CHAPTER 4: INTEGRALLY INSULATED CMU WALL

Masonry system 4 is a mass wall system with a single-wythe concrete masonry unit (CMU) wall structure, often comprised of split face block, and integral insulation. The components of this system, from interior to exterior, are described in Fig. 4-1. This system is appropriate for low-rise commercial applications; an example project application is shown in Fig. 4-2 on page 4-2.

Building Enclosure & Control layers

As noted in the Introduction, an above-grade wall system controls liquid water, air, heat, and possibly water vapor to function as an effective and durable environmental separator. Control of these elements, specific to this wall system, is provided by the following control layer systems and/or materials:

- Water control layer, primarily comprising the mass CMU wall
- Air control layer, comprising the air barrier system

**Fig. 4-1 Typical System 4 components from interior to exterior**
Water-shedding Surface and Control Layers

The water-shedding surface is most effective when free of gaps; therefore, movement joints and joints around fenestrations and penetrations should be continuously sealed with a backer rod and sealant.

Water Control Layer

The water control layer is a continuous control layer that is designed and installed to act as the innermost boundary against water intrusion. For this system, the CMU block, mortar, and grout (inclusive of any integral water repellents) provide the water control layer.

The water control layer is made continuous with the help of flashing membranes at parapet tops, fluid-applied flashings at fenestration rough openings, sealant joints, and fenestration systems as shown on the details included at the end of this chapter.

To increase the rain penetration resistance of this system, a Class IV vapor permeance fluid-applied WRB system may be applied to the inside face of the system, or an elastomeric coating applied to the exterior CMU wall face may also be considered. The WRB system may be a Class III vapor permeance fluid-applied membrane when carefully considered for the project-specific application. Refer to the Elastomeric Coatings discussion on page i-62 for additional information on elastomeric coatings.

Air Control Layer

The air barrier system provides the air control layer. In addition to controlling air, this layer also assists with controlling liquid water, heat, and water vapor. A general discussion of the air control layer and the air barrier system is provided in the Air Control Layer discussion on page i-26.
The air barrier system for this wall system is typically satisfied through "deemed to comply" options within Section C402.4 of the 2012 International Energy Conservation Code (IECC) and Section 502.4 of the 2014 Oregon Energy Efficiency Specialty Code (OEESC). These deemed to comply options include:

- "Concrete masonry walls coated with one application either of block filler or two applications of paint or sealer coating" as a deemed-to-comply air barrier system provided all joints are sealed.
- "A Portland cement/sand parge, stucco, or plaster minimum ½-inch in thickness" as a deemed-to-comply air barrier system.

The 2015 Washington State Energy Code (WSEC) and 2015 Seattle Energy Code (SEC) do not include deemed-to-comply air barrier materials or systems because the whole building is required to meet air leakage requirements per C402.5. The Code Airtightness Requirements discussion on page i-43 further addresses whole-building air leakage requirements.

Where a fluid-applied WRB system is used at the interior face of this wall system or where an exterior elastomeric coating is applied, these membranes—along with fenestration rough opening membranes—will typically form the air barrier system.

**Vapor Control Layer**

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

This system 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 wall system is typically classified as a mass above-grade opaque wall system for energy code compliance purposes. Prescriptive energy code compliance values for a mass wall are summarized in Table 4-2 on page 4-8 and describe:

- The minimum insulation R-values for a prescriptive insulation R-value method strategy.
- The maximum system U-factors for a prescriptive assembly U-factor method strategy. Note that the equivalent effective R-value of this U-factor has been calculated and is denoted in parenthesis ( ).
- The effective thermal performance of this system is dependent on the properties of the CMU (including density, size, and web configuration) and is also impacted by the grout schedule and core insulation type. System 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 when insulation and project use requirements are met. The following exception applies to the 2014 OEESC provided the following conditions are met:
“1) At least 50 percent of cores must be filled with vermiculite or equivalent fill insulation; and

2) the structure encloses 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, restroom/concessions, mechanical/electrical structures, storage area, warehouse (storage and retail), motor vehicle service facility.”

