cross-rods at 16 inches on-center made of hot-dipped galvanized steel or Type 304 stainless steel. Hooks are either hot-dipped galvanized steel or Type 304 stainless steel to match the ladder wire.
  - Thermally optimized screw tie with stainless steel barrel and carbon steel fastener. Hooks are either hot-dipped galvanized steel or Type 304 stainless steel.
  - Double eye and pintle plate tie (14 gauge). Hooks are either hot-dipped galvanized steel or Type 304 stainless steel to match the tie plate.
• Exterior Insulation – R-4.2/inch or R-6/inch insulation product. Insulation thicknesses of 3, 4, and 5 inches are considered. The R-values selected demonstrate the lower and upper thermal resistance of typical exterior insulation products.

• Shelf Angle Supports – Hot-dipped galvanized steel shelf angles. Either attached tight to the floor line structure (i.e., continuous shelf angle) as shown similar in Fig. 1-10 and Fig. 1-11 or offset to the depth of the exterior insulation and supported by intermittent hollow steel sections (HSS) at 4 feet on-center (i.e., standoff shelf angle) as shown similar in Fig. 1-12 and Fig. 1-13.

Thermal Modeling: Results

The results of this modeling are shown in Table 1-2, Fig. 1-14, and Fig. 1-15 (see page 1-12 and page 1-13) and demonstrate the assembly effective R-value under various conditions; Fig. 1-14, and Fig. 1-15 are graphical representations of the results summarized in Table 1-2. Discussion of these results is provided below and key points for thermally optimizing this assembly are italicized in boldface.

• As shown in the Without Shelf Angle column of Table 1-2, when masonry ties of any cross-sectional area are considered, they reduce the assembly effective thermal performance by 5 to 38%, depending on the tie type and as determined from the modeling results. Galvanized steel masonry ties provide the greatest reduction in assembly effective R-value at 23 and 38%. The most thermally efficient option modeled is the stainless steel ladder wire tie, followed by the thermally improved screw tie and the stainless steel plate tie. Note that greater spacing of masonry ties will increase the assembly effective R-value; however, the spacing will need to be coordinated with structural requirements.

• Stainless steel plate ties perform similarly to the thermally optimized screw tie option. Table 1-2 and Fig. 1-15 demonstrate similar R-values for these tie options, regardless of shelf angle inclusion. Performance targets can be met without proprietary cladding attachment systems. Stainless steel tie options may prove to be cost-effective and also provide a highly corrosion-resistant attachment.

• As read from Table 1-2; where no shelf angles occur, an R-19 effective wall target would require one of the scenarios listed below. As a result, when better-performing ties are used, a thinner wall assembly may be achieved without impacting the assembly’s effective R-value.

- 3 inches of insulation with a stainless steel ladder wire
- 4 inches with a stainless steel plate tie or thermally optimized screw tie
- 5 inches with a galvanized steel plate tie

• A continuous shelf angle reduces the assembly effective R-value significantly, as shown in Fig. 1-14. When considered with galvanized steel plate ties, a continuous shelf angle provides only 35 and 53% of the assembly's effective R-value when compared with uninterrupted exterior insulation. When a standoff angle is modeled, this effectiveness increases to 52 to 69%, varying with insulation thickness. As shown in Fig. 1-14, a thermally optimized shelf angle attachment has more thermal benefit than a continuous shelf angle.

Drainage, Ventilation, and Water Deflection

The anchored masonry veneer is expected to shed most water it is exposed to; however, some moisture is expected to penetrate the cladding and enter the rainscreen cavity. This moisture is drained through the rainscreen cavity and exits the rainscreen system where cross-cavity flashings are provided.

Drainage and Ventilation

In this assembly, a 2-inch deep rainscreen cavity between the anchored masonry veneer and exterior insulation should be provided to encourage drainage and ventilation. At minimum, a 1-inch gap may be provided and is the minimum code-Allowable depth. However, the risk that mortar droppings will reduce the drainage and ventilation within the rainscreen cavity is increased with smaller cavities. A 1-inch cavity should only be provided where a strict quality control program is implemented to ensure mortar droppings do not block the cavity. Fig. 1-16 on page 1-14 demonstrates a typical rainscreen cavity for this assembly.

Where the rainscreen cavity is reduced, such as at window rough openings with return brick, a compressible free-draining filler is recommended; semi-rigid mineral fiber insulation may be used. In any case, mortar should not be packed within these cavities.

The rainscreen cavity is ventilated through vents located at the top and bottom coursing of each wall section. Top vents typically occur just below parapet blocking and below intermittent bearing elements such as floor-line shelf angles.
Table 1-2 Assembly 1 thermal modeling results

<table>
<thead>
<tr>
<th>Exterior Insulation Thickness</th>
<th>Nominal Insulation R-Value</th>
<th>Exterior Insulation (Without Penetrations)</th>
<th>3D Thermal Modeling Effective R-Value of Assembly</th>
<th>Masonry Ties @ 16” x 16” O.C.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Without Shelf Angle</td>
<td>+ Standoff Shelf Angle</td>
</tr>
<tr>
<td>3”</td>
<td>12.6 - 18</td>
<td>15.9 – 21.3</td>
<td>Stainless Embedded Wire Tie (Ladder Eye-Wire) (0.02% Area)</td>
<td></td>
</tr>
<tr>
<td>4”</td>
<td>16.8 - 24</td>
<td>20.2 – 27.5</td>
<td>Stainless Embedded Wire Tie (Ladder Eye-Wire) (0.02% Area)</td>
<td></td>
</tr>
<tr>
<td>5”</td>
<td>21 - 30</td>
<td>24.4 – 33.4</td>
<td>Stainless Embedded Wire Tie (Ladder Eye-Wire) (0.02% Area)</td>
<td></td>
</tr>
</tbody>
</table>

Table 1-3 Assembly 1 prescriptive energy code compliance values excerpted from Table i-1 of the Introduction Chapter

<table>
<thead>
<tr>
<th>Energy Code</th>
<th>Climate Zone</th>
<th>Guide Assembly #</th>
<th>Classification</th>
<th>All Other</th>
<th>Group R</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012 IECC</td>
<td>5 and Marine</td>
<td>1A</td>
<td>CMU (or Concrete) Wall</td>
<td>Mass</td>
<td>All Other</td>
</tr>
</tbody>
</table>

---

**Fig. 1-14** Assembly 1 effective R-value comparison of galvanized steel tie and shelf angle options

**Fig. 1-15** Assembly 1 effective R-values for R-4.2/inch insulation, various tie types, and without shelf angle considerations
Bottom vents also serve as weeps to assist with drainage of the rainscreen cavity. These vents/weeps are typically located just above bearing elements such as loose-lintels, floor line shelf-angles or foundation walls.

Vents and weeps are recommended to be spaced a maximum of 24 inches on-center (e.g., every two to three masonry units) and filled with a cellular or mesh product that fills the head joint of a standard brick unit. It is important that weep fillers extend into the bed joint of the course to facilitate drainage. Weep tubes should not be used at vent/weep locations because they provide far less ventilation and are blocked easily with debris.

Mortar collection nets are recommended at all veneer-bearing locations to prevent mortar from blocking the rainscreen cavity and vents/weeps. It is best practice to use a trapezoidal-shaped open-weave, moisture-tolerant net.

Sheet-Metal Components

Sheet-metal components for this assembly are reflected throughout the details located at the end of this chapter. Cross-cavity sheet-metal components are typically located at all bearing elements such as the head of a penetration (e.g., window head), floor line shelf-angles, and foundation. These flashings assist with draining the rainscreen cavity and also serve to protect fluid-applied or flexible flashing membranes, which may exist beneath them. Counterflashing sheet-metal components assist only with watersheding and are typically located at window sill and parapet top conditions; they protect the cavity from water ingress while still allowing for cavity ventilation.

Refer to the Introduction Chapter of this guide for general recommendations on sheet-metal flashing products, including design considerations and materials.

Movement Joints

For this assembly, anchored clay masonry will expand over time as a result of irreversible moisture gain, and the mortar joints will shrink slightly over time. In the CMU wall structure, shrinkage will occur over time due to initial drying and carbonation. To avoid damage to the veneer or other wall components, differential movement between the wall structure and veneer must be considered. Expansion joints also must be provided to allow for overall expansion of the clay masonry veneer; control joints must be provided for shrinkage where concrete masonry veneer units are used.

Differential movement between the wall structure and veneer is accommodated with a horizontal gap between the veneer and elements that are directly attached to the wall structure, such as shelf angles, parapet blocking, and windows. Locations where this gap should occur are indicated with an asterisk (*) in the details at the end of this chapter. At each horizontal gap, either a backer rod and sealant joint or cross-cavity sheet-metal flashing should be placed. The sizing and location of joints will vary depending on the expected differential movement between the wall and veneer. It is the Designer of Record’s responsibility to appropriately locate and size each joint. In general, a minimum gap dimension of 3/8-inch should be provided.

Expansion/shrinkage of the veneer or differential movement between the veneer, penetrations, and different cladding materials is accommodated with vertical joints in the veneer system as shown similar in Fig. 1-17 on page 1-16. Vertical gaps minimize stresses between the veneer and other components to provide crack control for the masonry veneer. All vertical gaps should be sealed with a backer rod and sealant. It is the Designer of Record’s responsibility to appropriately locate and size each joint. In general, a minimum gap dimension of 3/8-inch should be provided.

Refer to the Introduction Chapter of this guide for more information on locating veneer joints and sealant joint best practices.
Prescriptive spacing requirements for anchored masonry veneer ties are included in Table 1-4 for special requirements for Seismic Design Categories D, E, and F and high wind zones with velocity pressures (qz) between 40 and 55 psf. These higher seismicity and wind speed areas are common to some parts of the Northwest and are dependent on the geography and building occupancy category. Refer to local building code requirements to ensure seismicity and wind speed criteria are properly evaluated for the building occupancy and site conditions.

**Typical tie types for reference are shown in Fig. 1-18 on page 1-18.** For masonry and concrete walls, adjustable ties are required and may include embedded wire or joint reinforcement or surface-mounted connectors with adjustable ties. Based on local best practices, double eye and pintle type ties (whether a plate or screw type) are preferred. Double eye and pintle ties are available from a number of manufacturers in a variety of sizes to meet project requirements in the Northwest. Test data are typically available to justify the use of these tie types when an engineered tie system is required rather than prescriptive compliance.

Prescriptive spacing requirements for anchored masonry veneers are included in Table 1-4 for special requirements for Seismic Design Categories D, E, and F and high wind zones with velocity pressures (qz) between 40 and 55 psf. These higher seismicity and wind speed areas are common to some parts of the Northwest and are dependent on the geography and building occupancy category. Refer to local building code requirements to ensure seismicity and wind speed criteria are properly evaluated for the building occupancy and site conditions.

**Fig. 1-17** Typical vertical brick expansion joint aligned with window jambs. Each joint continues the full height of the building and is not yet sealed with a backer rod and sealant joint.

**Table 1-4 Prescriptive spacing requirements for anchored masonry veneer ties**

<table>
<thead>
<tr>
<th>Spacing Designation</th>
<th>Requirement Category</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>General</td>
</tr>
<tr>
<td>Maximum Wall Area per Anchor</td>
<td>2.67 ft&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td>Maximum Horizontal Spacing</td>
<td>32-inches</td>
</tr>
<tr>
<td>Maximum Vertical Spacing</td>
<td>25-inches</td>
</tr>
<tr>
<td>Maximum Spacing at Opening&lt;sup&gt;(3)&lt;/sup&gt;</td>
<td>36-inches</td>
</tr>
<tr>
<td>Maximum Distance from Openings</td>
<td>12-inches</td>
</tr>
</tbody>
</table>

<sup>(1)</sup>Seismic design categories as determined by ASCE 7.

<sup>(2)</sup>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.

<sup>(3)</sup>For openings larger than 16-inches in either dimension.

Based on local best practices, use double eye and pintle type ties, whether a plate or screw type.

**Structural Considerations**

The CMU block (or concrete) wall of this assembly provides the primary structure of this assembly. It is the responsibility of the Designer of Record to ensure that all structural elements are designed to meet project-specific loads and local governing building codes. Generic placement of the grout and reinforced elements are demonstrated within the details of this chapter and are provided for diagrammatical purposes only.

**Masonry Ties**

Masonry ties are used to connect the veneer to the masonry (or concrete) wall structure. They are designed to resist the out-of-plane loads applied to the wall, typically wind and seismic. At the same time, ties must be flexible to allow the veneer to move in-plane relative to the backing wall.

Building codes provide prescriptive requirements for masonry ties secured to concrete or masonry that include spacing, size, placement, and tie type. These requirements are summarized in Table 1-4 and are based on ACI-530 provisions. The use of these prescriptive requirements are limited to masonry veneer assemblies with a weight less than 40 psf, a cavity depth no more than 4.5 inches, and where the ASCE-7 wind velocity pressure (qz) is less than 55 psf (previously wind speed less than 130 mph). Wall assemblies that exceed these criteria require the design professional to evaluate the building loads and materials and rationally design the anchorage system accordingly. The majority of masonry tie manufacturers have empirical testing data available to support the use of their anchorage systems when the cavity depth or loads exceed these criteria.

Based on local best practices, use double eye and pintle type ties, whether a plate or screw type.
Class B-2 or stainless steel that complies with AISI Type 304 or 316. Fasteners used with these ties should be corrosion-resistant, either galvanized steel or stainless steel, to match the tie selection.

It is important to also recognize that recent energy code changes may require insulation thickness to exceed 3.5 inches. In such cases, the wall cavity will exceed 4.5 inches (when including a minimum 1-inch air space), which will trigger the code requirement for an engineered anchor system, rather than prescriptive compliance.

**Vertical Support**

Anchored masonry veneers are supported vertically by the building's foundation or other structural components. There are generally three methods of supporting masonry veneers:

- **Structural bearing** (foundations, floor slabs, structural beams)
- **Intermediate supports** (continuous or standoff shelf angles)
- **Supports at openings** (loose lintel, shelf angle, reinforced masonry lintel, precast concrete lintel)

An example of both structural bearing and loose lintel vertical support elements are shown in Fig. 1-19.

While the function of each support method is different, they each must be designed to eliminate the possibility of cracking and deflection within the veneer. Selection of the appropriate support method should consider the design loads, material type, moisture control, movement provisions, and constructability.

Adjustable triangular wire ties are acceptable but may not be preferred by installers because the vertical tie orientation can complicate the exterior insulation installation process by requiring vertical orientation of insulation boards. Corrugated masonry ties and nonadjustable surface-mounted ties are not allowed by ACI-530 for this assembly.

To prevent pull-out or push-through of the tie, embed each tie a minimum of 1-1/2 inches into the veneer, with at least 5/8-inch mortar or grout cover at the outside face. The mortar bed thickness is to be at least twice the thickness of the tie. To prevent excess movement between connecting parts of adjustable tie systems, limit clearance between components to less than 1/16-inch. The vertical offset of adjustable pintle-type ties may not exceed 1-1/4 inches.

When using surface-mounted ties, fasten them directly to the concrete or masonry framing with hammer-driven, expanding pin fasteners with a stainless steel pin and a zinc-aluminum (Zamac) alloy jacket. Fasteners should be sized to provide pull-out capacity equal to or greater than the masonry tie itself.

Ties should be hot-dipped galvanized carbon steel that complies with ASTM A 153
For concrete and masonry backings, anchored masonry veneer should be supported vertically by noncombustible construction. Best practice for concrete- and masonry-backed veneers is to support the lowest portion of the masonry cladding directly on the concrete foundation.

The code does not place any height restrictions or requirements for intermediate support of masonry with concrete or masonry backings. However, the designer should provide intermediate support to accommodate movement and prevent cracking of the veneer associated with differential movement of the veneer, ties, building structure, and other building components. It is recommended that intermediate supports are provided every 20 feet or every 2 floors, whichever is greater, for structural considerations and to facilitate drainage and ventilation of the rainscreen cavity.

Intermediate supports for masonry should be provided with galvanized steel shelf angles, anchored directly at the floor slab level. The floor slab design should be sufficient to limit floor deflection to less than L/600 or 0.3 inches, whichever is less. As noted in the Movement Joints sections of this chapter and the Introduction Chapter, a joint should be provided beneath the angle and sealed with elastomeric sealant.

Masonry cladding must also be supported at openings within the veneer, such as at windows and doors. This may be done with shelf angles, for larger openings, or with loose lintels at smaller openings. Galvanized steel loose lintels are typically used except where architectural design dictates the use of reinforced masonry or precast concrete lintels for appearance. Steel angle lintels should span across the opening and bear a minimum of 6 inches onto the adjacent masonry at the jambs of the opening.

Refer to the details at the end of this chapter for detailing of typical support elements.

**Corrosion Resistance**

To avoid premature cladding replacement, the durability and longevity of metal components within this assembly should match that expected of the masonry veneer cladding system. Metal components within this assembly include veneer ties, vertical support ledgers and lintels, sheet-metal flashings, and fasteners. Veneer ties should be hot-dipped galvanized carbon steel that complies with ASTM A 153 Class B-2 or stainless steel that complies with AISI Type 304 or 316 such as that shown in Fig. 1-20. Steel support angles such as ledger angles and lintels should be a minimum G185 hot-dipped galvanized. Sheet-metal flashing components should be manufactured of ASTM A167 Type 304 or 316 stainless steel, which is nonstaining and resistant to the alkaline content of mortar materials.

Whereas the use of stainless steel sheet-metal flashing components is not always economically feasible or aesthetically desirable, prefinishing sheet-metal may be considered. Where used, the base sheet metal should receive a minimum G90 hot-dipped galvanized coating in conformance with ASTM A653 or minimum AZ50 galvalume coating in conformance with ASTM A792. It is recommended that the exposed top finish of the sheet metal be coated with an architectural-grade coating conforming to AAMA 2605.

Fasteners used with all metal components should be corrosion-resistant, either galvanized steel or stainless steel.

**Masonry Veneer**

There are several types of anchored masonry veneer products that may be used with this assembly. Those most typical within the Northwest include facing brick made of clay or shale. Concrete facing brick and concrete masonry units are also used.

When using facing brick made from clay or shale, anchored veneer units should comply with ASTM C216 and be severe weather (SW) grade. When using concrete facing brick, anchored veneer units should comply with ASTM C1634. Hollow concrete masonry units used for veneer applications are typically 4-inches deep and should comply with ASTM C90.

Mortar designed for the anchored masonry veneer units should conform to ASTM C270, and type selected should be appropriate for the veneer application; Type N mortar is acceptable for most anchored masonry veneer applications. When selecting mortar, the lowest compressive strength (softest) mortar

![Fig. 1-20 Thermally optimized screw tie with stainless steel hook and barrel as observed at a freestanding mock-up](image-url)
that satisfies the project requirements should be used. Appropriate product selection of masonry veneer unit and mortar materials is necessary to provide a durable and water-resistive cladding system. The masonry veneer units and mortar joints should also be installed in conformance with industry standard best practices and manufacturer requirements. The specifics of architectural characteristics and structural properties of the masonry veneer units, mortar, and reinforcing should be designed and reviewed by a qualified Designer of Record.

Various industry resources are available to assist with veneer design and are listed in the Resources section at the back of this guide.

**Clear Water Repellents**

A clear water repellent should be applied to the anchored masonry veneer of this assembly. Refer to the Introduction Chapter for more information on selecting an appropriate clear water repellent and for best practice installation guidelines.

**Pricing Analysis**

A pricing analysis for this assembly is provided in Table 1-5 on page 23 of this chapter. Pricing demonstrates the relative price per square foot and is based on a 10,000 square foot wall area with easy drive-up access. Pricing includes all components outboard of the CMU wall structure and provides no evaluation for interior finishes or CMU wall structure. Pricing for this assembly is for a CMU wall backup wall structure; a concrete backup wall structure is expected to be comparable.


**Online Availability**

The content of this guide and additional resources may be accessed online at www.masonrys systemsguide.com. Also available online are downloadable versions of two- and three-dimensional assembly details and cutaway sections as well as sample project specifications. Ongoing updates to references and resources included within this guide can also be accessed.

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**Table 1-5 Assembly 1A and Assembly 1B CMU (or concrete alternate) wall with anchored masonry veneer pricing analysis**

<table>
<thead>
<tr>
<th>Assembly Component</th>
<th>Baseline Product</th>
<th>Alternate (call for estimate)</th>
<th>Baseline Cost/ft² (incl. labor)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>INTERIOR</strong></td>
<td></td>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>1 Structural CMU (or concrete) wall</td>
<td>No evaluation of these components provided.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2* Air and water-resistant barrier</td>
<td>Fully adhered sheet-applied membrane</td>
<td>Fluid-applied membrane system</td>
<td>$1.50</td>
</tr>
<tr>
<td>3* Exterior insulation</td>
<td>Rigid XPS board insulation; 2-inch thickness</td>
<td>No specified alternate</td>
<td>$1.75</td>
</tr>
<tr>
<td>4 Air cavity</td>
<td>Not applicable</td>
<td>Not applicable</td>
<td></td>
</tr>
<tr>
<td>5* Anchored masonry veneer (without ties)</td>
<td>SW brick masonry modular unit (3-5/8” x 2-1/4” x 7-5/8”) FBX, running bond; Type S or N mortar</td>
<td>No specified alternate</td>
<td>$25.00</td>
</tr>
<tr>
<td>6* Anchored masonry veneer ties</td>
<td>14 ga hot-dipped galvanized or stainless-steel plate tie, including fasteners</td>
<td>Thermally optimized screw tie with stainless or hot-dipped galvanized hook</td>
<td>$2.25</td>
</tr>
<tr>
<td>7* Clear water repellent</td>
<td>Silane/siloxane blend</td>
<td>Antigraffiti clear water repellent</td>
<td>$1.75</td>
</tr>
</tbody>
</table>

**EXTERIOR**

Total cost to install 10,000 sq ft wall area w/easy drive-up access —> $32.25 | $38.00

**Pricing Analysis Discussion**

- Low and high baseline costs are based on baseline products. Call for an estimate for alternate product pricing.
- Baseline costs provided will vary based on product specific conditions and should be used as an estimate only.
- Veneer unit prices is for typical units as noted. Pricing will vary based on size, color, and finish and should be confirmed with the unit manufacturer.
- *See Resource Section of this guide for product recommendation
**LEGEND**

1. Typical Assembly:
   - Single-wythe CMU wall
   - Fluid-applied or self-adhered sheet AB/WRB field membrane
   - Exterior insulation
   - Air cavity
   - Anchored masonry veneer
   - Clear water repellent
2. Masonry veneer anchor, fasteners bed in sealant, fluid-applied flashing, or self-adhered membrane patch membrane per manufacturer recommendations
3. Continuous mortar collection mesh
4. Fluid-applied or self-adhered sheet AB/WRB head prestrip 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 1/2 inch hemmed drip edge and end dams beyond
8. Sheet-metal trim
9. Sealant over backer rod
10. Continuous AB sealant tied to continuous seal and window perimeter
11. Continuous back dam angle at rough opening perimeter, minimum 1 inch tall with window fastened through back dam angle per window manufacturer recommendations
12. Storefront window

**Detail Discussion**

- AB and WRB continuity is provided by the fluid-applied or self-adhered sheet AB/WRB field membrane, AB/WRB head prestrip membrane, and AB sealant transition to the storefront.

- The hot-dipped galvanized steel loose lintel location allows the exterior insulation to be continuous up to the rough opening; it may be replaced with a standoff shelf angle where vertical support is required (such as at a floor line).

- Replace the upper portion of the two-piece sheet-metal flashing with a flexible self-adhered flashing membrane for a thermal improvement; confirm self-adhered flashing membrane compatibility with fluid-applied AB/WRB manufacturer prior to installation. See Detail 2-C for an example of this detail approach.

- The hemmed drip edge of the sheet-metal head flashing sheds water away from the anchored masonry veneer above before it reaches the window and sill.
**LEGEND**

1. Typical Assembly:
   - Single wythe CMU wall
   - Fluid-applied or self-adhered sheet AB/WRB field membrane
   - Exterior insulation
   - Air cavity
   - Anchored masonry veneer
   - Clear water repellent
2. Storefront window on minimum 1/4-inch intermittent plastic shims
3. Sealant over bond breaker
4. Sheet-metal sill flashing with 1/2-inch hemmed drip edge and end dams beyond
5. Sloped precast sill
6. Masonry veneer anchor, fasteners bed in sealant, fluid-applied flashing, or self-adhered membrane patch per manufacturer recommendations
7. Continuous AB sealant tied to continuous seal at window perimeter
8. Continuous back dam angle at rough opening perimeter, minimum 1 inch tall, with window fastened through back dam angle per window manufacturer recommendations.
9. Fluid-applied or flexible self-adhered AB/WRB sill flashing membrane

**Detail Discussion**

- AB and WRB continuity is provided by the fluid-applied or self-adhered sheet AB/WRB field membrane, fluid-applied or flexible self-adhered AB/WRB sill flashing membrane, and AB sealant transition to the storefront.
- The sheet-metal sill flashing conceals the rainscreen cavity and protects the cavity insulation from UV exposure. Terminate the sill flashing with end dams at each jamb; counterflash each end dam with the sheet-metal jamb trim to close off the rainscreen cavity and complete the WSS.
- Do not place a sheet-metal flashing below the precast sill. It can prematurely degrade the mortar bed beneath the precast element.
Critical Barriers

1. Typical Assembly:
   - Single-wythe CMU wall
   - Fluid-applied or self-adhered sheet AB/WRB field membrane
   - Exterior insulation
   - Air cavity
   - Anchored masonry veneer
   - Clear water repellent

2. Storefront window

3. Sealant over bond breaker


5. Fluid-applied or self-adhered sheet AB/WRB jamb prestrip membrane

6. Masonry veneer anchor, fasteners bed in sealant, fluid-applied flashing, or self-adhered membrane patch per manufacturer recommendations

7. Continuous AB sealant, tie to continuous seal at window perimeter

8. Continuous back dam angle at rough opening perimeter, minimum 1 inch tall. Fasten window through back dam angle per window manufacturer recommendations

**Detail Discussion**

- AB and WRB continuity is provided by the fluid-applied or self-adhered sheet AB/WRB membrane, AB/WRB jamb prestrip membrane, and AB sealant transition to the storefront.

- This detail allows the exterior insulation to continue up to the rough opening. The sheet-metal attachment to the intermittent angle, exterior of the windows thermal break, improves thermal performance of the jamb condition. This detail is a thermally improved alternate to Detail 3-C.

- The sheet-metal jamb trim is bed in continuous sealant against the anchored masonry veneer for WSS continuity.
1. Typical Assembly:
   - Single-wythe CMU wall
   - Fluid-applied or self-adhered sheet AB/WRB field membrane
   - Exterior insulation
   - Air cavity
   - Anchored masonry veneer
   - Clear water repellent
2. Masonry veneer anchor, fasteners bed in sealant, fluid-applied flashing, or self-adhered membrane patch per manufacturer recommendations
3. Continuous mortar collection mesh
4. Sheet-metal flashing with 1/2-inch hemmed drip edge
5. Fluid-applied AB/WRB flashing membrane or flexible self-adhered flashing membrane
6. Vent/weep at maximum 24 inches on-center
7. Typical Assembly:
   - Concrete floor slab
   - Vapor barrier
   - Rigid XPS insulation
   - Capillary break
8. Rigid XPS insulation thermal break

A significant thermal bridge occurs at the foundation element. The insulation between the concrete floor slab and concrete foundation wall is typically referred to as a thermal break and helps reduce the amount of heat loss at the floor slab perimeter and concrete foundation element.

Vents/weeps at the wall base provide assistance to drain the rainscreen cavity and also provide ventilation. The mortar collection mesh helps keep vents/weeps clear of mortar droppings.
**Critical Barriers**

1. Typical Assembly
   - Single-wythe CMU wall
   - Fluid-applied or self-adhered sheet AB/WRB field membrane
   - Exterior insulation
   - Air cavity
   - Anchored masonry veneer
   - Clear water repellent
2. Inverted roof membrane assembly
3. Standing-seam sheet-metal coping with gasketed washer fasteners
4. High-temperature self-adhered membrane
5. Preservative treated blocking
6. Compressible filler
7. Vents at maximum 24 inches on-center
8. Masonry veneer anchor, fasteners bed in sealant, fluid-applied flashing, or self-adhered membrane patch per manufacturer recommendations
* Size joint for project specific building movement, minimum 3/8-inch wide

**Detail Discussion**

- The sheet-metal parapet cap with hemmed drip edge is held off the anchored masonry veneer face to allow ventilation through the vents.
- The fluid-applied or self-adhered sheet AB/WRB field membrane, self-adhered membrane at the parapet, and roof assembly provide the AB and WRB continuity in this detail. The CMU also contributes to airtightness where fully grouted.
- A compressible filler is used between the anchored masonry veneer and parapet blocking to allow building movement while preventing insects and debris from entering the rainscreen cavity.
- This detail may be thermally improved by framing the parapet on top of the roof structure and insulating the parapet cavity similar to Detail 2-E.
LEGEND

1. Single wythe CMU wall
2. Fluid-applied or self-adhered sheet AB/WRB field membrane
3. Fluid-applied or self-adhered sheet AB/WRB head and jamb prestrip membrane
4. Hot-dipped galvanized steel loose lintel
5. Two-piece sheet-metal head flashing with 1/2-inch hemmed drip edge and end dams beyond
6. Masonry veneer anchor, fasteners bed in sealant, fluid-applied flashing, or self-adhered membrane patch per manufacturer recommendations
7. Sloped preservative-treated wood blocking
8. High-temperature self-adhered membrane
9. Exterior insulation
10. Continuous mortar collection mesh
11. Anchored masonry veneer
12. Standing-seam sheet-metal coping with gasketed washer fasteners
13. Inverted roof membrane assembly and roof structure
14. Vents at maximum 24 inches on-center

3-D Detail Discussion

- Three-dimensional cutaway sections on the next three pages represent two-dimensional details of this assembly.

- In all details, WRB and WSS elements are shingle-lapped to encourage drainage, in both the rainscreen cavity and at the anchored masonry veneer face.

- As shown in Detail 1-F, horizontally oriented ties, such as a double eye and pintle plate ties, allow exterior insulation to be installed in horizontal strips between ties. This orientation can improve the efficiency of the anchored masonry veneer installation.

- The two-piece sheet-metal flashing at the window head, as shown in Detail 1-F, allows the upper flashing to be installed and integrated into the AB/WRB field membrane prior to installation of the lower sheet-metal flashing and hot-dipped galvanized steel loose lintel.

- As shown in Detail 1-F, the sheet-metal flashing above the lintel ends at a head joint. This location allows the sheet-metal head flashing to terminate with an end dam.

- Vents/weeps at the wall base, as shown in Detail 1-G provide both drainage and ventilation of the rainscreen cavity. Mortar collection mesh helps keep the vents/weeps and base flashing area free of mortar droppings.

- Detail 1-H describes a typical rough opening with continuous back dam angle. The back dam angle creates a sill pan below the window; intermittent shims below the storefront window promote drainage at the sill and into the rainscreen cavity.

- The sheet-metal jamb trim shown in all details conceals the rainscreen cavity from water exposure and protects the insulation from UV exposure.

- Exterior insulation should be tightly installed around all penetrations, including masonry ties.
LEGEND

1. Single-wythe CMU wall
2. Concrete foundation element
3. Fluid-applied AB/WRB flashing membrane or self-adhered flexible flashing membrane
4. Sheet-metal base flashing with 1/2-inch hemmed drip edge
5. Fluid-applied AB/WRB field membrane
6. Exterior insulation
7. Continuous mortar collection mesh
8. Fluid-applied AB/WRB jamb and sill prestrip membrane
9. Anchored masonry veneer
10. Storefront window
11. Sloped precast concrete sill with sheet-metal sill flashing
12. Vent/weep at maximum 24 inches on-center

Base of Wall Cutaway Section
Detail 1-G

LEGEND

1. Continuous back dam angle at rough opening perimeter, minimum 1 inch tall, with window fastened through back dam angle per window manufacturer recommendations
2. Fluid-applied or flexible self-adhered AB/WRB sill flashing membrane
3. Masonry veneer anchor, fasteners bed in sealant or fluid-applied flashing membrane per manufacturer recommendations
4. Intermittent minimum 1/4-inch shims
5. Precast concrete sill
6. Continuous AB sealant tied to continuous seal at window perimeter
7. Storefront window
8. Exterior insulation
9. Anchored masonry veneer
10. Sheet-metal sill flashing with 1/2-inch hemmed drip edge and end dams beyond
11. Sheet-metal jamb trim with hemmed edge, bed in sealant against anchored masonry veneer

Typical Window and Jamb Cutaway Section
Detail 1-H
CHAPTER 2:
STEEL-FRAMED WALL WITH ANCHORED MASONRY VENEER

The Chapter 2 assembly is a rainscreen design approach with steel-framed wall structure and anchored masonry veneer. The typical components of this assembly, from interior to exterior, are described below in Fig. 2-1. This assembly is appropriate for many applications including low-, mid-, or high-rise residential or commercial buildings. An example application of this assembly is shown in Fig. 2-2 on page 2-4. Benefits and special considerations for this assembly are discussed in Table 2-1 on page 2-3.

Building Enclosure Control Functions and Critical Barriers

As noted in the Introductory chapter, an above-grade wall assembly should provide control of water, air, heat, vapor, sound, and fire to serve as an effective and durable environmental separator. Control of these elements is provided by critical barriers such as a water-shedding surface (WSS), water-resistive barrier (WRB), air barrier system (AB), thermal envelope, and vapor retarder (VR). Refer to Fig. i-8 of the Introductory chapter for a list of primary building enclosure control functions and associated critical barriers.

**INTERIOR**
- Interior gypsum board
- Vapor retarder
- Steel-framed wall with batt insulation
- Exterior sheathing
- Vapor permeable air and water-resistive barrier
- Semi-rigid exterior insulation
- Air cavity
- Anchored masonry veneer
- Clear water repellent

**EXTERIOR**

*Fig. 2-1 Typical Assembly 2 components from interior to exterior.*
Fig. 2-3 illustrates the critical barrier locations for this assembly. The critical barriers for typical Chapter 2 assembly details are also provided adjacent to each detail at the end of this chapter.

As shown in Fig. 2-3, the WSS critical barrier occurs at the anchored masonry veneer with most watersh edding occurring at the wall face while some water will be stored within the masonry veneer to be released at a later time. The WRB and AB critical barriers occur at the same location exterior of the wall sheathing. As a result, a single membrane is typically used to provide these two critical barriers and is commonly referred to in this chapter as the air and water-resistive barrier (AB/WRB). The thermal envelope includes the exterior insulation and wall cavity insulation. The VR layer is located at the interior (warm side) of the steel-framed structure.

The following sections provide more information and discuss best practices for critical barriers specific to this assembly.

Water-Shedding Surface (WSS)

The water-shedding surface is a critical barrier that controls water.

The anchored masonry veneer cladding, including both mortar joints and masonry veneer units, is the primary WSS of this assembly. Additional components include sheet-metal flashings and drip edges, sealant joints, and fenestration systems as shown on the details included at the end of this assembly chapter.

To promote water shedding at the masonry cladding, joints between masonry units should be appropriately installed with a tooled concave (preferred) or “V” shape.

When finished, the WSS critical barrier should be free of gaps except where providing drainage and/or ventilation. Movement joints and joints around fenestrations and penetrations should be continuously sealed with a backer rod and sealant or counterflashed with a sheet-metal flashing to deflect wind-driven rain and shed water away from the rainscreen cavity.

Water-Resistive Barrier (WRB)

The water-resistive barrier is a critical barrier that controls water.

In this assembly the WRB critical barrier is primarily a self-adhered sheet- or fluid-applied membrane that also functions as the AB system; thus, it referred to as the AB/WRB membrane. Either a fluid-applied or self-adhered sheet AB/WRB field membrane is depicted in the details at the end of this chapter. An example of a fluid-applied AB/WRB membrane is shown in Fig. 2-4 on page 2-5. The AB/WRB membrane of this assembly may be:
Masonry veneer ties in this assembly will penetrate the AB/WRB critical barrier and should be detailed based on the membrane manufacturer's installation requirements. Typically, plate ties are bed in a compatible sealant or fluid-applied flashing product or attached through a self-adhered membrane patch, whereas screw ties with gasketing washers typically do not require any detailing at the AB/WRB plane.

