Are you Wasting Energy?

M-Day: September 19, 2018

Jason Thompson – National Concrete Masonry Association (NCMA)
Overview

Codes have evolved...and continue to evolve...on the energy efficiency front.

• What new CMU options exist for energy compliance.
• What resources/tools exist for designing the thermal envelope with CMU.
• How masonry codes have evolved in meeting more stringent energy code requirements.
• Applying these solutions in design practice.
Ground Rules...

Ask questions any
time...

Or shoot me an email if you forget...

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jthompson@ncma.org  
703-713-1900
Perceptions = Reality?

Fatherhood: Perception

Reality
The New Reality

Complying with energy codes has changed how we approach our designs. Adding finishes or cladding is one option…
The New Reality

Complying with energy codes has changed how we approach our designs. Keeping masonry exposed on both sides requires new thinking...
What’s Your Perception?

Perception: Codes require continuous insulation... single wythe is off the table.
Evolution of CMU

- Concrete masonry unit/CMU
- Cinder block
- Cement/Concrete block
- Breeze block

Product of many names...
For 70 years, unit configuration requirements have been standardized.

**TABLE 1 Minimum Thickness of Face Shells and Webs \(^A\)**

<table>
<thead>
<tr>
<th>Nominal Width (W) of Units, in. (mm)</th>
<th>Face Shell Thickness (t_{fs}), min, in. (mm) (^{B,C})</th>
<th>Web Thickness (t_w)</th>
<th>Equivalent Web Thickness, min, in./linear ft (^E) (mm/linear m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 (76.2) and 4 (102)</td>
<td>¾ (19)</td>
<td>¾ (19)</td>
<td>1⅞ (136)</td>
</tr>
<tr>
<td>6 (152)</td>
<td>1 (25)</td>
<td>1 (25)</td>
<td>2¼ (188)</td>
</tr>
<tr>
<td>8 (203)</td>
<td>1¼ (32)</td>
<td>1 (25)</td>
<td>2¼ (188)</td>
</tr>
<tr>
<td>10 (254) and greater</td>
<td>1¼ (32)</td>
<td>1⅞ (29)</td>
<td>2½ (209)</td>
</tr>
</tbody>
</table>

Designation: C90

\(^A\) For use with lightweight concrete masonry units. \(^B\) Oblique cross-section dimension. \(^C\) See Fig. 1. \(^D\) Referring to the width of a solid web. \(^E\) Oblique cross-section dimension.
Evolution of CMU

1930s Building Solution

2010s Building Solution
Evolution of CMU

The marketplace, however, has evolved well beyond ASTM C90.
Evolution of CMU

And Energy Efficiency

The webs are ‘thermal shorts’:

• Heat flows through the webs.
• Reduce the webs...increase the R-value.

Translation to envelope applications...
Evolution of CMU

But it’s not just the unit configuration, but the design of the assembly that impacts thermal efficiency.
The Question

Why do we need a three web, two cell unit??

Structurally, the webs play a key role in the performance/integrity of the assembly. Shear transfer for out-of-plane flexure, tensile splitting under axial compression, etc.
The Question

But how much web is necessary?

\[ I_n = \left( \frac{1}{12} \right) (15.625)(7.625)^3 - \left( \frac{1}{12} \right) (7.4375)(5.125)^3 (2) I_n \]

\[ = 410.4 \text{ in.}^4 \]

\[ Q = (1.25)(15.625)(3.1875) + (0.75)(2.5625)(1.28125) \]

\[ Q = 64.7 \text{ in.}^3 \]

\[ b = 0.75 \text{ in.} \]

\[ V = (220)(16)/12 = 293.3 \text{ lb} \]
The Question

Findings: A standard three web, two cell unit provides a worse case factor of safety of 37...about 10 times higher than what we generally target for a reasonable factor of safety.