Similarly, under the 2015 WSEC provisions, the following exception applies, provided the following conditions are met:

“1) At least 50 percent of cores must be filled with vermiculite or equivalent fill insulation; and

2) The building thermal envelope encloses one or more of the following uses: 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, storage area, motor vehicle service facility. 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 Table C402.1.3/U-factor from Table C402.1.4.”

A grouted area calculation chart is provided in Table 4-1 to assist with determining the area percentages of grouted cores versus ungrouted cores (e.g., cores available for insulation fill).

For all energy code compliance strategies except the prescriptive insulation R-value method strategy, this wall system’s U-factor will need to be calculated or determined from tables; however, it may or may not be required to be less than the prescriptive U-factors in Table 4-2 on page 4-8.

The Thermal Performance and Energy Code Compliance discussion on page i-33 and Fig. i-26 on page i-39 describe the typical process of navigating energy code compliance options.

<table>
<thead>
<tr>
<th>Horizontal Grout Spacing (Inches)</th>
<th>Vertical Grout Spacing (Inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>48</td>
<td>69/31</td>
</tr>
<tr>
<td>48</td>
<td>67/33</td>
</tr>
<tr>
<td>40</td>
<td>64/36</td>
</tr>
<tr>
<td>32</td>
<td>60/40</td>
</tr>
<tr>
<td>24</td>
<td>56/44</td>
</tr>
</tbody>
</table>

Project-specific thermal performance values for an opaque above-grade wall should be used for energy code compliance and determined from a source that is approved by the authority having jurisdiction. Thermal performance sources may include the Appendices of the 2015 WSEC, ASHRAE 90.1, COMcheck, thermal modeling and calculation exercises, or other industry resources.

Movement Joints

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 due to deflection, settlement, and various design loads will need to be addressed.

Consider crack control within the CMU to increase the rain penetration resistance of this system. Material properties and reinforcing methods of the CMU structural wall should be implemented to reduce cracking; however, control joints within the CMU wall also need to be implemented to provide a plane of weakness to reduce shrinkage stresses and provide continuity of the water-shedding surface 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 is installed at the joint as shown in Fig. 4-5 on page 4-8 to assist with water-shedding and to provide a continuous water control layer.

Refer to the Movement Joints discussion on page i-48 for more information on locating joints and sealant joint best practices.

Structural Considerations

The CMU block wall of this system provides the primary structure of this system. It is the responsibility of the Designer of Record to ensure that all structural elements of the wall are designed to meet project-specific loads and local governing building codes. Generic placement of the grout, reinforced elements, and supports/anchors are demonstrated within the details of this chapter and are provided for diagrammatic purposes only.
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 system (including through-wall flashings and sheet-metal drip flashings), it is best practice to provide components that are manufactured of ASTM A666 Type 304 or 316 stainless steel, which are nonstaining and resistant to the alkaline content of mortar and grout materials. Where stainless steel sheet-metal flashing components are not economically feasible or aesthetically desirable, prefinishing sheet-metal may be considered. Where used, this guide recommends the base sheet metal is a minimum G90 hot-dipped galvanized coating in conformance with ASTM A653 or minimum AZ50 galvalume coating in conformance with ASTM A792. Where stainless steel sheet-metal flashings include corrosion-resistant coating, the exposed top finish of the sheet metal with an architectural-grade coating is recommended.

**Water Repellents**

Both integral water-repellent admixtures and a surface-applied clear water repellent are used in this system and assist with reducing the water absorption of the CMU wall and encourage water shedding. Water-repellent admixtures should be used in both the CMU and the mortar. Admixture within block units should comply with ASTM C1384. More discussion on surface-applied clear water repellents is provided in the Surface-Applied Clear Water Repellents discussion on page i-59.

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

**Pricing Summary**

A pricing summary for this system is provided on Table 4-3 on page 4-12. 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 is valid for 2018. 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 system details and cutaway sections, sample project specifications, and ongoing updates to references and resources included within this guide.