Air Barrier (AB)

The air barrier system is a critical barrier that primarily controls air, heat, and vapor. The AB system also controls water, sound, and fire.

In this assembly, the AB system critical barrier is the same self-adhered sheet-or fluid-applied field membrane that also serves as the WRB critical barrier. The components described in the above Water-Resistive Barrier (WRB) section are also part of the AB system, except sheet-metal flashings.

Thermal Envelope

The thermal envelope is a critical barrier that controls heat and assists with controlling vapor, sound, and fire.

In this wall assembly, the cavity and exterior insulation provide the thermal envelope. At transition details, the thermal envelope also includes exterior insulation across floor lines, parapet cavity insulation, and insulation at the roof assembly, slab, and foundation elements. Windows and doors that penetrate this assembly are part of the thermal envelope.

Additional thermal envelope discussion is provided in the Thermal Performance and Energy Code Compliance section of this chapter and the introductory chapter.

Insulation Selection

The cavity insulation in this assembly is typically a vapor-permeable fiberglass or mineral fiber batt insulation product.

The exterior insulation in this assembly is typically semi-rigid mineral fiberboard insulation (R-4.2/inch), which is hydrophobic, tolerates moisture, and has free-draining capabilities. Its vapor permeance allows it to be acceptable for use exterior of a vapor-permeable WRB/AB membrane without inhibiting assembly drying. An example of this insulation is shown in Fig. 2-5 on page 2-7. The semi-rigid properties of the insulation allow it to be fit tightly around penetrations such as masonry veneer ties.

Fig. 2-4 Double eye and pintle plate ties are attached through compatible self-adhered membrane patches over top of the fluid-applied air and water-resistive barrier. Ties penetrate the continuous rigid insulation.
A vapor-impermeable rigid board insulation such as XPS or moisture-resistant polyisocyanurate may be appropriate when a vapor-impermeable AB/WRB membrane is used. Refer to the Water-Resistive Barrier section of this chapter for discussion regarding AB/WRB permeability.

Vapor Retarder (VR)

The VR critical barrier is a layer that retards or greatly reduces (e.g., vapor barrier) the flow of water vapor due to vapor pressure differences across enclosure assemblies. Unlike the other critical barriers presented in this guide, the VR is not always necessary or required to be continuous.

When a vapor-permeable AB/WRB critical barrier is used within this assembly (see the Water-Resistive Barrier section of this chapter), the VR of this assembly is located on the interior (warm side) and is typically at the face of or just behind the interior gypsum board. The VR for this assembly should comply with Section 1405.3 of the governing International Building Code (IBC). In the Northwest, typical VR products include PVA vapor-retarding primer, asphalt-coated kraft paper, or a polyamide film retarder membrane. These products are discussed further in the Introductory chapter.

When a vapor-impermeable membrane is used for the AB/WRB critical barrier (see the Water-Resistive Barrier (WRB) section of this chapter), the VR critical barrier is the AB/WRB membrane, and a separate VR membrane should not be used within this assembly.

Thermal Performance and Energy Code Compliance

This chapter assembly is typically classified as a “metal-framed” (or “steel-framed”) above-grade wall for energy code compliance purposes. Prescriptive energy code compliance values for this assembly are summarized in Table 2-4 on page 2-14 and describes:

- Minimum insulation R-values for a prescriptive R-value compliance strategy.
- Maximum assembly U-factors for a prescriptive U-factor alternative compliance strategy. Note, the equivalent assembly effective R-value of this maximum U-factor has been calculated and is denoted in parenthesis () for easy comparison to thermal modeling results included within this chapter.

For cavity insulation, steel-stud walls are typically constructed with 16-inch on-center stud spacing and can accommodate up to an R-15 batt insulation for 3-5/8 inch studs or R-21 batt insulation for 6-inch studs. Alternate insulation products may also be used to fill the cavity. Steel framing, because of its high thermal conductivity, can reduce the nominal thermal performance of the stud cavity insulation by approximately 40 to 60%. For this reason, continuous insulation is typically needed to meet prescriptive energy code compliance strategies.

When a non-prescriptive compliance option (e.g., a trade-off strategy or whole-building modeling strategy) is used for energy code compliance, this assembly’s effective thermal performance will need to be calculated; however, it may or may not be required to meet the prescriptive values shown in Table 2-4.

Fig. i-17 on page i-29 of the introductory chapter describes the typical process of navigating energy code compliance strategies and options. Thermal modeling results demonstrated within this chapter may be used to assist with estimating insulation and tie selection to achieve a target thermal performance value. Options for thermally optimizing this assembly, as determined through the modeling results are also provided.
Assembly Effective Thermal Performance

Masonry ties and floorline shelf angles penetrate the exterior insulation in this assembly and create areas of thermal bridging. Examples of the thermal bridging are described in Fig. 2-7 through Fig. 2-12. Where shown in Fig. 2-8, Fig. 2-10, and Fig. 2-12 the lighter blue thermal gradient color at the attachment describes a warmer temperature than the adjacent darker blue insulation face, which is an indicator of heat loss at the penetration through the insulation. Thermal bridging of the steel studs and concrete slabs are also depicted where the thermal gradient is orange (warmer) at studs and transitions to yellow (cooler) where cavity insulation occurs. Thermal bridging reduces the assembly’s actual thermal performance.

Three-dimensional thermal modeling demonstrates this assembly’s effective thermal performance with various insulation thicknesses, insulation R-values, masonry veneer ties, and standoff shelf angle options. A discussion on the modeling performed for this guide is included in the Introduction Chapter and the Appendix.

Thermal Modeling: Variables

The following are modeling variables specific to this assembly—steel-framed wall with anchored masonry veneer:

- **Framing and Cavity Insulation:** 3 and 5/8-inch steel stud wall with R-15 batt insulation. A full-height steel stud wall including the top and bottom track adjacent to a concrete slab, but does not include the wall area at the slab edge.

- **Masonry Ties:** Various tie types are considered at 16-inches by 16-inches on-center spacing. Tie types are shown in Fig. 2-6 and include:
  - Thermally optimized screw tie with stainless steel barrel and carbon steel fastener. Hooks are either hot-dipped galvanized steel or Type 304 stainless steel.
  - Double eye and pintle plate tie (14-gauge). Hooks are either hot-dipped galvanized steel or Type 304 stainless steel to match the tie plate.
• **Exterior Insulation:** R-4.2/inch or R-6/inch insulation product. Insulation thicknesses of 2, 3, and 4 inches are considered. The R-values selected demonstrate the lower and upper thermal resistance of typical exterior insulation products.

• **Shelf Angle Supports:** The peripheral concrete slab edges that typically occur on a building with this assembly are classified as a mass above-grade wall by the IECC; mass wall prescriptive requirements may be found in tables within Chapters 1, 4, 5, and 6. As a result, the influence the slab edge has on the steel stud assembly thermal performance is not included within the assembly modeling results but is presented separately. Either attached tight to the floor line structure (i.e., continuous shelf angle) as shown in Fig. 2-9 and Fig. 2-10 or offset to the depth of the exterior insulation and supported by intermittent hollow steel sections (HSS) at 4 feet on-center (i.e., standoff shelf angle) as shown similar in Fig. 2-11 and Fig. 2-12.

**Thermal Modeling: Results**

The results of this modeling demonstrate the assembly effective R-value under various conditions and are shown in Table 2-2, Table 2-3, Fig. 2-13, and Fig. 2-14 (see page 2-13 and page 2-14); Fig. 2-13, and Fig. 2-14 are graphical representations of the results summarized in Table 2-2. Discussion of these results is provided below and key points for thermally optimizing this assembly are italicized in bold face.

• The assembly effective R-value for “Cavity + Exterior Insulation (Without Penetrations)” is reduced by 9 to 33% when masonry tie penetrations are considered. Note that a 16 inch-by-16 inch on-center spacing is modeled for this guide; reducing the frequency of ties will increase the effective thermal performance of the assembly but will need to be coordinated with structural requirements.

• Stainless steel plate ties reduce the assembly effective R-value less than both galvanized steel and thermally optimized tie options as shown in Fig. 2-13 and Fig. 2-14. As determined from Table 2-2, stainless steel masonry ties reduce the assembly effective R-value by 9 to 16%, while galvanized steel masonry ties reduce it by 19 to 33%. Use of a stainless steel plate tie may prove to be a cost-effective option in comparison to thermally improved proprietary tie options and also provides a highly corrosion-resistant attachment.

• As determined from Fig. 2-14, if an effective R-24 is desired, approximately 2.75 inches of R-6/inch insulation with a stainless steel plate tie, 3.25 inches of R-6/inch insulation with a thermally optimized screw tie (with stainless steel hook) or 4 inches of R-6/inch insulation with a galvanized steel plate tie are all options; however, the stainless steel plate tie would facilitate a thinner wall design. This demonstrates that a thinner wall assembly may be achieved without impacting the effective R-value when better-performing ties are used.

• Table 2-3 demonstrates the effective R-value of exterior insulation at two shelf angle options: standoff and continuous. As shown, a continuous shelf angle provides a lower effective R-value than a standoff shelf angle. When compared to the effective R-value of the slab edge without a shelf-angle, the effective assembly R-value is reduced to 12 to 13% with a continuous shelf angle and 33 to 39% with a standoff shelf angle. When shelf angle supports are needed for this assembly, a standoff angle will provide a greater effective R-value at the slab edge condition.

**Sheathing Selection**

Exterior sheathing on this assembly is typically a gypsum-based product and should be a product resistant to organic growth and moisture. Fiberglass-faced products should be used; paper face products should be avoided.

**Drainage, Ventilation, and Water Deflection**

The anchored masonry veneer is expected to shed most water it is exposed to; however, some moisture is expected to penetrate the cladding and enter the rainscreen cavity. This moisture is drained through the rainscreen cavity and exits the rainscreen system where cross-cavity flashings are provided.

**Drainage and Ventilation**

In this assembly, a 2-inch-deep rainscreen cavity between the anchored masonry veneer and exterior insulation should be provided to encourage drainage and ventilation. At minimum, a 1-inch gap may be provided and is the minimum code-allowable depth. However, the risk that mortar droppings will reduce the drainage and ventilation within the rainscreen cavity is increased with smaller cavities. A 1-inch cavity should only be provided where a strict quality control program is implemented to ensure mortar droppings do not block the cavity. Fig. 2-15 on page 2-15 demonstrates a typical rainscreen cavity for this assembly.

Where the rainscreen cavity is reduced, such as at window rough openings with return brick, a compressible free-draining filler is recommended; semi-rigid mineral fiber insulation may be used. In any case, mortar should not be packed within these cavities.
Table 2-2 Assembly 2 thermal modeling results

<table>
<thead>
<tr>
<th>Exterior Insulation Thickness</th>
<th>Nominal Insulation R-Value (Cavity + Exterior)</th>
<th>3D Thermal Modeling Effective R-Value (ft²·°F·hr/Btu)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Cavity + Exterior Insulation (Without Penetrations)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Masonry Ties @ 16&quot; x 16&quot; O.C.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Galvanized Hook</td>
</tr>
<tr>
<td>2&quot;</td>
<td>15 + 8.4–12</td>
<td>17.7–20.9</td>
</tr>
<tr>
<td>3&quot;</td>
<td>15 + 12.6–18</td>
<td>20.9–24.9</td>
</tr>
<tr>
<td>4&quot;</td>
<td>15 + 16.8–24</td>
<td>24.4–29.6</td>
</tr>
<tr>
<td>2&quot;</td>
<td>15 + 8.4–12</td>
<td>17.0–19.3</td>
</tr>
<tr>
<td>3&quot;</td>
<td>15 + 12.6–18</td>
<td>19.9–23.4</td>
</tr>
<tr>
<td>4&quot;</td>
<td>15 + 16.8–24</td>
<td>23.1–27.5</td>
</tr>
</tbody>
</table>

Table 2-3 Concrete floor line thermal modeling results

<table>
<thead>
<tr>
<th>Exterior Insulation Thickness</th>
<th>Nominal Exterior Insulation R-Value</th>
<th>3D Thermal Modeling Effective R-Value (ft²·°F·hr/Btu)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Exterior Insulation (Without Penetrations)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Standoff Shelf Angle</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Continuous Shelf Angle</td>
</tr>
<tr>
<td>2&quot;</td>
<td>8.4–12</td>
<td>6.6–6.8</td>
</tr>
<tr>
<td>3&quot;</td>
<td>12.6–18</td>
<td>7.2–7.3</td>
</tr>
<tr>
<td>4&quot;</td>
<td>16.8–24</td>
<td>7.6–8.2</td>
</tr>
</tbody>
</table>

Table 2-4 Assembly 2 prescriptive energy code compliance values excerpted from Table i-2 of the introductory chapter

<table>
<thead>
<tr>
<th>Guide Assembly #</th>
<th>Classification</th>
<th>2012 SEC</th>
<th>2012 WSEC</th>
<th>2014 OEEC</th>
<th>2012 IECC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>S, 6 and Marine 4</td>
<td>S, 6 and Marine 4</td>
<td>S, 6 and Marine 4</td>
<td>S, 6 and Marine 4</td>
</tr>
<tr>
<td>2</td>
<td>Steel-Framed Wall with Anchored Masonry Veneer</td>
<td>Steel-Framed</td>
<td>U-0.055</td>
<td>R-10.0 (R-18.2)</td>
<td>U-0.055</td>
</tr>
</tbody>
</table>

Fig. 2-13 Effective R-value modeling results for R-4.2/inch exterior insulation, various insulation thicknesses and various tie types.

Fig. 2-14 Assembly 2 effective R-value comparison of different tie types. A range of insulation R-value per inch is represented.
The rainscreen cavity is ventilated through vents located at the top and bottom coursing of each wall section. Top vents typically occur just below parapet blocking and below intermittent bearing elements such as floor line shelf-angles. Bottom vents also serve as weeps to assist with drainage of the rainscreen cavity. These vents/weeps are typically located just above bearing elements such as loose lintels, floor line shelf angles, or foundation walls.

Vents and weeps should be spaced a maximum of 24 inches on-center (e.g., every 2 to 3 masonry units) and filled with a cellular or mesh product that fills the head joint of a standard brick unit. It is important that weep fillers extend into the bed joint of the course to facilitate drainage. Weep tubes should not be used at vent/weep locations because they provide far less ventilation and are blocked easily with debris.

Mortar collection nets are recommended at all veneer-bearing locations to prevent mortar from blocking the rainscreen cavity and vents/weeps. It is best practice to use a trapezoidal-shaped open-weave, moisture-tolerant net.

Sheet-Metal Components

Sheet-metal components for this assembly are reflected throughout the details located at the end of this chapter. Cross-cavity sheet-metal components are typically located at all bearing elements such as the head of a penetration (e.g., window head), floor line shelf angles, and the foundation. These flashings assist with draining the rainscreen cavity and also serve to protect fluid-applied or flexible flashing membranes that may exist beneath them. Counterflashing sheet-metal components assist only with watershedding and are typically located at window sill and parapet top conditions; they protect the cavity from water ingress while still allowing for cavity ventilation. An example of sheet-metal components is shown in Fig. 2-16.

Refer to the Introductory chapter for general recommendations on sheet-metal flashing products, including design considerations and materials.

Movement Joints

For this assembly, anchored clay masonry will expand over time as a result of irreversible moisture gain, and the mortar joints will shrink slightly overtime. In the support system, the steel-framed members will experience little volume change. To avoid veneer damage, breaks must be provided in the veneer to compensate for differential movement between the cladding and support wall. Expansion joints also must be provided to allow for overall expansion of the clay masonry veneer; control joints must be provided for shrinkage where concrete masonry veneer units are used.

Differential movement between the wall structure and veneer is accommodated with a horizontal gap between the veneer and elements that are directly attached to the wall structure, such as shelf angles, parapet blocking, and windows. Locations where this gap should occur are indicated with an asterisk (*) in the details at the end of this chapter. At each horizontal gap, either a backer rod...
and sealant joint or cross-cavity sheet-metal flashing should be placed. The sizing and location of movement joints will vary depending on the expected differential movement between the wall and veneer. It is the Designer of Record’s responsibility to appropriately locate and size each joint. In general, a minimum gap dimension of 3/8-inch should be provided.

Expansion/shrinkage of the veneer or differential movement between the veneer, penetrations, and different cladding materials is accommodated with vertical joints in the veneer system. Vertical gaps minimize stresses between the veneer and other components and provide crack control for the masonry veneer. An example of expansion joint locations is shown in Fig. 2-17. All vertical gaps should be sealed with a backer rod and sealant. It is the Designer of Record’s responsibility to appropriately locate and size each joint. In general, a minimum gap dimension of 3/8-inch should be provided.

Refer to the Introductory chapter for more information on locating movement joints and sealant joint best practices.

**Structural Considerations**

The steel frame walls and concrete floor slabs of this assembly provide the primary structure of this assembly. It is the responsibility of the Designer of Record to ensure that all structural elements are designed to meet project-specific loads and local governing building codes. Generic placement of the framing members and support elements are demonstrated within the details of this chapter and are provided for diagrammatic purposes only.

**Masonry Ties**

Masonry ties are used to connect the veneer to the metal stud-framed backup wall. They are designed to resist the out-of-plane loads applied to the wall, typically wind and seismic. At the same time, these ties must be flexible to allow the veneer to move in-plane relative to the metal stud framed wall.

Building codes provide prescriptive requirements for masonry ties secured to metal stud-framed walls, which include spacing, size, placement, and anchor type. The spacing requirements are summarized in Table 2-5 and are based on ACI-530 provisions. The use of these prescriptive requirements is limited to masonry veneer assemblies with a weight less than 40 psf, a cavity depth no more than 4.5 inches, and where the ASCE-7 wind velocity pressure (qz) is less than 55 psf (previously wind speed less than 130 mph). Wall assemblies that exceed these criteria require the designer of record to evaluate the building loads and materials and rationally design the anchorage system accordingly. The majority of masonry tie manufacturers have empirical testing data available to support the use of their anchorage systems when the cavity depth or loads exceed these criteria.

Prescriptive spacing requirements for anchored masonry veneers in Table 2-5

<table>
<thead>
<tr>
<th>Spacing Designation</th>
<th>Prescriptive Spacing for Adjustable Two-Piece Masonry Veneer Ties</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Requirement Category</td>
</tr>
<tr>
<td>Maximum Wall Area per Anchor</td>
<td>2.67 ft²</td>
</tr>
<tr>
<td>Maximum Horizontal Spacing</td>
<td>32-inches</td>
</tr>
<tr>
<td>Maximum Vertical Spacing</td>
<td>25-inches</td>
</tr>
<tr>
<td>Maximum Spacing at Openings(3)</td>
<td>36-inches</td>
</tr>
<tr>
<td>Maximum Distance from Openings</td>
<td>12-inches</td>
</tr>
</tbody>
</table>

(1)Seismic design categories as determined by ASCE 7.
(2)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.
(3)For openings larger than 16-inches in either dimension.
include special requirements for Seismic Design Categories D, E, and F and high-wind zones with velocity pressures \( (q_z) \) between 40 and 55 psf. These higher seismicity and wind speed areas are common to some parts of the Northwest and are dependent on the geography and building occupancy category. Refer to local building code requirements to ensure seismicity and wind speed criteria are properly evaluated for the building occupancy and site conditions.

Typical tie types for reference are shown in Fig. 2-18. For steel stud–framed walls, the use of adjustable ties is required by the code. Based on local best practices, double eye and pintle type ties, whether a plate or screw type are preferred. Double eye and pintle ties are available from a number of manufacturers in a variety of sizes to meet project requirements in the Northwest.

Adjustable triangular wire ties are acceptable but may not be preferred by installers because the vertical tie orientation can complicate the exterior insulation installation process by requiring vertical orientation of insulation boards. Corrugate masonry ties and nonadjustable surface-mounted ties are not allowed by code for this assembly.

To prevent pull-out or push-through of the tie, embed each anchor a minimum of 1-1/2 inches into the veneer, with at least 5/8-inch mortar or grout cover at the outside face. The mortar bed thickness is to be at least twice the thickness of the anchor. To prevent excess movement between connecting parts of adjustable anchor systems, limit clearance between components to less than 1/16 of an inch. The vertical offset of adjustable pintle-type anchors may not exceed 1.25 inches.

Masonry ties should be fastened directly to the steel stud framing, through the exterior sheathing with minimum #10 self-tapping screws (0.190-inch shank diameter). They should not be fastened to the sheathing alone. While the code allows a horizontal anchor spacing up to 32 inches on-center, it is recommended that anchors be placed at 16 inches on-center horizontally to align with the typical stud spacing.

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Ties should be hot-dipped galvanized carbon steel complying with ASTM A 153 Class B-2 or stainless steel complying with AISI Type 304 or 316. Fasteners used with these anchors shall be corrosion-resistant, either galvanized steel or stainless steel to match the anchor selection.

It is important to also recognize that recent energy code changes may require insulation thickness to exceed 3.5 inches. In such cases, the wall cavity will exceed 4.5 inches (when including a minimum 1-inch air space), which will trigger the code requirement for an engineered anchor system, rather than prescriptive compliance.

Vertical Support

Anchored masonry veneers are supported vertically by the building's foundation or other structural components. There are generally three methods of supporting masonry veneers:

- Structural bearing (foundations, floor slabs, structural beams)
- Intermediate supports (continuous or standoff shelf angles)
- Supports at openings (loose lintel, shelf angle, reinforced masonry lintel, precast concrete lintel)

While the function of each support method is different, they each must be designed to eliminate the possibility of cracking and deflection within the veneer. Selection of the appropriate support method should consider the design loads, material type, moisture control, movement provisions, and constructability.

For steel stud–framed wall assemblies, anchored masonry veneer must be supported by noncombustible construction, and any veneer that exceeds 30 feet in height must be supported at each story above 30 feet. Masonry below 30 feet in height must also be supported at each floor when used in Seismic Design Categories D, E, and F. Best practice for commercial construction is to support...
the lowest portion of the masonry cladding directly on the concrete foundation wall.

Intermediate support should be provided at every floor above 30 feet using galvanized steel shelf angles anchored directly to the floor slab. Fastening the shelf angle directly to the metal stud–framed wall should be avoided where possible due to the relative flexibility of the wall assembly and additional engineering design requirements. When fastening to the floor slab, shelf angles may be fastened directly against the floor slab, but it is recommended that they be anchored with discrete anchor to reduce thermal bridging through the insulation. The floor slab design should be sufficient to limit floor deflection to less than L/600 or 0.3 inches, whichever is less. Consideration must also be given to the vertical expansion and deflection between the shelf angle and the wall assemblies below. As noted in the Movement Joints sections of this chapter and the Introductory chapter, a joint should be provided beneath the angle and sealed with elastomeric silicone sealant.

Masonry cladding must also be supported at openings within the veneer, such as windows and doors. This may be done with shelf angles, as described above for larger openings, or with loose lintels at smaller openings. An example of lintel supports is shown in Fig. 2-19. Galvanized steel angles are typically used as lintels, except where architectural design dictates the use of reinforced masonry or precast concrete lintels for appearance. Steel angle lintels should span across the opening and bear a minimum 6 inches onto the adjacent masonry at the jambs of the opening.

Refer to the details at the end of this chapter for detailing of typical support elements.

Corrosion Resistance

To avoid premature cladding replacement, the durability and longevity of metal components within this assembly should match that expected of the masonry veneer cladding system. Metal components within this assembly include veneer ties, vertical support ledgers and lintels, sheet-metal flashings, and fasteners.

Veneer ties should be hot-dipped galvanized carbon steel that complies with ASTM A 153 Class B-2 or stainless steel that complies with AISI Type 304 or 316 such as that shown in Fig. 2-18. Steel support angles such as ledger angles and lintels should be a minimum G185 hot-dipped galvanized. Sheet-metal flashing components should be manufactured of ASTM A167 Type 304 or 316 stainless steel, which is nonstaining and resistant to the alkaline content of mortar materials.

Whereas the use of stainless steel sheet-metal flashing components is not always economically feasible or aesthetically desirable, prefinishing sheet metal may be considered. Where used, the base sheet metal should receive a minimum G90 hot-dipped galvanized coating in conformance with ASTM A653 or minimum AZ50 galvalume coating in conformance with ASTM A792. It is recommended that the exposed top finish of the sheet metal be coated with an architectural-grade coating conforming to AAMA 2605.

Fasteners used with all-metal components should be corrosion-resistant, either galvanized steel or stainless steel.

Masonry Veneer

There are several types of anchored masonry veneer products that may be used with this assembly. Those most typical within the Northwest include facing brick made of clay or shale. Concrete facing brick and concrete masonry units are also used.

When using **facing brick** made from clay or shale, anchored veneer units should comply with ASTM C216 and be severe weather (SW) grade. When using **concrete facing brick**, anchored veneer units should comply with ASTM C1634. Hollow **concrete masonry units** used for veneer applications are typically 4-inches deep and should comply with ASTM C90.

Mortar designed for the anchored masonry veneer units should conform to ASTM C270, and the type selected should be appropriate for the veneer application; Type N mortar is acceptable for most anchored masonry veneer applications. When selecting mortar, the lowest compressive strength (softest) mortar that
satisfies the project requirements should be used.

Appropriate product selection of masonry veneer unit and mortar materials is necessary to provide a durable and water-resistant cladding system. The masonry veneer units and mortar joints should also be installed in conformance with industry standard best practices and manufacturer requirements. The specifics of architectural characteristics and structural properties of the masonry veneer units, mortar, and reinforcing should be designed and reviewed by a qualified Designer of Record.

Various industry resources are available to assist with veneer design and installation methods and are listed in the References section.

Clear Water Repellents

A clear water repellent should be applied to the anchored masonry veneer of this assembly. Refer to the Introductory chapter for more information on selecting an appropriate clear water repellent and for best practice installation guidelines.

Pricing Analysis

A pricing analysis for this assembly is provided on Table 2-6 on page 2-24. Pricing demonstrates the relative price per square foot and is based on a 10,000 square foot wall area with easy drive-up access. Pricing includes all components outboard of the exterior wall sheathing and provides no evaluation for interior finishes (including VR), framing/sheathing, or cavity insulation.


Online Availability

The content of this guide and additional resources may be accessed online at www.masonrysystemsguide.com. Also available online are downloadable versions of two- and three-dimensional assembly details and cutaway sections as well as sample project specifications. Ongoing updates to references, resources, and pricing included within this guide can also be accessed.

### Table 2-6 Assembly 2 steel-framed wall with anchored masonry veneer pricing analysis

<table>
<thead>
<tr>
<th>Assembly Component</th>
<th>Baseline Product</th>
<th>Alternate (call for estimate)</th>
<th>Baseline Cost/ft² (incl. labor)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>INTERIOR</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Interior gypsum board</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Vapor retarder</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Steel-framed wall with batt insulation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Exterior sheathing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5* Air and water-resistant barrier</td>
<td>Fully adhered or mechanically attached sheet-applied membrane</td>
<td>Fluid-applied membrane system</td>
<td>$1.50</td>
</tr>
<tr>
<td>6* Semi-rigid insulation</td>
<td>Semi-rigid mineral fiber board; 2 inch thickness</td>
<td>No specified alternate</td>
<td>$1.75</td>
</tr>
<tr>
<td>7 Air cavity</td>
<td>Not applicable</td>
<td>Not applicable</td>
<td>-</td>
</tr>
<tr>
<td>8* Anchored masonry veneer (without ties)</td>
<td>SW brick masonry modular unit (3-5/8&quot; x 2-1/4&quot; x 7-5/8&quot;) FBX, running bond; Type S or N mortar</td>
<td>No specified alternate</td>
<td>$25.00</td>
</tr>
<tr>
<td>9* Anchored masonry veneer ties</td>
<td>14-gauge hot-dipped galvanized or stainless-steel plate tie, including fasteners</td>
<td>Thermally optimized screw tie with stainless or hot-dipped galvanized hook</td>
<td>$2.25</td>
</tr>
<tr>
<td>10* Clear water repellent</td>
<td>Silane/siloxane blend</td>
<td>Antigraffiti clear water repellent</td>
<td>$1.75</td>
</tr>
<tr>
<td><strong>EXTERIOR</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total cost to install 10,000 sq ft wall area w/easy drive-up access --&gt;</td>
<td></td>
<td></td>
<td>$32.25</td>
</tr>
</tbody>
</table>

**Pricing Analysis Discussion**

- Low and high baseline costs are based on the baseline products listed. Call for an estimate for alternate product pricing.
- Baseline costs provided will vary based on product specifics and should be used as an estimate only.
- Veneer unit prices are for typical units as noted. Pricing can vary based on size, color, and finish and should be confirmed with the unit manufacturer.
- *See the Resource section of this guide for a list of resources related to this component.
**Critical Barriers**

1. Typical Assembly:
   - Interior gypsum board
   - Vapor retarder
   - Steel-framed wall with batt insulation
   - Exterior sheathing
   - Vapor-permeable self-adhere sheet or fluid-applied AB/WRB field membrane
   - Semi-rigid exterior insulation
   - Air cavity
   - Anchored masonry veneer
   - Clear water repellent
2. Masonry veneer anchor, fasteners bed in sealant, fluid-applied flashing membrane, or self-adhered membrane patches per manufacturer recommendations
3. Continuous mortar collection mesh
4. AB/WRB rough opening head prestrip
5. Hot-dipped galvanized steel loose lintel
6. Weep at maximum 24 inches on-center
7. Two-piece sheet-metal head flashing with 1/2-inch hemmed drip edge and end dams beyond
8. Sheet-metal trim
9. Sealant over backer rod
10. Window strap anchor, bed in AB sealant at sealant joint plane
11. Non-flanged window
12. AB sealant over backer rod tied to continuous seal at window perimeter

**Detail Discussion**

- AB and WRB continuity is provided by the self-adhered sheet or fluid-applied AB/WRB field membrane, the AB/WRB rough opening head prestrip membrane, and the AB sealant transition to the window. Window strap anchors are bed in sealant during fastening to eliminate an AB discontinuity behind the strap anchor that would otherwise lead to both air leakage and water ingress.

- A non-flanged window is used here. It facilitates future window repair and replacement without the need to remove the masonry veneer.

- The hot-dipped galvanized steel loose lintel location allows the exterior insulation to be continuous up to the rough opening. Replace the upper portion of the two-piece sheet-metal flashing with a flexible self-adhered flashing membrane for a thermal improvement; confirm self-adhered flashing membrane compatibility with the AB/WRB manufacturer prior to installation. See Detail 2-D for an example of this detail approach.
Typical Precast and Sheet-Metal Window Sill

**Detail Discussion**

- AB and WRB continuity is provided by the self-adhered sheet or fluid-applied AB/WRB field membrane, the AB/WRB sill membrane, and the AB sealant transition to the window.
- The sheet-metal sill flashing conceals the rainscreen cavity. Terminate the sill flashing with end dams at each jamb. Counterflash each end dam with the sheet-metal jamb trim to close off the rainscreen cavity and complete the WSS.
- Do not place a sheet-metal flashing below the precast sill; it can prematurely degrade the mortar bed beneath the precast element.
**Legend**

1. Typical Assembly:
   - Interior gypsum board
   - Vapor retarder
   - Steel-framed wall with batt insulation
   - Exterior sheathing
   - Vapor permeable self-adhered sheet or fluid-applied AB/WRB field membrane
   - Semi-rigid exterior insulation
   - Air cavity
   - Anchored masonry veneer
   - Clear water repellent
2. Non-flanged window
3. Sealant over bond breaker
5. AB/WRB jamb prestrip membrane
6. Masonry veneer anchor, fasteners bed in sealant, fluid-applied flashing membrane, or self-adhered membrane patches per manufacturer recommendations
7. AB sealant over backer rod, tied to continuous seal at window perimeter
8. Window strap anchor, bed in AB sealant at sealant joint plane

**Detail Discussion**

- AB and WRB continuity is provided by the fluid-applied AB/WRB field membrane, the fluid-applied AB/WRB jamb prestrip membrane, and the AB sealant transition to the window. Window strap anchors are bed in sealant during fastening to eliminate an AB discontinuity behind the strap anchor that would otherwise lead to both air leakage and water ingress.

- This detail allows the exterior insulation to continue up to the rough opening. The sheet-metal attachment to the intermittent angle, exterior of the window's thermal break, improves thermal performance of the jamb condition. This detail is a thermally improved alternative to Detail 3-C.

- The sheet-metal jamb trim is bed in continuous sealant against the anchored masonry veneer for WSS continuity.

- Exterior insulation should be tightly installed around all penetrations including masonry ties.
LEGEND

1. Typical Assembly:
   - Interior gypsum board
   - Vapor retarder
   - Steel-framed wall with batt insulation
   - Exterior sheathing
   - Vapor permeable self-adhered sheet or fluid-applied AB/WRB field membrane
   - Semi-rigid exterior insulation
   - Air cavity
   - Anchored masonry veneer
   - Clear water repellent
2. Flexible self-adhered flashing membrane over semi-rigid insulation and shelf edge
3. Continuous mortar collection net
4. Hot-dipped galvanized steel standoff shelf angle anchored on intermittent knife plates or HSS
5. Vents/weeps at maximum 24 inches on-center
6. Sheet-metal flashing with 1/2-inch hemmed drip edge
7. Backer rod and sealant
8. Vents at maximum 24 inches on-center
9. Fluid-applied flashing membrane, extended onto intermittent knife plate or HSS connection
10. Masonry veneer anchor, fasteners bed in sealant or fluid-applied flashing membrane per manufacturer recommendations
* Size joint for project specific building movement, minimum 3/8-inch.

Detail Discussion

- A flexible self-adhered flashing membrane over the semi-rigid insulation promotes drainage of the rainscreen cavity at the floor line. It is a thermally improved alternative detail to a two-piece sheet-metal flashing as shown in Detail 2-A. When installing the self-adhered membrane ensure it is fit tightly to the substrate and sloped to drain.

- The hot-dipped galvanized steel loose lintel reduces the amount of thermal bridging at the floor line shelf-angle when compared to a continuous shelf angle mounted tight to the concrete slab face.

- Refer to the introductory chapter for alternative lip brick details that reduce the visibility of the backer rod and sealant movement joint. Note this joint is necessary for differential movement that will occur between the structure and anchored masonry veneer.

Typical Standoff Shelf Angle at Floor Line
Detail 2-D
Typical Parapet at Inverted Roof System

**Detail Discussion**

- The concrete roof structure provides the VR layer at this detail.

- Vents are located at the top masonry course to encourage ventilation of the rainscreen cavity. The sheet-metal parapet cap is offset from the face of the anchored masonry veneer so as not to block the ventilation path. The sheet-metal coping and drip edge overhangs the vents to protect the masonry veneer opening from wind-driven rain.

- A compressible filler is used between the anchored masonry veneer and parapet blocking to allow building movement while preventing insects and debris from entering the rainscreen cavity.

- Parapet cavity insulation is provided to create a continuous thermal envelope at the roof-to-wall transition.

**LEGEND**

1. Parapet Assembly
   - Interior gypsum board
   - Vapor retarder
   - Steel-framed wall with batt insulation
   - Exterior sheathing
   - Vapor permeable self-adhered sheet or fluid-applied WRB field membrane
   - Semi-rigid exterior insulation
   - Air cavity
   - Anchored masonry veneer
   - Clear water repellent

2. Inverted roof membrane assembly
3. Standing-seam sheet-metal coping with gasketed washer fasteners
4. Preservative-treated blocking
5. High-temperature self-adhered membrane
6. Compressible filler
7. Vent at maximum 24 inches on-center
8. Masonry veneer anchor, fasteners bed in sealant or fluid-applied flashing membrane per manufacturer recommendations
9. Closed-cell spray foam insulation plug (AB)

* Size joint for project specific building movement, minimum 3/8 inch wide.
LEGEND

1. Steel-framed wall with batt insulation
2. Exterior sheathing
3. Concrete roof structure
4. Steel stud parapet framing
5. Closed-cell spray foam insulation plug (AB)
6. Preservative-treated blocking
7. Vapor-permeable self-adhered sheet or fluid-applied AB/WRB field membrane
8. Fluid-applied AB/WRB head and jamb prestrip membrane
9. Masonry veneer anchor, fasteners bed in sealant or fluid-applied flashing membrane per manufacturer recommendations
10. Two-piece sheet-metal head flashing with 1/2-inch hemmed drip edge and end dams beyond
11. Semi-rigid exterior insulation
12. Hot-dipped galvanized steel loose lintel
13. High-temperature self-adhered membrane
14. Anchored masonry veneer
15. Standing-seam sheet-metal coping with gasketed washer fasteners
16. Inverted roof membrane assembly
17. Non-flanged window
18. Sheet-metal jamb trim

3-D Detail Discussion

- Three-dimensional cutaway sections on the remaining pages of this Chapter represent the two-dimensional details provided for this assembly.