Change the codes...
TABLE 1 Minimum Face Shells and Web Requirements\textsuperscript{A}

<table>
<thead>
<tr>
<th>Nominal Width (W) of Units, in. (mm)</th>
<th>Face Shell Thickness (t\textsubscript{W}), min. in. (mm)\textsuperscript{BD}</th>
<th>Web Thickness (t\textsubscript{W}), min. in. (mm)</th>
<th>Normalized Web Area (A\textsubscript{nw}), min. in.\textsuperscript{2}/ft\textsuperscript{2} (mm\textsuperscript{2}/m\textsuperscript{2})\textsuperscript{D}</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 (76.2) and 4 (102)</td>
<td>3/4 (19)</td>
<td>3/4 (19)</td>
<td>6.5 (45, 140)</td>
</tr>
<tr>
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<td>1 (25)</td>
<td>3/4 (19)</td>
<td>6.5 (45, 140)</td>
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<tr>
<td>8 (203) and greater</td>
<td>1 1/4 (32)</td>
<td>3/4 (19)</td>
<td>6.5 (45, 140)</td>
</tr>
</tbody>
</table>

\textsuperscript{A} Average of measurements on a minimum of 3 units when measured as described in Test Methods C140.
\textsuperscript{B} When this standard is used for units having split surfaces, a maximum of 10% of the split surface is permitted to have thickness less than those shown, but not less than 3/8 in. (19.1 mm). When the units are to be solid grouted, the 10% limit does not apply and Footnote C establishes a thickness requirement for the entire faceshell.
\textsuperscript{C} When the units are to be solid grouted, minimum face shell and web thickness shall be not less than 3/8 in. (16 mm).
\textsuperscript{D} Minimum normalized web area does not apply to the portion of the unit to be filled with grout. The length of that portion shall be deducted from the overall length of the unit for the calculation of the minimum web cross-sectional area.

**Tables and Web Requirements\textsuperscript{A}**

<table>
<thead>
<tr>
<th>Webs</th>
<th>Normalized Web Area (A\textsubscript{nw}), min. in.\textsuperscript{2}/ft\textsuperscript{2} (mm\textsuperscript{2}/m\textsuperscript{2})\textsuperscript{D}</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/4 (19)</td>
<td>6.5 (45, 140)</td>
</tr>
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If the split surface is permitted to have thickness less than those shown, but not less than 3/8 in. (19.1 mm). When the units are to be solid grouted, the 10% limit does not apply and Footnote C establishes a thickness requirement for the entire faceshell. The length of that portion shall be deducted from the overall length of the unit.
ASTM C90 Web Revisions

What does this (literally/abstractly) mean?

Literally, this new requirement means that for every square foot of wall surface, no less than 6.5 in.\(^2\) of web must connect the front and back face shells, with no web measuring less than 0.75 in. in thickness.
ASTM C90 Web Revisions
ASTM C90 Web Revisions
3-Web Unit Configuration
ASTM C90 Web Revisions
2-Web Unit Configuration
ASTM C90 Web Revisions

1-Web Unit Configuration
Design Implications

Design of alternative web configurations is exactly the same, except if designing unreinforced masonry or if incorporating integral insulation – which requires a supplemental check of the web shear stresses.

\[ f_v = \frac{VQ}{I_n b} \leq 1.5 \sqrt{f'_m} \]
Design Implications

For grouted masonry, the addition of grout (even lightly grouted/reinforced assemblies) more than compensates for reduced webs to transfer shear between face shells.

For ungrouted masonry, the 6.5 in.²/ft² web area limit was back-calculated as the lower bound before web shear controlled the design under extreme loading scenarios.
Design Implications

H Block

Corner Unit

Stretcher Unit

A Block
Design Implications

Section properties vary slightly, but within the range of ‘conventional’ units.

<table>
<thead>
<tr>
<th>Face Shell Bedding Only</th>
<th>Three-Web Corner Unit</th>
<th>Three-Web Stretcher Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net Area (An)</td>
<td>30.0</td>
<td>30.0</td>
</tr>
<tr>
<td>Net MOI (In)</td>
<td>308.7</td>
<td>308.7</td>
</tr>
<tr>
<td>Full Mortar Bedding</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net Area (An)</td>
<td>38.6</td>
<td>38.6</td>
</tr>
<tr>
<td>Net MOI (In)</td>
<td>327.6</td>
<td>327.6</td>
</tr>
<tr>
<td>Solid Grouted</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net Area (An)</td>
<td>90.1</td>
<td>84.3</td>
</tr>
<tr>
<td>Net MOI (In)</td>
<td>440.2</td>
<td>427.5</td>
</tr>
<tr>
<td>Grout @ 16 in.</td>
<td></td>
<td></td>
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<tr>
<td>Net Area (An)</td>
<td>61.5</td>
<td>58.6</td>
</tr>
<tr>
<td>Net MOI (In)</td>
<td>383.9</td>
<td>371.3</td>
</tr>
<tr>
<td>Grout @ 120 in.</td>
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<td></td>
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<tr>
<td>Net Area (An)</td>
<td>34.2</td>
<td>33.8</td>
</tr>
<tr>
<td>Net MOI (In)</td>
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<td>317.0</td>
</tr>
</tbody>
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Design Implications