Chapter References

1. Northwest Concrete Masonry Association. Tek Note: Rain-Resistant Architectural Concrete Masonry: (Mill Creek, WA: Northwest Concrete Masonry Association, 2014).


5. 2015 Seattle Energy Code, 2015 Washington State Energy Code as Amended by the City of Seattle. (Adopted by Seattle Department of Construction and Inspections, July 1, 2016).


### Table 4-3 System 4 integrally insulated CMU pricing summary

<table>
<thead>
<tr>
<th>System 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* 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>$20.00</td>
<td>$27.50</td>
<td></td>
</tr>
<tr>
<td>2 Optional</td>
<td>Groundface block and colors alternates</td>
<td>No specified alternate</td>
<td>$0.75</td>
<td>$2.75</td>
<td></td>
</tr>
<tr>
<td>3 Rebar</td>
<td>Standard code reinforcement; minimum Category D requirement</td>
<td>Additional reinforcing</td>
<td>$2.00</td>
<td>$5.00</td>
<td></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>
<td>$1.75</td>
<td></td>
</tr>
<tr>
<td>5* Clear water repellent</td>
<td>Surface-applied clear water repellent</td>
<td>No specified alternate</td>
<td>$1.75</td>
<td>$2.50</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>EXTERIOR</strong></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total cost to install 10,000 sq ft wall w/easy drive-up access</strong></td>
<td></td>
<td></td>
<td></td>
<td>$25.75</td>
<td>$39.50</td>
</tr>
</tbody>
</table>

### Pricing Summary Discussion
- Low and high baseline costs are based on baseline products and installed labor costs. Call for an estimate for alternative product pricing.
- Baseline costs provided will vary based on product-specific conditions as well as project location 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.
LEGEND

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

Water-Shedding Surface and Control Layers

- Water
- Air
- Vapor
- Thermal

* when an air barrier material is applied to the interior face of the CMU wall

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. This flashing is sealed into a kerf in the underside of the CMU rough opening head.

- Air control layer continuity is provided by the grouted and insulated CMU cores, the fluid-applied flashing membrane at the rough opening, and the air barrier sealant transition to the storefront window.

- The backer rod and sealant at the window perimeter provides continuity of the water-shedding surface between the CMU wall and storefront window face.
**Detail Discussion**

- Intermittent shims support the window frame and allow the window rough opening to drain to the exterior. The exterior backer rod and sealant joint at the sill is wept at quarter points along the sill to drain the rough opening.

- When a sill can is used with the storefront system, a fluid-applied flashing membrane and wept sealant joint at the rough opening should still be used as shown in this detail.
**Detail Discussion**

- A fluid-applied flashing membrane 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 air barrier sealant (and thus, the air control layer) at the window perimeter. Project-specific window attachment methods should be confirmed with the window manufacturer during the design phase of the project.
LEGEND

1. Typical Assembly:
   - Single-wythe CMU wall with water-repellent admixture at block and mortar
   - Core insulation or grout
   - Clear water repellent
2. Continuous air seal
3. Typical Assembly:
   - Thickened concrete floor slab
   - Vapor barrier
   - Rigid XPS insulation
   - Capillary break
4. Sheet-metal base-of-wall flashing with hemmed edge
5. Rigid XPS insulation
6. Fluid-applied or self-adhered flashing membrane
7. Damp proofing

Water-Shedding Surface and Control Layers

Control Layers:
- Water
- Air
- Vapor
- Thermal

* when an air barrier material is applied to the interior face of the CMU wall

Detail Discussion

- The base-of-wall sheet-metal flashing protects the rigid XPS foundation insulation from UV exposure and damage. The hemmed edge strengthens the sheet-metal flashing. 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 water that may exist at the wall base to collect below the finished floor elevation. This guide recommends a minimum 2-inch step.

- The continuous sealant joint at the interior floor line provides air control layer continuity from the CMU wall assembly to the concrete floor slab.