- In all details, WRB and WSS elements are shingle-lapped to encourage water shed in both the rainscreen cavity and at the anchored masonry veneer face.

- As shown in Detail 2-F, horizontally oriented ties such as a double eye and pintle plate ties allow exterior insulation to be installed in horizontal strips between ties. This orientation can improve the efficiency of the anchored masonry veneer installation.

- The two-piece sheet-metal flashing at the window head as shown in Detail 2-F allows the upper flashing to be installed and integrated into the AB/WRB field membrane prior to installation of the lower sheet-metal flashing and hot-dipped galvanized steel loose lintel. As shown, the sheet-metal flashing above the lintel ends at a head joint. This location allows the sheet-metal head flashing to terminate with an end dam.

- Vents/weeps at the floor line above the lintel, as shown in Detail 2-G, provide both drainage and ventilation of the rainscreen cavity above. Mortar collection mesh helps keep the weeps and the base of the rainscreen cavity free of mortar droppings. Vents below the floor line lintel provide ventilation of the rainscreen cavity.

- Detail 2-H describes a typical rough opening with continuous back dam angle. The back dam angle creates a sill pan below the window; intermittent shims below the window promote drainage at the sill and into the rainscreen cavity.

- The sheet-metal jamb trim shown in all details conceals the rainscreen cavity from water exposure and protects the insulation from UV exposure.
1. Steel-framed wall with batt insulation
2. Exterior sheathing
3. Concrete floor slab edge
4. Hot-dipped galvanized steel standoff shelf angle anchored on intermittent knife plates or HSS
5. Vapor-permeable self-adhered sheet or fluid-applied AB/WRB field membrane
6. Masonry veneer anchor, fasteners bed in sealant or fluid-applied flashing membrane per manufacturer recommendations
7. Semi-rigid exterior insulation
8. Sheet-metal flashing with 1/2-inch hemmed drip edge
9. Continuous mortar collection mesh
10. Anchored masonry veneer
11. Non-flanged window
12. Sloped precast concrete sill with sheet-metal sill flashing
13. Vents/weeps at maximum 24 inches on-center

1. Continuous back dam angle at rough opening sill, minimum 1 inch tall. Fasten window through back dam angle per window manufacturer recommendations.
2. Vapor-permeable self-adhered sheet or fluid-applied AB/WRB field membrane
3. Fluid-applied or flexible self-adhered flashing AB/WRB sill membrane
4. Intermittent minimum 1/4-inch shims
5. Continuous AB sealant, tied to continuous seal at window perimeter
6. Non-flanged window
7. AB sealant over backer rod, tied to continuous seal at window perimeter
8. Sloped precast concrete sill with sheet-metal sill flashing
9. Sheet-metal sill flashing with hemmed drip edge, bed in sealant against precast sill
10. Sealant over bond breaker tape between window frame and sheet-metal sill flashing
11. Sheet-metal jamb trim with hemmed edge, bed in sealant against anchored masonry veneer
12. Masonry veneer anchor, fasteners bed in sealant or fluid-applied flashing membrane per manufacturer recommendations
13. Anchored masonry veneer
CHAPTER 3:
WOOD-FRAMED WALL WITH ANCHORED MASONRY VENEER

This Chapter 3 assembly is a rainscreen design approach with wood-framed wall structure and anchored masonry veneer. The components of this assembly, from interior to exterior, are described in Fig. 3-1. This assembly is appropriate for many applications including low- or mid-rise residential or commercial buildings. An example application of this assembly is shown in Fig. 3-2 on page 3-3. Benefits and special considerations for this assembly are discussed in Table 3-1 on page 3-2.

Building Enclosure Control Functions and Critical Barriers

As noted in the introductory chapter of this guide, an above-grade wall assembly should provide control of water, air, heat, vapor, sound, and fire to serve as an effective and durable environmental separator. Control of these elements is provided by critical barriers such as a water-shedding surface (WSS), water-resistive barrier (WRB), air barrier system (AB), thermal envelope, and vapor retarder (VR). Refer to Fig. i-8 on page i-15 of the introductory chapter for a list of primary building enclosure control functions and associated critical barriers.

INTERIOR
- Interior gypsum board
- Vapor retarder
- Wood-framed wall with batt insulation
- Exterior sheathing
- Vapor-permeable air and water-resistive barrier
- Air cavity
- Anchored masonry veneer
- Clear water repellent

Fig. 3-1 Typical Assembly 3 components from interior to exterior.
Table 3-1 Assembly 3 comparison matrix

<table>
<thead>
<tr>
<th>Assembly</th>
<th>No Exterior Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recommended Occupancy Type</td>
<td>Residential or Commercial Recommended</td>
</tr>
<tr>
<td>Building Enclosure Design Approach and Recommended Exposure</td>
<td>Rainscreen Design Approach, Low- to Mid-Rise Exposure</td>
</tr>
<tr>
<td>Long-Term Wall Assembly Durability</td>
<td>Resilient due to rainscreen drainage cavity; effect of split insulation must be carefully considered if provided</td>
</tr>
<tr>
<td>Typical Wall Thickness</td>
<td>Typical thickness for masonry veneer wall</td>
</tr>
<tr>
<td>Typical Cladding Design Compliance</td>
<td>Prescriptive cladding design allowed based on ACI-530 up to 4.5-inch cavity depth (face of backup wall to back of veneer)</td>
</tr>
<tr>
<td>Typical Thermal Performance</td>
<td>Low-conductivity wood framing</td>
</tr>
<tr>
<td>Special Construction Considerations</td>
<td>Anchored systems require code compliant bearing elements</td>
</tr>
<tr>
<td>Construction Ease with Limited / No Exterior Access (property line applications)</td>
<td>Requires exterior access</td>
</tr>
<tr>
<td>Fire Resistivity Considerations</td>
<td>Fire resistivity moderate. Exterior insulation where used may affect fire propagation requirements</td>
</tr>
<tr>
<td>Maintenance Considerations</td>
<td>Regular maintenance required; clear water repellent recommended. Consider flashings and other water-shedding features to reduce quantity of moisture on the face of the masonry</td>
</tr>
<tr>
<td>Price Per Square Foot</td>
<td>Low and High Baseline Cost: $24.25 - $36.50</td>
</tr>
</tbody>
</table>

Fig. 3-3 illustrates the critical barrier locations for this assembly. The critical barriers for typical Chapter 3 assembly details are also provided adjacent to each detail at the end of this chapter.

As shown in Fig. 3-3, the WSS critical barrier occurs at the anchored masonry veneer with most watershielding occurring at the wall face, while some water will be stored within the masonry veneer to be released at a later time. The WRB and AB critical barriers occur at the same location exterior of the wall sheathing. As a result, a single membrane is typically used to provide these two critical barriers and is commonly referred to in this chapter as the air and water-resistive barrier (AB/WRB). The thermal envelope includes the cavity insulation. The VR critical barrier is located at the interior (warm side) of the wood-framed structure.

The following sections provide more information and discuss best practices for critical barriers specific to this assembly.

**Water-Shedding Surface (WSS)**

The water-shedding surface is a critical barrier that controls water.

The anchored masonry veneer cladding, including both mortar joints and masonry veneer units, is the primary WSS of this assembly. Additional components include sheet-metal flashings and drip edges, sealant joints, and fenestration systems as shown on the assembly details included at the end of this chapter.

To promote water shedding at the masonry cladding, joints between masonry units should be appropriately installed with a tooled concave (preferred) or “V” shape.

When finished, the WSS critical barrier should be free of gaps except where providing drainage and/or ventilation. Movement joints and joints around windows and penetrations should be continuously sealed with a backer rod and sealant or counterflushed with a sheet-metal flashing to deflect wind-driven rain and shed water away from the rainscreen cavity.

**Water-Resistive Barrier (WRB)**

The water-resistive barrier is a critical barrier that controls water.

In this assembly, the WRB critical barrier is primarily a vapor-permeable mechanically attached sheet membrane, a self-adhered sheet membrane, or a fluid-applied membrane (that also functions as the AB). A vapor-permeable WRB membrane allows this assembly to dry to the exterior. Drying ability to the exterior...
is not only beneficial during the service life of the building but also helps relieve construction-related moisture that may occur at wood framing or wood-based sheathing products. A vapor-permeable mechanically attached sheet membrane is depicted in the details at the end of this chapter. An example of this WRB membrane type is shown in Fig. 3-4.

The AB/WRB layer must be continuous across the wall face to serve as an effective critical barrier. In addition to the AB/WRB field membrane, the WRB critical barrier also includes fluid-applied or flexible flashing membranes, sealants, sheet-metal flashings, and interfaces with fenestration systems (e.g., windows and doors) as shown in the detail drawings that follow this chapter discussion. Where sheet-metal flashing components occur, the back leg of the sheet-metal flashing is lapped into the AB/WRB field membrane to encourage water at the WRB layer to drain toward the building exterior.

Masonry veneer ties in this assembly will penetrate the AB/WRB critical barrier and should be detailed based on the membrane manufacturer’s installation requirements. Typically, plate ties are bed in a compatible sealant or fluid-applied flashing product or attached through a self-adhered membrane patch, whereas screw ties with gasketing washers typically do not require any detailing at the AB/WRB plane.

Air Barrier (AB)

The air barrier system is a critical barrier that primarily controls air, heat, and vapor. The AB also controls water, sound, and fire.

In this assembly, the AB system critical barrier is the same field membrane that also serves as the WRB critical barrier. The components described in the above Water-Resistive Barrier (WRB) section are also part of the AB layer, except sheet-metal flashings.

Thermal Envelope

The thermal envelope is a critical barrier that controls heat and assists with controlling vapor, sound, and fire.

In this wall assembly, the cavity insulation provides the thermal envelope. At transition details, the thermal envelope also includes parapet cavity insulation and insulation at the roof assembly, slab, and foundation elements. Windows and doors that penetrate this wall are part of the thermal envelope. Exterior insulation may also be used with this assembly as shown in Fig. 3-5 to increase thermal performance.

Additional thermal envelope discussion is provided in the Thermal Performance and Energy Code Compliance section of this chapter and the introductory chapter.

Insulation Selection

The cavity insulation in this assembly is a vapor-permeable fiberglass or mineral fiber batt insulation product.

When exterior insulation is used with this assembly, it is semi-rigid mineral fiber board insulation, which is hydrophobic, tolerates moisture, and has free-draining capabilities. Its vapor permeance allows it to be acceptable for use exterior of a vapor-permeable AB/WRB membrane. The semi-rigid properties of the insulation allow it to be fit tightly around intermittent

Although masonry is defined as a noncombustible cladding material, the use of a combustible air and water-resistive barrier or foam plastic insulation within a wall cavity can trigger fire propagation considerations and requirements. Depending on the local jurisdiction, IBC Section 1403.5 regarding vertical and lateral flame propagation as it relates to a combustible water-resistive barrier may require acceptance criteria for NFPA 285. The use of foam plastic insulation within a wall cavity should also be addressed for IBC Chapter 26 provisions.
attachments such as masonry ties. Vapor-impermeable exterior insulation such as XPS or polyisocyanurate is not recommended for use in this assembly because it limits assembly drying to the exterior.

**Vapor Retarder (VR)**

The VR critical barrier is a layer that retards or greatly reduces (e.g., vapor barrier) the flow of water vapor due to vapor pressure differences across enclosure assemblies.

The VR critical barrier of this assembly is located on the interior (warm side) and is typically at the face of or just behind the interior gypsum board. The VR for this assembly should comply with Section 1405.3 of the governing International Building Code (IBC). In the Northwest, typical VR products include PVA vapor-retarding primer, asphalt-coated kraft paper, or a polyamide film retarder membrane. These products are further discussed in the Introductory chapter.

**Thermal Performance and Energy Code Compliance**

This chapter assembly is typically classified as a “wood-framed and other” above-grade wall for energy code compliance purposes. Prescriptive energy code compliance values for this assembly are summarized in Table 3-3 on page 3-11 and describe:

- Minimum insulation R-values for a prescriptive R-value compliance strategy.
- Maximum assembly U-factors for a prescriptive U-factor alternative compliance strategy. Note, the equivalent assembly effective R-value of this maximum U-factor has been calculated and is denoted in parenthesis ( ) for easy comparison to thermal modeling results included within this chapter.

Wood-framed walls are typically constructed with 16-inch on-center stud spacing for standard framing or 24-inches on-center stud spacing for advanced framing methods. Nominal 2x6 framing accommodates up to an R-21 fiberglass or R-23 mineral fiber batt insulation and nominal 2x8 framing up to an R-30 mineral fiber batt insulation. When continuous insulation requirements are to be met, this assembly will have insulation exterior of the wood frame structure and AB/WRB critical barrier, as shown in Fig. 3-5 on page 3-5.

When a non-prescriptive compliance option (e.g., a trade-off strategy or whole-building modeling strategy) is used for energy code compliance, this assembly’s effective thermal performance will need to be calculated; however, it may or may not be required to meet the prescriptive values shown in Table 3-3 on page 3-11.

Fig. i-17 on page i-29 of the introductory chapter describes the typical process of navigating energy code compliance strategies and options. Thermal modeling results demonstrated within this chapter may be used to assist with estimating insulation and tie selection to achieve a target thermal performance value. Options for thermally optimizing this assembly, as determined through the modeling results are also provided.

**Assembly Effective Thermal Performance**

Exterior insulation in this assembly may or may not be required to meet project-specific energy code compliance; however, when exterior insulation is used, cladding attachments and supports (e.g., masonry ties and shelf angles) will penetrate the exterior insulation and create areas of thermal bridging (i.e., heat loss). An example of the thermal bridging is described by Fig. 3-6 through Fig. 3-9 on page 3-8 and shows the comparative thermal impact of either a continuous or standoff floor line shelf angle. Fig. 3-7 shows a dark blue thermal gradient color (colder temperature) at the floor line edge for the continuous floor line shelf angle, whereas the floor line with a standoff shelf angle is light blue and yellow, indicating warmer temperatures. Thermal bridging reduces the assembly’s effective thermal performance.

Three-dimensional thermal modeling demonstrates this assembly’s effective thermal performance with various insulation thicknesses, insulation R-values, masonry veneer ties, and standoff shelf angle options. A discussion on the modeling performed for this guide is included in the Introduction Chapter and the Appendix.

**Thermal Modeling: Variables**

The following are modeling variables specific to this assembly:

- **Framing and Cavity Insulation:** 2x6 with R-21 batt insulation or 2x8 with R-30 batt insulation. Modeling results include a full-height wood-framed wall with a floor line. Standard framing allowance for 77% insulated cavity and 23% framing members such as studs, plates, and headers is used.
Masonry Ties: Various tie types are considered at 16 inches by 16 inches on-center spacing. Tie types are shown in Fig. 3-10 and include:

- Thermally optimized screw tie with stainless barrel and carbon steel fastener. Hooks are either hot-dipped galvanized steel or Type 304 stainless steel.
- Double eye and pintle plate tie (14-gauge). Hooks are either hot-dipped galvanized steel or Type 304 stainless steel to match the tie plate.

Exterior Insulation: This assembly with and without exterior insulation is considered and includes insulation materials with either a thermal resistance of R-4.2/inch or R-6/inch in thicknesses of 1, 2, and 3 inches. The R-values selected demonstrate the lower and upper thermal resistance of typical exterior insulation products.

Shelf Angle Supports: Hot-dipped galvanized steel shelf angles. Either attached tight to the floor line structure (i.e., continuous shelf angle) as shown in Fig. 3-6 and Fig. 3-7 or offset to the depth of the exterior insulation and supported by intermittent hollow steel sections (HSS) at 4 feet on-center (i.e., standoff shelf angle) as shown similar in Fig. 3-8 and Fig. 3-9.

Thermal Modeling: Results

The results of this modeling are shown in Table 3-2, Fig. 3-11, and Fig. 3-12 on page 3-11 see page 3-10 and page 3-11) and demonstrate the assembly effective R-value under various conditions; Fig. 3-11 and Fig. 3-12 are graphical representations of the results summarized in Table 3-2. Discussion of these results is provided below and key points for thermally optimizing this assembly are italicized in boldface.

- As shown in Table 3-2, the assembly effective R-value without penetrations, as read from the “Cavity + Exterior Insulation (Without Penetrations)” column, is lesser than if the “Nominal Insulation R-Value (Cavity + Exterior)” values were combined. This difference is due to wood framing that creates thermal bridges through the cavity insulation. When masonry ties are considered as shown in the “Without Shelf Angle” column, the assembly effective R-value is further reduced.

- As shown in Table 3-2, the assembly effective R-value without penetrations is reduced anywhere between 2 and 12% when masonry tie penetrations are considered. **Reducing the frequency of ties will increase the effective thermal performance of the assembly but will also need to be coordinated with structural requirements.**

- Stainless steel plate ties and thermally optimized screw ties reduce the assemblies effective R-value without penetrations by 2 and 7%; whereas, galvanized steel plate ties reduce the effective R-value without penetrations by 3 to 12%. Galvanized steel plate ties provide a lesser effective R-value than both the stainless steel or thermally optimized screw tie options as shown in Fig. 3-11. Both stainless steel and thermally optimized screw ties provide similar effective R-value performance. Whether galvanized steel hooks or stainless steel hooks are used for thermally optimized tie selection makes...
**Table 3-2 Assembly 3 thermal modeling results**

<table>
<thead>
<tr>
<th>Exterior Insulation Thickness</th>
<th>Nominal Insulation R-Value (Cavity + Exterior)</th>
<th>Cavity + Exterior Insulation (Without Penetrations)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0&quot;</td>
<td>21 + 0</td>
<td>18.3</td>
</tr>
<tr>
<td>1&quot;</td>
<td>21 + 4.2-6</td>
<td>22.6-24.4</td>
</tr>
<tr>
<td>2&quot;</td>
<td>21 + 8.4-12</td>
<td>26.9-30.6</td>
</tr>
<tr>
<td>3&quot;</td>
<td>21 + 12.6-18</td>
<td>31.1-36.5</td>
</tr>
<tr>
<td>0&quot;</td>
<td>21 + 0</td>
<td>18.3</td>
</tr>
<tr>
<td>1&quot;</td>
<td>21 + 4.2-6</td>
<td>22.6-24.4</td>
</tr>
<tr>
<td>2&quot;</td>
<td>21 + 8.4-12</td>
<td>26.9-30.6</td>
</tr>
<tr>
<td>3&quot;</td>
<td>21 + 12.6-18</td>
<td>31.1-36.5</td>
</tr>
</tbody>
</table>

**Table 3-3 Assembly 3 prescriptive energy code compliance values excerpted from Table i-1 of the introductory chapter**

<table>
<thead>
<tr>
<th>Guide Assembly #</th>
<th>Classification</th>
<th>2012 SEC</th>
<th>2012 WSEC</th>
<th>2014 OESC</th>
<th>2012 IECC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Wood-Framed Wall with Anchored Masonry Veneer</td>
<td>R-13 + R-7.5ci</td>
<td>R-21 int</td>
<td>R-21 int</td>
<td>R-21 int</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.051</td>
<td>U-0.051</td>
<td>U-0.054</td>
<td>U-0.051</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(R-19.6)</td>
<td>(R-19.6)</td>
<td>(R-16.5)</td>
<td>(R-19.6)</td>
</tr>
</tbody>
</table>

**Fig. 3-11 Assembly 3 effective R-value modeling results for various tie types and R-4.2/inch insulation**

**Fig. 3-12 Assembly 3 effective R-value comparison of a galvanized steel plate tie and shelf angle options.**
little difference; however, stainless steel hooks provide better corrosion resistance. Use of a standard all-stainless steel tie option may prove to be a cost-effective option when compared to thermally improved proprietary tie options, and it also provides a highly corrosion-resistant attachment.

- A shelf angle further reduces the assembly effective R-value after ties are considered as shown in Table 3-2 and Fig. 3-12. When considering ties, continuous shelf angles can reduce the assembly's effective R-value by 4 to 20%. However, this is reduced to 2 to 13% when a standoff shelf angle is used. As determined from Fig. 3-12, up to an additional half-inch of insulation may be required to achieve the same effective thermal performance for this assembly if a continuous angle is used in lieu of a standoff shelf angle. **Use of a standoff shelf angle in lieu of the continuous shelf angle improves the effective thermal performance of this assembly and may allow for thinner insulation thicknesses to meet the same assembly effective R-value.**

Sheathing Selection

The exterior sheathing of this assembly is typically a wood- or gypsum-based product and is designated by structural requirements. Where wood-based products are used, plywood is generally recommended for its moisture tolerance. Where gypsum board is used, a product resistant to organic growth and moisture is recommended. Fiberglass-faced gypsum board products should be also used; paper face products should be avoided.

Drainage, Ventilation, and Water Deflection

The anchored masonry veneer is expected to shed most water it is exposed to; however, some moisture is expected to penetrate the cladding and enter the rainscreen cavity. This moisture is drained through the rainscreen cavity and exits the rainscreen system where flashings are provided.

Drainage and Ventilation

A 2-inch-deep rainscreen cavity between the anchored masonry veneer and exterior insulation should be provided to encourage drainage and ventilation. At a minimum, a 1-inch gap may be provided and is also the minimum code-allowable depth. However, the risk that mortar droppings will reduce the drainage and ventilation within the rainscreen cavity is increased with smaller cavities. A 1-inch cavity should only be provided where a strict quality control program is implemented to ensure mortar droppings do not block the cavity. Fig. 3-13 on page 3-13 demonstrates a typical rainscreen cavity for this assembly.
Where the rainscreen cavity is reduced, such as at window rough openings with return brick, a compressible free-draining filler is recommended; semi-rigid mineral fiber board insulation may be used. In any case, mortar should not be packed within these cavities.

The rainscreen cavity is ventilated through vents located at the top and bottom coursing of each wall section. Top vents typically occur just below parapet blocking and below intermittent bearing elements such as floor line shelf-angles. Bottom vents also serve as weeps to assist with drainage of the rainscreen cavity. These vents/weeps are typically located just above bearing elements such as loose lintels, floor line shelf-angles, or foundation walls.

Vents and weeps should be spaced a maximum of 24 inches on-center (e.g., every 2 to 3 masonry units) and filled with a cellular or mesh product that fills the head joint of a standard brick unit. It is important that weep fillers extend into the bed joint of the course to facilitate drainage. Weep tubes should not be used at vent/weep locations because they provide far less ventilation and are blocked easily with debris. An example of a weep/vent and vent at a floor line shelf angle condition are shown in Fig. 3-14.

Mortar collection nets are recommended at all veneer-bearing locations to prevent mortar from blocking the rainscreen cavity and vents/weeps. It is best practice to use a trapezoidal-shaped open-weave, moisture-tolerant net.

Sheet-Metal Components

Sheet-metal components for this assembly are reflected throughout the details located at the end of this chapter. Cross-cavity sheet-metal components are typically located at all bearing elements such as the head of a penetration (e.g., window head), floor line shelf-angles, and foundation. These flashings assist with draining the rainscreen cavity and also serve to protect fluid-applied or flexible flashing membranes that may exist beneath them. Counterflashing sheet-metal components assist only with watershedding and are typically located at windowsill and parapet top conditions; they protect the cavity from water ingress while still allowing for cavity ventilation.

Refer to the Introductory chapter for general recommendations on sheet-metal flashing products, including design considerations and materials.

Movement Joints

For this assembly, anchored clay masonry will expand over time as a result of irreversible moisture gain, and the mortar joints will shrink slightly overtime. In the support system, the wood-framed members will shrink due to moisture loss. To avoid veneer damage, breaks must be provided in the veneer to compensate for differential movement between the cladding and support wall. Expansion joints also must be provided to allow for overall expansion of the clay masonry veneer; control joints must be provided for shrinkage where concrete masonry veneer units are used.

Differential movement between the wall structure and veneer is accommodated with a horizontal gap between the veneer and elements that are directly attached to the wall structure, such as shelf angles, parapet blocking, and windows. Locations where this gap should occur are indicated with an asterisk (*) in the details at the end of this chapter. At each horizontal gap, either a backer rod and sealant joint or a cross-cavity sheet-metal flashing should be placed. The sizing and location of vertical movement joints will vary depending on the expected differential movement between the wall and veneer. It is the Designer of Record’s responsibility to appropriately locate and size each joint. In general, a minimum gap dimension of 3/8 of an inch should be provided.

Expansion/shrinkage of the veneer or differential movement between the veneer, penetrations, and different cladding materials is accommodated with vertical

Fig. 3-14 Cross-cavity sheet-metal flashing with weep/vent above the flashing and vent below the flashing. Staggering the weep/vent locations reduces the likelihood of exposing the vent below the flashing to drainage from the weep location above.
joints in the veneer system. Vertical gaps minimize stresses between the veneer and other components and provide crack control for the masonry veneer. It is the Designer of Record’s responsibility to appropriately locate and size each joint. In general, a minimum gap dimension of 3/8 of an inch should be provided.

Refer to the Introductory chapter for more information on locating movement joints and sealant joint best practices.

Structural Considerations

The wood framing provides the primary structure of this assembly. It is the responsibility of the Designer of Record to ensure that all structural elements are designed to meet project-specific loads and local governing building codes. Generic placement of the framing members and support elements are demonstrated within the details of this chapter and are provided for diagrammatical purposes only.

Masonry Ties

Masonry ties are used to connect the veneer to the wood-framed backup wall and should be designed to resist the out-of-plane loads applied to the wall, typically wind and seismic. At the same time, ties must be flexible to allow the veneer to move in-plane relative to the wood-framed wall.

Building codes provide prescriptive requirements for masonry ties secured to wood-framed walls, including spacing, size, placement and anchor type. These requirements are summarized in Table 3-4 and are based on ACI-530 provisions. The use of these prescriptive requirements is limited to masonry veneer assemblies with a weight less than 40 psf, a cavity depth no more than 4.5 inches, and where the ASCE-7 wind velocity pressure (qz) is less than 55 psf (previously 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). The majority of masonry tie manufacturers have empirical testing data available to support the use of their anchorage systems when the cavity depth or loads exceed these criteria.

Prescriptive spacing requirements for anchored masonry veneers in Table 3-4 include special requirements for Seismic Design Categories D, E, and F and high wind zones with velocity pressures (qz) between 40 and 55 psf. These higher

### Table 3-4 Minimum spacing for anchored masonry veneer ties

<table>
<thead>
<tr>
<th>Spacing Designation</th>
<th>Requirement Category</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>General</td>
</tr>
<tr>
<td>Maximum Wall Area per Anchor</td>
<td>2.67 ft&lt;sup&gt;2&lt;/sup&gt; (75% of General Requirement Max.)</td>
</tr>
<tr>
<td>Maximum Horizontal Spacing</td>
<td>32-inches</td>
</tr>
<tr>
<td>Maximum Vertical Spacing</td>
<td>25-inches</td>
</tr>
<tr>
<td>Maximum Spacing at Opening&lt;sup&gt;(3)&lt;/sup&gt;</td>
<td>36-inches</td>
</tr>
<tr>
<td>Maximum Distance from Openings</td>
<td>12-inches</td>
</tr>
</tbody>
</table>

<sup>(1)</sup>Seismic design categories as determined by ASCE 7.

<sup>(2)</sup>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.

<sup>(3)</sup>For openings larger than 16-inches in either dimension.

seismicity and wind speed areas are common to some parts of the Northwest and are dependent on the geography and building occupancy category. Refer to local building code requirements to ensure seismicity and wind speed criteria are properly evaluated for the building occupancy and site conditions.

Typical tie types for reference are shown in Fig. 3-15 on page 3-18. For wood-framed walls, the code does not restrict the use of any tie type; however, based on local best practices, double eye and pintle type ties—whether a plate or screw type—are preferred. Double eye and pintle ties are available from a number of manufacturers in a variety of sizes to meet project requirements in the Northwest.

Adjustable triangular wire ties are acceptable but may not be preferred by installers because the vertical tie orientation can complicate the exterior insulation installation process by requiring vertical orientation of insulation boards. Do not use corrugate masonry ties due to their limited corrosion resistance. Nonadjustable surface-mounted ties are also not recommended.

To prevent pull-out or push-through of the tie, tie embedment should be a minimum 1.5 inches into the veneer, with at least 5/8 of an inch mortar or grout cover at the outside face. The mortar bed thickness is to be at least twice the thickness of the anchor. To prevent excess movement between connecting parts of adjustable tie systems, limit clearance between components to less than 1/16 of an inch. The vertical offset of an adjustable pintle tie may not exceed 1.25 inches.
Masonry tie should be fastened directly to the wood framing through the exterior sheathing. Masonry anchors are not to be fastened to the sheathing alone. The code requires the use of 8d common nails or fasteners with equivalent pull-out strength. However, in Seismic Design Categories D, E, and F, the code requires the use of 8d ring-shank nails or No. 10 corrosion-resistant screws with a nominal minimum shank diameter of 0.190 inches. It is recommended to use No. 10 corrosion-resistant screws or better.

While the code allows a horizontal anchor spacing up to 32 inches on-center, it is recommended that anchors be placed at 16 inches on-center horizontally to align with the typical stud spacing.

Vertical Supports

Anchored masonry veneers are supported vertically by the building’s foundation or other structural components. There are generally three methods of supporting masonry veneers:

- Structural bearing (foundations, floor slabs, structural beams)
- Intermediate supports (continuous or standoff shelf angles)
- Supports at openings (loose lintel, shelf angle, reinforced masonry lintel, precast concrete lintel)

A structural bearing support and lintel are both shown in Fig. 3-16.

While the function of each support method is different, they must each be designed to eliminate the possibility of cracking and deflection within the veneer. Selection of the appropriate support method should consider the design loads, material type, moisture control, movement provisions, and constructibility.

For wood-framed backings, anchored masonry veneer supported vertically by noncombustible construction may be installed up to a height of 30 feet. Wherever the masonry veneer is supported by wood construction, it must be supported every 12 feet. Best practice for commercial wood-framed construction is to support the lowest portion of the masonry cladding directly on the concrete foundation wall.

When intermediate support is needed above 30 feet, provide vertical support at each floor slab, not exceeding a vertical spacing of 12 feet. When fastening to the floor slab, the masonry must be isolated from the wood construction and should be supported by steel shelf angles anchored directly to the wood-framed rim joist at each floor slab. Do not support the veneer through the vertical wall studs above or below the floor slab. The floor slab design should be sufficient to limit floor deflection to less than L/600 or 0.3 inches, whichever is less. As noted in the above Movement Joints section, a joint should be provided beneath the angle and sealed with elastomeric silicone sealant.

Masonry cladding must also be supported at openings within the veneer, such as windows and doors. This may be done with shelf angles for larger openings, or with loose lintels at smaller openings. Galvanized steel angles are typically used as lintels, except where architectural design dictates the use of reinforced masonry or precast concrete lintels for appearance. Steel angle lintels should span the
opening and bear a minimum of 6 inches onto the adjacent masonry at the jambs of the opening.

**Corrosion Resistance**

To avoid premature cladding replacement, the durability and longevity of metal components within this assembly should match that expected of the masonry veneer cladding system. Metal components within this assembly include veneer ties, vertical support ledgers and lintels, sheet-metal flashings, and fasteners.

Veneer ties should be hot-dipped galvanized carbon steel that complies with ASTM A 153 Class B-2 or stainless steel that complies with AISI Type 304 or 316 such as that shown in Table 3-4. Steel support angles such as ledger angles and lintels should be a minimum G185 hot-dipped galvanized. Sheet-metal flashing components should be manufactured of ASTM A167 Type 304 or 316 stainless steel, which is nonstaining and resistant to the alkaline content of mortar materials.

Whereas the use of stainless steel sheet-metal flashing components is not always economically feasible or aesthetically desirable, prefinishing sheet-metal may be considered. Where used, the base sheet metal should receive a minimum G90 hot-dipped galvanized coating in conformance with ASTM A653 or minimum AZ50 galvalume coating in conformance with ASTM A792. It is recommended that the exposed top finish of the sheet metal be coated with an architectural-grade coating conforming to AAMA 2605.

Fasteners used with all metal components should be corrosion-resistant, either galvanized steel or stainless steel. Consideration should be given to the fastener selection when used with preservative-treated wood to prevent galvanic corrosion.

**Masonry Veneer**

There are several types of anchored masonry veneer products that may be used with this assembly. Those most typical within the Northwest include facing brick made of clay or shale. Concrete facing brick and concrete masonry units are also used.

When using facing brick made from clay or shale, anchored veneer units should comply with ASTM C216 and be severe weather (SW) grade. When using concrete facing brick, anchored veneer units should comply with ASTM C1634. Hollow concrete masonry units used for veneer applications are typically 4-inches deep and should comply with ASTM C90.

Mortar designed for the anchored masonry veneer units should conform to ASTM C270, and type selected should be appropriate for the veneer application; Type N mortar is acceptable for most anchored masonry veneer applications. When selecting mortar, the lowest compressive strength (softest) mortar that satisfies the project requirements should be used.

Appropriate product selection of masonry veneer unit and mortar materials is necessary to provide a durable and water-resistant cladding system. The veneer units and mortar joints should also be installed in conformance with industry standard best practices and manufacturer requirements. The specifics of architectural characteristics and structural properties of the veneer unit, mortar, and reinforcing should be designed and reviewed by a qualified Designer of Record.

Various industry resources are available to assist with veneer design and installation methods and are listed in the References section of this guide.

**Clear Water Repellents**

A clear water repellent should be applied to the anchored masonry veneer of this assembly. Refer to the Introductory chapter for more information on selecting an appropriate clear water repellent and best practice installation guidelines.

**Pricing Analysis**

A pricing analysis for this assembly is provided on Table 3-5 on page 3-22. Pricing demonstrates the relative price per square foot and is based on a 10,000-square-foot wall area with easy drive-up access. Pricing includes all components outboard of the exterior wall sheathing and provides no evaluation for interior finishes (including VR), framing/sheathing, or cavity insulation. Pricing is valued for the 2015–2016 calendar year. Current pricing is also available at www.masonrysystemsguide.com.

**Online Availability**

The content of this guide and additional resources may be accessed online at www.masonrysystemsguide.com. Also available online are downloadable versions of two- and three-dimensional assembly details and cutaway sections as well as sample project specifications. Ongoing updates to references and resources included within this guide can also be accessed.
### Table 3-5 Assembly 3: Wood-framed wall with anchored masonry veneer pricing analysis

<table>
<thead>
<tr>
<th>Assembly Component</th>
<th>Baseline Product</th>
<th>Alternate (call for estimate)</th>
<th>Baseline Cost/ft² (incl. labor)</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>INTERIOR</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Interior gypsum board</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Vapour retarder</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Wood-framed wall with batt insulation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Exterior sheathing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5* Air and water-resistant barrier (AB/WRB)</td>
<td>Fully adhered or mechanically attached sheet-applied membrane</td>
<td>Fluid-applied membrane system</td>
<td>$1.50</td>
<td>$3.50</td>
<td></td>
</tr>
<tr>
<td>6 Air cavity</td>
<td>Not applicable</td>
<td>Not applicable</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7* Anchored masonry veneer (without ties)</td>
<td>SW brick masonry modular unit (3-5/8&quot; x 2-1/4&quot; x 7-5/8&quot;) FBX, running bond; Type S or N mortar</td>
<td>No specified alternate</td>
<td>$25.00</td>
<td>$26.50</td>
<td></td>
</tr>
<tr>
<td>8* Anchored masonry veneer ties</td>
<td>14-gauge hot-dipped galvanized or stainless steel plate tie, including fasteners</td>
<td>Thermally optimized screw tie with stainless or hot dipped galvanized hook</td>
<td>$2.25</td>
<td>$5.00</td>
<td></td>
</tr>
<tr>
<td>9* Clear water repellent</td>
<td>Silane/siloxane blend</td>
<td>Antigraffiti clear water repellent</td>
<td>$1.75</td>
<td>$2.25</td>
<td></td>
</tr>
<tr>
<td><strong>EXTERIOR</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total cost to install 10,000 sq ft wall area w/easy drive-up access</td>
<td></td>
<td></td>
<td></td>
<td>$30.50</td>
<td>$37.25</td>
</tr>
</tbody>
</table>

### Pricing Analysis Discussion

- Low and high baseline costs are based on the baseline products listed. Call for an estimate for alternate product pricing.
- Baseline costs provided will vary based on product specifics and should be used as an estimate only.
- Veneer unit prices are for typical units as noted. Pricing can vary based on size, color, and finish and should be confirmed with the unit manufacturer.
- *See the Resources section of this guide for a list of resources related to this component.
LEGEND

1. Typical Assembly:
   - interior gypsum board
   - vapor retarder
   - wood-framed wall with batt insulation
   - exterior sheathing
   - vapor-permeable sheet-applied AB/WRB field membrane
   - air cavity
   - anchored masonry veneer
   - clear water repellent
2. Masonry veneer anchor over flexible self-adhered membrane patch
3. Continuous mortar collection mesh
4. Continuous AB sealant
5. Hot-dipped galvanized steel lintel (loose or anchored)
6. Vapor-permeable sheet-applied or fluid-applied AB/WRB head prestrip membrane
7. Weep at maximum 24 inches on-center
8. Sheet-metal head flashing with 1/2-inch hemmed drip edge and end dams beyond
9. Sealant over backer rod
10. AB sealant over backer rod, tie to continuous seal at window perimeter
11. Flanged window

Detail Discussion

- AB and WRB continuity is provided by the sheet-applied AB/WRB field membrane, sheet-applied or fluid-applied AB/WRB rough opening head prestrip membrane, continuous AB sealant, and AB sealant transition to the window.