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<table>
<thead>
<tr>
<th></th>
<th>Three-Web Corner Unit</th>
<th>Three-Web Stretcher Unit</th>
<th>A-Block</th>
<th>H-Block</th>
</tr>
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<td>Face Shell</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
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</tr>
<tr>
<td>Full Mortar</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bedding</td>
<td>Net Area (An)</td>
<td>38.6</td>
<td>38.6</td>
<td>35.8</td>
</tr>
<tr>
<td></td>
<td>Net MOI (In)</td>
<td>327.6</td>
<td>327.6</td>
<td>321.4</td>
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<tr>
<td>Solid Grouted</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>319.0</td>
</tr>
</tbody>
</table>
Evolution of CMU

Conventional 3 Web CMU

Reduced Web CMU
Evolution of CMU

Make CMU Stronger…

\[ \zeta = 1.0 - \frac{2.3 A_{sc}}{d^2 s} \]  
(Equation 2-13)

Where: \( \frac{2.3 A_{sc}}{d^2 s} \leq 1.0 \)

\( A_{sc} \) is the area of the transverse bars at each end of the lap splice and shall not be taken greater than 0.35 in\(^2\) (226 mm\(^2\)).

(a) Grade 40 or Grade 50 reinforcement: 20,000 psi (137.9 MPa)
(b) Grade 60 reinforcement: 32,000 psi (220.7 MPa)

\[ q_{n inf} = 105 \left( f'_{m} \right)^{0.75} \left( \frac{\alpha_{arch}}{l_{inf}^{0.25}} + \frac{\beta_{arch}}{h_{inf}^{0.25}} \right) \]  
(Equation B-5)

\[ f_{v} = \frac{VQ}{I_{n} b} \]

2.3.4.2.2 The compressive stress in masonry due to flexure or due to flexure in combination with axial load shall not exceed 0.45 \( f'_{m} \) provided that the calculated compressive stress due to the axial load component, \( f_{a} \), does not exceed the allowable stress, \( F_{a} \), in Section 2.2.3.1.
Evolution of CMU

Same system...more strength.

18 ft wall, 8 in. CMU
40 psf wind pressure
3,000 lb/ft axial

<table>
<thead>
<tr>
<th>Code Edition(^1)</th>
<th>Reinforcement Size</th>
<th>Reinforcement Spacing</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009 IBC(^2)</td>
<td>No. 5</td>
<td>40 inches</td>
</tr>
<tr>
<td>2012 IBC(^2)</td>
<td>No. 5</td>
<td>48 inches</td>
</tr>
<tr>
<td>2015 IBC(^3)</td>
<td>No. 5</td>
<td>96 inches(^4)</td>
</tr>
</tbody>
</table>


\(^2\)\(f'_m\) = 1,500 psi

\(^3\)\(f'_m\) = 2,000 psi

\(^4\)Incorporating 9 gage bed joint reinforcement at 16 inches.
Same Aesthetic... Better Functionality
Tools and Resources

Avoiding the pitfall: Flexibility = Complexity

Everything is available online for free download: www.ncma.org

Click on “Solutions Center”
Tools and Resources

Thermal Catalog of Concrete Masonry Assemblies

- Section One: 3-Web CMU Assemblies
- Section Two: 2-Web CMU Assemblies
- Section Three: Hybrid Assemblies
Tools and Resources

Thermal Catalog of Concrete Masonry Assemblies - Table Based Designs

**SINGLE WYTHE CONCRETE MASONRY ASSEMBLIES
CELL INSULATION**

Assembly 2-1: Polyurethane foamed-in-place insulation in ungrouted cells, exposed masonry (interior and exterior)