- See the next pages for an alternative floor slab detail.
**LEGEND**

1. Typical Assembly:
   - Single-wythe CMU wall with water-repellent admixture at block and mortar
   - Core insulation or grout
   - Clear water repellent
2. Typical Assembly:
   - Concrete floor slab
   - Vapor barrier
   - Rigid XPS insulation
   - Capillary break
3. Slab isolation joint
4. Damp proofing (optional)
5. Hardscape sealant joint

**Water-Shedding Surface and Control Layers**

- **Water-Shedding Surface**
- **Control Layers:**
  - Water
  - Air
  - Vapor
  - Thermal

* when an air barrier material is applied to the interior face of the CMU wall

**Detail Discussion**

- See Detail 4-D on the previous page for an alternative floor slab detail.
- The thermal performance of the concrete floor slab assembly may be improved by providing a thermal insulation break between the floor slab and CMU wall.

*Concrete Slab/CMU Foundation Detail*

**Detail 4-E**
LEGEND

1. Typical Parapet Assembly:
   - Inverted roof membrane
   - Single-wythe CMU wall with water-repellent admixture at block and mortar
   - Core insulation or grout
   - Clear water repellent
2. Inverted roof membrane system
3. Typical Assembly:
   - Single-wythe CMU wall with water-repellent admixture at block and mortar
   - Core insulation or grout
   - Clear water repellent
4. Sloped 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 sheds water away from the wall top and CMU wall face below. It is recommended that the sheet-metal cap counterflash the top course of block by a minimum of 3-inches.

- When a fluid-applied membrane is applied to the interior face of the single-wythe CMU (to increase the rain penetration resistance and/or to assist with airtightness), as discussed in Water Control Layer on page 4-3, this membrane should extend onto the bottom of the roof structure and should be continuous around anchors.

* when an air barrier material is applied to the interior face of the CMU wall

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Water-Shedding Surface and Control Layers

Control Layers:

- Water
- Air
- Vapor
- Thermal

Parapet at Inverted Roof Membrane System

Detail 4-F
LEGEND

1. Single-wythe CMU wall with water-repellent admixture within block and mortar
2. Partially grouted CMU wall
3. Sloped, preservative-treated wood blocking
4. High-temperature self-adhered membrane
5. Sloped 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 system.

- This system is deemed to comply with some energy code exceptions when at least 50% of the CMU cores are insulated as discussed in Thermal Performance and Energy Code Compliance on page 4-5. Some cores may be grouted as shown in Detail 4-G and others insulated as shown in Detail 4-H.

- The high-temperature self-adhered membrane and standing-seam sheet-metal coping protect the top of the wall from water. The sheet-metal drip edge deflects water away from the wall face.

- Detail 4-I 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-H, insulation below the thickened concrete floor slab and exterior of the foundation wall provides additional protection against heat loss at the wall-to-slab interface. The sheet-metal flashing protects the XPS insulation from UV and damage.
1. Thickened concrete floor slab and foundation element
2. Damp proofing
3. Fluid-applied or self-adhered flashing membrane
4. Rigid XPS foundation insulation
5. Base-of-wall sheet-metal flashing
6. Single-wythe CMU wall with water-repellent admixture within block and mortar
7. Core insulation
8. Sloped precast concrete sill
9. Concrete sidewalk or other hardscape, sloped away from structure
10. Continuous hardscape sealant joint
11. Continuous sealant joint at wall-to-slab interface

1. Single-wythe CMU wall with water-repellent admixture within block and mortar
2. Sloped precast concrete sill
3. Fluid-applied flashing membrane at rough opening and continuous perimeter back dam angle
4. Minimum 1/4-inch intermittent shims for drainage
5. Continuous air barrier sealant tied to continuous seal at window perimeter
6. Storefront window
7. Wept backer rod and sealant joint

Base-of-Wall Cutaway Section
Detail 4-H

Window Jamb and Sill Cutaway Section
Detail 4-I

LEGEND