- A flanged window is depicted. Consider using a non-flanged window unit to facilitate future window repair and replacement without the need to remove the anchored masonry veneer. Refer to window strap anchor detailing in Chapter 2 details when a non-flanged window is used.

- Refer to the introductory chapter of this guide for lip brick detailing options which can minimize the appearance of the sheet-metal flashing shown in this detail.

- Weeps located above the lintel provide rainscreen cavity ventilation and drainage. The mortar collection mesh keep weeps clear of mortar droppings.
**LEGEND**

1. Typical Assembly:
   - interior gypsum board
   - vapor retarder
   - wood-framed wall with batt insulation
   - exterior sheathing
   - vapor-permeable sheet-applied AB/WRB field membrane
   - air cavity
   - anchored masonry veneer
   - clear water repellent
2. Flanged window
3. Sealant over backer rod
4. Intermittent minimum 1/4-inch shims
5. Intermittent minimum 1/4-inch shims behind sill flange for drainage
6. Sloped precast concrete sill
7. Fluid-applied AB/WRB sill membrane (or flexible self-adhered flashing membrane)
8. Masonry veneer anchor over flexible self-adhered membrane patch per AB/WRB field membrane manufacturer recommendations
9. Continuous AB sealant. Tie to continuous seal at window perimeter.
10. Continuous back dam angle at rough opening sill, minimum 1 inch tall. Fasten window through back dam angle per window manufacturer recommendations.

**Detail Discussion**

- AB and WRB continuity is provided by the sheet-applied AB/WRB field membrane, fluid-applied AB/WRB sill membrane (or flexible self-adhered flashing membrane), and AB sealant transition to the window.

- A flanged window is depicted. Consider using a non-flanged window unit to facilitate future window repair and replacement without the need to remove the anchored masonry veneer. Refer window strap anchor detailing in Chapter 2 details when a non-flanged window is used.

- Do not place a sheet-metal flashing below the precast sill. It can prematurely degrade the mortar bed beneath the precast element.
**LEGEND**

1. Typical Assembly:
   - interior gypsum board
   - vapor retarder
   - wood framed wall with batt insulation
   - exterior sheathing
   - vapor-permeable sheet-applied AB/WRB field membrane
   - air cavity
   - anchored masonry veneer
   - clear water repellent
2. Flanged window
3. Sealant over backer rod
4. Minimum 1/2 inch drainage path, fill with free draining compressible material
5. Vapor-permeable sheet-applied or fluid-applied AB/WRB jamb prestrip membrane
6. Masonry veneer anchor over flexible self-adhered membrane patch per AB/WRB field membrane manufacturer recommendations

**Detail Discussion**

- AB and WRB continuity is provided by the sheet-applied AB/WRB field membrane, sheet-applied or fluid-applied AB/WRB rough opening sill membrane, and AB sealant transition to the window.

- Maintain a clear drainage cavity between the brick return and AB/WRB by placing a free draining material such as semi-rigid mineral fiber board insulation between the masonry veneer and sheet-applied AB/WRB jamb prestrip. Do not fill this space with mortar.

- When exterior insulation is used with this assembly, consider the Chapter 2 rough opening details with sheet-metal jamb trim and sill flashing. Chapter 2 details are a thermally improved alternate to returning the masonry veneer at the jamb which reduce the exterior insulation thickness at the window perimeter.

**Typical Brick Return at Window Jamb**

Detail 3-C
**LEGEND**

1. Typical Assembly:
   - interior gypsum board
   - vapor retarder
   - wood-framed wall with batt insulation
   - exterior sheathing
   - vapor-permeable sheet-applied AB/WRB field membrane
   - air cavity
   - anchored masonry veneer
   - clear water repellent
2. Continuous AB sealant
3. Flexible self-adhered flashing membrane or fluid-applied flashing membrane
4. Continuous mortar collection mesh
5. Hot-dipped galvanized steel shelf angle anchored to structure
6. Rigid XPS insulation, sealed or foamed at perimeter and joints
7. Weep at minimum 24 inches on-center
8. Sheet-metal flashing with hemmed drip edge
9. Sealant over backer rod
10. Flexible self-adhered or fluid-applied flashing membrane
11. Masonry veneer anchor over flexible self-adhered membrane patch per AB/WRB field membrane manufacturer recommendations

* Size joint for project-specific building movement, minimum 3/8-inch wide.

**Detail Discussion**

- AB and WRB continuity is provided by the sheet-applied AB/WRB field membrane, flexible self-adhered or fluid-applied flashing membrane, and continuous AB sealant. Use of a flexible self-adhered or fluid-applied flashing membrane behind the lintel reduces the opportunity for air leakage at anchor locations.

- Mortar collection mesh and weeps are provided to encourage drainage and ventilation of the rainscreen cavity.

- The floor line is insulated with a rigid board insulation and sealed at the edges to provide both thermal envelope continuity and VR layer continuity.

- Refer to the Introductory chapter for alternate lip brick details which reduce the visibility of the backer rod and sealant movement joint. Note this joint is necessary for differential movement that will occur between the structure and anchored masonry veneer.

*Typical Floor Line with Continuous Shelf Angle*  
Detail 3-D
1. Parapet Assembly
   - conventional roof membrane
   - exterior sheathing
   - vented wood-framed parapet
   - exterior sheathing
   - vapor-permeable sheet-applied AB/WRB field membrane
   - air cavity
   - anchored masonry veneer
   - clear water repellent
2. Conventional roof assembly
3. Standing-seam sheet-metal coping with gasketed washer fasteners
4. High-temperature self-adhered membrane
5. Compressible filler
6. Weep at minimum 24 inches on-center
7. Masonry veneer anchor over flexible self-adhered membrane patch per AB/WRB field membrane manufacturer recommendations
8. Continuous bead of AB sealant
9. Closed-cell spray foam insulation plug (AB)
10. Preservative-treated blocking
11. Insect screen
   * Size joint for project specific building movement, minimum 3/8 inch wide

**Detail Discussion**

- A weep is located at the top masonry course to encourage ventilation of the rainscreen cavity. The sheet-metal parapet cap is offset from the face of the anchored masonry veneer so as not to block the ventilation path. The sheet-metal coping and weep overhang the weeps to protect the masonry veneer opening from wind-driven rain.

- A compressible filler is used between the anchored masonry veneer and parapet blocking to allow building movement while preventing insects and debris from entering the rainscreen cavity.

- Parapet cavity insulation is provided to create a continuous thermal envelope at the roof-to-wall transition.

- AB continuity in this assembly is created by the continuous AB sealant at the parapet and closed cell spray foam insulation within the wood-framed parapet cavity.
LEGEND

1. Wood-framed wall with batt insulation
2. Exterior sheathing
3. Wood-framed parapet
4. Closed-cell spray foam insulation plug (AB)
5. Preservative treated blocking, sloped to drain toward roof
6. Vapor-permeable AB/WRB field membrane
7. Vapor-permeable sheet-applied or fluid-applied AB/WRB head prestrip membrane
8. Masonry veneer anchor over flexible self-adhered membrane patch per AB/WRB field membrane manufacturer recommendations
9. Anchored masonry veneer
10. Hot-dipped galvanized steel loose or anchored lintel
11. Sheet-metal head flashing with 1/2-inch hemmed drip edge and end dams beyond
12. Continuous AB sealant
13. Conventional roof assembly
14. High-temperature self-adhered membrane
15. Standing-seam sheet-metal coping with gasketed washer fasteners
16. Rigid insulation sealed at perimeter and joints

3-D Detail Discussion

- Three-dimensional cutaway sections on the next three pages represent two-dimensional details of this assembly.

- In all details, WRB and WSS elements are shingle lapped to encourage water shed, in both the rainscreen cavity and at the anchored masonry veneer face.

- As shown in Detail 3-F, the lintel is placed above the window head and shingle lapped into the AB/WRB field membrane. The continuous AB sealant above this location provides AB continuity between the AB/WRB head prestrip and AB/WRB field membrane.

- AB continuity is created at the parapet in Detail 3-F with the line of continuous AB sealant at the parapet and closed cell spray foam insulation within the parapet cavity framing. These components assist with transferring the AB critical barrier across the parapet sheathing to the AB at the roof assembly.

- Terminate the loose lintel and two-piece sheet-metal head flashing in Detail 3-F at a masonry veneer head joint. This allows for an end dam to be formed at the sheet metal termination.

- Weeps at the floor line lintel, as shown in Detail 2-G, provide both drainage and ventilation of the rainscreen cavity above. Mortar collection mesh helps keep the weeps and base of the rainscreen cavity free of mortar droppings.

- Detail 3-H describes a typical rough opening with sill back dam angle. The back dam angle creates a sill pan below the window; intermittent shims encourage drainage at the sill and into the rainscreen cavity.
**Base of Wall Section Model**

Detail 3-G

1. Wood-framed wall with batt insulation
2. Rigid XPS thermal insulation, sealed or foamed at perimeter and joints
3. Exterior sheathing
4. Flexible self-adhered or fluid-applied flashing membrane
5. Sheet-metal flashing with hemmed drip edge over hot-dipped galvanized steel shelf angle anchored to rim joist
6. Flexible self-adhered or fluid-applied flashing membrane
7. Continuous bead of AB sealant
8. Vapor permeable AB/WRB field membrane
9. Continuous mortar collection mesh
10. Masonry veneer anchor over flexible self-adhered membrane patch per AB/WRB field membrane manufacturer recommendations
11. Anchored masonry veneer
12. Sealant over backer rod (movement joint)
13. Weep at minimum 24 inches on-center

**Window Jamb / Sill Section Model**

Detail 3-H

1. Continuous back dam angle at rough opening sill, minimum 1-inch tall. Fasten window through back dam angle per window manufacturer recommendations.
2. Vapor permeable sheet-applied AB/WRB field membrane
3. Fluid-applied AB/WRB sill membrane (or flexible self-adhered flashing membrane)
4. Vapor-permeable sheet-applied or fluid-applied AB/WRB jamb prestrip membrane
5. Intermittent minimum 1/4-inch shims
6. Continuous AB sealant, tie to continuous seal at window perimeter
7. Masonry veneer anchor over flexible self-adhered membrane patch per AB/WRB field membrane manufacturer recommendations
8. Anchored masonry veneer
9. Flanged window
10. Precast concrete sill
11. Sealant between precast sill and window frame. Tie to sealant between window jamb and masonry veneer.
CHAPTER 4:
INTEGRALLY INSULATED CMU WALL

The Chapter 4 assembly is a mass wall design approach with a single-wythe concrete masonry unit (CMU) wall structure and core insulation. The components of this assembly, from interior to exterior, are described in Fig. 4-1. Commonly, split-face block is used for this assembly. This assembly is appropriate for low-rise commercial applications; an example application is shown in Fig. 4-2 on page 4-3. Benefits and special considerations for this assembly are discussed in Table 4-1 on page 4-2.

Building Enclosure Control Functions and Critical Barriers

As noted in the Introduction, an above-grade wall assembly should provide control of water, air, heat, vapor, sound, and fire to serve as an effective and durable environmental separator. Control of these elements is provided by critical barriers such as a water-shedding surface (WSS), water-resistive barrier (WRB), air barrier system (AB), thermal envelope, and vapor retarder (VR). Refer to Fig. i-8 on page i-15 of the introductory chapter for a list of primary building enclosure control functions and associated critical barriers.

**INTERIOR**
- Single-wythe CMU wall with water-repellent admixture
- Core insulation (or grout, where required)
- Clear water-repellent

**EXTERIOR**
Fig. 4-3 illustrates the locations of the critical barrier locations for this assembly. The critical barriers for this assembly are also provided adjacent to each detail at the end of this chapter.

As shown in Fig. 4-3, the WRB and WSS critical barriers occur at/near the CMU wall structure face; the CMU wall structure is also the AB under certain provisions as discussed later in this chapter. The thermal envelope consists of the intermittent foam-insulated core, which may be either resinous foam insulation or loose fill such as perlite. This assembly has no defined VR critical barrier.

The following sections provide more information and discuss best practices for the specific critical barriers of this assembly.

**Water-Shedding Surface (WSS)**

The WSS is a critical barrier that controls water.

The CMU wall itself, along with grout and core insulation provide the WSS of this assembly. Additional components include sheet-metal flashings and drip edges, sealant joints, and fenestration systems as shown on the details included at the end of this chapter.

Water repellent admixtures are added to the block and mortar of this assembly and a surface-applied clear-water repellent is also recommended. These repellents—along with other measures such as tooled “V” or concave shape (preferred) mortar joints, sufficient sheet-metal parapet cap design, and other general design recommendations as discussed in the Northwest Concrete Masonry Association (NWCMA) TEK Note on Rain-Resistant Architectural Concrete Masonry—serve to encourage water shed.

When finished, the WSS critical barrier should be free of gaps. Movement joints and joints around fenestrations and penetrations should be continuously sealed with a backer rod and sealant.

**Water-Resistive Barrier (WRB)**

The water-resistive barrier is a critical barrier that controls water.

Like the WSS, the CMU wall itself along with grout, mortar, and core insulation provide the WRB critical barrier of this assembly. The addition of water-repellent admixtures within the block and mortar and the use of a surface-applied clear water repellent at the wall face will assist with increasing the water-resistivity of the assembly. Additional measures, such as those discussed in the Water-Shedding Surface (WSS) section of this chapter and addressed within the NWCMA Tek Note on Rain Resistant Architectural Concrete Masonry, increase the water-resistivity of the assembly.

---

**Table 4-1 Assembly 4 comparison matrix excerpt from the introductory chapter**

<table>
<thead>
<tr>
<th>Assembly Category</th>
<th>Integrally Insulated CMU Wall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recommended Occupancy Type</td>
<td>Commercial</td>
</tr>
<tr>
<td>Building Enclosure Design Approach and Exposure</td>
<td>Mass Wall Design Approach, Low-Rise Exposure</td>
</tr>
<tr>
<td>Long-Term Wall Assembly Durability</td>
<td>Structural durability high. Water repellents (admixture and surface applied) and/or opaque coatings provide water resistivity.</td>
</tr>
<tr>
<td>Typical Wall Thickness</td>
<td>Typical-thickness for single-wythe CMU wall</td>
</tr>
<tr>
<td>Typical Cladding Design Compliance</td>
<td>Prescriptive/Engineered</td>
</tr>
<tr>
<td>Typical Thermal Performance</td>
<td>Core insulation provided to meet code compliance; may qualify for energy code compliance exceptions in some areas</td>
</tr>
<tr>
<td>Special Construction Considerations</td>
<td>Single-wythe wall only; lacks additional cladding and insulation; added moisture control measures recommended</td>
</tr>
<tr>
<td>Construction Ease with Limited / No Exterior Access (property line applications)</td>
<td>No exterior access required; however, installation of repellents or coatings is limited</td>
</tr>
<tr>
<td>Fire Resistivity Considerations</td>
<td>Fire resistivity high.</td>
</tr>
<tr>
<td>Maintenance Considerations</td>
<td>Regular maintenance required; clear water repellent recommended.</td>
</tr>
<tr>
<td>Price Per Square Foot</td>
<td>Low and High Baseline Cost: $24.25 - $36.50</td>
</tr>
</tbody>
</table>

---

**Fig. 4-2 Typical Assembly 4 application**

**Fig. 4-3 Critical barrier locations for Assembly 4**
Additional WRB components include flexible flashing membranes at parapet tops, fluid-applied flashings at rough openings, sealant joints, and fenestration systems as shown on the details included at the end of this assembly chapter.

To increase the water-resistivity of this assembly, a vapor-permeable fluid-applied WRB may be applied to the inside face of the assembly, or an elastomeric coating applied to the exterior CMU wall face may be considered. Refer to the introductory chapter for more information on vapor-permeable WRB discussion.

Air Barrier (AB)

The air barrier is a critical barrier that primarily controls air, heat, and vapor. The AB also controls water, sound, and fire.

The AB system in this assembly is typically satisfied through “deemed to comply” options within the energy codes that govern in the Northwest. Section C402.4 of the 2012 International Energy Conservation Code (IECC), Washington State Energy Code (WSEC), Seattle Energy Code (SEC) and Section 502.4 of the 2014 Oregon Energy Efficiency Specialty Code (OEESC) include “deemed to comply” air barrier considerations including:

- Fully grouted concrete block masonry is a deemed to comply AB material.
- “Concrete masonry walls coated with one application either of block filler or two applications of paint or sealer coating” is a deemed-to-comply air barrier assembly provided all joints are sealed.
- “A Portland cement/sand parge, stucco, or plater minimum 1/2-inch in thickness” is a deemed-to-comply air barrier assembly.

Where a fluid-applied AB and WRB membrane is opted for at the interior face of this assembly or an exterior elastomeric coating applied, these membranes along with window rough opening detailing form the AB system.

Thermal Envelope

The thermal envelope is a critical barrier that controls heat and assists with controlling vapor, sound, and fire.

In this wall assembly, the core insulation provides the thermal envelope. At transition details, the thermal envelope also includes insulation at the roof assembly, slab, and foundation elements. Windows and doors that penetrate this wall are part of the thermal envelope.

The CMU wall of this assembly is also a thermal mass; thus, may provide thermal mass benefits as discussed in the introductory chapter.

Additional thermal envelope discussion is provided in the Thermal Performance and Energy Code Compliance section of this chapter and the introductory chapter.

Insulation Selection

This assembly uses core insulation to meet thermal performance requirements of the energy code. Insulation may be loose fill such as perlite but is commonly an expanding resinous foam-in-place insulation product. Foam-in-place insulation is injected through ports typically drilled through the CMU mortar joints following the construction of the CMU wall and grouting similar to that shown in Fig. 4-4.

Vapor Retarder (VR)

The VR critical barrier is a layer that retards or greatly reduces (e.g., vapor barrier) the flow of water vapor due to vapor pressure differences across enclosure assemblies. Unlike the other critical barriers presented in this guide, the VR is not always necessary or required to be continuous.

This assembly has no vapor retarder and utilizes the IBC Section 1405.3 vapor retarder exception for “construction where moisture or its freezing will not damage the materials.” Note that the partially grouted cells do have some vapor-retarding properties but are not relied upon for control of vapor diffusion.

Thermal Performance and Energy Code Compliance

This chapter assembly is typically classified as a “mass” for energy code compliance purposes. Prescriptive energy code compliance values for this assembly are summarized in Table 4-3 on page 4-8 and describe:

- Minimum insulation R-values for a prescriptive R-value compliance strategy. When complying with this strategy, Chapters 1, 5, and 6 assemblies should be considered.
• Maximum assembly U-factors for a prescriptive U-factor alternative compliance strategy. The effective thermal performance of this assembly is dependent on the properties of the CMU (including density, size, and web configuration) and is also impacted by the grouting schedule and core insulation type. Assembly thermal performance values may be determined from the Thermal Catalog of Concrete Masonry Assemblies published by the National Concrete Masonry Association.

• Footnote (2) for compliance by exception. The exception within the 2012 WSEC and 2014 OEESC may be used:

"Provided at least 50% of block cores are filled with vermiculite (or equivalent fill insulation) and enclosing one of the following uses: gymnasium, auditorium, church chapel, arena, kennel, manufacturing plant, indoor swimming pool, pump station, water and wastewater treatment facility, storage facility, and motor vehicle service facility."

The 2012 WSEC further clarifies:

"Where additional uses not listed (such as office, retail, etc.) are contained within the building, the exterior walls that enclose these areas may not utilize this exception."

A grouted area calculation chart is provided in Table 4-2 to assist with determining the area percentages of grouted cores versus ungrouted cores (e.g., cores available for insulation fill).

When a non-prescriptive compliance option (e.g., a trade-off strategy or whole-building modeling strategy) is used for energy code compliance, this assembly’s effective thermal performance will need to be calculated; however, it may or may not be required to meet the prescriptive values shown in Table 4-3.

Refer to Fig. i-17 on page i-29 of the introductory chapter, which describes the typical process of navigating energy code compliance strategies and options.

### Movement Joints

The CMU wall of this assembly functions as both the WSS and the structure. CMU is a concrete-based product. It, along with the mortar, will shrink over time due to initial drying, temperature fluctuations, and carbonation. Not only will shrinkage movement need to be considered, but differential movement between the CMU structure and other structural elements, deflection, settlement, and various design loads will need to be addressed.

Crack control within the CMU should be considered to increase water-resistivity of this assembly. Material properties and reinforcing methods of the CMU structural wall should be implemented to reduce cracking; however, control joints within the CMU wall should be implemented to provide a plane of weakness to reduce shrinkage stresses and provide continuity of the WSS at these locations. Control joints in CMU can be constructed in a number of ways. Regardless of the method used, a continuous backer rod and sealant joint should be installed at the joint as shown in Fig. 4-5 on page 4-8 to assist with water shedding and water penetration resistance.

Refer to the introductory chapter for more information on locating movement joints and sealant joint best practices.

### Structural Considerations

The CMU block wall of this assembly provides the primary structure of this assembly. It is the responsibility of the Designer of Record to ensure that all structural elements are designed to meet project-specific loads and local governing building codes. Generic placement of grout and reinforced elements are demonstrated within the details of this chapter and are provided for diagrammatic purposes only.

![Project-specific thermal performance values for the opaque above-grade wall assembly of this chapter should be used for energy code compliance and should be determined from a source that is approved by the local governing jurisdiction. Sources may include the Appendices of the WSEC and SEC, ASHRAE 90.1, COMcheck, thermal modeling, or other industry resources.](image-url)
#### Opaque Above-Grade Wall - Thermal Envelope Requirements

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Climate Zone</td>
<td>5 and Marine 4</td>
<td>5 and Marine 4</td>
<td>5 and Marine 4</td>
<td>5 and Marine 4</td>
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<tr>
<td>Guide Assembly</td>
<td>Classification</td>
<td>All Other</td>
<td>Group R</td>
<td>All Other</td>
</tr>
<tr>
<td>4</td>
<td>Integrally Insulated CMU</td>
<td>Mass</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| | Exposed: R-16ci | | | | | | | |
| | (1) | | | | | | | |
| | Interior: R-13ci | | | | | | | |
| | (2) | | | | | | | |
| | Interior: R-13ci | | | | | | | |
| | (2) | | | | | | | |
| | Interior: R-13ci | | | | | | | |
| | (2) | | | | | | | |
| | Interior: R-13ci | | | | | | | |
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| | Interior: R-13ci | | | | | | | |
| | (2) | | | | | | | |
Online Availability

The content of this guide and additional resources may be accessed online at www.masonrysystemsguide.com. Also available online are downloadable versions of two- and three-dimensional assembly details and cutaway sections as well as sample project specifications. Ongoing updates to references and resources included within this guide can also be accessed.

Table 4-4 Assembly 4 integrally insulated CMU pricing analysis

<table>
<thead>
<tr>
<th>Assembly Component</th>
<th>Baseline Product</th>
<th>Alternate (call for estimate)</th>
<th>Baseline Cost/ft² (incl. labor)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>INTERIOR</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1* Structural CMU wall</td>
<td>8&quot;x8&quot;x16&quot; standard split-face block with integral block and mortar water repellent; partially grouted</td>
<td>No specified alternate</td>
<td>$19.00</td>
</tr>
<tr>
<td>2 Optional</td>
<td>Groundface block and colors alternates</td>
<td>No specified alternate</td>
<td>$0.75</td>
</tr>
<tr>
<td>3 Rebar</td>
<td>Standard code reinforcement; minimum Category D requirement</td>
<td>Additional reinforcing</td>
<td>$2.00</td>
</tr>
<tr>
<td>4 Core insulation</td>
<td>Resinous foam insulation at block cores</td>
<td>Perlite insulated cores</td>
<td>$1.25</td>
</tr>
<tr>
<td>5* Clear water repellent</td>
<td>Surface-applied clear water repellent</td>
<td>No specified alternate</td>
<td>$1.25</td>
</tr>
<tr>
<td><strong>EXTERIOR</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total cost to install 10,000 sq ft wall area w/easy drive-up access</td>
<td>$24.25</td>
<td>$36.50</td>
<td></td>
</tr>
</tbody>
</table>

Pricing Analysis Discussion

- Low and high baseline costs are based on the baseline products listed. Call for an estimate for alternate product pricing.
- Baseline costs provided will vary based on product specifics and should be used as an estimate only.
- Block prices are for typical units as noted. Pricing can vary based on size, color, and finish and should be confirmed with the unit manufacturer.
- * See the Resources section of this guide for a list of resources related to this component.
**Critical Barriers**

1. Typical Assembly:
   - Single-wythe CMU wall with water-repellent admixture at block and mortar
   - Partial core insulation
   - Clear water repellent
2. Sealant over backer rod
3. Fluid-applied AB/WRB flashing membrane
4. Continuous AB sealant, tie to continuous seal at window perimeter
5. Continuous back dam angle at rough opening perimeter, minimum 1 inch tall. Fasten window through back dam angle per window manufacturer recommendations
6. Storefront window

**Detail Discussion**

- To promote watershed away from the window and wall below, consider a sheet-metal flashing with hemmed drip edge as shown in Fig. 4-6.
- AB and WRB continuity is provided by the fully grouted or insulated CMU cores, fluid-applied flashing membrane at the rough opening, and AB sealant transition to the storefront.
- The WSS and WRB critical barriers are at/near the face of the CMU wall. The backer rod and sealant provides continuity of the WSS between the CMU wall and storefront window.

**Fig. 4-6 Assembly 4 alternate sheet-metal head flashing**
Critical Barriers

1. Typical Assembly:
   - Single-wythe CMU wall with water-repellent admixture at block and mortar
   - Partial core insulation
   - Clear water repellent
2. Storefront window
3. Minimum 1/4-inch intermittent shims
4. Fluid-applied AB/WRB flashing membrane
5. Wept backer rod and sealant joint
6. Sloped precast concrete sill
7. Continuous AB sealant tied to continuous seal at window perimeter
8. Continuous back dam angle at rough opening perimeter, minimum 1-inch tall, with window fastened through the back dam angle per window manufacturer recommendations

Detail Discussion

- Intermittent shims which support the sill allow the window rough opening to drain to the exterior. The exterior backer rod and sealant joint at the sill is wept at 1/4-points along the sill to allow for drainage.

- When a sill can is used with the storefront system, a fluid-applied flashing membrane at the rough opening should still be used as shown in this detail. The sealant joint at the sill is wept to provide drainage of the window rough opening.

Precast Window Sill
Detail 4-B
1. Typical Assembly:
   - Single wythe CMU wall with water-repellent admixture at block and mortar
   - Partial core insulation
   - Clear water repellent
2. Storefront window
3. Sealant over backer rod
4. Fluid-applied AB/WRB flashing membrane
5. Continuous AB sealant tied to continuous seal at window perimeter
6. Continuous back dam angle at rough opening perimeter, minimum 1 inch tall with the window fastened through the back dam angle per window manufacturer recommendations

**Detail Discussion**

- A fluid-applied flashing is recommended at the window rough opening due to its self-terminating properties.
- The continuous back dam angle shown allows for perimeter attachment of the storefront window without the need for F-clips or similar anchors which often inhibit the AB system critical barrier at the window perimeter. Attachment methods for the storefront window should be confirmed with the window manufacturer during the design phase of the project.
**Detail Discussion**

- The sheet-metal base-of-wall flashing protects the rigid XPS foundation insulation from UV exposure and damage. The hemmed edge strengthens the sheet-metal flashing to reduce visual oil-canning. Acceptability of this sheet-metal flashing placement should be confirmed with the project's structural engineer.

- A step at the thickened concrete floor slab perimeter encourages any water collection at the wall base to occur below the finish floor elevation. A minimum of 2-inches should be provided.

- The continuous AB seal transfers the AB system critical barrier from the CMU wall assembly to the concrete floor slab.
**Critical Barriers**

1. Parapet Assembly
   - Inverted roof membrane system
   - Single-wythe CMU wall with water-repellent admixture at block and mortar
   - Partial core insulation
   - Clear water repellent
2. Inverted roof membrane assembly
3. Typical Assembly:
   - Single-wythe split-face CMU wall with water-repellent admixture at block and mortar
   - Partial core insulation
   - Clear water repellent
4. Standing-seam sheet-metal coping with gasketed washer fasteners
5. Preservative-treated blocking
6. High-temperature self-adhered membrane

**Detail Discussion**

- The sheet-metal coping with hemmed drip edge protects the wall top and assists with shedding water away from the CMU wall face. The sheet-metal cap should counterflash the top course of block by a minimum of 3-inches.
- When a fluid-applied AB/WRB membrane is applied to the interior face of the single-wythe CMU (to increase water-resistivity and/or to assist with airtightness) this membrane should extend onto the bottom of the roof structure and should be continuous around anchors.

**Typical Parapet at Inverted Roof Membrane Assembly**

**Detail 4-E**
LEGEND

1. Single-wythe CMU wall with water-repellent admixture within block and mortar
2. Partially grouted CMU wall
3. Preservative-treated blocking
4. High-temperature self-adhered membrane
5. Standing-seam sheet-metal coping with gasketed washer fasteners
6. Inverted roof membrane assembly
7. Storefront window

3-D Detail Discussion

- Three-dimensional cutaway sections on the next three pages represent two-dimensional details of this assembly.
- This assembly is deemed to comply with some energy code exceptions when at least 50% of the CMU cores are insulated. Some cores may be grouted as shown in Detail 4-F and others insulated as shown in Detail 4-G.
- The high-temperature self-adhered membrane and standing-seam sheet-metal coping protect the top of the wall from water exposure. The sheet-metal drip edge deflects water away from the wall face.
- Detail 4-H describes a typical rough opening with continuous back dam angle. The sill back dam angle creates a sill pan below the window; intermittent shims below the storefront window promote drainage at the sill and out through the sealant joint weeps.
- As shown in Detail 4-G, insulation below the thickened concrete floor slab and exterior of the foundation wall provide additional protection against heat loss at the wall-to-slab interface. The sheet-metal flashing protects the XPS insulation from UV and damage.
Base of Wall Cutaway Section
Detail 4-G

- 1. Thickened concrete floor slab
- 2. Damp-proofing
- 3. Fluid-applied AB/WRB flashing membrane or flexible self-adhered flashing membrane
- 4. Rigid XPS foundation insulation
- 5. Sheet-metal base-of-wall flashing with hemmed edge
- 6. Single-wythe CMU wall with water-repellent admixture within block and mortar
- 7. Core insulation
- 8. Sloped precast sill
- 9. Concrete sidewalk or other hardscape
- 10. Continuous hardscape sealant joint

Window Jamb and Sill Cutaway Section
Detail 4-H

- 1. Single-wythe CMU wall with water-repellent admixture within block and mortar
- 2. Sloped precast sill
- 3. Fluid-applied AB/WRB flashing membrane
- 4. Minimum 1/4-inch intermittent shims for drainage
- 5. Continuous AB sealant tied to continuous seal at window perimeter
- 6. Storefront window
- 7. Wept backer rod and sealant joint
CHAPTER 5:
INTERIOR-INSULATED CMU WALL

Assembly 5 is a mass wall design approach with a concrete masonry unit (CMU) wall structure with interior insulation. The components of this assembly, from interior to exterior, are described in Fig. 5-1. It is most appropriate for low- to mid-rise commercial applications but may be used for residential application and higher-rise structures. An example application of this assembly is shown in Fig. 5-2 on page 5-3. Benefits and special considerations for this assembly are discussed in Table 5-1 on page 5-2.

Building Enclosure Control Functions and Critical Barriers

As noted in the Introduction, an above-grade wall assembly should provide control of water, air, heat, vapor, sound, and fire to serve as an effective and durable environmental separator. Control of these elements is provided by critical barriers such as a water-shedding surface (WSS), water-resistant barrier (WRB), air barrier system (AB), thermal envelope, and vapor retarder (VR). Refer to Fig. i-8 on page i-15 of the introductory chapter for a list of primary building enclosure control functions and associated critical barriers.

Fig. 5-3 on page 5-3 illustrates the locations of the critical barrier locations...
for this assembly. The critical barriers for typical Chapter 5 assembly details are also provided adjacent to each detail at the end of this chapter.

As shown in Fig. 5-3, the WRB and WSS critical barriers occur at the CMU wall structure face. The AB layer occurs at the closed cell spray foam insulation (CCSPF). The CCSPF also provides the thermal envelope of this assembly and functions as a VR.

The following sections provide more information and discuss best practices for the specific critical barriers of this assembly.

**Water-Shedding Surface (WSS)**

The WSS is a critical barrier that controls water.

The CMU wall along with grouted cores provide the WSS of this assembly. Additional components include sheet-metal flashings and drip edges, sealant joints, and fenestration systems as shown on the details included at the end of this chapter. Water repellent admixtures are added to block and mortar of this assembly and a surface applied clear-water repellent is also recommended. These repellents along with other measures such as tooled “V” or concave shape

<table>
<thead>
<tr>
<th>Assembly Comparison Category</th>
<th>Assembly #5 Interior-Insulated CMU Wall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recommended Occupancy Type</td>
<td>Residential OR Commercial</td>
</tr>
<tr>
<td>Building Enclosure Design Approach and Recommended Exposure</td>
<td>Mass Wall Design Approach, Low-to Mid-Rise Exposure</td>
</tr>
<tr>
<td>Long-Term Wall Assembly Durability</td>
<td>Structural durability high. Water repellents (admixture and surface applied) and/or opaque coatings provide water resistivity.</td>
</tr>
<tr>
<td>Typical Wall Thickness</td>
<td>Continuous insulation and offset framing increase thickness vs. CMU wall (Chapter #4 Assembly)</td>
</tr>
<tr>
<td>Typical Cladding Design Compliance</td>
<td>Prescriptive/Engineered</td>
</tr>
<tr>
<td>Typical Thermal Performance</td>
<td>Interior closed-cell spray foam insulation provides highest R-value per inch</td>
</tr>
<tr>
<td>Special Construction Considerations</td>
<td>Multiple functions of interior spray foam reduces construction complexity; added measures for moisture control recommended</td>
</tr>
<tr>
<td>Construction Ease with Limited / No Exterior Access (property line applications)</td>
<td>No exterior access required; however, installation of repellents or coating is limited</td>
</tr>
<tr>
<td>Fire Resistivity Considerations</td>
<td>Fire resistivity high. Insulation may affect fire propagation requirements.</td>
</tr>
<tr>
<td>Maintenance Considerations</td>
<td>Regular maintenance required; clear water repellent recommended.</td>
</tr>
<tr>
<td>Price Per Square Foot</td>
<td>Low and High Baseline Cost: $49.50 - $60.75</td>
</tr>
</tbody>
</table>

when determining thermal insulation may need to be considered.

Continuous exterior insulation typically required.

**Water-Resistive Barrier (WRB)**

The WRB is a critical barrier that controls water.

Like the WSS, the CMU wall itself, along with grouted cores provide the WRB of this assembly. The addition of water repellent admixtures within the block and mortar and the use of a surface applied clear water repellent at the wall face will assist with increasing the water-resistivity of the assembly. Additional measures, such as those discussed in the Water-Shedding Surface (WSS) section of this chapter and addressed within the NWCMA Tek Note on Rain Resistant Architectural Concrete Masonry increase the water-resistivity of the assembly.