**Concrete Masonry Assembly R-Values (hr-ft²·F/Btu) and U-Factors (Btu/hr-ft²·F)**

<table>
<thead>
<tr>
<th>Density of CMU, PCF</th>
<th>Ungroated</th>
<th>Lightly Reinforced</th>
<th>Heavily Reinforced</th>
<th>Fully Grouted</th>
<th>Ungroated</th>
<th>Lightly Reinforced</th>
<th>Heavily Reinforced</th>
<th>Fully Grouted</th>
</tr>
</thead>
<tbody>
<tr>
<td>85</td>
<td>9.48 (0.105)</td>
<td>5.45 (0.183)</td>
<td>3.64 (0.275)</td>
<td>1.77 (0.564)</td>
<td>12.97 (0.077)</td>
<td>6.84 (0.146)</td>
<td>4.40 (0.227)</td>
<td>2.07 (0.483)</td>
</tr>
<tr>
<td>95</td>
<td>8.37 (0.119)</td>
<td>5.01 (0.200)</td>
<td>3.40 (0.294)</td>
<td>1.69 (0.592)</td>
<td>11.41 (0.088)</td>
<td>6.28 (0.159)</td>
<td>4.10 (0.244)</td>
<td>1.96 (0.509)</td>
</tr>
<tr>
<td>105</td>
<td>7.36 (0.136)</td>
<td>4.59 (0.218)</td>
<td>3.18 (0.315)</td>
<td>1.62 (0.619)</td>
<td>9.98 (0.100)</td>
<td>5.75 (0.174)</td>
<td>3.83 (0.261)</td>
<td>1.87 (0.535)</td>
</tr>
<tr>
<td>115</td>
<td>6.43 (0.155)</td>
<td>4.19 (0.239)</td>
<td>2.97 (0.337)</td>
<td>1.55 (0.645)</td>
<td>8.69 (0.115)</td>
<td>5.25 (0.191)</td>
<td>3.58 (0.279)</td>
<td>1.79 (0.559)</td>
</tr>
<tr>
<td>125</td>
<td>5.61 (0.178)</td>
<td>3.82 (0.262)</td>
<td>2.78 (0.360)</td>
<td>1.49 (0.670)</td>
<td>7.53 (0.133)</td>
<td>4.78 (0.209)</td>
<td>3.34 (0.299)</td>
<td>1.72 (0.583)</td>
</tr>
<tr>
<td>135</td>
<td>4.88 (0.205)</td>
<td>3.47 (0.288)</td>
<td>2.59 (0.386)</td>
<td>1.44 (0.693)</td>
<td>6.51 (0.154)</td>
<td>4.34 (0.230)</td>
<td>3.12 (0.321)</td>
<td>1.65 (0.605)</td>
</tr>
</tbody>
</table>
Tools and Resources

For more detailed analysis – Spreadsheet Calculators
Code Compliance Options

Paths the IECC offers:

• Prescriptive
  ◦ R-Value (which DOES require CI)
  ◦ U-Factor (which DOES NOT require CI)

• Total Building Design (AKA: Trade-Off)

• Whole Building Energy Cost Budgeting

Different projects benefit from different compliance paths.
Prescriptive: R-Value

Prescriptive R-Value requires continuous insulation...

<table>
<thead>
<tr>
<th>CLIMATE ZONE</th>
<th>3</th>
<th>4 EXCEPT MARINE</th>
<th>5 AND MARINE 4</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>R</td>
<td>All other</td>
<td>Group R</td>
<td>All other</td>
<td>Group R</td>
</tr>
<tr>
<td>Attic and other</td>
<td>3</td>
<td>R-38</td>
<td>R-38</td>
<td>R-38</td>
</tr>
<tr>
<td>Walls, above grade</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\( ^{a,b} \) Indicates air barrier.  
\( ^{c} \) Indicates mass.  
\( ^{cd} \) Indicates vertical distance.  
\( ^{de} \) Indicates horizontal distance.  
\( ^{ef} \) Indicates vertical continuity.  
\( ^{fg} \) Indicates horizontal continuity.
Prescriptive: U-Factor

Prescriptive U-Factor does NOT require continuous insulation...

<table>
<thead>
<tr>
<th>CLIMATE ZONE</th>
<th>2</th>
<th>3</th>
<th>4 EXCEPT MARINE</th>
<th>5 AND MARINE 4</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>All other</td>
<td>U-0.039</td>
<td>U-0.039</td>
<td>U-0.039</td>
<td>U-0.032</td>
<td>U-0.032</td>
</tr>
<tr>
<td>Group R</td>
<td>U-0.039</td>
<td>U-0.039</td>
<td>U-0.039</td>
<td>U-0.032</td>
<td>U-0.032</td>
</tr>
<tr>
<td>All other</td>
<td>U-0.035</td>
<td>U-0.035</td>
<td>U-0.035</td>
<td>U-0.035</td>
<td>U-0.035</td>
</tr>
<tr>
<td>Group R</td>
<td>U-0.035</td>
<td>U-0.035</td>
<td>U-0.035</td>
<td>U-0.035</td>
<td>U-0.035</td>
</tr>
<tr>
<td>All other</td>
<td>U-0.027</td>
<td>U-0.027</td>
<td>U-0.027</td>
<td>U-0.027</td>
<td>U-0.027</td>
</tr>
<tr>
<td>Group R</td>
<td>U-0.027</td>
<td>U-0.027</td>
<td>U-0.027</td>
<td>U-0.027</td>
<td>U-0.027</td>
</tr>
</tbody>
</table>

- **Walls, above grade**

<table>
<thead>
<tr>
<th></th>
<th>2</th>
<th>3</th>
<th>4 EXCEPT MARINE</th>
<th>5 AND MARINE 4</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass</td>
<td>U-0.151</td>
<td>U-0.123</td>
<td>U-0.123</td>
<td>U-0.104</td>
<td>U-0.090</td>
</tr>
<tr>
<td>Metal building</td>
<td>U-0.079</td>
<td>U-0.079</td>
<td>U-0.052</td>
<td>U-0.052</td>
<td>U-0.052</td>
</tr>
</tbody>
</table>
Design Example: Livonia Warehouse
Design Example: Livonia Warehouse
Design Example

Baseline Building

<table>
<thead>
<tr>
<th>Assembly</th>
<th>Gross Area or Perimeter</th>
<th>Cavity R-Value</th>
<th>Cont. R-Value</th>
<th>Proposed U-Factor</th>
<th>Budget U-Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roof 1: Insulation Entirely Above Deck, [Bldg. Use 1 - Warehouse]</td>
<td>6066</td>
<td>---</td>
<td>30,0</td>
<td>0.032</td>
<td>0.032</td>
</tr>
<tr>
<td>NORTH</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exterior Wall 1: Other Mass Wall, Heat capacity 9.4, [Bldg. Use 1 - Warehouse] (b)</td>
<td>1456</td>
<td>---</td>
<td>---</td>
<td>0.090</td>
<td>0.090</td>
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<tr>
<td>EAST</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exterior Wall 2: Other Mass Wall, Heat capacity 9.4, [Bldg. Use 1 - Warehouse] (b)</td>
<td>1456</td>
<td>---</td>
<td>---</td>
<td>0.090</td>
<td>0.090</td>
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<tr>
<td>SOUTH</td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Exterior Wall 3: Other Mass Wall, Heat capacity 9.4, [Bldg. Use 1 - Warehouse] (b)</td>
<td>908</td>
<td>---</td>
<td>---</td>
<td>0.090</td>
<td>0.090</td>
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<tr>
<td>WEST</td>
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</tr>
<tr>
<td>Exterior Wall 4: Other Mass Wall, Heat capacity 9.4, [Bldg. Use 1 - Warehouse] (b)</td>
<td>1433</td>
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<td>---</td>
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<td>0.090</td>
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<tr>
<td>Door 1: Insulated Metal, Swinging, [Bldg. Use 1 - Warehouse]</td>
<td>67</td>
<td>---</td>
<td>---</td>
<td>0.370</td>
<td>0.370</td>
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<tr>
<td>Door 2: Insulated Metal, Non-Swinging, [Bldg. Use 1 - Warehouse]</td>
<td>504</td>
<td>---</td>
<td>---</td>
<td>0.179</td>
<td>0.179</td>
</tr>
</tbody>
</table>

(a) Budget U-factors are used for software baseline calculations ONLY, and are not code requirements.
(b) ‘Other’ components require supporting documentation for proposed U-factors.