Additional WRB components include sheet-metal flashings and drip edges, sealant joints, fenestration systems, and rough opening fluid-applied flashing membranes as shown on the details included at the end of this chapter.
The CCSPF insulation at the interior face of the CMU may also provide additional water-resistivity. For this reason, and others discussed in the sections below, the CCSPF should be installed as continuously as possible—up to rough openings and tight to penetrations—to function as an effective critical barrier. Recommended CCSPF material properties are included in the Air Barrier (AB) section of this chapter.

The WRB layer must be continuous across the wall face to serve as an effective critical barrier. Whereas this wall manages water at the CMU face and may manage some water at the CCSPF layer, window rough openings between these two planes must also have a WRB component. Typically, this is a fluid-applied air and water-resistive barrier membrane (AB/WRB), commonly referred to as an air and water-resistive barrier (AB/WRB). It protects rough opening against water ingress and air leakage and is depicted it the details at the end of this chapter.

**Air Barrier (AB)**

The AB is a critical barrier which primarily controls air, heat, and vapor. The AB also controls water, sounds, and fire.

The AB system in this assembly is typically the CCSPF interior of the CMU wall structure and has the following material properties:

- **Air Penetration Resistance:** As discussed in the introductory chapter
- **Water Vapor Transmission:** A maximum of 1 perm at 2-inch thickness when tested to ASTM E96
- **Closed-Cell Content:** > 95% when tested to ASTM D6226
- **Density:** ≥ 2 lb/ft³ when tested to ASTM C518

To serve as an effective AB system and to reduce the risk of air leakage condensation on the interior CMU face, CCSPF should be installed continuously up to rough openings, penetrations, and roof and floor structures.

Perform installation of CCSPF insulation in strict conformance with the manufacturer’s installation instructions to avoid excessive heat buildup. Improper installation could lead to premature cracking, delamination from the substrate, and increases the risk of fire during installation. Use only experienced applicators who are approved by the CCSPF product manufacturer.

Other considerations when using closed-cell spray foam insulation includes fire propagation and volatile organic compound (VOC) compliance. Product selection, application, and use should comply with local jurisdiction requirements.

The thermal envelope is a critical barrier which controls heat and assist with controlling vapor, sound, and fire.

The interior CCSPF insulation serves as the thermal envelope critical barrier. At transition details, the thermal envelope includes interior insulation across bond beams and up to rough openings, windows and doors, and roof assembly insulation as well as slab and foundation insulation.

The thermal envelope should be as continuous as possible across all assemblies and transitions to minimize heat loss, reduce condensation risk, and improve occupant thermal comfort. Continuity of interior insulation can be difficult to
achieve at areas such as floor line slab edges and some wall to roof transitions. These transitions should be carefully considered for whole building energy performance implications as well as energy code compliance.

The CMU wall of this assembly is also a thermal mass; thus, may provide thermal mass benefits as discussed in the introductory chapter.

Additional thermal envelope discussion is provided in the Thermal Performance and Energy Code Compliance section of this chapter and the introductory chapter.

Insulation Selection

CCSPF is recommended for this assembly, as noted in the preceding sections. Use of alternate insulation types should be carefully considered along with the projects specific application and exposure.

- Vapor- and Air-Permeable Insulation. This includes fiberglass and mineral fiber batt or semi-rigid mineral fiber insulation. These products alone do not serve as VR, AB, or WRB critical barriers; thus, require additional products or systems. When additional products are implemented to serve as these critical barriers, the risk for condensation on the interior face of the CMU wall should be carefully considered. Lack of a fully adhered WRB at the interior (or exterior face) of this assembly reduces the water-resistivity as compared to the CCSPF application.

- Rigid Board Insulation. This includes extruded polystyrene (XPS) or moisture-resistant foil-faced polyisocyanurate insulation types. These products provide a VR and AB when the interior face of the product is fully taped and/or sealed at seams, edges, penetrations and to perimeter elements such as floor slabs. Rigid board insulation products require notching around wall projections such as roof joists and pipe penetrations; thus, additional insulating and sealing mechanisms should be considered at these locations to ensure a continuous barrier is provided. Rigid board insulation products do not provide continuous adhesion to the CMU wall structure like a CCSPF product. As a result, if water is allowed to bypass the CMU wall structure it is not contained within the wall but instead may reach horizontal elements. This risk can be minimized by stepping foundation elements to terminate the insulation at a lower elevation than floor slab finishes and by installing an elastomeric coating to the exterior wall face (see the introductory chapter for more information).

Vapor Retarder (VR)

The VR critical barrier is a layer that retards or greatly reduces (e.g., vapor barrier) the flow of water vapor due to vapor pressure differences across enclosure assemblies.

In this assembly the VR is the CCSPF which controls vapor diffusion. As this assembly is insulated to the interior, it is important that the VR is continuous across the walls interior face and up to rough openings and penetrations.

The CCSPF insulation has a minimum 2 lb/ft³ density and is applied at a minimum of 2 inches to be considered a Class II vapor retarder (perm rating greater than 0.1 and less than or equal to 1.0).

Manufacturer installation requirements for closed-cell spray foam insulation should be strictly followed to ensure VR performance.

Thermal Performance and Energy Code Compliance

This chapter assembly is typically classified as a “mass” above-grade wall for energy code compliance purposes. Prescriptive energy code compliance values for this assembly are summarized in Table 5-2 on page 5-10 and describe:

- Minimum insulation R-values for a prescriptive R-value compliance strategy.

- Maximum assembly U-factors for a prescriptive U-factor alternative compliance strategy. Note, the equivalent assembly effective R-value of this maximum U-factor has been calculated and is denoted in parenthesis () for easy comparison to thermal modeling results included within this chapter.

- Footnote (2) for compliance by exception. The ability to use this option depends on the jurisdiction, building’s occupancy type, and availability of CMU cores to be filled with insulation. If this exception is to be used, refer to the Chapter 4 Thermal Performance and Energy Code Compliance section.

When a non-prescriptive compliance option (e.g., a trade-off strategy or whole-building modeling strategy) is used for energy code compliance, this assembly's effective thermal performance will need to be calculated; however, it may or may not be required to meet the prescriptive values shown in Table 5-2.

Fig. i-17 on page i-29 of the introductory chapter describes the typical process of navigating energy code compliance strategies and options. Thermal modeling results demonstrated within this chapter may be used to assist with
estimating the location of steel framing and insulation thicknesses to achieve a target thermal performance value. Options for thermally optimizing this assembly, as determined through the modeling results, are also provided.

**Assembly Effective Thermal Performance**

The depth and location of the steel studs in this assembly will impact the assemblies effective thermal performance depending on placement relative to the assemblies interior insulation. As shown in Fig. 5-5 and Fig. 5-6, various levels of thermal bridging can occur depending on steel stud placement relative to the CMU and insulation product. This thermal bridging reduces the assembly’s effective thermal performance.

Three-dimensional thermal modeling demonstrates this assembly’s effective thermal performance with various framing locations (relative to the insulation and CMU wall) and insulation thicknesses. A discussion on the modeling performed for this guide is included in the Introduction Chapter and the Appendix.

**Thermal Modeling: Variables**

The following are modeling variables specific to this assembly—CMU wall with interior insulation:

- **Wall Structure:** An 8-inch medium-weight block.
- **Wall Framing:** Galvanized steel studs at 16-inches on-center, including a top and bottom track. Various assembly options for locating framing relative to insulation are considered and depicted in Fig. 5-7 on page 5-11.
- **Insulation:** R-6/inch insulation product either continuous or bridged by steel studs as indicated in the results table. The R-value selected demonstrates a typical CCSPF thermal resistance and is used consistently for all thermal modeling analysis in this chapter to demonstrate comparative thermal performance results.

**Thermal Modeling: Results**

The results of this modeling are shown in Table 5-3 on page 5-11 and demonstrate the effective assembly R-value of the assembly under various conditions. Of the modeling results presented, many of the insulation strategies provide an effective assembly R-value that satisfies the various prescriptive energy code requirements shown in Table 5-2. Although these strategies may meet minimum allowable thermal envelope performance requirements, additional considerations for how the various insulation strategies impact the remaining critical barriers is also discussed in this section. Key points for thermally optimizing this assembly are italicized in boldface.

- Option 4 with 2 inches of CCSPF between the CMU and steel studs and an additional 2 inches of CCSPF between studs provides an effective assembly R-value of R-23.4. The continuous CCSPF option provides an uninterrupted VR and AB/WRB installation. The installation of 2-inches of CCSPF within the stud space leaves room for services to be installed between the insulation and interior gypsum board if needed.
- As shown with Option 3, 4 inches of CCSPF may be installed between the CMU wall and steel studs to provide an effective assembly R-value of 27.2. When thermally optimizing this assembly it is most effective to add continuous insulation rather than insulation bridged by steel stud framing.
Table 5-2 Assembly 5 prescriptive energy code compliance values

<table>
<thead>
<tr>
<th>Energy Code</th>
<th>Climate Zone</th>
<th>Classification All Other Group R</th>
<th>Assembly #</th>
<th>Guide Assembly #</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012 SEC</td>
<td>All Other</td>
<td>R-13 + R-6 ci, or R-13 + R-10 ci</td>
<td>6</td>
<td>S.9</td>
</tr>
<tr>
<td>2014 OESC</td>
<td>All Other</td>
<td>R-13.3 ci</td>
<td>5</td>
<td>S.5</td>
</tr>
<tr>
<td>2015 WESC</td>
<td>All Other</td>
<td>R-11.6 ci</td>
<td>4</td>
<td>S.4</td>
</tr>
<tr>
<td>2012 IECC</td>
<td>All Other</td>
<td>R-13.5 ci</td>
<td>3</td>
<td>S.3</td>
</tr>
<tr>
<td>2012 WSEC</td>
<td>All Other</td>
<td>R-13.5 ci</td>
<td>2</td>
<td>S.2</td>
</tr>
<tr>
<td>2012 IECC</td>
<td>Marine</td>
<td>R-13.5 ci</td>
<td>1</td>
<td>S.1</td>
</tr>
</tbody>
</table>

Guide Assembly #

- When using interior insulation: R-13 + R-6 ci for wood studs or R-13 + R-10 ci for metal stud; when using exterior insulation R-16 ci.
- Provided at least 50% of block cores are filled with vermiculite (or equivalent fill insulation), and enclosing one of the following uses: gymnasium, auditorium, church chapel, arena, kennel manufacturing plant, indoor swimming pool, pump station, water and waste water treatment facility, storage facility, restroom/concessions, mechanical/electric structures, storage area, warehouse (storage and retail), and motor vehicle service.

Table 5-3 Assembly 5 Effective R-value comparison chart. Insulation options may be referenced from Fig. 5-7

<table>
<thead>
<tr>
<th>Insulation Option</th>
<th>Interior Insulation Depth</th>
<th>Nominal Insulation R-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2&quot;</td>
<td>12 ci</td>
</tr>
<tr>
<td>2</td>
<td>2&quot;</td>
<td>R-12 Continuous Insulation</td>
</tr>
<tr>
<td>3</td>
<td>4&quot;</td>
<td>12 cavity</td>
</tr>
<tr>
<td>4</td>
<td>4&quot;</td>
<td>R-12 Cavity Insulation with R-12 Continuous Insulation</td>
</tr>
<tr>
<td>5</td>
<td>4&quot;</td>
<td>24 cavity</td>
</tr>
<tr>
<td>6</td>
<td>4&quot;</td>
<td>R-24 Cavity Insulation with a 1-inch Air Space Between Framing and CMU</td>
</tr>
</tbody>
</table>

Movement Joints

The CMU wall of this assembly functions as both the WSS and the structure. CMU is a concrete-based product. It, along with the mortar, will shrink over time due to initial drying, temperature fluctuations, and carbonation. Not only will shrinkage movement need to be considered, but differential movement between the CMU and steel studs is also a possibility. The CMU wall functions as both the WSS and the structure. CMU is a concrete-based product. It, along with the mortar, will shrink over time due to initial drying, temperature fluctuations, and carbonation. Not only will shrinkage movement need to be considered, but differential movement between the CMU and steel studs is also a possibility.

- Cavity-only insulation produces an assembly effective R-value of 7.2 for 2 inches of CCSFP (Option 2) and an assembly effective R-value of 9.1 for 4 inches (Option 5). This option significantly reduces the thermal performance of the insulation (e.g., by 42% to 62%). Whereas the steel studs and CCSFP may still provide a vapor retarder for this assembly, the foam insulation is debridged from the CMU at vertical framing and head and sill tracks, creating discontinuities in the AB/WRB. Providing cavity-only insulation within this assembly is not the most effective insulation strategy.

- Commonly, a 1-inch air cavity is provided between CMU wall and steel studs. In this case, cavity insulation is only provided. This strategy is often considered with the hope of reducing thermal bridging between the CMU and steel stud framing. As shown in Table 5-3, this option results in a slightly higher effective R-value (R-9.1 to R-12.1 when comparing Options 3 and 6) than when in direct content. Little thermal benefit is gained when separating the insulation from the CMU wall; a more thermally effective option is to fill the offset with CCSFP.

Fig. 5-7 Assembly 5 insulation options reflected in three-dimensional thermal modeling results shown in Table 5-3
structure and other structural elements, deflection, settlement, and various design loads will need to be addressed.

Crack control within the CMU should be considered to increase water-resistivity of this assembly. Material properties and reinforcing methods of the CMU structural wall should be implemented to reduce cracking; however, control joints within the CMU wall should be implemented to provide a plane of weakness to reduce shrinkage stresses and provide continuity of the WSS at these locations. Control joints in CMU can be constructed in a number of ways. Regardless of the method used, a continuous backer rod and sealant joint should be installed at the joint to assist with water shed and water penetration resistance.

Refer to the introductory chapter for more information on locating movement joints and sealant joint best practices.

**Structural Considerations**

The CMU block wall of this assembly provides the primary structure of this assembly. It is the responsibility of the Designer of Record to ensure that all structural elements are designed to meet project-specific loads and local governing building codes. Generic placement of the grouted and reinforced elements are demonstrated within the details of this chapter and are provided for diagrammatical purposes only.

**CMU Wall**

The CMU in this assembly should comply with ASTM C90. Mortar designed for the CMU should conform to ASTM C270 as well as ASTM C1714 when specifying preblended mortar. The mortar type selected should be appropriate for the CMU application; Type S is typically specified. Grout components should comply with ASTM C 476 while aggregate within the grout should comply with ASTM C 404.

Block and mortar should both be specified and provided with a water-repellent admixture as discussed in the Water Repellents section of this chapter and the introductory chapter. Refer to the Northwest Concrete Masonry Association for additional information on specifying block, mortar, and grout.

The CMU and mortar joints should be installed in conformance with industry standard best practices, manufacturer requirements, and guidelines outlined in the NWCMA Tek Note on Rain Resistant Architectural Concrete Masonry. Appropriate product selection and installation of CMU and mortar materials is necessary to provide a durable and water-resistive cladding system. The specifics of architectural characteristics and structural properties of the block, mortar, grout, and reinforcing should be designed and reviewed by a qualified Designer of Record. Various industry resources are available to assist with CMU wall design and are listed in the resources section at the back of this guide.

**Corrosion Resistance**

For sheet-metal flashings that are integrated within this assembly (including through-wall flashings and sheet-metal drip flashings), it is best practice to provide components that are manufactured of ASTM A167 Type 304 or 316 stainless steel, which is nonstaining and resistant to the alkaline content of mortar and grout materials.

Whereas the use of stainless steel sheet-metal flashing components is not always economically feasible or aesthetically desirable, prefinishing sheet-metal may be considered. Where used, the base sheet metal should receive a minimum G90 hot-dipped galvanized coating in conformance with ASTM A653 or minimum AZ50 galvalume coating in conformance with ASTM A792. The exposed top finish of the sheet metal is recommended to have an architectural-grade coating conforming to AAMA 2605.

**Water Repellents**

Both integral water-repellent admixtures and a surface-applied clear water repellent are included with this assembly and assist with reducing the water absorption of the CMU wall and encourage watershed. Water-repellent admixtures should be used both in the CMU and mortar. Admixture within block units should comply with NCMA TEK 19-7 while mortar admixture should comply with ASTM C1384. More discussion on surface-applied clear water repellents is provided in the introductory chapter.

Both CMU and mortar admixtures as well as surface-applied water repellent should have known compatibility performance.

**Pricing Analysis**

A pricing analysis for this assembly is provided on Table 5-4 on page 5-15. Pricing demonstrates the relative price per square foot and is based on a 10,000-square-foot wall area with easy drive-up access. Pricing provided does not include interior finishes or steel framing components.

Online Availability

The content of this guide and additional resources may be accessed online at www.masonrysystemsguide.com. Also available online are downloadable versions of two- and three-dimensional assembly details and cutaway sections as well as sample project specifications. Ongoing updates to references and resources included within this guide can also be accessed.

Table 5-4 Assembly 5 CMU wall with interior insulation pricing analysis

<table>
<thead>
<tr>
<th>Assembly Component</th>
<th>Baseline Product</th>
<th>Alternate (call for estimate)</th>
<th>Baseline Cost/ft² (incl. labor)</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTERIOR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Interior gypsum board</td>
<td>No evaluation of these components provided.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Steel framing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3* Closed-cell spray foam insulation between studs</td>
<td>2-lb density closed-cell spray polyurethane foam, 2” thickness</td>
<td>No specified alternate</td>
<td>$4.00 $4.00</td>
</tr>
<tr>
<td>4* Continuous closed-cell spray polyurethane foam insulation</td>
<td>2-lb density closed-cell spray polyurethane foam, 2” thickness</td>
<td>No specified alternate</td>
<td>$4.00 $4.00</td>
</tr>
<tr>
<td>5* Single-wythe cmu wall</td>
<td>8&quot;x8&quot;x16&quot; standard block, fully grouted with standard code-required rebar</td>
<td>No specified alternate</td>
<td>$18.00 $24.00</td>
</tr>
<tr>
<td>6* Clear water repellent</td>
<td>Silane/siloxane blend</td>
<td>Antigraffiti clear water repellent</td>
<td>$1.75 $2.25</td>
</tr>
<tr>
<td>EXTERIOR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total cost to install 10,000 sq ft wall area w/easy drive-up access</td>
<td></td>
<td>$27.75 $34.25</td>
<td></td>
</tr>
</tbody>
</table>

Pricing Analysis Discussion

- Low and high baseline costs are based on the baseline products listed. Call for an estimate for alternate product pricing.
- Baseline costs provided will vary based on product specifics and should be used as an estimate only.
- Block unit prices are for typical units as noted. Pricing can vary based on size, color, and finish and should be confirmed with the unit manufacturer.
- *See the Resources section of this guide for a list of resources related to this component.
LEGEND

1. Typical Assembly:
   - Interior gypsum board
   - Steel-framed wall
   - Closed-cell spray foam insulation between studs (CCSPF)
   - 2 inches continuous closed-cell spray foam insulation (CCSPF)
   - Single-wythe CMU wall with water-repellent admixture
   - Clear water-repellent
2. Preservative treated blocking and plywood
3. Sealant over backer rod
4. Fluid-applied AB/WRB flashing membrane
5. Continuous back dam angle at rough opening perimeter, minimum 1 inch tall. Fasten window through back dam angle per window manufacturer recommendations.
6. Continuous AB sealant, tie to continuous seal at window perimeter
7. Storefront window

Critical Barriers

WSS
WRB
AB
Thermal Envelope
VR

Detail Discussion

- A sheet-metal flashing as shown in Chapter 4 Fig. 4-6 on page 4-13 may also be considered.
- AB continuity is provided by the CCSPF, by fluid-applied flashing membrane at the rough opening, and by AB sealant transition to the storefront.
- WRB continuity is provided at the CMU face, fluid-applied flashing membrane at the rough opening, and at the AB sealant transition to the storefront.
- Preservative-treated blocking and plywood provide a low thermal conductivity structural support for the window perimeter and a suitable substrate for the fluid-applied flashing membrane application.

Storefront Window Head
Detail 5-A
LEGEND

1. Typical Assembly:
   - Interior gypsum board
   - Steel-framed wall
   - Closed-cell spray foam insulation between studs (CCSPF)
   - 2 inches continuous closed-cell spray foam insulation (CCSPF)
   - Single-wythe CMU wall with water-repellent admixture
   - Clear water-repellent

2. Storefront window on minimum 1/4-inch intermittent shims
3. Sealant over bond breaker tape
4. Sheet-metal sill flashing with 1/2-inch hemmed drip edge
5. Drainage mesh or minimum 1/4-inch intermittent shims
6. Fluid-applied AB/WRB flashing membrane
7. Preservative-treated blocking and plywood
8. Sloped precast concrete sill
9. Continuous AB sealant, tie to continuous seal at window perimeter
10. Continuous back dam angle at rough opening perimeter, minimum 1 inch tall. Fasten window through back dam angle per window manufacturer recommendations.

Detail Discussion

- AB continuity is provided by the CCSPF, fluid-applied flashing membrane at the rough opening, and AB sealant transition to the storefront.
- Intermittent shims below the storefront window and sheet-metal sill flashing encourage drainage of the window rough opening to the exterior environment.
- The sheet-metal sill flashing promotes watershed at the sill area and protects the fluid-applied AB/WRB flashing from UV exposure. The projected precast sill also promotes watershed away from the wall face.
- Anchor locations for rough opening preservative-treated blocking should be confirmed with the project's structural engineer.
Critical Barriers

1. Typical Assembly:
   - Interior gypsum board
   - Steel-framed wall
   - Closed-cell spray foam insulation between studs (CCSPF)
   - 2 inches continuous closed-cell spray foam insulation (CCSPF)
   - Single-wythe CMU wall with water-repellent admixture
   - Clear water-repellent
2. Storefront window
3. Sealant over backer rod
4. Preservative-treated blocking and plywood
5. Fluid-applied AB/WRB flashing membrane
6. Continuous AB sealant, tie to continuous seal at window perimeter
7. Continuous back dam angle at rough opening perimeter, minimum 1 inch tall. Fasten window through back dam angle per window manufacturer recommendations.

Detail Discussion

- AB continuity is provided by the CCSPF, fluid-applied flashing membrane at the rough opening, and AB sealant transition to the storefront.
- The sealant and backer rod joint between the storefront window and CMU wall provides WSS layer continuity.
- The continuous back dam angle shown allows for perimeter attachment of the storefront window without the need for F-clips or similar anchors, which often inhibit the AB system critical barrier at the window perimeter. Attachment methods for the storefront window should be confirmed with the window manufacturer during the design phase of the project.
**LEGEND**

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

**Detail Discussion**

- The XPS insulation between the concrete floor slab and concrete foundation wall acts as a thermal break. It reduces the amount of heat loss at the floor slab perimeter.
**Critical Barriers**

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

**Detail Discussion**

- The sheet-metal coping with hemmed drip edge protects the wall top and assists with shedding water away from the CMU wall face.
- The CCSPF extends tight up to the underside of the deck, around roof structure and anchor elements. This reduces the opportunity for warm moisture-laden interior air from contacting the deck and CMU wall where it's coldest.
**LEGEND**

1. Single-wythe CMU wall with water-repellent admixture
2. Preservative-treated blocking and plywood anchored to CMU wall
3. Roof structure
4. Steel-framed wall
5. Preservative-treated blocking
6. Inverted roof membrane assembly
7. High-temperature self-adhered membrane
8. Standing-seam sheet-metal coping with gasketed washer fasteners
9. Continuous back dam angle at rough opening perimeter, minimum 1 inch tall. Fasten window through back dam angle per window manufacturer recommendations.
10. Continuous AB sealant. Tie to continuous seal at window perimeter.
11. Storefront window
12. CCSPF per assembly
13. Interior gypsum board

**3-D Detail Discussion**

- Three-dimensional cutaway sections on the next three pages represent two-dimensional details of this assembly.

- As shown in Detail 5-F, the preservative-treated blocking and plywood at the window rough opening provide a low thermal conductivity structural support for the window perimeter and also provide a suitable substrate for the fluid-applied flashing membrane. The preservative-treated blocking and plywood is 2 inches deep to accommodate the minimum continuous CCSPF depth necessary to achieve a VR layer.

- As shown in Detail 5-F, the steel studs bridge the interior most 2 inches of CCSPF. The steel-stud framing may be moved inboard of the insulation entirely to eliminate thermal bridging and improve the assembly’s thermal performance.

- Detail 5-H describes a typical rough opening with continuous back dam angle. The sill back dam angle creates a sill pan below the window; intermittent shims below the storefront window promote drainage at the sill and out through the sealant joint weeps.

- As shown in Detail 5-G, the XPS insulation between the concrete floor slab and concrete foundation wall acts as a thermal break and reduces the amount of heat loss at the floor slab perimeter. This detail allows continuous interior insulation from the wall to the floor slab.
BASE OF WALL DETAIL @ CONCRETE

1. Concrete floor slab
2. Single-wythe CMU wall with water-repellent admixture
3. Damp-proofing
4. Drainage composite or gravel backfill
5. Hardscape
6. Hardscape sealant joint between hardscape and CMU wall
7. Steel-framed wall
8. CCSPF insulation per assembly
9. Sheet metal flashing
10. Fluid-applied AB/WRB flashing membrane
11. Storefront Window
12. Sloped precast concrete sill

WINDOW JAMB AND SILL SECTION CUTAWAY SECTION

1. Single-wythe CMU wall with water-repellent admixture
2. Minimum 1/4 inch intermittent shims
3. Continuous back dam angle at rough opening perimeter, minimum 1 inch tall. Fasten window through back dam angle per window manufacturer recommendations.
4. Sloped precast concrete sill
5. Fluid-applied AB/WRB flashing membrane
6. Continuous AB sealant. Tie to continuous seal at window perimeter.
7. Storefront window
8. Sheet-metal sill flashing over drainage mesh or minimum 1/4-inch intermittent shims
9. Sealant over backer rod
CHAPTER 6:  
CMU WALL WITH ADHERED MASONRY VENEER

Assembly 6 is a **rainscreen design approach** with concrete masonry unit (CMU) structure and thin-set masonry veneer over cement backer board. The components of this assembly, from interior to exterior, are described in Fig. 6-1. This assembly is appropriate for many applications including low- or mid-rise residential or commercial buildings. An example application of this assembly is shown in Fig. 6-2 on page 6-3. Benefits and special considerations for this assembly are discussed in Table 6-1 on page 6-2.

**Building Enclosure Control Functions and Critical Barriers**

As noted in the Introduction, an above-grade wall assembly should provide control of water, air, heat, vapor, sound, and fire to serve as an effective and durable environmental separator. Control of these elements is provided by critical barriers such as a water-shedding surface (WSS), water-resistive barrier (WRB), air barrier system (AB), thermal envelope, and vapor retarder (VR). Refer to Fig. i-8 on page i-15 of the introductory chapter for a list of primary building enclosure control functions and associated critical barriers.

---

**INTERIOR**

- Single-wythe CMU wall
- Air and water-resistive barrier
- Intermittent standoff clip with 1-inch vertical Z-girt
- Exterior insulation
- Cement backer board
- Crack isolation membrane
- Adhesive thinset mortar
- Adhered masonry veneer with grouted joints
- Clear water repellent

**EXTERIOR**

*Fig. 6-1 Typical Assembly 6 components from interior to exterior.*
Fig. 6-3 illustrates the critical barrier locations for this assembly. The critical barriers for typical Chapter 6 assembly details are also provided adjacent to each detail at the end of this chapter.

As shown in Fig. 6-3, the WSS critical barrier occurs at the adhered masonry veneer with most watersheding occurring at the wall face, while a minimal amount of water will be stored within the masonry veneer to be released at a later time. The WRB, AB, and VR critical barriers are all depicted at the same location at the exterior face of the CMU wall structure. As a result, a single membrane is used to serve as the WRB and AB (and may serve as the VR); this membrane is commonly referred to in this chapter as the air- and water-resistant barrier (AB/WRB). The thermal envelope barrier includes the exterior insulation between the wall structure and masonry veneer.

The following sections provide more information and discuss best practices for the specific critical barriers of this assembly.

**Water-Shedding Surface (WSS)**

The water-shedding surface is a critical barrier that controls water.

The adhered masonry veneer cladding—including both stuck joints and masonry veneer—serves as the primary WSS of this assembly. Additional components include sheet-metal flashings and drip edges, sealant joints, and fenestration systems as shown on the details included at the end of this assembly chapter.

To promote water shedding at the masonry cladding, grooved joints between veneer units should be appropriately installed with a tooled concave (preferred) or “V” shape.

When finished, the WSS critical barrier should be free of gaps except where providing drainage. Movement joints and joints around fenestrations and penetrations should be continuously sealed with a backer rod and sealant joint or counterflashed with a sheet-metal flashing to deflect wind-driven rain and shed water away from the rainscreen cavity.

**Water-Resistive Barrier (WRB)**

The water-resistive barrier is a critical barrier that controls water.

In this assembly, the WRB is a sheet-applied or fluid-applied membrane (that also functions as an AB and may function as a VR). Either a fluid-applied or self-adhered sheet-applied membrane is depicted in the details at the end of this chapter. An example of a fluid-applied WRB membrane is shown in Fig. 6-4 on page 6-4. This membrane may be either vapor-permeable or vapor-impermeable product because it is located interior (warm side) of the assembly’s thermal envelope. Physical properties such as vapor permeability of WRB products are discussed in

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**Table 6-1 Assembly 6 Comparison Matrix**

<table>
<thead>
<tr>
<th>Assembly Comparison Category</th>
<th>#6 Assembly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recommended Occupancy Type</td>
<td>Residential OR Commercial</td>
</tr>
<tr>
<td>Building Enclosure Design Approach and Recommended Exposure</td>
<td>Rainscreen Design Approach, Low- to Mid-Rise Exposure. Consider access for maintenance on high-rise applications.</td>
</tr>
<tr>
<td>Long-Term Wall Assembly Durability</td>
<td>Resilient due to exterior insulation and rainscreen drainage cavity</td>
</tr>
<tr>
<td>Typical Wall Thickness</td>
<td>CMU structure thicker than wood or steel (Chapters #7 and #8 Assemblies); thinner than anchored wall (Chapter #1 Assembly); continuous insulation increases thickness</td>
</tr>
<tr>
<td>Typical Cladding Design Compliance</td>
<td>Cladding system typically engineered. When proprietary cladding attachment systems are used, contact manufacturer</td>
</tr>
<tr>
<td>Typical Thermal Performance</td>
<td>Similar to Chapter #1 Assembly, continuous exterior insulation typically required. Cladding support penetrations through the insulation may need to be considered when determining thermal performance</td>
</tr>
<tr>
<td>Special Construction Considerations</td>
<td>Several cladding components and stages required</td>
</tr>
<tr>
<td>Construction Ease with Limited/No Exterior Access (property line applications)</td>
<td>Requires exterior access</td>
</tr>
<tr>
<td>Fire Resistivity Considerations</td>
<td>Fire resistivity high. Exterior insulation may affect fire propagation requirements</td>
</tr>
<tr>
<td>Maintenance Considerations</td>
<td>Regular maintenance required. Additional maintenance/review recommended to ensure adhered veneer integrity</td>
</tr>
<tr>
<td>Price Per Square Foot</td>
<td>Low and High Baseline Cost: $49.50 - $60.75</td>
</tr>
</tbody>
</table>
The WRB layer must be continuous across the wall face to serve as an effective critical barrier. In addition to the field membrane, the WRB layer of this assembly also includes fluid-applied or flexible flashing membranes, sealants, sheet-metal flashings, and interfaces with fenestration systems (e.g., windows and doors) as shown in the detail drawings that follow this chapter discussion. Where sheet-metal flashing components occur, the back leg of the sheet-metal flashing is lapped into the fluid-applied membrane to encourage water at the WRB layer to drain toward the building exterior.

Cladding support clip fasteners in this assembly will penetrate the AB/WRB critical barrier and should be detailed based on the WRB manufacturer’s installation requirements. Typically, fasteners may be required to be set in a compatible sealant or fluid-applied flashing product or be attached through a self-adhered membrane patch.

Air Barrier (AB)

The AB system is a critical barrier that primarily controls air, heat, and vapor. The AB system also controls water, sounds, and fire.

In this assembly, the AB system critical barrier is the same self-adhered sheet or fluid-applied field membrane that also serves as the WRB critical barrier. The components described in the above Water-Resistive Barrier (WRB) section are also part of the AB layer, except sheet-metal flashings.

Thermal Envelope

The thermal envelope is a critical barrier that controls heat and assists with controlling vapor, sound, and fire.

In this wall assembly, the exterior insulation provides the thermal envelope. At transition details, the thermal envelope includes exterior insulation across bond beams, peripheral floor lines, and roof assembly insulation as well as slab and foundation insulation. Windows and doors that penetrate this wall are also part of the thermal envelope.

Exterior insulation provides the following benefits:

1. It allows for exterior insulation across floor lines (which are typically required to meet similar energy code compliance values as this wall assembly).
2. It keeps the structure warm (which reduces the risk that condensation may form interior face of the WRB).
3. It protects the AB/WRB from both extreme temperature fluctuations and damage during veneer installation.

The CMU (or concrete) in this assembly is also a thermal mass; thus, may provide thermal mass benefits as discussed in the introductory chapter.

Additional thermal envelope discussion is provided in the Thermal Performance and Energy Code Compliance section of this chapter and the introductory chapter.

Insulation Selection

Where exterior insulation is provided, semi-rigid mineral fiberboard insulation or moisture-tolerant rigid board insulation products (e.g., polyisocyanurate or XPS) may be used. Refer to the introductory chapter for a

Although masonry is defined as a noncombustible cladding material, a combustible air and water-resistive barrier or foam plastic insulation within a wall cavity can trigger fire propagation considerations and requirements. Depending on the local jurisdiction, IBC Section 1403.5 regarding vertical and lateral flame propagation as it relates to a combustible water-resistive barrier may require acceptance criteria for NFPA 285. The use of foam plastic insulation within a wall cavity should also be addressed for IBC Chapter 26 provisions.
discussion on various insulation types and considerations.

Vapor Retarder (VR)

The VR critical barrier is a layer that retards or greatly reduces (e.g., vapor barrier) the flow of water vapor due to vapor pressure differences across enclosure assemblies. Unlike the other critical barriers presented in this guide, the VR is not always necessary or required to be continuous.

For this assembly, a VR is not necessary. The risk of condensation development or damage to the structure due to outward vapor drive and condensation is unlikely due to all of the assembly’s insulation being located exterior of the wall structure and the AB/WRB.

Note that Fig. 6-3 identifies the VR at the exterior face of the CMU. This represents the exterior-most plane of the CMU wall structure, which has some vapor resistance. It would also represent the location of a VR if an impermeable AB/WRB membrane is used.

Thermal Performance and Energy Code Compliance

This chapter assembly is typically classified as a “mass” above-grade wall for energy code compliance purposes. Prescriptive energy code compliance values for this assembly are summarized in Table 6-2 on page 10 and describe:

- Minimum insulation R-values for a prescriptive R-value compliance strategy.
- Maximum assembly U-factors for a prescriptive U-factor alternative compliance strategy. Note, the equivalent assembly effective R-value of this maximum U-factor has been calculated and is denoted in parenthesis ( ) for easy comparison to thermal modeling results included within this chapter.
- Footnote (2) for compliance by exception. The ability to use this option depends on the jurisdiction, building’s occupancy type, and availability of CMU cores to be filled with insulation. If this exception is to be used, refer to the Chapter 4 Thermal Performance and Energy Code Compliance section.

When a non-prescriptive compliance option (e.g., a trade-off strategy or whole-building modeling strategy) is used for energy code compliance, this assembly’s effective thermal performance will need to be calculated; however, it may or may not be required to meet the prescriptive values shown in Table 6-2.

Fig. i-17 on page i-29 of the introductory chapter describes the typical process of navigating energy code compliance strategies and options. Thermal modeling results demonstrated within this chapter may be used to assist with estimating insulation thickness and cladding support clip type/material to achieve a target thermal performance value. Options for thermally optimizing this assembly, as determined through the modeling results are also provided.

Assembly Effective Thermal Performance

Claddings support clips, such as intermittent Z-girts or fiberglass clips as shown in Fig. 6-5, penetrate the exterior insulation in this assembly and create areas of thermal bridging (i.e., heat loss). An example of thermal bridging is described by Fig. 6-6 and Fig. 6-7 on page 6-8, which show the relative thermal gradient of this assembly when thermally modeled with an intermittent Z-girt. The lighter blue thermal gradient color at the attachment describes a warmer temperature than the adjacent darker blue insulation face—an indicator of heat loss at the penetration through the insulation. This thermal bridging reduces the assembly’s effective thermal performance.