Envelope PASSES: Design 0.0% better than code
Design Example

Spoiler Alert...
Design Example

Basic Assembly Properties:
• Unit Density = 115 pcf
• Foam-in-Place Insulation in Non-Grouted Cells. R = 4.6/inch
• Vertically Grouted Cell: 120 in. o.c. (86 in. o.c. averaged trim steel)
• Horizontal Bond Beam at Roof Line
Design Example

Option 1A:
12 in. CMU; exposed both sides

We need: $U = 0.090 \ (R = 11.1)$

Conventional three web unit...
$U = 0.139 \ (R = 7.19)$
Design Example

Option 1B:
12 in. CMU; exposed both sides

We need: \( U = 0.090 \) (\( R = 11.1 \))

New ASTM C90 two web unit...
\( U = 0.098 \) (\( R = 10.14 \))
## Design Example

**Option 1B:** 12 in. CMU; exposed both sides; 2 web unit

<table>
<thead>
<tr>
<th>Assembly</th>
<th>Gross Area Perimeter</th>
<th>Cavity R-Value</th>
<th>Cont. R-Value</th>
<th>Proposed U-Factor</th>
<th>Budget U-Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roof 1: Insulation Entirely Above Deck, [Bldg. Use 1 - Warehouse]</td>
<td>6066</td>
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<td>38.5</td>
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<td>NORTH</td>
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</tr>
<tr>
<td>Exterior Wall 1: Other Mass Wall, Heat capacity 9.4, [Bldg. Use 1 - Warehouse] (b)</td>
<td>1456</td>
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<td>---</td>
<td>0.098</td>
<td>0.090</td>
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<tr>
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<tr>
<td>Exterior Wall 2: Other Mass Wall, Heat capacity 9.4, [Bldg. Use 1 - Warehouse] (b)</td>
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<td>---</td>
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<td>Exterior Wall 3: Other Mass Wall, Heat capacity 9.4, [Bldg. Use 1 - Warehouse] (b)</td>
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<td>Exterior Wall 4: Other Mass Wall, Heat capacity 9.4, [Bldg. Use 1 - Warehouse] (b)</td>
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<td>Door 1: Insulated Metal, Swinging, [Bldg. Use 1 - Warehouse]</td>
<td>67</td>
<td>---</td>
<td>---</td>
<td>0.370</td>
<td>0.370</td>
</tr>
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<td>Door 2: Insulated Metal, Non-Swinging, [Bldg. Use 1 - Warehouse]</td>
<td>504</td>
<td>---</td>
<td>---</td>
<td>0.179</td>
<td>0.179</td>
</tr>
</tbody>
</table>

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**Envelope PASSES:** Design 1% better than code
Design Example

Option 1C: 12 in. lightweight CMU; exposed both sides; 2 web unit

<table>
<thead>
<tr>
<th>Assembly</th>
<th>Gross Area or Perimeter</th>
<th>Cavity R-Value</th>
<th>Cont. R-Value</th>
<th>Proposed U-Factor</th>
<th>Budget U-Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roof 1: Insulation Entirely Above Deck, [Bldg. Use 1 - Warehouse]</td>
<td>6066</td>
<td>---</td>
<td>30.0</td>
<td>0.032</td>
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<tr>
<td>NORTH</td>
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<tr>
<td>Exterior Wall 1: Other Mass Wall, Heat capacity 9.4, [Bldg. Use 1 - Warehouse] (b)</td>
<td>1456</td>
<td>---</td>
<td>---</td>
<td>0.089</td>
<td>0.090</td>
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<td>EAST</td>
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<td>Exterior Wall 2: Other Mass Wall, Heat capacity 9.4, [Bldg. Use 1 - Warehouse] (b)</td>
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<td>0.090</td>
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<td></td>
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<tr>
<td>Exterior Wall 3: Other Mass Wall, Heat capacity 9.4, [Bldg. Use 1 - Warehouse] (b)</td>
<td>908</td>
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<td>---</td>
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<tr>
<td>Exterior Wall 4: Other Mass Wall, Heat capacity 9.4, [Bldg. Use 1 - Warehouse] (b)</td>
<td>1433</td>
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<td>---</td>
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<td>Door 1: Insulated Metal, Swinging, [Bldg. Use 1 - Warehouse]</td>
<td>67</td>
<td>---</td>
<td>---</td>
<td>0.370</td>
<td>0.370</td>
</tr>
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<td>Door 2: Insulated Metal, Non-Swinging, [Bldg. Use 1 - Warehouse]</td>
<td>504</td>
<td>---</td>
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<td>0.179</td>
<td>0.179</td>
</tr>
</tbody>
</table>

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Envelope PASSES: Design 1% better than code
Design Example

Option 2A:
8 in. CMU; exposed both sides

We need: \( U = 0.090 \) (\( R = 11.1 \))

Conventional three web unit...
\( U = 0.211 \) (\( R = 4.73 \))
Option 2B:  
8 in. CMU; exposed both sides 

We need: $U = 0.090 \ (R = 11.1)$

New ASTM C90 two web unit...  
$U = 0.151 \ (R = 6.63)$
Design Example

Option 2C: 8 in. CMU; Inside Finished; 1.5 inch polyisocyanurate, metal furring, $\frac{1}{2}$ inch gypsum

We need: $U = 0.090$ (R = 11.1)

Two web unit...

$U = 0.055$ (R = 18.2)
Design Example

We don’t need to finish all interior surfaces... only those that need it.
Design Example

Option 2C – Interior finish on 3 of 4 walls.

<table>
<thead>
<tr>
<th>Assembly</th>
<th>Gross Area or Perimeter</th>
<th>Cavity R-Value</th>
<th>Cont. R-Value</th>
<th>Proposed U-Factor</th>
<th>Budget U-Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roof 1: Insulation Entirely Above Deck, [Bldg. Use 1 - Warehouse]</td>
<td>6066</td>
<td>---</td>
<td>30.0</td>
<td>0.032</td>
<td>0.032</td>
</tr>
<tr>
<td>NORTH</td>
<td></td>
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<tr>
<td>Exterior Wall 1: Other Mass Wall, Heat capacity 9.4, [Bldg. Use 1 -</td>
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<td>---</td>
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<td>0.151</td>
<td>0.090</td>
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<tr>
<td>Warehouse] (b)</td>
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<td>SOUTH</td>
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<tr>
<td>Exterior Wall 3: Other Mass Wall, Heat capacity 9.4, [Bldg. Use 1 -</td>
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<td>Warehouse] (b)</td>
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<td>Exterior Wall 4: Other Mass Wall, Heat capacity 9.4, [Bldg. Use 1 -</td>
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<td>Warehouse] (b)</td>
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<td>Door 1: Insulated Metal, Swinging, [Bldg. Use 1 - Warehouse]</td>
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<td>---</td>
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<td>0.370</td>
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<td>Door 2: Insulated Metal, Non-Swinging, [Bldg. Use 1 - Warehouse]</td>
<td>504</td>
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<td>0.179</td>
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</tr>
</tbody>
</table>

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Envelope PASSES: Design 3% better than code
Design Example

Option 2C: Interior finish on upper portion of walls.

<table>
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<tr>
<th>Assembly</th>
<th>Gross Area or Perimeter</th>
<th>Cavity R-Value</th>
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<td>Exterior Wall 1: Other Mass Wall, Heat capacity 9.4, [Bldg. Use 1 - Warehouse] (b)</td>
<td>250</td>
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<tr>
<td>Exterior Wall 3: Other Mass Wall, Heat capacity 9.4, [Bldg. Use 1 - Warehouse] (b)</td>
<td>906</td>
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<tr>
<td>Exterior Wall 4: Other Mass Wall, Heat capacity 9.4, [Bldg. Use 1 - Warehouse] (b)</td>
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<td>Exterior Wall 5: Other Mass Wall, Heat capacity 9.4, [Bldg. Use 1 - Warehouse] (b)</td>
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<td>Exterior Wall 6: Other Mass Wall, Heat capacity 9.4, [Bldg. Use 1 - Warehouse] (b)</td>
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<td>855</td>
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<td>0.071</td>
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</tr>
</tbody>
</table>

Envelope PASSES: Design 0.3% better than code
Single Wythe CMU – Viable Solution for all Climates
Final Thoughts: R-Values

R-Value (U-Factor) has diminishing returns.
Final Thoughts – Air Barriers

Code requires them. Several code solutions detailed here...

CONTROL OF AIR LEAKAGE IN CONCRETE MASONRY WALLS

But!
Many of the solutions to reducing air permeability also reduce vapor permeability.

Exterior wall envelopes often unintentionally trap moisture inside with separate layers of vapor retarders.

Detailing Goal: Let the masonry breathe.
Final Thoughts – Vapor Barriers

The IBC doesn’t prohibit the use of vapor retarders (and may be needed in unique conditions...e.g., natatorium).

Unless you need a vapor retarder, lose it. It’s just an added expense and is likely to cause more problems than it solves.
Questions?

Information overload?

Or shoot me an email…

Jason Thompson
jthompson@ncma.org
703-713-1900