To demonstrate this assembly’s effective thermal performance with various insulation thicknesses, insulation R-values, and cladding support clips/materials, three dimensional thermal modeling was performed. A discussion on the modeling performed for this guide is included in the Introduction Chapter and the Appendix.

Thermal Modeling: Variables

The following are modeling variables specific to this assembly—CMU wall with adhered masonry veneer:

- Wall Structure: An 8-inch medium-weight block
- Cladding Supports Clips and Fasteners: Two example cladding support systems are
This assembly has a greater effective R-value when fiberglass clips or other low-conductivity clip supports are used in lieu of intermittent Z-girts. A number of systems are commercially available and new products continue to be developed. Most manufacturers of proprietary clip systems will have thermal modeling results available for use in determining the assembly’s thermal performance for energy code compliance.

- Greater assembly effective R-values occur when comparing the same insulation thickness for different fiberglass clip fastener types as shown in Table 6-3, Fig. 6-8, and Fig. 6-9. This guide’s modeling exercise demonstrated that the assembly effective R-value with Exterior Insulation (Without Penetrations) is reduced by 11 to 19% for stainless steel fasteners and by 20 to 32% for galvanized steel fasteners. **Stainless steel fasteners through fiberglass clips perform better than galvanized steel fasteners.**

- As determined from Table 6-3, intermittent stainless steel Z-girts reduce the assembly’s effective R-value for Exterior Insulation (Without Penetrations) by 21 to 32%. Galvanized steel intermittent Z-girts reduce it by 35 to 53%. **Greater assembly effective R-values are achieved with stainless steel intermittent Z-girts as opposed to galvanized steel Z-girts.**

- Assembly effective R-values are similar for both fiberglass clips with galvanized steel fasteners or stainless steel intermittent Z-girts as shown in Table 6-3, Fig. 6-8, and Fig. 6-9. **This demonstrates that some performance targets can be met without proprietary cladding attachment systems. This consideration may prove to be a cost-effective solution.**

**Drainage, Ventilation, and Water Deflection**

The adhered veneer cladding is expected to shed most water it is exposed to; however, some moisture is expected to penetrate the cladding and enter the rainscreen cavity. This moisture is drained through the cavity created by the continuous Z-girts that support the cladding and through the drainable, semi-rigid insulation.

**Drainage and Ventilation**

The rainscreen cavity is created by 1-inch minimum continuous Z-girts typically spaced at 16 inches on-center. These Z-girts should be broken at horizontal joints where movement joints occur or where cross-cavity sheet-metal flashings occur; typically at every floor line for structures 3 stories or taller.
Table 6-2 Assembly 6 prescriptive energy code compliance values excerpted from Table i-1 of the introductory chapter

<table>
<thead>
<tr>
<th>Guide Assembly</th>
<th>Classification</th>
<th>All Other In 5 and Marine</th>
<th>Group R</th>
<th>All Other In S, 6 and Marine</th>
<th>Group R</th>
<th>All Other In S and Marine</th>
<th>Group R</th>
<th>All Other In S and Marine</th>
<th>Group R</th>
<th>All Other In S and Marine</th>
<th>Group R</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>CMU Wall with Adhered Masonry Veneer</td>
<td>Mass</td>
<td>U-0.057 (R-17.5)</td>
<td>U-0.057 (R-17.5)</td>
<td>U-0.057 (R-17.5)</td>
<td>U-0.057 (R-17.5)</td>
<td>U-0.057 (R-17.5)</td>
<td>U-0.057 (R-17.5)</td>
<td>U-0.057 (R-17.5)</td>
<td>U-0.057 (R-17.5)</td>
<td>U-0.057 (R-17.5)</td>
</tr>
</tbody>
</table>

(1) When using interior insulation: R-13 + R-6 ci for wood studs or R-13 + R-10 ci for metal stud
(2) Provided at least 50% of block cores are filled with vermiculite (or equivalent fill insulation), and enclosing one of the following uses: gymnasium, auditorium, church chapel, arena, kennel manufacturing plant, indoor swimming pool, pump station, water and waste water treatment facility, storage facility, restroom/concessions, mechanical/electric structures, storage area, warehouse (storage and retail), and motor vehicle service facility. In Washington, where additional uses not listed (such as office, retail, etc.) are contained within the building, the exterior walls that enclose these areas may not utilize this exception.

Table 6-3 Assembly 6 thermal modeling results

<table>
<thead>
<tr>
<th>Exterior Insulation Thickness</th>
<th>Nominal Exterior Insulation R-Value</th>
<th>3D Thermal Modeling Effective R-Value (ft²·°F·hr/Btu)</th>
<th>Exterior Insulation (Without Penetrations)</th>
<th>Fiber glass Clips (0.8% Area)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Stainless Fasteners</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(12.5–15.3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(15.5–19.1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(18.4–22.7)</td>
</tr>
</tbody>
</table>

Fig. 6-8 Assembly 6 effective R-value modeling results for R-4.2/inch insulation and various types of cladding support clips

Fig. 6-9 Assembly 6 effective R-value comparison of various cladding support clips and a range of insulation R-values per inch
The rainscreen cavity should be open at the top and bottom to encourage ventilation and should be protected with an insect screen. This can be achieved by wrapping the insulation and base of the Z-girt. Insect screen should be placed at all locations where the rainscreen cavity is open to the exterior (e.g., base of walls, window head flashings, parapets, and cross-cavity flashings at floor lines).

Sheet-Metal Components

Sheet-metal components for this assembly are reflected throughout the details located at the end of this chapter. Cross-cavity sheet-metal components are located at the head of a penetration (e.g., a window head) and at cross-cavity floor line locations similar to that shown in Fig. 6-10. These flashings assist with draining the rainscreen cavity. Counterflashing sheet-metal components assist with watershed and are located at window sill and parapet cap to protect the cavity from water ingress while still allowing for cavity ventilation.

Sheet-metal flashing components that bridge the exterior insulation degrade the thermal performance of the assembly; however, they are a necessary element for the rainscreen design approach.

Refer to the introductory chapter for general recommendations on sheet-metal flashing products, including design considerations and materials.

Movement Joints

In this assembly, the thin masonry units are bonded to a crack isolation membrane over cement backer board. If using clay masonry units, they will expand over time, whereas manufacturer concrete veneer products and grout joints between units will shrink. Movement of the thin masonry veneer is accommodated within the grout, cement backer board, and crack isolation membrane.

The cement backer board and cladding support intermittent Z-girts and Z-furring will experience some movement along with the CMU backup structure which is expected to shrink over time due to initial drying, temperature fluctuations, and carbonation. As a result, both horizontal and vertical movement joints are needed to accommodate differential movement between the structure, cladding support system, and veneer.

Horizontal gaps within the veneer and cladding support system are recommended at every floor line for buildings taller than three stories. These gaps are typical and provided at cross-cavity sheet-metal flashing locations and should be continuous across all elevations of the building. Gaps above and below penetrations (such as windows) and below structure projections (such as parapet blocking) should also be provided. Locations where this gap should occur are indicated with an asterisk (*) in the details at the end of this chapter. At each horizontal gap, place either a backer rod and sealant joint or a cross-cavity sheet-metal flashing. The sizing and location of vertical movement joints will vary depending on the expected differential movement between the wall and veneer. It is the Designer of Record's responsibility to appropriately locate and size each joint. In general, a minimum gap dimension of 3/8 inch should be provided.

Vertical joint recommendations vary throughout the industry and should be confirmed with the veneer unit manufacturer for the project-specific application. This guide recommends that vertical movement joints be located throughout the veneer system and that horizontal-to-vertical placement relationships are also considered. Refer to the Joint Location section of the introductory chapter for more information on locating joints. For vertical joints, provide a minimum gap dimension of 3/8 of an inch.

Structural Considerations

Adhered masonry veneers rely on adhesion to secure the masonry units and should be designed to comply with local building codes and ACI 530.

The code requires that adhered veneers be applied over concrete or masonry backings and, traditionally, adhered masonry was applied directly over these wall types. However, recent code cycles requiring exterior insulation have dictated that adhered veneers over a CMU wall include some insulation at the exterior face of the backup wall and WRB plane.

Adhesion between adhered veneer units and the backer board must have a minimum shear strength at of at least 50 psi in accordance with ASTM C482. The units should be adhered in a thin-set mortar adhesive application to form a continuous bed free of voids. It is best practice to adhere veneer units with a modified mortar adhesive over a crack isolation membrane and water-resistive cement backer board.

When exterior insulation is required, the thin masonry assembly is supported
by an intermittent cladding support clips and continuous vertical Z-girts such as those shown in Fig. 6-11. The spacing of the supports and the sizing of the girts will need to be designed by the Designer of Record to resist building loads and limit out-of-plane deflection of the wall to less than L/360. Limiting this deflection will reduce the likelihood of flexural cracking. Minimizing the cladding support spacing may be considered to limit out-of-plane deflection but should be considered for impact on the effective thermal performance of the assembly. As shown in Fig. 6-12, smaller cladding support clip spacing is necessary to resist greater wind loads. As clip spacing is reduced, the effective thermal performance of the assembly is also reduced. Using lower conductivity structural supports can reduce the effect that cladding support clips have.

**Corrosion Resistance**

To avoid premature cladding replacement, the durability and longevity of metal components within this assembly should match that expected of the masonry veneer cladding system. Metal components within this assembly include intermittent Z-girts (when constructed of metal), continuous Z-furring, sheet-metal flashings, and fasteners such as screws and anchors. Where available, metal components should be manufactured of Type 304 or 316 stainless steel, which is nonstaining, resistant to the alkaline content of mortar materials, and tolerant of the high humidity conditions that can exist within a rainscreen cavity. Where stainless steel components may not be available, minimum G185 hot-dipped galvanized steel products should be considered.

Whereas the use of stainless steel sheet-metal flashing components is not always economically feasible or aesthetically desirable, prefinishing sheet metal may be considered. Where used, the base sheet metal should receive a minimum G90 hot-dipped galvanized coating in conformance with ASTM A653 or minimum AZ50 galvalume coating in conformance with ASTM A925.

![Fig. 6-11 Hot-dipped galvanized steel Z-girts attached to fiberglass cladding support clips](image)

![Fig. 6-12 Assembly effective R-value as it compares to maximum-allowable wind loads for various fiberglass cladding support clip spacing. These results assume fiberglass cladding support clips with two stainless steel screws spaced at 3 inches vertically and attached into a CMU substrate. The clips resist vertical gravity loads equally and receive horizontal loads based on their tributary areas. The design is generally limited by the pull-out resistance of the upper screw through the clip, which is under tension from the weight of the cladding and from horizontal wind suction pressures. The allowable screw loads are based on testing data and are specific to the type of screw modeled. The allowable wind pressure should always be compared to the specified wind pressure acting on the cladding, as determined by the local building code in the applicable jurisdiction. These structural values provide a schematic relationship between thermal and structural performance and are not intended to be used as structural design values. In the structural design graphs, the cladding weight was set at 20 psf for all assemblies. The horizontal clip spacing remained at 16 inches on-center. The vertical spacing options are 24 and 36 inches and the exterior insulation thickness ranges from 1 to 5 inches.](image)
with ASTM A792. The exposed top finish of the sheet metal should be coated with an architectural grade coating conforming to AAMA 2605.

Cement Backer Board

Cement backer board used within this assembly should be exterior-grade water-, mold-, and mildew-resistant, which meets ASTM C1325 Type A (exterior applications) or ANSI 118.9. The cement backer board should be attached to the continuous vertical Z-girts as required by the backer board manufacturer and project-specific design loads. The attachment method used should be appropriate for the Z-furring and intermittent cladding support design.

Joints of the cement board should be staggered and treated with a mesh tape bed in the veneer bonding material. Cement backer board product should be installed in conformance with the manufacturer installation instructions and set to provide a maximum 1/4-inch per 10 feet of tolerance. The cement backer board should not span joints within the veneer that are expected to accommodate movement.

Crack Isolation Membrane

A crack isolation membrane, like that shown in Fig. 6-13, is a flexible fluid-applied membrane used in thin masonry veneer applications where the veneer is adhered to a cement backer board. The crack isolation membrane is applied following installation of the cement backer board and treatment of the board joints. This membrane assists with:

- Reducing veneer cracking. The thin veneer adheres to the membrane, which allows the cement backer board to move independently of the veneer.

- Reducing fastener corrosion risk. The membrane protects cement board fasteners from moisture held within the veneer and bond coat.

- Reducing cement board exposure to moisture. The membrane reduces the moisture exchanged between the cement board and veneer bond coat and can increase the longevity of the board.

- Reducing efflorescence. The membrane reduces the moisture exchanged between the cement board and veneer bond coat and may result in reduced efflorescence.

Traditionally, this membrane may have been installed to protect the primary structure from moisture exposure. However, in this rainscreen assembly, the crack isolation membrane is not a replacement for the AB/WRB membrane, which is located on the exterior face of the CMU wall.

It is best practice to use a crack isolation membrane over cement backer board in thin masonry veneer applications. Some manufacturers may require this membrane to achieve a warrantable cladding installation.

Masonry Veneer

There are several types of adhered masonry veneer products that may be used with this assembly. Those most typical within the Northwest include thin veneer brick units made of clay or shale or manufacturer stone masonry veneer units.

Thin veneer brick used for this assembly should comply with ASTM C1088 and should be exterior-grade. Manufacturer stone masonry veneer units should comply with ASTM C1670.

For thin-set applications over cement board, as shown in this assembly, modified mortars at-minimum should conform to ANSI A118.4.
Appropriate product selection of masonry veneer unit and mortar materials is necessary to provide a durable and water-resistive cladding system. The veneer units and mortar bed and joints should also be installed in conformance with industry standard best practices and manufacturer requirements and should comply with ASTM C1780. The specifics of architectural characteristics and structural properties of the veneer system, including mortar and cladding support systems, should be designed and reviewed by a qualified Designer of Record.

Various industry resources are available to assist with veneer design and are listed in the Resources section.

Clear Water Repellents

A clear water repellent should be applied to the adhered masonry veneer of this assembly. Refer to the introductory chapter for more information on selecting an appropriate clear water repellent and best practice installation guidelines.

Pricing Analysis

A pricing analysis for this assembly is provided in Table 6-4 on page 6-19. Pricing demonstrates the relative price per square foot and is based on a 10,000-square-foot wall area with easy drive-up access. Pricing includes all components outboard of the CMU wall structure and provides no evaluation for interior finishes or CMU wall structure.


Online Availability

The content of this guide and additional resources may be accessed online at www.masonrysystemsguide.com. Also available online are downloadable digital versions of two- and three-dimensional assembly details and cutaway sections as well as sample project specifications. Ongoing updates to references and resources included within this guide can also be accessed.
Critical Barriers

1. Typical Assembly:
   - Single-wythe CMU wall
   - Fluid-applied or self-adhered sheet AB/WRB
   - Exterior insulation
   - Intermittent cladding support clip with 1-inch vertical Z-girt
   - Cement backer board
   - Crack isolation membrane
   - Adhesive thinset mortar
   - Adhered masonry veneer with grouted joints
   - Clear water repellent
2. Fluid-applied or self-adhered sheet AB/WRB head prestrip membrane
3. Sheet-metal head flashing with 1/2-inch hemmed drip edge and end dams beyond
4. Insect screen
5. Sealant over backer rod
6. Continuous back dam angle at rough opening perimeter, minimum 1 inch tall, with window fastened through back dam angle per window manufacturer recommendations
7. Continuous AB sealant, tide to continue seal at window perimeter
8. Storefront window
   * Size joint for project-specific building movement, minimum 3/8-inch.

**Detail Discussion**

- AB and WRB continuity is provided by the fluid-applied or self-adhered sheet AB/WRB field membrane, AB/WRB head prestrip membrane, and AB sealant transition to the storefront.
- The hemmed drip edge of the sheet-metal head flashing sheds water away from the masonry veneer above before it reaches the window and sill.
- The insect screen extends from the face of the CMU to the face of the vertical Z-girt to protect the cavity from insects while still allowing for ventilation and drainage.

Storefront Window Head
Detail 6-A
**Critical Barriers**

1. **Typical Assembly:**
   - Single-wythe CMU wall
   - Fluid-applied or self-adhered sheet AB/WRB
   - Exterior insulation
   - Intermittent cladding support clip with 1-inch vertical Z-girt
   - Cement backer board
   - Crack isolation membrane
   - Adhesive thinset mortar
   - Adhered masonry veneer with grouted joints
   - Clear water repellent

2. Storefront window on minimum 1/4-inch intermittent shims

3. Sealant over bond breaker

4. Insect screen

5. Sheet-metal sill flashing with 1/2-inch hemmed drip edge and end dams beyond

6. Fluid-applied AB/WRB sill membrane (or flexible self-adhered flashing membrane)

7. Continuous AB sealant, tied to continuous seal at window perimeter

8. Continuous back dam angle, minimum 1 inch tall, with window fastened through back dam angle per window manufacturer recommendations.

* Size joint for project-specific building movement, minimum 3/8-inch wide.

**Legend**

**Detail Discussion**

- AB and WRB continuity is provided by the fluid-applied or self-adhered sheet AB/WRB field membrane, fluid-applied or flexible self-adhered AB/WRB sill flashing membrane, and AB sealant transition to the storefront.

- The sheet-metal sill flashing conceals the rainscreen cavity and protects the cavity insulation from UV exposure. Terminate the sill flashing with end dams at each jamb; counterflash each end dam with the sheet-metal jamb trim to close off the rainscreen cavity and complete the WSS.

- The sheet-metal sill flashing sheds water from the window above and protects the rainscreen cavity. The hemmed drip of the sheet-metal flashing projects away from the cladding to promote watershed away from the masonry veneer face.
LEGEND

1. Typical Assembly:
   - Single-wythe CMU wall
   - Fluid-applied or self-adhered sheet AB/WRB
   - Exterior insulation
   - Intermittent cladding support clip with 1-inch vertical Z-girt
   - Cement backer board
   - Crack isolation membrane
   - Adhesive thinset mortar
   - Adhered masonry veneer with grouted joints
   - Clear water repellent
2. Storefront window
3. Sealant over backer rod
4. Fluid-applied or self-adhered sheet AB/WRB jamb prestrip membrane
5. Sheet-metal jamb trim bed in sealant at masonry veneer and counterflashed over sill flashing end dams below. Attach trim to nearest vertical Z-girt as shown.
6. Intermittent cladding support clip with 1-inch vertical Z-girt
7. Continuous back dam angle at rough opening perimeter, minimum 1 inch tall, with window fastened through back dam angle per window manufacturer recommendations.
8. Continuous AB sealant, tie to continuous seal at window perimeter

Detail Discussion

- AB and WRB continuity is provided by the fluid-applied or self-adhered sheet AB/WRB membrane, AB/WRB jamb prestrip membrane, and AB sealant transition to the storefront.

- Where needed, the exterior insulation should be supported with intermittent fasteners such as mechanically attached impaling pins. Consult with the AB/WRB manufacturer for requirements on detailing these pin attachments through the plane of the AB/WRB field membrane.
LEGEND

1. Typical Assembly:
   - Single-wythe CMU wall
   - Fluid-applied or self-adhered sheet AB/WRB
   - Exterior insulation
   - Intermittent cladding support clip with 1-inch vertical Z-girt
   - Cement backer board
   - Crack isolation membrane
   - Adhesive thinset mortar
   - Adhered masonry veneer with grouted joints
   - Clear water repellent
2. Insect screen
3. Sheet-metal flashing with 1/2-inch hemmed drip edge
4. Fluid-applied AB/WRB flashing membrane or flexible self-adhered flashing membrane
5. Drainage composite (optional)
6. Rigid XPS foundation insulation
7. Damp-proofing
8. Typical Assembly:
   - Concrete floor slab
   - Vapor barrier
   - Rigid XPS insulation
   - Capillary break

Detail Discussion

- The sheet-metal flashing protects the rigid XPS foundation insulation and damp-proofing from UV exposure.
- Insulating below the slab and exterior of the foundation wall is an alternative approach to the thermal break shown in Chapter 1, Detail 1-D.
**Detail Discussion**

- The sheet-metal parapet cap with hemmed drip edge is held off the adhered masonry veneer face to promote ventilation through the rainscreen cavity.

- The fluid-applied or self-adhered sheet AB/WRB field membrane, the high temperature self-adhered membrane at the parapet, and the roof assembly provide the AB and WRB continuity in this detail. The CMU also contributes to airtightness where fully grouted.

- A insect screen around the insulation and vertical Z-girt cavity prevents insects and debris from entering the rainscreen cavity, while still allowing ventilation.
### LEGEND

1. Single-wythe CMU wall
2. Fluid-applied or self-adhered sheet AB/WRB field membrane
3. Fluid-applied or self-adhered sheet AB/WRB head and jamb prestrip membrane
4. Storefront window
5. Sheet-metal head flashing with 1/2-inch hemmed drip edge and end dams beyond
6. Fluid-applied or self-adhered sheet AB/WRB field membrane
7. Sloped preservative treated blocking
8. High-temperature self-adhered membrane
9. Intermittent cladding attachment support clips with 1-inch Z-girt
10. Exterior insulation
11. Cement backer board
12. Crack isolation membrane
13. Adhesive thinset mortar
14. Adhered masonry veneer with grouted joints
15. Standing-seam sheet-metal coping with gasketed washer fasteners

### 3-D Detail Discussion

- Three-dimensional cutaway sections on the next three pages represent two-dimensional details of this assembly.

- In all details, WRB and WSS elements are shingle-lapped to encourage water shed in both the rainscreen cavity and at the masonry veneer face.

- As shown in Detail 6-F and Detail 6-G, exterior insulation fits between the intermittent cladding supports clips. When using XPS rigid board insulation, the insulation may require notching around clips. Where needed, the exterior insulation should be supported with intermittent fasteners such as mechanical impaling pins.

- End dams are formed at the ends of the sheet-metal head flashing shown in Detail 6-F to direct water away from the rainscreen cavity and back to the exterior.
**Base of Wall Section Model**

Detail 6-G

1. Concrete foundation element
2. Single-wythe CMU wall
3. Below-grade damp proofing
4. Fluid-applied AB/WRB flashing membrane or self-adhered flashing membrane
5. Drainage composite (optional)
6. Below-grade rigid XPS insulation
7. Sheet-metal base flashing with 1/2-inch hemmed drip edge for rigidity
8. Fluid-applied or self-adhered sheet AB/WRB field membrane
9. Storefront window
10. Exterior insulation
11. Cement backer board, crack isolation membrane, thinset mortar, adhered masonry veneer with grouted joints
12. Hardscape over gravel fill
13. Sealant over backer rod

**Window Jamb / Sill Cutaway Section**

Detail 6-H

1. Continuous back dam angle at rough opening perimeter, minimum 1 inch tall, with window fastened through back dam angle per window manufacturer recommendations
2. Fluid-applied or self-adhered sheet AB/WRB field membrane
3. Fluid-applied or flexible self-adhered AB/WRB sill flashing membrane
4. Continuous AB sealant, tied to continuous seal at window perimeter
5. Storefront window
6. Intermittent standoff clip with 1-inch Z-girt
7. Exterior insulation
8. Sheet-metal sill flashing with 1/2-inch hemmed drip edge, end dam into bed joint at jamb veneer beyond
9. Sealant over bond break
10. Cement backer board, crack isolation membrane, thinset mortar, adhered masonry veneer with grouted joints
CHAPTER 7:
STEEL-FRAMED WALL WITH ADHERED MASONRY VENEER

The Chapter 7 assembly is a rainscreen design approach with steel-framed wall structure and adhered masonry veneer. The components of this assembly, from interior to exterior, are shown in Fig. 7-1. This assembly is appropriate for many applications including low- or mid-rise residential or commercial buildings. An example application of this assembly is shown in Fig. 7-2 on page 7-3. Benefits and special considerations for this assembly are discussed in Table 7-1 on page 7-2.

Building Enclosure Control Functions and Critical Barriers

As noted in the Introduction, an above-grade wall assembly should provide control of water, air, heat, vapor, sound, and fire to serve as an effective and durable environmental separator. Control of these elements is provided by critical barriers such as a water-shedding surface (WSS), water-resistive barrier (WRB), air barrier system (AB), thermal envelope, and vapor retarder (VR). Refer to Fig. i-8 on page i-15 of the introductory chapter for a list of primary building enclosure control functions and associated critical barriers.
Table 7-1 Assembly 7 comparison matrix

<table>
<thead>
<tr>
<th>Assembly Recommendation</th>
<th>Category</th>
<th>Steel-Framed Wall with Adhered Masonry Veneer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recommended Occupancy Type</td>
<td>Residential OR Commercial</td>
<td></td>
</tr>
<tr>
<td>Building Enclosure Design Approach and Recommended Exposure</td>
<td>Rainscreen Design Approach, Low- to Mid-Rise Exposure. Consider access for maintenance on high-rise applications.</td>
<td></td>
</tr>
<tr>
<td>Long-Term Wall Assembly Durability</td>
<td>Resilient due to rainscreen drainage cavity; effect of split insulation must be carefully considered</td>
<td></td>
</tr>
<tr>
<td>Typical Wall Thickness</td>
<td>Thinner than anchored (Chapter #2 Assembly); continuous insulation increases thickness</td>
<td></td>
</tr>
<tr>
<td>Typical Cladding Design Compliance</td>
<td>Cladding system typically engineered. When proprietary cladding attachment systems are used, contact manufacturer.</td>
<td></td>
</tr>
<tr>
<td>Typical Thermal Performance</td>
<td>Continuous exterior insulation typically required to compensate for highly conductive steel framing. Cladding support penetrations through the exterior insulation may need to be considered when determining thermal performance.</td>
<td></td>
</tr>
<tr>
<td>Special Construction Considerations</td>
<td>Several cladding components and stages required</td>
<td></td>
</tr>
<tr>
<td>Construction Ease with Limited / No Exterior Access (property line applications)</td>
<td>Requires exterior access</td>
<td></td>
</tr>
<tr>
<td>Fire Resistivity Considerations</td>
<td>Fire resistivity moderate. Exterior insulation may affect fire propagation requirements.</td>
<td></td>
</tr>
<tr>
<td>Maintenance Considerations</td>
<td>Regular maintenance required. Additional maintenance/review recommended to ensure adhered veneer integrity.</td>
<td></td>
</tr>
<tr>
<td>Price Per Square Foot</td>
<td>Low and High Baseline Cost: $49.50 - $62.75</td>
<td></td>
</tr>
</tbody>
</table>

Fig. 7-3 illustrates the critical barrier locations for this assembly. The critical barriers for typical Chapter 7 assembly details are also provided adjacent to each detail at the end of this chapter.

As shown in Fig. 7-3, the WSS critical barrier occurs at the adhered masonry veneer, with most watersheding occurring at the wall face while a minimal amount of water will be stored within the masonry veneer to be released at a later time. The WRB and AB critical barriers occur at the same location exterior of the wall sheathing. As a result, a single membrane is typically used to provide these two critical barriers and is commonly referred to in this chapter as the air and water-resistive barrier (AB/WRB). The thermal envelope includes the exterior insulation and wall cavity insulation. The VR layer is located at the interior (warm side) of the steel-framed structure.

The following sections provide more information and discuss best practices for critical barriers specific to this assembly.

Water-Shedding Surface (WSS)

The WSS is a critical barrier that controls water.

The adhered masonry veneer cladding, including both grout joints and masonry veneer units, is the primary WSS of this assembly. Additional components include sheet-metal flashings and drip edges, sealant joints, and fenestration systems as shown on the details included at the end of this assembly chapter.

To promote water-shedding at the masonry cladding, grouted joints between veneer units should be appropriately installed with a tooled concave (preferred) or “V” shape.

When finished, the WSS critical barrier should be free of gaps, except where providing drainage. Movement joints and joints around fenestrations and penetrations should be continuously sealed with a backer rod and sealant joint or counterflashed with a sheet-metal flashing to deflect wind-driven rain and shed water away from the rainscreen cavity.

Water-Resistive Barrier (WRB)

The water-resistive barrier is a critical barrier that controls liquid water.

In this assembly, the WRB is a fluid-applied or self-adhered sheet membrane (that also functions as the AB). Either a fluid-applied or self-adhered sheet-applied membrane is depicted in the details at the end of this chapter. An example of a self-adhered sheet membrane is shown in Fig. 7-4 on page 7-4. The AB/WRB membrane of this assembly may be designed as:

- Vapor-permeable regardless of the amount of insulation within the cavity or
exterior of the AB/WRB critical barrier.

- **Vapor-impermeable** when at least 1/2 to 2/3 the total nominal insulation R-value of the assembly is placed exterior of the AB/WRB membrane. Note that where a vapor-impermeable membrane is used, it will also become the VR critical barrier. As a result, a separate VR critical barrier, as discussed at the interior side of the framing, should be omitted.

Refer to the introductory chapter for a discussion on the physical properties of both vapor-permeable and vapor-impermeable membranes.

The AB/WRB layer must be continuous across the wall face to serve as an effective critical barrier. In addition to the AB/WRB field membrane, the WRB critical barrier also includes fluid-applied or flexible flashing membranes, sealants, sheet-metal flashings, and interfaces with fenestration systems (e.g., windows and doors) as shown in the detail drawings that follow this chapter discussion. Where sheet-metal flashing components occur, the back leg of the sheet-metal flashing is lapped into the AB/WRB field membrane to encourage water at the WRB layer to drain toward the building exterior.

Cladding support clip fasteners in this assembly will penetrate the AB/WRB critical barrier and should be detailed based on the WRB manufacturer’s installation requirements. Typically, cladding support clips may be required to be set in a compatible sealant, fluid-applied flashing product, or attached through a self-adhered membrane patch.

**Air Barrier (AB)**

The air barrier is a critical barrier that primarily controls air, heat, and vapor. The AB also controls water, sound, and fire.

In this assembly, the AB system critical barrier is the same self-adhered sheet- or fluid-applied field membrane that also serves as the WRB critical barrier. The components described in the above Water-Resistive Barrier (WRB) section are also part of the AB layer, except sheet-metal flashings.

**Thermal Envelope**

The thermal envelope is a critical barrier that controls heat and assists with controlling vapor, sound, and fire.

In this wall assembly, the cavity and exterior insulation provide the thermal envelope. At transition details, the thermal envelope also includes exterior insulation across headers and floor lines, parapet cavity insulation, and insulation at the roof assembly, slab and foundation elements. Windows and doors that penetrate this wall are part of the thermal envelope.

Additional thermal envelope discussion is provided in the Thermal Performance and Energy Code Compliance section of this chapter and the introductory chapter.

**Insulation Selection**

The cavity insulation in this assembly is typically a vapor-permeable fiberglass or mineral fiber batt insulation product.

The exterior insulation typically used in this assembly is semi-rigid mineral fiber board insulation (R-4.2/inch), which is hydrophobic, tolerates moisture, and has free draining capabilities. Its vapor permeance allows it to be acceptable for use exterior of a vapor permeable AB/WRB membrane. An example of this insulation is shown in Fig. 7-4. The semi-rigid properties of the insulation allow it to be fit tightly around penetrations such as cladding support clips. A vapor-impermeable rigid board insulation such as XPS or moisture-resistant polyisocyanurate may be
appropriate when a vapor-impermeable AB/WRB membrane is used. Refer to the Water-Resistive Barrier section of this chapter for discussion regarding AB/WRB permeability.

Although masonry is defined as a noncombustible cladding material, the use of a combustible air and water-resistive barrier or foam plastic insulation within a wall cavity can trigger fire propagation considerations and requirements. Depending on the local jurisdiction, IBC Section 1403.5 regarding vertical and lateral flame propagation as it relates to a combustible water-resistive barrier may require acceptance criteria for NFPA 285. The use of foam plastic insulation within a wall cavity should also be addressed for IBC Chapter 26 provisions.

Vapor Retarder (VR)
The VR critical barrier is a layer that retards or greatly reduces (e.g., vapor barrier) the flow of water vapor due to vapor pressure differences across enclosure assemblies. Unlike the other critical barriers presented in this guide, the VR is not always necessary or required to be continuous.

When a vapor-permeable AB/WRB critical barrier is used within this assembly (see the Water-Resistive Barrier section of this chapter), the VR of this assembly is located on the interior (warm side) and is typically at the face of or just behind the interior gypsum board. The VR for this assembly should comply with Section 1405.3 of the governing International Building Code (IBC). In the Northwest, typical VR products include PVA vapor-retarding primer, asphalt-coated kraft paper, or a polyamide film retarder membrane. These products are discussed further in the introductory chapter.

When a vapor-impermeable membrane is used for the AB/WRB critical barrier (see the Water-Resistive Barrier (WRB) section of this chapter), the VR critical barrier is the AB/WRB membrane, and a separate VR membrane should not be used within this assembly.

Thermal Performance and Energy Code Compliance
This chapter assembly is typically classified as a “metal-framed” above-grade wall for energy code compliance purposes. Prescriptive energy code compliance values for this assembly are summarized in Table 7-2 on page 7-10 and describe:

- Minimum insulation R-values for a prescriptive R-value compliance strategy.
- Maximum assembly U-factors for a prescriptive U-factor alternative compliance strategy. Note, the equivalent assembly effective R-value of this maximum U-factor has been calculated and is denoted in parenthesis ( ) for easy comparison to thermal modeling results included within this chapter.

For cavity insulation, steel-stud walls are typically constructed with 16-inch on-center stud spacing and can accommodate up to an R-15 batt insulation for 4-inch studs or R-21 batt insulation for 6-inch studs. Alternate insulation products may also be used to fill the cavity but are not discussed within this guide. Steel framing, because of its high thermal conductivity properties, can reduce the nominal thermal performance of the stud cavity insulation by approximately 40 to 60%. For this reason, continuous insulation is necessary for prescriptive energy code compliance.

When a non-prescriptive compliance option (e.g., a trade-off strategy or whole-building modeling strategy) is used for energy code compliance, this assembly’s effective thermal performance will need to be calculated; however, it may or may not be required to meet the prescriptive values shown in Table 7-2 on page 7-10.

Fig. i-17 on page i-29 of the introductory chapter describes the typical process of navigating energy code compliance strategies and options. Thermal modeling results demonstrated within this chapter may be used to assist with estimating insulation thickness and cladding support clip type/material to achieve a target thermal performance value. Options for thermally optimizing this assembly, as determined through the modeling results, are also provided.

Assembly Effective Thermal Performance
Claddings support clips, such as intermittent Z-girts or fiberglass clips as shown in Fig. 7-5, penetrate the exterior insulation in this assembly and create areas of thermal bridging (i.e., heat loss). An example of the thermal bridging is described by Fig. 7-6 and
Steel. Clips are 6 inches tall and spaced at 24 inches on-center vertically, 16 inches on-center horizontally.

- Fiberglass standoff clips spaced at 24 inches on-center vertically and 16 inches on-center horizontally. Both stainless steel and galvanized steel fasteners are considered for the fiberglass clip option.

**Exterior Insulation:** R-4.2/inch or R-6/inch insulation product in thicknesses of 2, 3, and 4 inches. The R-values selected demonstrate the lower and upper thermal resistance of typical exterior insulation products.

**Thermal Modeling: Results**

The results of this modeling are shown in Table 7-3, Fig. 7-8, and Fig. 7-9 (see page 7-10 and page 7-11) and demonstrate the assembly effective R-value under various conditions; Fig. 7-8, and Fig. 7-9 are graphical representations of the results summarized in Table 7-3. Discussion of these results is provided below and key points for thermally optimizing this assembly are italicized in boldface.

- When comparing the same insulation thickness for the fiberglass clips and intermittent Z-girts, Table 7-3 results demonstrate that fiberglass clips will reduce the assembly’s effective R-value for Cavity + Exterior Insulation (Without Penetrations) by 10 to 29%, while intermittent Z-girts will reduce the performance by 16 to 24%.

Thermally improved cladding attachment options can achieve better effective thermal performance values. A number of systems are commercially available and new products continue to be developed. Most manufacturers of proprietary clip systems will have thermal modeling results available for use in determining the assembly’s thermal performance for energy code compliance.

- As determined from Table 7-3, when comparing the same insulation thickness for the fiberglass clips and intermittent Z-girts, Table 7-3 results demonstrate that fiberglass clips will reduce the assembly’s effective R-value for Cavity + Exterior Insulation (Without Penetrations) by 10 to 29%, while intermittent Z-girts will reduce the performance by 16 to 24%. Thermally improved cladding attachment options can achieve better effective thermal performance values. A number of systems are commercially available and new products continue to be developed. Most manufacturers of proprietary clip systems will have thermal modeling results available for use in determining the assembly’s thermal performance for energy code compliance.

- Greater effective R-values occur for intermittent Z-girts made of stainless steel than for galvanized steel when comparing the same insulation thickness for the different Z-girt types in both Fig. 7-8, and Fig. 7-9. Overall, stainless steel Z-girts reduce the assembly’s effective R-value by 16 to 26%, while galvanized steel Z-girts reduce it by 26 to 42%. *Intermittent Z-girts made of stainless steel perform better than galvanized steel.*

**Thermal Modeling: Variables**

The following are modeling variables specific to this assembly—steel-framed wall with adhered masonry veneer:

- **Framing and Cavity Insulation:** 3 5/8-inch steel stud wall with R-15 batt insulation. A full-height steel-stud wall including the top and bottom track adjacent to a concrete slab, but do not include the wall area at the slab edge.

- **Cladding Supports, Clips, and Fasteners,** where applicable: Two example cladding support systems are considered and are shown in Fig. 7-5 on page 7-7:
  - Intermittent Z-girts (16-gauge) made of either stainless steel or galvanized steel. Clips are 6 inches tall and spaced at 24 inches on-center vertically, 16 inches on-center horizontally.
  - Fiberglass standoff clips spaced at 24 inches on-center vertically and 16 inches on-center horizontally. Both stainless steel and galvanized steel fasteners are considered for the fiberglass clip option.

**Fig. 7-6 Three-dimensional section of an intermittent galvanized steel Z-girt supported adhered masonry veneer**

**Fig. 7-7 Three-dimensional thermal image of the attachment depicted in Fig. 7-6**
Table 7.2 Assembly 7 prescriptive energy code compliance values excerpted from Table i-1 of the introductory chapter

<table>
<thead>
<tr>
<th>Guide Assembly #</th>
<th>Classification</th>
<th>Opaque Above-Grade Wall - Thermal Envelope Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Steel-Framed Wall with Adhered Masonry Veneer</td>
<td>Steel-Framed Wall with Adhered Masonry Veneer</td>
</tr>
</tbody>
</table>

**Table 7.3 Assembly 7 thermal modeling results**

<table>
<thead>
<tr>
<th>Exterior Insulation Thickness</th>
<th>Nominal Insulation R-Value (Cavity + Exterior)</th>
<th>Effective R-Value (ft²·°F·hr/Btu)</th>
<th>Fiber Glass Clips (0.8% Area)</th>
<th>Stainless Fasteners</th>
<th>Galvanized Fasteners</th>
</tr>
</thead>
<tbody>
<tr>
<td>2&quot;</td>
<td>15 + 8.4–12</td>
<td>19.1–22.9</td>
<td>Stainless Fasteners</td>
<td>17.2–20.0</td>
<td>15.6–17.7</td>
</tr>
<tr>
<td>3&quot;</td>
<td>15 + 12.6–18</td>
<td>23.3–28.9</td>
<td>Galvanized Fasteners</td>
<td>20.6–24.4</td>
<td>18.5–21.3</td>
</tr>
<tr>
<td>4&quot;</td>
<td>15 + 16.8–24</td>
<td>27.7–35.1</td>
<td>Stainless Girt</td>
<td>24.1–29.1</td>
<td>21.4–24.9</td>
</tr>
</tbody>
</table>

**Fig. 7.8** Assembly 7 effective R-value modeling results for R-4.2/in - R-6/in exterior insulation and various cladding support clip options

**Fig. 7.9** Assembly 7 effective R-value comparison for a range of insulation thicknesses and various cladding support clip options
• Fig. 7-9 can be used to demonstrate how effective thermal performance and exterior insulation depth can help determine the best combination of the insulation and cladding support clip type/material. For example, if an effective R-24 is desired, the following options are described below. This exercise can help with determining the most cost-effective solution for reducing the wall thickness while meeting an energy performance target. This exercise can also help optimize effective thermal performance if a maximum exterior insulation thickness is known. Consider the selection of insulation and cladding support as a combination especially when wall thickness is important.

  - 3 inches (approx.) of R-6/inch insulation with fiberglass clips and stainless steel screws
  - 3.5 inches of R-6/inch insulation with intermittent stainless steel Z-girts
  - 4 inches (approx.) for R-6/inch insulation with fiberglass clips and galvanized steel fasteners or R-4.2/inch insulation with fiberglass clips and stainless steel fasteners

Drainage, Ventilation, and Water Deflection

The adhered veneer cladding is expected to shed most water exposure; however, some moisture is expected to penetrate the cladding and enter the rainscreen cavity. This moisture is drained through the cavity created by the continuous Z-girts that support the cladding and through the drainable, semi-rigid insulation.

Drainage and Ventilation

The rainscreen cavity is created by a 1-inch minimum continuous Z-girt typically spaced at 16 inches on-center to match the wall framing. These Z-girts should be broken at horizontal movement joints or where cross-cavity sheet-metal flashings occur; typically at every floor line for structures 3 stories or taller.

The rainscreen cavity should be open at the top and bottom to encourage ventilation and should be protected with an insect screen. This can be achieved by wrapping the insulation and base of the Z-girt. Insect screen should be placed at all locations where the rainscreen cavity is open to the exterior (e.g., base of walls, window head flashings, parapets, and cross-cavity flashings at floor lines).

Sheet-Metal Components

Sheet-metal components for this assembly are reflected throughout the details located at the end of this chapter. Cross-cavity sheet-metal components are located at the head of a penetration (e.g., a window head) and at cross-cavity floor line locations similar to that shown in Fig. 7-10. These flashings assist with draining the rainscreen cavity. Counterflashing sheet-metal components assist with watersheding and are located at window sills and parapet caps to protect the cavity from water ingress while still allowing for cavity ventilation.

Sheet-metal flashing components that bridge the exterior insulation degrade the thermal performance of the assembly; however, they are a necessary element for the rainscreen design approach.

Refer to the introductory chapter for general recommendations on sheet-metal flashing products, including design considerations and materials.

Movement Joints

In this assembly, the thin masonry units are bonded to a crack isolation membrane over cement backer board. If using clay masonry units, they will expand over time, whereas manufactured concrete veneer products and grout joints between units will shrink. Movement of the thin masonry veneer is accommodated within the grout, cement backer board, and crack isolation membrane.

The cement backer board and cladding support system as well as the steel framing are expected to experience some movement; as a result, both horizontal and vertical movement joints are recommended to allow for some differential movement between the structure, cladding support system, and veneer.

Horizontal gaps within the veneer and cladding support system should be
provided at every floor line for buildings taller than three stories. These gaps are typically provided at cross-cavity sheet-metal flashing locations and should be continuous across the elevation of the building. Gaps above and below penetrations (such as windows) and below structure projections (such as parapet blocking) should also be provided. Locations where this gap should occur are indicated with an asterisk (*) in the details at the end of this chapter. Either a backer rod and sealant joint or through-wall sheet-metal flashing should be placed at each horizontal gap. The sizing and location of vertical movement joints will vary depending on the expected differential movement between the wall and veneer. It is the Designer of Record’s responsibility to appropriately locate and size each joint. In general, a minimum gap dimension of 3/8 of an inch should be provided.

Vertical joint recommendations vary throughout the industry and should be confirmed with the veneer unit manufacturer for the project-specific application. This guide recommends that vertical movement joints are located throughout the veneer system and that horizontal-to-vertical placement relationships are also considered. Refer to the Joint Location section of the introductory chapter for more information on locating joints. For vertical joints, a minimum gap dimension of 3/8 of an inch should be provided.

**Structural Considerations**

Adhered masonry veneers rely on adhesive to secure the masonry units and should be designed to comply with local building codes and ACI 530.

The code requires that adhered veneers be applied over concrete or masonry backings and, traditionally, adhered masonry was applied directly over these wall types. However, recent code cycles requiring exterior insulation have dictated that adhered veneers over steel stud framed walls include some insulation at the exterior face of the framed wall and water barrier.

Steel framing in this assembly is recommended to be 20 gauge or heavier, spaced at a maximum of 16 inches on-center and designed to limit the out-of-plane deflection of the wall to less than L/360 to reduce cracking in the veneer. Relative to other wall types, metal stud framing is relatively flexible, and stiffness rather than strength may be a controlling factor in the wall design. Fasteners used to secure cladding support clips through the exterior sheathing and back to the metal stud framing are recommended to be stainless steel, self-tapping, minimum #10 self-tapping screws (0.190-inch shank diameter). Fasteners should penetrate through the stud a minimum of 3/8 of an inch. Steel stud base metal thickness should be a minimum of 0.043 inches to prevent fastener pull-out.

Adhesion between adhered veneer units and the backer board must have a minimum shear strength at of at least 50 psi in accordance with ASTM C482. The units should be adhered in a thin-set mortar adhesive application to form a continuous bed free of voids. It is best practice to adhere veneer units with a modified mortar adhesive over a crack isolation membrane and water-resistive cement backer board.

When exterior insulation is required, the adhered veneer assembly is supported by intermittent cladding supports and continuous vertical Z-girts as shown in Fig. 7-11. The spacing of the supports and the sizing of the girts will need to be designed by the Designer of Record to resist building loads and limit out-of-plane deflection of the wall to less than L/360. Limiting this deflection will reduce the likelihood of flexural cracking. Minimizing the cladding support spacing may be considered to limit out-of-plane deflection but should be considered for impact on the effective thermal performance of the assembly. As shown in Fig. 7-12 on page 7-16, smaller cladding support clip spacing is required to resist greater wind loads. As clip spacing is reduced, the effective thermal performance of the assembly is also reduced. Using lower conductivity structural supports can reduce the impact of cladding support clips.

**Corrosion Resistance**

To avoid premature cladding replacement, the durability and longevity of metal components within this assembly should match that expected of the masonry veneer cladding system. Metal components within this assembly include intermittent Z-girts (when constructed of metal), continuous Z-furring, sheet-metal flashings, and fasteners such as screws and anchors. Where available, metal components should be manufactured of Type 304 or 316 stainless steel, which
is nonstaining, resistant to the alkaline content of mortar materials, and tolerant of the high humidity conditions that can exist within a rainscreen cavity. Where stainless steel components may not be available, minimum G185 hot-dipped galvanized products should be considered.

Whereas the use of stainless steel sheet-metal flashing components is not always economically feasible or aesthetically desirable, prefinishing sheet metal may be considered. Where used, the base sheet metal should receive a minimum G90 hot-dipped galvanized coating in conformance with ASTM A653 or minimum AZ50 galvalume coating in conformance with ASTM A792. The exposed top finish of the sheet metal should be coated with an architectural-grade coating conforming to AAMA 2605.

**Cement Backer Board**

Cement backer board used within this assembly should be exterior-grade water-, mold-, and mildew-resistant, which meets ASTM C1325 Type A (exterior applications). The cement backer board, as shown in Fig. 7-13, should be attached to the continuous vertical Z-girts as required by the backer board manufacturer and project-specific design loads. The attachment method used should be appropriate for the Z-furring and intermittent cladding support design.

Joints of the cement board should be staggered and treated with a mesh tape bed in the veneer bonding material. Cement backer board product should be installed in conformance with the manufacturer installation instructions and set to provide a maximum 1/4-inch/10 feet tolerance. The cement backer board should not span joints within veneer that are expected to accommodate movement or crack control.

**Crack Isolation Membrane**

A crack isolation membrane is a flexible fluid-applied membrane used in thin masonry veneer applications where the veneer is adhered to a cement backer board. The crack isolation membrane is applied following installation of the
cement backer board and treatment of the board joints. This membrane assists with:

- Reducing veneer cracking. The thin veneer adheres to the membrane, which allows the cement backer board to move independently of the veneer.
- Reducing fastener corrosion risk. The membrane protects cement board fasteners from moisture held within the veneer and bond coat.
- Reducing cement board exposure to moisture. The membrane reduces the moisture exchanged between the cement board and veneer bond coat and can increase the longevity of the board.
- Reducing efflorescence. The membrane reduces the moisture exchanged between the cement board and veneer bond coat and may result in reduced efflorescence.

Traditionally, this membrane may have been installed to protect the primary structure from moisture exposure. However, in this rainscreen assembly, the crack isolation membrane is not a replacement for the AB/WRB membrane, which is located on the exterior face of the CMU wall.

It is best practice to use a crack isolation membrane over cement backer board in thin masonry veneer applications. Some manufacturers may require this membrane to achieve a warrantable cladding installation. A crack isolation membrane is shown in Fig. 7-14.

Masonry Veneer

There are several types of adhered masonry veneer products that may be used with this assembly. Those most typical within the Northwest include thin veneer brick units made of clay or shale or manufacturer stone masonry veneer units.

Thin veneer brick used for this assembly should comply with ASTM C1088 and should be exterior-grade. Manufacturer stone masonry veneer units should comply with ASTM C1670.

For thin-set applications over cement board, as shown in this assembly, modified mortars should (at-minimum) conform to ANSI A118.4.

Appropriate product selection of masonry veneer units and mortar materials is necessary to provide a durable and water-resistive cladding system. The veneer units, mortar bed, and joints, should also be installed in conformance with industry standard best practices, manufacturer requirements, and comply with ASTM C1780. The specifics of architectural characteristics and structural properties of the veneer system, including mortar and cladding support systems, should be designed and reviewed by a qualified Designer of Record.

Various industry resources are available to assist with veneer design and are listed in the Resources section.

Clear Water Repellents

A clear water repellent should be applied to the adhered masonry veneer of this assembly. Refer to the introductory chapter for more information on selecting an appropriate clear water repellent and best practice installation guidelines.

Pricing Analysis

A pricing analysis for this assembly is provided on Table 7-4 on page 7-20. Pricing demonstrates the relative price per square foot and is based on a 10,000-square-foot wall area with easy drive-up access. Pricing includes all components outboard of the exterior wall sheathing and provides no evaluation for interior finishes (including VR), framing/sheathing, or cavity insulation.


Online Availability

The content of this guide and additional resources may be accessed online at www.masonrysistemsguide.com. Also available online are downloadable digital versions of two- and three-dimensional assembly details and cutaway sections as well as sample project specifications. Ongoing updates to references and resources included within this guide can also be accessed.
### Table 7-4 Assembly 7 steel-framed wall with adhered masonry veneer pricing analysis

<table>
<thead>
<tr>
<th>Assembly Component</th>
<th>Baseline Product</th>
<th>Alternate (call for estimate)</th>
<th>Baseline Cost/ft² (incl. labor)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>INTERIOR</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Interior gypsum board</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Vapor retarder</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Steel-framed wall with batt insulation</td>
<td>Fully adhered or mechanically attached sheet-applied membrane</td>
<td>Fluid-applied membrane system</td>
<td>$1.50 $3.50</td>
</tr>
<tr>
<td>4 Exterior sheathing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5* Air and water-resistive barrier</td>
<td>Semi-rigid mineral fiber board; 2 inch thickness</td>
<td>6-inch-tall clips at 34&quot; O.C. vertical; clips and girts G185 hot-dipped galvanized; self-tapping fasteners</td>
<td>$1.75 $2.75</td>
</tr>
<tr>
<td>6* Semi-rigid insulation</td>
<td>No specified alternate</td>
<td>Stainless clips or thermally improved proprietary cladding support system</td>
<td>$3.00 $9.00</td>
</tr>
<tr>
<td>4* Intermittent standoff clip with 1-inch Z-girt</td>
<td>Modular (3/4&quot; x 2-1/4&quot; x 7-5/8&quot;) extruded TBX; running bond; 3/8 inch mortar joints</td>
<td>Alternate veneer products</td>
<td>$39.00 $41.00</td>
</tr>
<tr>
<td>5* Cement backer board</td>
<td>Moisture-resistant 5/8&quot;-thick, taped &amp; fastened</td>
<td>No specified alternate</td>
<td>$2.50 $4.00</td>
</tr>
<tr>
<td>6* Adhered masonry or stone veneer with grouted joints, includes polymer modified thin-set</td>
<td>Various</td>
<td>Alternate veneer products</td>
<td>$39.00 $41.00</td>
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<tr>
<td>7* Clear water repellent</td>
<td>Silane/siloxane blend</td>
<td>Antigraffiti clear water repellent</td>
<td>$1.75 $2.50</td>
</tr>
<tr>
<td><strong>EXTERIOR</strong></td>
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<td></td>
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</tr>
<tr>
<td>Total cost to install 10,000 sq ft wall area w/easy drive-up access</td>
<td></td>
<td></td>
<td>$49.50 $62.75</td>
</tr>
</tbody>
</table>

### Pricing Analysis Discussion

- Low and high baseline costs are based on the baseline products listed. Call for an estimate for alternate product pricing.
- Baseline costs provided will vary based on product specifics and should be used as an estimate only.
- Veneer unit prices are for typical units as noted. Pricing can vary based on size, color, and finish and should be confirmed with the unit manufacturer.
- * See the Resource section of this guide for a list of resources related to this component.

### Assembly Plan View

![Assembly Plan View](image)
Typical Window Head
Detail 7-A

**LEGEND**

1. Typical Assembly:
   - Interior gypsum board
   - VR
   - Steel-framed wall with batt insulation
   - Exterior gypsum sheathing
   - Vapor-permeable fluid-applied or self-adhered sheet AB/WRB field membrane
   - Semi-rigid mineral fiber insulation
   - Intermittent cladding support clip with 1-inch vertical Z-girt
   - Cement backer board
   - Crack isolation membrane
   - Adhesive thinset mortar
   - Adhered masonry veneer with grouted joints
   - Clear water repellent

2. Fluid-applied or self-adhered sheet AB/WRB head prestrip membrane

3. Sheet-metal head flashing with 1/2-inch hemmed drip edge and end dams beyond

4. Insect screen

5. Sealant over backer rod

6. Window strap anchoring, bed in AB sealant at sealant joint plane

7. Non-flanged window

8. AB sealant over backer rod, tied to continuous seal at window perimeter

* Size joint for project-specific building movement and drainage, minimum 3/8-inch.

**Detail Discussion**

- AB and WRB continuity is provided by the fluid-applied or self-adhered sheet AB/WRB field membrane, AB/WRB head prestrip membrane, and AB sealant transition to the window. Window strap anchors are bed in sealant during fastening to eliminate any AB discontinuity behind the strap anchor that would otherwise lead to both air leakage and water ingress.

- A non-flanged window is used here. It facilitates future window repair and replacement without the need to remove the masonry veneer.

- Intermittent cladding support clips (beyond) may need to be bed in sealant, fluid-applied flashing membrane, or attached through self-adhered flexible membrane patches per AB/WRB manufacturer recommendations when fastening to the steel-framed structure. This ensures both airtightness and watertightness where the fasteners penetrate the AB/WRB field membrane.
**Critical Barriers**

**Detail Discussion**

- AB and WRB continuity is provided by the fluid-applied or self-adhered sheet AB/WRB field membrane, AB/WRB sill membrane, and AB sealant transition to the window.

- The sheet-metal sill flashing conceals the rainscreen cavity. Terminate the sill flashing with end dams at each jamb. Counterflash each end dam with the sheet-metal jamb trim to close off the rainscreen cavity and complete the WSS.

- Intermittent shims below the window encourage drainage of the window rough opening into the rainscreen cavity.
**Critical Barriers**

1. Typical Assembly:
   - Interior gypsum board
   - VR
   - Steel-framed wall with batt insulation
   - Exterior gypsum sheathing
   - Vapor-permeable fluid-applied or self-adhered sheet AB/WRB
   - Semi-rigid mineral fiber insulation
   - Intermittent cladding support clip with 1-inch vertical Z-girt
   - Cement backer board
   - Crack isolation membrane
   - Adhesive thinset mortar
   - Adhered masonry veneer with grouted joints
   - Clear water repellent
2. Non-flanged window
3. Sealant over backer rod
4. Fluid-applied or self-adhered sheet AB/WRB jamb prestrip membrane
5. Sheet-metal jamb trim bed in sealant at masonry veneer and counterflushed over sill flashing end dams below. Attach trim to nearest vertical Z-girt as shown.
6. Intermittent cladding support clip with 1-inch vertical Z-girt
7. Continuous AB sealant, tied to continuous seal at window perimeter
8. Window strap anchor, bed in AB sealant at sealant joint plane

**Detail Discussion**

- AB and WRB continuity is provided by the fluid-applied or self-adhered sheet AB/WRB membrane, the AB/WRB jamb prestrip membrane, and the AB sealant transition to the window.
- Where needed, the exterior insulation should be supported with intermittent fasteners such as mechanically attached impaling pins. Consult with the AB/WRB manufacturer for requirements on detailing these pin attachments through the plane of the AB/WRB field membrane.

---

**Typical Window Jamb**

Detail 7-C
**LEGEND**

1. Typical Assembly:
   - Interior gypsum board
   - VR
   - Steel-framed wall with batt insulation
   - Exterior gypsum sheathing
   - Vapor-permeable fluid-applied or self-adhered sheet AB/WRB
   - Semi-rigid mineral fiber insulation
   - Intermittent cladding support clip with 1-inch vertical Z-girt
   - Cement backer board
   - Crack isolation membrane
   - Adhesive thinset mortar
   - Adhered masonry veneer with grouted joints
   - Clear water repellent
2. Insect screen, typical
3. Sheet-metal flashing with 1/2-inch hemmed drip edge and end dams

* Size joint for building movement, minimum 3/8-inch separation for building movement, drainage, and ventilation.

**Detail Discussion**

- The cross cavity sheet-metal flashing conceals the rainscreen cavity from debris and wind-driven rain, while still allowing ventilation.

- Space above and below the cross cavity sheet-metal flashing is necessary to allow for relative movement between the structure and veneer.
**LEGEND**

1. Parapet Assembly
   - Interior gypsum board
   - VR
   - Steel-framed wall with batt insulation
   - Exterior gypsum sheathing
   - Vapor-permeable fluid-applied or self-adhered sheet AB/WRB field membrane
   - Semi-rigid mineral fiber insulation
   - Intermittent cladding support clip with 1-inch vertical Z-girt
   - Cement backer board
   - Crack isolation membrane
   - Adhesive thinset mortar
   - Adhered masonry veneer with grouted joints
   - Clear water repellent
2. Inverted roof membrane assembly
3. Standing-seam sheet-metal coping with gasketed washer fasteners
4. Preservative-treated blocking
5. High-temperature self-adhered membrane
6. Insect screen
7. Closed-cell spray foam insulation plug (AB)
   * Size joint for building movement, minimum 3/8-inch separation for building movement, drainage, and ventilation.

**Detail Discussion**

- The sheet-metal parapet cap with hemmed drip edge is held off the adhered masonry veneer face to promote ventilation through the rainscreen cavity.

- A insect screen around the insulation and vertical Z-girt cavity prevents insects and debris from entering the rainscreen cavity, while still allowing ventilation.

**Typical Parapet at Inverted Roof Membrane System**

Detail 7-E
LEGEND

1. Steel-framed wall with batt insulation
2. Exterior gypsum sheathing
3. Steel-framed parapet framing
4. Closed-cell spray foam insulation plug (AB)
5. Preservative-treated blocking
6. Inverted roof membrane assembly
7. Vapor-permeable fluid-applied or self-adhered sheet AB/WRB field membrane
8. Fluid-applied or self-adhered sheet AB/WRB head and jamb prestip membrane
9. Non-flanged window
10. Sheet-metal head flashing with 1/2-inch hemmed drip edge and end dams
11. Fluid-applied or self-adhered sheet AB/WRB field membrane
12. High-temperature self-adhered membrane
13. Standing seam sheet-metal coping with gasketed washer fasteners
14. Intermittent cladding support clips with 1-inch vertical Z-girt
15. Semi-rigid mineral fiber exterior insulation
16. Cement backer board
17. Crack isolation membrane
18. Adhesive thinset mortar
19. Adhered masonry veneer with grouted joints

3-D Detail Discussion

- Three-dimensional cutaway sections on the next three pages represent two-dimensional details of this assembly.
- In all details, WRB and WSS elements are shingle-lapped to encourage water shed in both the rainscreen cavity and at the adhered masonry veneer face.
- As shown in Detail 7-F and Detail 7-G, exterior insulation fits between the intermittent cladding supports clips. If using rigid board insulation, the insulation may require notching around clips. Where needed, the exterior insulation should be supported with intermittent fasteners such as mechanically attached impaling pins. Consult with the AB/WRB manufacturer for detailing requirements where impaling pins are attached through the AB/WRB field membrane.
- End dams are formed at the ends of the sheet-metal head flashing shown in Detail 7-F to direct water away from the rainscreen cavity and back to the exterior.
Floor Line Cutaway Section
Detail 7-G

1. Steel-framed wall with batt insulation
2. Exterior gypsum sheathing
3. Vapor-permeable fluid-applied or self-adhered sheet AB/WRB field membrane
4. Sheet-metal cross cavity flashing with 1/2-inch hemmed drip edge and end dams
5. Vapor-permeable fluid-applied or self-adhered sheet AB/WRB field membrane
6. Fluid-applied or self-adhered sheet AB/WRB head and jamb prestrip membrane
7. Non-flanged window
8. Sheet-metal sill flashing with 1/2-inch hemmed drip edge and end dams
9. Exterior semi-rigid mineral fiber insulation and intermittent cladding support clip with 1-inch vertical Z-girt
10. Adhered masonry veneer with grout joints over adhesive thinset mortar, crack isolation membrane, and cement backer board

Window Jamb / Sill Cutaway Section
Detail 7-H

1. Continuous back dam angle across sill, minimum 1 inch tall, with window fastened through back dam angle per window manufacturer recommendations
2. Vapor-permeable fluid-applied AB/WRB field membrane
3. Fluid-applied or flexible self-adhered AB/WRB sill flashing membrane
4. Intermittent minimum 1/4-inch shims
5. Continuous AB sealant, tied to continuous seal at window perimeter
6. Non-flanged window
7. Continuous AB sealant over backer rod
8. Sheet-metal sill flashing with 1/2-inch hemmed drip edge and end dams
9. Sealant over bond breaker
10. Intermittent cladding support clips with 1-inch vertical Z-girt
11. Exterior insulation semi-rigid insulation
12. Adhered masonry veneer with grout joints over adhesive thinset mortar, crack isolation membrane, and cement backer board
CHAPTER 8:
WOOD-FRAMED WALL WITH ADHERED MASONRY VENEER

The Chapter 8 assemblies are a **rainscreen design approach** with wood-framed wall structure and an adhered masonry veneer. The components of this assembly, from interior to exterior, are described in Fig. 8-1 for two assemblies, Option A and Option B. The thin masonry cladding is either applied with a thick bed method (scratch and bond coat) or thin bed method (thinset over cement backer board) and may be either fired clay masonry or manufactured stone. The thick bed method of application is identified in this chapter as Option A and is most appropriate for low-rise structures. The thin bed method is identified within this chapter as Option B and is most appropriate for low- to mid-rise structures. Both assemblies are appropriate for residential and commercial applications. An example application of this assembly is shown in Fig. 8-2 on page 8-3. Benefits and special considerations for this assembly are discussed in Table 8-1 on page 8-2.

**INTERIOR**
- Interior gypsum board
- Vapor retarder
- Wood-framed wall with batt insulation
- Exterior sheathing
- Vapor-permeable air and water-resistant barrier
  - Option A:
    - 1/2-inch-thick drainage matrix
    - Filter fabric
    - Metal lath
    - Scratch coat
    - Bond coat
  - Option B:
    - 1/2-inch drainage cavity with
    - Preservative-treated furring strips
    - Cement backer board
    - Crack isolation membrane
    - Adhesive thinset mortar
    - Adhered masonry veneer with grouted joints
    - Clear water repellent

**EXTERIOR**

*Fig. 8-1 Typical Assembly 8 components from interior to exterior.*
Building Enclosure Control Functions and Critical Barriers

As noted in the Introduction, an above-grade wall assembly should provide control of water, air, heat, vapor, sound, and fire to serve as effective and durable environmental separator. Control of these elements is provided by critical barriers such as a water-shedding surface (WSS), water-resistant barrier (WRB), air barrier system (AB), thermal envelope, and vapor retarder (VR). Refer to Fig. i-8 on page i-15 of the introductory chapter for a list of primary building enclosure control functions and associated critical barriers.

Fig. 8-3 illustrates the critical barrier locations for this assembly. The critical barriers for typical Chapter 8 assembly details are also provided adjacent to each detail at the end of this chapter.

As shown in Fig. 8-3, the WSS critical barrier occurs at the adhered masonry veneer with most watersheding occurring at the wall face, while a minimal amount of water will be stored within the masonry veneer to be released at a later time. The WRB and AB barriers occur at the same location exterior of the wall sheathing. As a result, a single membrane is used to provide these two critical barriers and is commonly referred to in this chapter as the air and water-resistive barrier (AB/WRB). The thermal envelope includes the cavity insulation. The VR layer is located at the interior (warm side) of the wood-framed structure.

The following sections provide more information and discuss best practices for the specific critical barriers of this assembly.

Water-Shedding Surface (WSS)

The water-shedding surface is a critical barrier that controls water.

The adhered masonry veneer cladding, including both grouted joints and masonry veneer units, is the primary WSS of this assembly. Additional components include sheet-metal flashings and drip edges, sealant joints, and fenestration systems as shown on the details included at the end of this assembly chapter.

To promote watersheding at the masonry cladding, grouted joints between veneer units should be appropriately installed with a tooled concave (preferred) or "V" shape.
When finished, the WSS critical barrier should be free of gaps except where providing drainage. Movement joints and joints around fenestrations and penetrations should be continuously sealed with a backer rod and sealant joint or counterflashed with a sheet-metal flashing to deflect wind-driven rain and shed water away from the rainscreen cavity.

Water-Resistive Barrier (WRB)

The water-resistive barrier is a critical barrier that controls liquid water. In this assembly, the WRB is a vapor-permeable mechanically attached sheet membrane, self-adhered sheet membrane, or fluid-applied membrane (that also functions as the AB). A vapor-permeable AB/WRB membrane allows this assembly to dry to the exterior. Drying ability to the exterior is not only beneficial during the service life of the building but also helps relieve construction-related moisture that may occur at the wood framing or wood-based sheathing products. A vapor-permeable mechanically attached sheet membrane is depicted in the details at the end of this chapter. An example of this WRB membrane type is shown in Fig. 8-4.

The AB/WRB layer must be continuous across the wall face to serve as an effective critical barrier. In addition to the AB/WRB field membrane, the WRB critical barrier also includes fluid-applied or flexible flashing membranes, sealants, sheet-metal flashings, and interfaces with fenestration systems (e.g., windows and doors) as shown in the detail drawings that follow this chapter discussion. Where sheet-metal flashing components occur, the back leg of the sheet-metal flashing is lapped into the AB/WRB field membrane to encourage water at the WRB layer to drain toward the building exterior.

Cladding support clip fasteners in this assembly will penetrate the AB/WRB critical barrier and should be detailed based on the WRB manufacturer's installation requirements. Typically, cladding support clips may be required to be set in a compatible sealant, fluid-applied flashing product, or attached through a self-adhered membrane patch.

Air Barrier (AB)

The air barrier is a critical barrier that primarily controls air, heat, and vapor. The AB also controls water, sounds, and fire.

In this assembly, the AB system critical barrier is the same field membrane that also serves as the WRB critical barrier. The components described in the above Water-Resistive Barrier (WRB) section are also part of the AB layer, except sheet-metal flashings.

Mechanically attached sheet-applied AB/WRB barrier materials should be attached per manufacturer recommendations to avoid membrane displacement and damage during wind events. For Option A of this assembly, manufacturer-recommended fasteners may be washer head nails or fasteners. The installation of drainage matrix and cladding components will also assist with holding the AB/WRB membrane in place. For Option B of this assembly, furring strips serve as the mechanical attachment as shown in Fig. 8-4. Note that furring strips should be installed immediately following AB/WRB membrane installation. Where furring strips are not immediately installed, manufacturer-recommended washer cap fasteners should be installed.

Thermal Envelope

The thermal envelope is a critical barrier that controls heat and assists with controlling vapor, sound, and fire.

In this wall assembly, the cavity insulation provides the thermal envelope. At transition details, the thermal envelope also includes parapet cavity insulation and insulation at the roof assembly, slab, and foundation elements. Windows and doors that penetrate this wall are part of the thermal envelope.

Exterior insulation may also be used with this assembly, as shown in Fig. 8-5 on page 8-6, to increase the assembly’s effective thermal performance.

Additional thermal envelope discussion is provided in the Thermal Performance and Energy Code Compliance section of this chapter and the introductory chapter.
Insulation Selection

The cavity insulation in this assembly is typically a vapor-permeable fiberglass or mineral fiber batt insulation product.

Exterior insulation is not recommended with Option A due to the difficulty of fastening insulation, drainage matrix, and metal lath materials and the difficulty in supporting final veneer components with this system.

Where exterior insulation is desired, Option B of this assembly should be considered. The adhered masonry veneer is supported with a cladding attachment support system made of intermittent clips and Z-girt furring as shown similarly in Fig. 8-5 and Fig. 8-6. Refer to Chapter 7 for additional discussion on insulation selection, cladding attachment supports, and cladding discussion when exterior insulation is to be used.

Vapor Retarder (VR)

The VR critical barrier is a layer that retards or greatly reduces (e.g., vapor barrier) the flow of water vapor due to vapor pressure differences across enclosure assemblies.

The VR of this assembly is located on the interior (warm side) and is typically at the face of or just behind the interior gypsum board. The VR for this assembly should comply with Section 1405.3 of the governing International Building Code (IBC). The use of foam plastic insulation within a wall cavity should also be addressed for IBC Chapter 26 provisions.

Although masonry is defined as a noncombustible cladding material, the use of a combustible air and water-resistive barrier or foam plastic insulation within a wall cavity can trigger fire propagation considerations and requirements. Depending on the local jurisdiction, IBC Section 1403.5 regarding vertical and lateral flame propagation as it relates to a combustible water-resistive barrier may require acceptance criteria for NFPA 285. The use of foam plastic insulation within a wall cavity should also be addressed for IBC Chapter 26 provisions.

Thermal Performance and Energy Code Compliance

This chapter assembly is typically classified as a “wood-framed and other” above-grade wall for energy code compliance purposes. Prescriptive energy code compliance values for this assembly are summarized in Table 8-3 on page 8-13 and describe:

- Minimum insulation R-values for a prescriptive R-value compliance strategy.
- Maximum assembly U-factors for a prescriptive U-factor alternative compliance strategy. Note, the equivalent assembly effective R-value of this maximum U-factor has been calculated and is denoted in parenthesis ( ) for easy comparison to thermal modeling results included within this chapter.

Wood-framed walls are typically constructed with 16-inch on-center stud spacing for standard framing or 24 inches on-center stud spacing for advanced framing methods. Nominal 2x6 framing typically accommodates up to an R-21 fiberglass or R-23 mineral fiber batt insulation and nominal 2x8 framing typically accommodates up to an R-30 mineral fiber batt insulation.

When continuous insulation requirements are to be met, this assembly will have insulation exterior of the wood frame structure and AB/WRB field membrane, as shown similarly in the Chapter 7 assembly.

When a non-prescriptive compliance option (e.g., a trade-off strategy or whole-building modeling strategy) is used for energy code compliance, this assembly’s effective thermal performance will need to be calculated; however, it may or may not be required to meet the prescriptive values shown in Table 8-3.

Fig. i-17 on page i-29 of the introductory chapter describes the typical process of navigating energy code compliance strategies and options.
modeling results demonstrated within this chapter may be used to assist with estimating insulation thickness and cladding support clip type/material (for an exterior insulated option) to achieve a target thermal performance value. Options for thermally optimizing this assembly, as determined through the modeling results are also provided.

Assembly Effective Thermal Performance

When exterior insulation is used with Option B of this assembly, cladding attachments supports such as intermittent Z-girts or fiberglass clips will penetrate the exterior insulation and create areas of thermal bridging (i.e., heat loss). An example of the thermal bridging is described by Fig. 8-7 and Fig. 8-8 which show the relative thermal gradient of this assembly when thermally modeled with an intermittent galvanized steel Z-girt. The lighter blue thermal gradient color at the attachment describes a warmer temperature than the adjacent darker blue insulation face—an indicator of isolated heat loss at the penetration through the insulation. This thermal bridging reduces the assembly’s effective thermal performance.

Three-dimensional thermal modeling demonstrates the effective thermal performance of the Option B assembly with and without exterior insulation (refer to Fig. 8-5). Also demonstrated through modeling is the effective thermal performance of the Option A assembly with various cavity insulation. A discussion on the modeling performed for this guide is included in the Introduction Chapter and the Appendix.

Thermal Modeling: Variables

The following are assembly-specific modeling variables:

- **Framing and Cavity Insulation:** 2x6 with R-21 batt insulation or 2x8 with R-30 batt insulation. Modeling results include a full-height wood-framed wall with a floor line. Standard framing allowance for 77% insulated cavity and 23% framing members such as studs, plates, and headers are used.

- **Cladding Supports Clips and Fasteners**, where applicable: Two example cladding support systems are considered and are shown in Fig. 8-9:
  - Intermittent Z-girts (16-gauge) made of either stainless steel or galvanized steel. Clips are 6 inches tall and spaced at 24 inches on-center vertically and 16 inches on-center horizontally.
  - Fiberglass standoff clips spaced at 24 inches on-center vertically and 16 inches on-center horizontally. Both stainless steel and galvanized steel fasteners are considered for the fiberglass clip option.

- **Exterior Insulation:** This assembly is considered with and without exterior insulation and includes insulation materials with either a thermal resistance of R-4.2/inch or R-6/inch in thicknesses of 1, 2, and 3 inches. The R-values selected demonstrate the lower and upper thermal resistance of typical exterior insulation products.

Thermal Modeling: Results

The results of this modeling are shown in Table 8-2, Fig. 8-11, and Fig. 8-12 (see page 8-11 and page 8-13) and demonstrate the assembly effective R-value under various conditions; Fig. 8-11, and Fig. 8-12 are graphical depictions of Table 8-2 results. Discussion of these results is provided below and key points for thermally optimizing this assembly are italicized in boldface. Results discussions are separated by assembly option.
Option A

- Modeling results shown in Table 8-2 demonstrate that an assembly effective R-value of 17.7 with a 2x6 wall and R-21 batt. An assembly effective R-value of 22.2 is achieved with a 2x8 wall and R-30 batt. When compared to the prescriptive energy code values in Table 8-1, results demonstrate than an R-30 cavity batt is an alternate approach to providing exterior continuous insulation within this assembly.

Option B

- Fiberglass clips and stainless steel intermittent Z-girts provide relatively similar assembly effective R-values (as shown in Fig. 8-12 and Table 8-2). Use of these clips reduce the Cavity + Exterior Insulation (Without Penetrations) assembly effective R-value by 3 to 10%. The most optimal effective R-value is provided with a fiberglass clip and stainless steel fasteners.

- Similar assembly effective R-values are achieved whether fiberglass clips with galvanized steel fasteners or intermittent stainless steel Z-girts are used as shown in Fig. 8-11 and Fig. 8-12. These results demonstrate that some performance targets can be met without proprietary cladding attachment systems. This consideration may prove to be a cost-effective solution.

Sheathing Selection

The exterior sheathing of this assembly is typically a wood- or gypsum-based product and is designated by structural requirements. Where wood-based products are used, plywood is recommended for its moisture tolerance. Where gypsum board is used, a moisture-resistant product with fiberglass facer is recommended.

Drainage, Ventilation, and Water Deflection

The adhered veneer cladding is expected to shed most water exposure; however, some moisture is expected to penetrate the cladding and enter the rainscreen cavity. This moisture is either drained through the drainage matrix layer of Option A (Fig. 8-10 on page 8-11) or through the cavity created by the furring strips of Option B (Fig. 8-13 on page 8-14). Water that drains through the rainscreen cavity is deflected back to the exterior of the cladding or evaporates by way of ventilation behind the cladding.

Drainage and Ventilation

For Option A, the rainscreen ventilation and drainage cavity is created by the drainage matrix. An example of entangled-filament drainage matrix and filter fabric is shown in Fig. 8-10. A plastic-dimpled drainage may be used as an alternate to the filament type of drainage matrix. This drainage material allows drainage of liquid water and some ventilation. A minimum drainage depth of 3/4 of an inch is recommended, while 1/2 an inch is acceptable in non-marine areas. A moisture-tolerant filter fabric between the drainage matrix and the mortar bed protects the drainage cavity from mortar droppings. This fabric is typically factory-adhered to the drainage matrix and replaces the need for a separate installation of building paper prior to scratch coat application.

For Option B, the rainscreen cavity is created by 3/4-inch-thick preservative-treated furring strips that align with stud framing as shown in Fig. 8-13. Furring strips allow for more ventilation within the cavity than drainage matrix or mat products. Furring strips should be broken at floor lines to allow for building movement.

In both assemblies, the rainscreen cavity should be open at the top and bottom to allow ventilation and should be protected with an insect screen. This can be achieved by wrapping the drainage matrix perimeter in Option A and wrapping the ends of the furring strips in Option B as shown in Fig. 8-13. Insect screen should be placed at all locations where the rainscreen cavity is open to the exterior (e.g., base of walls, window head flashings, parapets, and cross-cavity flashings at floor lines).
### Table 8-3 Assembly 8 prescriptive energy code compliance values excerpted from Table i-1 of the introductory chapter

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**Fig. 8-12 Assembly 8 Option B effective R-values for different cladding support clips and R-4.2/inch insulation**

**Fig. 8-11 Assembly 8 effective R-value modeling results for various cladding support clips and a range of insulation R-values/inch.**
Sheet-Metal Components

Sheet-metal components for this assembly are reflected throughout the details located at the end of this chapter. Cross-cavity sheet-metal components are located at the head of a penetration (e.g., a window head) and at cross-cavity floor line locations. These flashings assist with draining the rainscreen cavity. Counterflashing sheet-metal components assist only with watershed and are located at the window sill and parapet cap to protect the cavity from water ingress while still allowing for cavity ventilation.

Refer to the introductory chapter for general recommendations on sheet-metal flashing products, including design considerations and materials.

Movement Joints

For both options of this assembly, the wood-framed structure will undergo shrinkage. For Option A, the cementitious-based scratch and bond coat, and mortar joints will shrink. Clay masonry veneer units will expand over time, whereas manufacturer concrete veneer products and grout joints between units will shrink. While the reinforcing mesh of Option A will assist with crack control, movement within the veneer and between the veneer and backup wall structure should still be accommodated with horizontal and vertical movement joints. Similarly, with Option B volumetric changes will occur between the veneer and wood-framed wall and must be accommodated. For additional discussion regarding movement of adhered veneers in cement backer board applications refer to the Movement Joints section of Chapter 7.

For both Options A and B, horizontal gaps within the veneer and cladding support system should be provided at every floor line for buildings taller than three stories. These gaps are typically provided at cross-cavity sheet-metal flashing locations and should be continuous across the elevation of the building. Gaps above and below penetrations (such as windows) and below structure projections (such as parapet blocking) should also be provided. Locations where this gap should occur are indicated with an asterisk (*) in the details at the end of this chapter. Either a backer rod and sealant joint or cross-cavity sheet-metal flashing should be placed at each horizontal gap. The sizing and location of vertical movement joints will vary depending on the expected differential movement between the wall and veneer. It is the Designer of Record’s responsibility to appropriately locate and size each joint. In general, provide a minimum gap dimension of 3/8 of an inch.

Vertical movement joint recommendations vary throughout the industry and should be confirmed with the veneer unit manufacturer for the project-specific application. This guide recommends that vertical movement joints are located throughout the veneer system and that horizontal to vertical placement relationships are also considered. Refer to the Joint Location section of the introductory chapter for more information on locating joints. For vertical joints, provide a minimum gap dimension of 3/8 of an inch.

Example locations for an adhered masonry veneer application are shown in Fig. 8-14 on page 8-16.

Structural Considerations

For Option A, the masonry veneer is adhered with a bond coat to the mortar scratch coat. Metal lath reinforces the mortar and is attached back to the wood-framed structure. The thin masonry veneer should be designed to comply with local building code and ACI 530 requirements. The code requires that adhered masonry veneers be applied over concrete or masonry backings and, as such, there are special requirements for installing adhered veneer over wood-framed walls.

In Option A, the metal lath reinforces the scratch coat of mortar and controls cracking that may occur due to mortar shrinkage. Metal lath for this assembly is recommended to be a minimum 3.4 lbs/sq yd complying with ASTM C847 and should be installed in conformance with ASTM C1780. Fasteners used to secure the metal lath should be stainless steel nails with a minimum 3/4-inch embedment directly into the wood-framed structure. Fasteners should be spaced no more than 6 inches on-center in the vertical direction. An example of the Option A veneer is shown in Fig. 8-15.

The wood-framed wall itself should be designed to limit the out-of-plane deflection of the wall to less than L/360 to reduce cracking in the veneer. Framing
G185 hot-dipped galvanized products should be considered.

Whereas the use of stainless steel sheet-metal flashing components is not always economically feasible or aesthetically desirable, prefinishing sheet-metal may be considered. Where used, the base sheet metal should receive a minimum G90 hot-dipped galvanized coating in conformance with ASTM A653 or minimum AZ50 galvalume coating in conformance with ASTM A792. It is recommended that the exposed top finish of the sheet metal be coated with an architectural-grade coating conforming to AAMA 2605.

**Masonry Veneer**

There are several types of adhered masonry veneer products that may be used with this assembly. Those most typical within the Northwest include thin veneer brick units made of clay or shale or manufacturer stone masonry veneer units.

Thin veneer brick used for this assembly should comply with ASTM C1088 and should be exterior-grade. Manufacturer stone masonry veneer units should comply with ASTM C1670.

For thick bed applications as shown in Option A, the scratch coat should comply with ASTM C270 for site mix applications or ASTM C1714 for preblended mortar and should be Type S or N. Setting bed mortar should also conform to these standards or may conform to ANSI 118.4.

For thin-set applications over cement board as shown in Option B, modified mortars at minimum should conform to ANSI A118.4.

**Corrosion Resistance**

To avoid premature cladding replacement, the durability and longevity of metal components within this assembly should match that expected of the masonry veneer cladding system. Metal components within this assembly include metal lath, sheet-metal flashings, and fasteners such as nails, screws, and staples. Where available, metal components should be manufactured of Type 304 or 316 stainless steel, which is nonstaining and resistant to the alkaline content of mortar materials. Where stainless steel components may not be available, minimum
Appropriate product selection of masonry veneer unit and mortar materials is necessary to provide a durable and water-resistive cladding system. The veneer units and mortar bed and joints should also be installed in conformance with industry-standard best practices and manufacturer requirements and should comply with ASTM C1780. For Option A, veneer installation methods may also be referenced from the Masonry Veneer Manufacturers Association Installation Guide and Detailing Options for Compliance with ASTM C1780. The specifics of architectural characteristics and structural properties of the veneer system, including mortar and cladding support system, should be designed and reviewed by a qualified Designer of Record.

Various industry resources are available to assist with veneer design and are listed in the Resources section of this guide.

Clear Water Repellents

Applied clear water repellents are recommended for this assembly whether using Option A or Option B. Refer to the introductory chapter of this guide for more information on selecting an appropriate clear water repellent and best practice installation guidelines.

Pricing Analysis

A pricing analysis for this assembly is provided in Table 8-4 on page 8-20 and Table 8-5 on page 8-21. Pricing demonstrates the relative price per square foot and is based on a 10,000-square-foot wall area with easy drive-up access. Pricing includes all components outboard of the exterior wall sheathing and provides no evaluation for interior finishes (including VR), framing/sheathing, or cavity insulation. Where Option B may be used with exterior insulation and a cladding attachment support system, refer to the Chapter 7 Pricing Analysis.


Online Availability

The content of this guide and additional resources may be accessed online at www.masonrysystemsguide.com. Also available online are downloadable versions of two- and three-dimensional assembly details and cutaway sections as well as sample project specifications. Ongoing updates to references and resources included within this guide can also be accessed.
### Table 8-4  Assembly 8A wood-framed wall with adhered masonry veneer (thick-set) pricing analysis

<table>
<thead>
<tr>
<th>Assembly Component</th>
<th>Baseline Product</th>
<th>Alternate (call for estimate)</th>
<th>Baseline Cost/ft² (incl. labor)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>INTERIOR</strong></td>
<td></td>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>1 Interior gypsum board</td>
<td></td>
<td>No evaluation of these components provided.</td>
<td></td>
</tr>
<tr>
<td>2 Vapor retarder</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Wood-framed wall with batt insulation</td>
<td>Fully adhered or mechanically attached sheet-applied membrane</td>
<td>$1.50</td>
<td>$3.25</td>
</tr>
<tr>
<td>4 Exterior sheathing</td>
<td>Entangled filament drainage matrix with moisture-resistant filter fabric</td>
<td>No specified alternate</td>
<td>$1.25</td>
</tr>
<tr>
<td>5* Vapor-permeable air and water-resistant barrier</td>
<td>Fluid-applied membrane system</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 Minimum 1/2-inch drainage matrix with filter fabric</td>
<td>3/4-inch-thick preservative treated furring strips</td>
<td>No specified alternate</td>
<td>$1.50</td>
</tr>
<tr>
<td>7* Metal lath</td>
<td>Moisture-resistant 5/8&quot;-thick, taped &amp; fastened</td>
<td>No specified alternate</td>
<td>$2.50</td>
</tr>
<tr>
<td>8* Mortar bed</td>
<td>Modular (3/4&quot; x 2-1/4&quot; x 7-5/8&quot;) extruded TBX; running bond; 3/8-inch mortar joints</td>
<td>No specified alternate</td>
<td>$39.00</td>
</tr>
<tr>
<td>9* Adhered masonry or stone veneer with grouted joints</td>
<td>Silane/siloxane blend</td>
<td>No specified alternate</td>
<td>$1.75</td>
</tr>
<tr>
<td>10* Clear water repellent</td>
<td>Antigraffiti clear water repellent</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**EXTERIOR**

Total cost to install 10,000 sq ft wall area w/easy drive-up access $38.75 $55.25

**Pricing Analysis Discussion**

- Low and high baseline costs are based on baseline products. Call for an estimate for alternate product pricing.
- Baseline costs provided will vary based on product-specific conditions and should be used as an estimate only.
- Veneer unit prices are for typical units as noted. Pricing will vary based on size, color, and finish and should be confirmed with the unit manufacturer.
- See the Resource section of this guide for product recommendation.

---

### Table 8-5  Assembly 8B wood-framed wall with adhered masonry veneer (thin-set) pricing analysis

<table>
<thead>
<tr>
<th>Assembly Component</th>
<th>Baseline Product</th>
<th>Alternate (call for estimate)</th>
<th>Baseline Cost/ft² (incl. labor)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>INTERIOR</strong></td>
<td></td>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>1 Interior gypsum board</td>
<td></td>
<td>No evaluation of these components provided.</td>
<td></td>
</tr>
<tr>
<td>2 Vapor retarder</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Wood-framed wall with batt insulation</td>
<td>Fully adhered or mechanically attached sheet-applied membrane</td>
<td>Fluid-applied membrane system</td>
<td>$1.50</td>
</tr>
<tr>
<td>4 Exterior sheathing</td>
<td>3/4-inch-thick preservative treated furring strips</td>
<td>No specified alternate</td>
<td>$1.50</td>
</tr>
<tr>
<td>5* Vapor-permeable air and water-resistant barrier</td>
<td>Moisture-resistant 5/8&quot;-thick, taped &amp; fastened</td>
<td>No specified alternate</td>
<td>$2.50</td>
</tr>
<tr>
<td>6 Furring strips</td>
<td>Modular (3/4&quot; x 2-1/4&quot; x 7-5/8&quot;) extruded TBX; running bond; 3/8-inch mortar joints</td>
<td>No specified alternate</td>
<td>$39.00</td>
</tr>
<tr>
<td>7* Cement backer board</td>
<td>Silane/siloxane blend</td>
<td>No specified alternate</td>
<td>$1.75</td>
</tr>
</tbody>
</table>

**EXTERIOR**

Total cost to install 10,000 sq ft wall area w/easy drive-up access $46.25 $53.00

**Assembly Plan View**

- Low and high baseline costs are based on baseline products. Call for an estimate for alternate product pricing.
- Baseline costs provided will vary based on product-specific conditions and should be used as an estimate only.
- Veneer unit prices are for typical units as noted. Pricing will vary based on size, color, and finish and should be confirmed with the unit manufacturer.
- See the Resource section of this guide for product recommendation.
LEGEND

1. Typical Assembly: (Option A)
   - Interior gypsum board
   - VR
   - Wood-framed wall with batt insulation
   - Exterior grade sheathing
   - Vapor-permeable AB / WRB field membrane
   - Filter fabric over minimum 1/2-inch drainage matrix
   - Metal lath
   - Bond and scratch coat
   - Adhered masonry veneer with grouted joints
   - Clear water repellent
2. Continuous AB sealant between AB/WRB prestrip and field membrane
3. Vapor-permeable sheet-applied or fluid applied AB/WRB head prestrip membrane
4. Sheet-metal head flashing with 1/2-inch hemmed drip edge and end dams beyond
5. Insect screen
6. Sealant over backer rod
7. Window strap anchor, bed in AB sealant at sealant joint plane
8. AB sealant over backer rod, tied to continuous seal at window perimeter
9. Non-flanged window
* Provide minimum 3/8-inch gap for drainage, ventilation, and movement.

Detail Discussion

- AB and WRB continuity is provided by the sheet-applied AB/WRB field membrane, sheet-applied or fluid applied AB/WRB rough opening head prestrip membrane, continuous AB sealant, and AB sealant transition to the window. A non-flanged window is used here. It facilitates future window repair and replacement without the need to remove the masonry veneer.

- The intermittent window clips are bed in sealant prior to fastening to prevent the passage of air and water leaks behind clip locations.

- See Chapter 7 detailing where a fluid applied or self-adhered sheet field membrane will be used for this assembly.
LEGEND

1. Typical Assembly: (Option A)
   - Interior gypsum board
   - VR
   - Wood-framed wall with batt insulation
   - Exterior grade sheathing
   - Vapor-permeable AB / WRB field membrane
   - Filter fabric over minimum 1/2-inch drainage matrix
   - Metal lath
   - Bond and scratch coat
   - Adhered masonry veneer with grouted joints
   - Clear water repellent

2. Non-flanged window on 1/4-inch intermittent shims for drainage

3. Intermittent L-angle for sill flashing attachment, fastened to window per window manufacturer recommendations

4. Sealant over bond break

5. Sheet-metal flashing with 1/2-inch hemmed drip edge with end dam into bed joint at jamb veneer beyond

6. Fluid-applied AB/WRB sill membrane (or flexible self-adhered flashing membrane)

7. Continuous AB sealant, tied to continuous seal at window perimeter

8. Continuous back dam angle, minimum 1 inch tall with window fastened through angle per window manufacturer recommendations

9. Insect screen

* Provide minimum 3/8-inch gap for drainage, ventilation, and movement.

Detail Discussion

- AB and WRB continuity is provided by the sheet-applied AB/WRB field membrane, the fluid-applied AB/WRB sill membrane (or flexible self-adhered flashing membrane), and the AB sealant transition to the window.

- The continuous back dam angle forms the sill pan. The window is set on intermittent shims over the sill pan to encourage rough opening drainage into the rainscreen cavity, where it can exit the cladding system below.

- The sheet-metal sill flashing sheds water from the window and cladding above, directing it away from the rainscreen cavity. The hemmed drip encourages watershed away from the masonry veneer face.
Critical Barriers

1. Typical Assembly: (Option A)
   - Interior gypsum board
   - VR
   - Wood-framed wall with batt insulation
   - Exterior grade sheathing
   - Vapor-permeable AB / WRB field membrane
   - Filter fabric over minimum 1/2-inch drainage matrix
   - Metal lath
   - Bond and scratch coat
   - Adhered masonry veneer with grouted joints
   - Clear water repellent

2. Non-flanged window

3. Sealant over backer rod

4. Vapor-permeable sheet-applied or fluid-applied AB/WRB rough opening sill membrane

5. AB sealant over backer rod, tied to continuous seal at window perimeter

6. Window strap anchor, bed in AB sealant at sealant joint plane

Detail Discussion

- AB and WRB continuity is provided by the sheet-applied AB/WRB field membrane, the sheet-applied or fluid-applied AB/WRB rough opening sill membrane, and the AB sealant transition to the window.

- The intermittent window clips are bed in sealant prior to fastening to prevent air and water passage behind clip locations.

- The backer rod and sealant between the window and adhered masonry veneer provides a continuous WSS across the window-to-wall transition.

Window Jamb
Detail 8a-C
**Legend**

1. Typical Assembly: (Option A)
   - Interior gypsum board
   - VR
   - Wood-framed wall with batt insulation
   - Exterior grade sheathing
   - Vapor-permeable AB/WRB field membrane
   - Filter fabric over minimum 1/2-inch drainage matrix
   - Metal lath
   - Bond and scratch coat
   - Adhered masonry veneer with grouted joints
   - Clear water repellent
2. Continuous AB sealant
3. Sheet-metal cross-cavity flashing with 1/2-inch hemmed drip edge and end dams beyond at intersecting elements
4. Closed-cell spray foam thermal insulation (VR)
5. Expansion gap
6. Insect screen

* Size joint for building movement, minimum 3/8-inch separation for building movement, drainage, and ventilation.

**Detail Discussion**

- Floor line insulation is provided with closed-cell spray foam to provide a continuous vapor retarder. Refer to Assembly 3 for an alternative approach.
- Space above and below the sheet-metal flashing allow for framing movement at the floor line without disrupting the sheet-metal flashing or veneer system.
Critical Barriers

1. Parapet Assembly (Option A)
   - Conventional roof membrane
   - Exterior grade sheathing
   - Wood-framed vented parapet
   - Exterior grade sheathing
   - Vapor-permeable AB / WRB field membrane
   - Filter fabric over minimum 1/2-inch drainage matrix
   - Metal lath
   - Bond and scratch coat
   - Adhered masonry veneer with grouted joints
   - Clear water repellent
2. Conventional roof assembly
3. Standing-seam sheet-metal coping with gasketed washer fasteners
4. High-temperature self-adhered membrane
5. Insect screen
6. Closed-cell spray foam insulation plug (AB)
7. Continuous bead of AB sealant
8. Closed-cell spray foam insulation plug (AB)
9. Insect screen
   * Size joint for building movement, minimum 3/8-inch separation for building movement and ventilation.

Detail Discussion

- A continuous bead of sealant behind the AB/WRB field membrane transfers the AB from the mechanically attached sheet field membrane to the sheathing and closed-cell spray foam plug at the parapet cavity.
- At minimum, parapet cavity and roof insulation R-values should be equivalent.
- The sheet-metal parapet cap is offset from the face of the masonry veneer to avoid blocking the ventilation path.

Typical Parapet at Conventional Roof System
Detail 8a-E
3-D Detail Discussion

- Three-dimensional cutaway sections on the next three pages represent two-dimensional details of this assembly.

- In all details, WRB and WSS elements are shingle-lapped to encourage water shed in both the rainscreen cavity and at the adhered masonry veneer face.

- AB continuity is created at the parapet in Detail 8a-F with the line of continuous AB sealant at the parapet and closed-cell spray foam insulation within the parapet cavity framing. These components assist with transferring the AB critical layer across the parapet sheathing to the AB at the roof assembly.

- Detail 8a-H describes a typical rough opening with sill back dam angle. The back dam angle creates a sill pan below the window. Intermittent shims encourage drainage at the sill and into the rainscreen cavity.

- The filter fabric over drainage matrix shown in all three-dimensional cutaway sections protects the drainage layer from getting clogged with mortar during scratch coat application.

- Washer-head fasteners shown in Details 8a-F through 8a-H secure the mechanically attached sheet AB/WRB field membrane to the wall structure. Manufacturer recommended attachment methods should be used and fully implemented to avoid damage to or displacement of the membrane prior to cladding installation and to ensure long-term support of the membrane throughout the service life of the building.
1. Sealant over backer rod at window perimeter
2. Sheet-metal flashing with 1/2-inch hemmed drip edge, end dam into bed joint at jamb veneer beyond
3. Vapor-permeable AB/WRB jamb prestrip membrane
4. Vapor-permeable AB/WRB field membrane
5. Exterior grade sheathing
6. Continuous AB sealant between AB/WRB field membrane lap
7. Cross-cavity sheet-metal flashing with 1/2-inch hemmed drip edge
8. Vapor-permeable AB/WRB field membrane
9. Filter fabric over drainage matrix
10. Adhered masonry veneer over bond coat and scratch coat
11. Batt Insulation
12. Closed-cell spray foam insulation and VR

See 8a-H

Window Sill / Through Wall Flashing Section Model
Detail 8a-G

1. Vapor-permeable AB/WRB field membrane
2. Continuous back dam angle at sill
3. Fluid-applied AB/WRB sill membrane (or flexible self-adhered flashing membrane)
4. AB/WRB jamb prestrip, continuously sealed/taped to sill membrane
5. Sheet-metal sill flashing with 1/2-inch hemmed drip edge
6. Sealant over backer rod flush with veneer face and window face
7. Sealant over backer rod between window frame and sheet-metal sill flashing
8. AB sealant over backer rod, tied to continuous seal at window perimeter
9. Adhered masonry veneer over bond coat and scratch coat
10. Non-flanged window
11. Filter fabric over drainage matrix

Window Jamb/Sill Section Model
Detail 8a-H
LEGEND

1. Typical Assembly: (Option B)
   - Interior gypsum board
   - VR
   - Wood-framed wall with batt insulation
   - Exterior grade sheathing
   - Vapor-permeable AB/WRB field membrane
   - 1/2-inch drainage cavity with preservative-treated furring strips
   - Cement backer board
   - Crack isolation membrane
   - Adhesive thinset mortar
   - Adhered masonry veneer with grouted joints
   - Clear water repellent

2. Continuous AB sealant between AB/WRB head prestrip and field membrane
3. Vapor-permeable sheet-applied or fluid applied AB/WRB head prestrip membrane
4. Sheet-metal head flashing with 1/2-inch hemmed drip edge and end dams beyond
5. Insect screen
6. Sealant over backer rod
7. Window strap anchor, bed in AB sealant at sealant joint plane
8. AB sealant over backer rod, tied to continuous seal at window perimeter
9. Non-flanged window

* Provide minimum 3/8-inch gap for drainage, ventilation, and movement.

Detail Discussion

- AB and WRB continuity is provided by the sheet-applied AB/WRB field membrane, the sheet-applied or fluid applied AB/WRB rough opening head prestrip membrane, the continuous AB sealant, and the AB sealant transition to the window.

- A non-flanged window is used here. It facilitates future window repair and replacement without the need to remove the masonry veneer.

- The intermittent window clips are bed in sealant prior to fastening to prevent the passage of air and water behind clip locations.

- See Chapter 7 detailing where a fluid applied or self-adhered sheet field membrane will be used for this assembly.

Window Head
Detail 8b-A
**Legend**

1. Typical Assembly (Option B):
   - Interior gypsum board
   - VR
   - Wood-framed wall with batt insulation
   - Exterior grade sheathing
   - Vapor-permeable AB/WRB field membrane
   - 1/2-inch drainage cavity with preservative-treated furring strips
   - Cement backer board
   - Crack isolation membrane
   - Adhesive thinset mortar
   - Adhered masonry veneer with grouted joints
   - Clear water repellent

2. Non-flanged window on 1/4-inch intermittent shims for drainage

3. Intermittent L-angle for sill flashing attachment, fastener to window per window manufacturer recommendations

4. Sealant over backer rod

5. Sheet-metal flashing with 1/2-inch hemmed drip edge, end dam into bed joint at jamb veneer beyond

6. Fluid-applied AB/WRB sill membrane (or flexible self-adhered flashing membrane)

7. Continuous AB sealant, tied to continuous seal at window perimeter

8. Continuous back dam angle at rough opening sill, minimum 1 inch tall, with window fastened through back dam angle per window manufacturer recommendations

9. Insect screen

* Provide minimum 3/8-inch gap for drainage, ventilation, and movement.

**Detail Discussion**

- AB and WRB continuity is provided by the sheet-applied AB/WRB field membrane, the fluid-applied AB/WRB sill membrane (or flexible self-adhered flashing membrane), and the AB sealant transition to the window.

- The continuous back dam angle forms the sill pan. The window is set on intermittent shims over the sill pan to encourage rough opening drainage into the rainscreen cavity where it can exit the cladding system below.

- The sheet-metal sill flashing sheds water from the window and cladding above, directing it away from the rainscreen cavity. The hemmed drip encourages watershed away from the masonry veneer face.
**LEGEND**

1. Typical Assembly: (Option B)
   - Interior gypsum board
   - VR
   - Wood-framed wall with batt insulation
   - Exterior grade sheathing
   - Vapor-permeable AB/WRB field membrane
   - 1/2-inch drainage cavity with preservative treated furring strips
   - Cement backer board
   - Crack isolation membrane
   - Adhesive thinset mortar
   - Adhered masonry veneer with grouted joints
   - Clear water repellent
2. Non-flanged window
3. Sealant over backer rod
4. Vapor-permeable sheet-applied or fluid-applied AB/WRB rough opening sill membrane
5. AB sealant over backer rod, tied to continuous seal at window perimeter
6. Window strap anchor, bed in AB sealant at sealant joint plane

**Detail Discussion**

- AB and WRB continuity is provided by the sheet-applied AB/WRB field membrane, the sheet-applied or fluid-applied AB/WRB rough opening sill membrane, and the AB sealant transition to the window.

- The intermittent window clips are bed in sealant prior to fastening to prevent the passage of air and water behind clip locations.

- The backer rod and sealant between the window and adhered masonry veneer provides a continuous WSS across the window-to-wall transition.

---

**Window Jamb**

Detail 8b-C
LEGEND

1. Typical Assembly: (Option B)
   - Interior gypsum board
   - VR
   - Wood-framed wall with batt insulation
   - Exterior grade sheathing
   - Vapor-permeable AB/WRB field membrane
   - 1/2-inch drainage cavity with preservative treated furring strips
   - Cement backer board
   - Crack isolation membrane
   - Adhesive thinset mortar
   - Adhered masonry veneer with grouted joints
   - Clear water repellent
2. Continuous AB sealant
3. Sheet-metal cross-cavity flashing with 1/2-inch hemmed drip edge and end dams beyond at intersecting elements
4. Closed-cell spray foam insulation and VR
5. Expansion gap
6. Insect screen
* Size joint for building movement, minimum 3/8-inch separation for building movement, drainage, and ventilation.

Detail Discussion

- Floor line insulation is provided with closed-cell spray foam to provide a continuous vapor retarder. Refer to Assembly 3 for an alternative approach.
- Space above and below the sheet-metal flashing allows for framing movement at the floor line without disrupting the sheet-metal flashing or veneer system.
LEGEND

1. Parapet Assembly: (Option B)
   - Interior gypsum board
   - VR
   - Wood-framed wall with batt insulation
   - Exterior grade sheathing
   - Vapor-permeable AB/WRB field membrane
   - 1/2-inch drainage cavity with preservative treated furring strips
   - Cement backer board
   - Crack isolation membrane
   - Adhesive thinset mortar
   - Adhered masonry veneer with grouted joints
   - Clear water repellent
2. Conventional roof assembly
3. Standing-seam sheet-metal coping with gasketed washer fasteners
4. Preservative-treated blocking
5. Insect screen
6. High-temperature self-adhered membrane
7. Closed-cell spray foam insulation plug (AB)
8. Continuous bead of AB sealant
9. Closed-cell spray foam insulation and VR
10. Insect Screen

* Size joint for building movement, minimum 3/8-inch separation for building movement, drainage, and ventilation.

Detail Discussion

- A continuous bead of sealant behind the AB/WRB field membrane transfers the AB from the field membrane to the sheathing and closed-cell spray foam plug at the parapet cavity.
- At minimum, parapet cavity and roof insulation R-values should be equivalent.
- The sheet-metal parapet cap is offset from the face of the masonry veneer so as not to block the ventilation path.

Typical Parapet at Conventional Roof System
Detail 8b-E
LEGEND

1. Standing-seam sheet-metal coping
2. High-temperature self-adhered membrane
3. Parapet framing
4. Conventional roofing system
5. Exterior grade sheathing
6. Continuous AB sealant between sheathing and AB/WRB field membrane
7. Vapor-permeable AB/WRB field membrane
8. Continuous AB sealant between AB/WRB field membrane and AB/WRB head prestrip
9. AB/WRB head prestrip at window head, continuously taped/sealed to AB/WRB jamb prestrip
10. Sheet-metal head flashing with 1/2-inch hemmed drip edge and end dams
11. Non-flanged window
12. Preservative-treated furring
13. Adhered masonry veneer over thinset adhesive mortar, crack isolation membrane, and cement backer board
14. Closed-cell spray foam insulation
15. Closed-cell spray foam insulation plug
16. Batt insulation

3-D Detail Discussion

- Three-dimensional cutaway sections on the next three pages represent two-dimensional details of this assembly.
- In all details, WRB and WSS elements are shingle-lapped to encourage water shed, in both the rainscreen cavity and at the masonry veneer face.
- AB continuity is created at the parapet in Detail 8b-F with the line of continuous AB sealant at the parapet and closed-cell spray foam insulation within the parapet cavity framing. These components assist with transferring the AB critical barrier across the parapet sheathing to the AB at the roof assembly.
- Detail 8b-H describes a typical rough opening with sill back dam angle. The back dam angle creates a sill pan below the window. Intermittent shims encourage drainage at the sill and into the rainscreen cavity.
- Furring strips shown in Details 8b-F through 8b-H secure the mechanically attached sheet AB/WRB field membrane to the wall structure. Manufacturer recommended attachment methods should be used and fully implemented to avoid damage to or displacement of the membrane prior to cladding installation and to ensure long-term support of the membrane throughout the service life of the building.
1. Sealant over backer rod at window perimeter
2. Sheet-metal flashing with 1/2-inch hemmed drip edge, end dam into bed joint at jamb veneer beyond
3. Vapor-permeable sheet-applied or fluid-applied AB/WRB jamb prestrip membrane
4. Preservative-treated furring
5. Exterior grade sheathing
6. Continuous AB sealant between AB/WRB field membrane lap
7. Vapor-permeable AB/WRB field membrane
8. Fluid-applied AB/WRB sill membrane (or flexible self-adhered flashing membrane)
9. Sheet-metal sill flashing with 1/2-inch hemmed drip edge
10. Non-flanged window
Thermal modeling for this guide was undertaken using HEAT3 (buildingphysics.com). HEAT3 is a three-dimensional finite element thermal analysis software tool, commonly used by the building industry to analyze building assemblies in three dimensions, which three-dimensional analysis tools (such as THERM) cannot accurately analyze. It allows for the more detailed analysis of building 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 modeled assembly.

The boundary conditions used for this modeling are industry standard ASHRAE winter exterior and interior boundary conditions with temperatures of 0°F and 70°F and surface films 0.165 ft²·°F·hr/BTU and 0.68 ft²·°F·hr/BTU respectively. The material conductivities used for the modeling are provided in Table A-1.

Additional modeling parameters include the following:

- Material properties used are based on the following references:
  - ASHRAE Handbook - Fundamentals 2013
  - ASHRAE Standard 90.1-2010
  - Product testing data
  - Data provided in the thermal modeling software
- All thermal modeling and resulting R-Values are for standard wall assemblies, including the floor line where applicable, but do not account for additional framing and resulting heat flow around penetrations such as windows and doors, unless otherwise noted.
- Continuous Z-girts exterior of clips/girts for adhered masonry assemblies are modeled at 18-gauge thickness with 1-inch-deep air space for all cases.
- Modeling was completed for various clips, girts, masonry ties, and shelf angle systems based on common products available to the market but does not necessarily reflect the exact design and dimensions of these products.
- All air spaces will be assigned R-values based on values given for plane air spaces in the ASHRAE Handbook - Fundamentals.
REFERENCES

Codes


Technical and Industry Guides


Installation Guide and Detailing Options for Compliance with ASTM C1780 for Adhered Manufactured Stone Veneer 4th Ed. 3rd Print. Masonry Veneer
Manufacturers Association. 2015


Organizations

Brick Industry Association

National Concrete Masonry Association

Northwest Concrete Masonry Association

Masonry Institute of Washington

Masonry Promotion Group of Spokane

International Masonry Institute

Masonry Institute of Oregon

Mason Contractors Association of America

WA State Conference of Mason Contractors

RESOURCES

Accessories

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