Thermal Analysis
Effective R-Value Calculations
for
12” Omni Block
Insulated Concrete Block Walls
March 2013
Revised May 2017

Thermal Analysis
Effective R-Value Calculations
for
Omni Block
12 x 8 x 16
Insulated Concrete Block Wall System

March 2013
Revised May 2017

Facts

According to the National Concrete Masonry Association (NCMA) the tested R-Value for a standard 12x8x16 concrete masonry unit (CMU) is 2.3 at 105 lb. density.

The tested solid grouted R-Value for the same unit is 2.0 proving that air is a better insulator than grout (which is a form of concrete).

Expanded Polystyrene (EPS) has a tested R-Value of 4 per inch at a 1.3 lb. density, which is significantly higher than air.

Asssumptions

Improving the CMU design and utilizing an insulating material within the CMU would greatly increase the R-Value of the CMU.

Findings

Omni Block consists of a unique block design that utilizes two additional middle lineal walls (face shells), which are parallel to the interior and exterior block face shells.

The additional middle lineal walls allow the block design to include offset and constricted cross webs (see drawings within).

The four face shells and offset and constricted cross webs create unique cells (or cores) that house specifically molded EPS insulation inserts.

The three layers of EPS inserts protrude below the block and the interior layer over laps from block-to-block, thus thermally protecting all horizontal and vertical mortar joints.

Each layer of EPS inserts has a less than a 10% continuous insulation correction factor.

It is this combination of additional middle lineal walls, offset and constricted cross webs, and insulating cores that provide significantly higher R-values than standard CMU (see Table within).

May 2017 Revision

Graphics only were added; no change to calculations or results.

Block Face Shell Configuration Section

Face Shell - Standard nominally dimensioned 12" x 8" x 16" CMU consists of two (2) face shells.

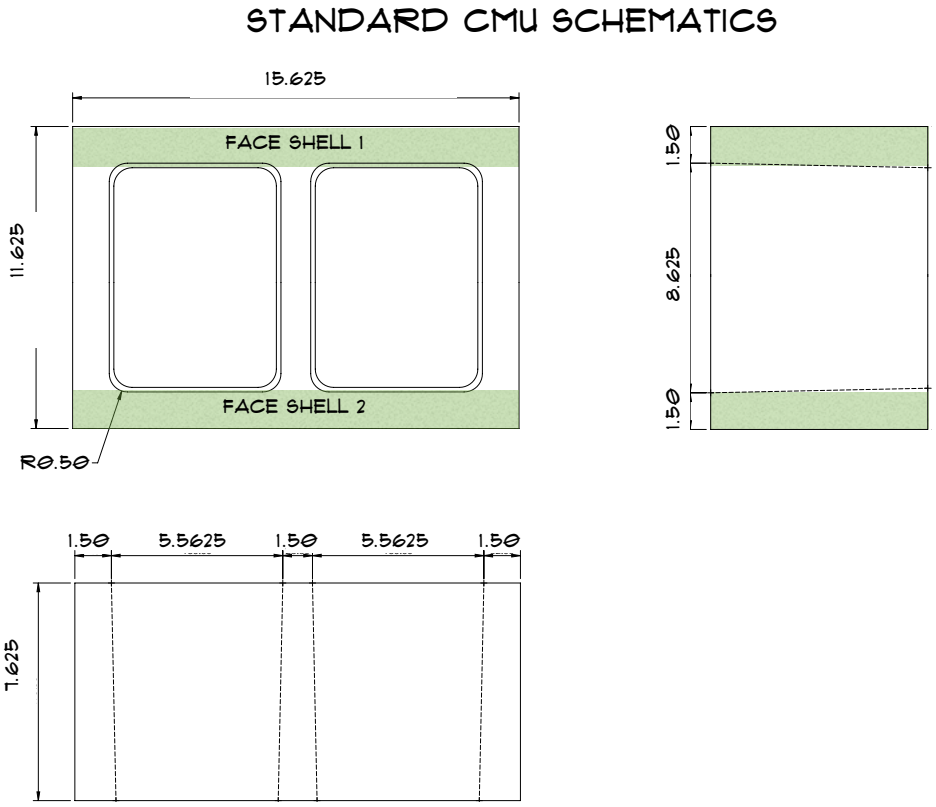
I. Determine cubic inches of two (2) standard nominal 8" high CMU face shells (see green shaded areas):

Given:

$15^{5/8}$ = width of CMU face shell, in inches
$7^{5/8}$ = height of CMU face shell, in inches
$1^{1/2}$ = depth of CMU face shell, in inches
2 = quantity of CMU face shells

Then:

15.625 w x 7.625 h x 1.50 d = 178.71 cubic inches per face shell
178.71 x 2 = 357.42 total cubic inches of two standard nominal 12" CMU face shells



Face Shell - The nominally dimensioned Omni Block 12" stretcher unit consists of four (4) face shells.

II. Determine cubic inches of four (4) Omni Block 12" stretcher face shells (see orange shaded areas):

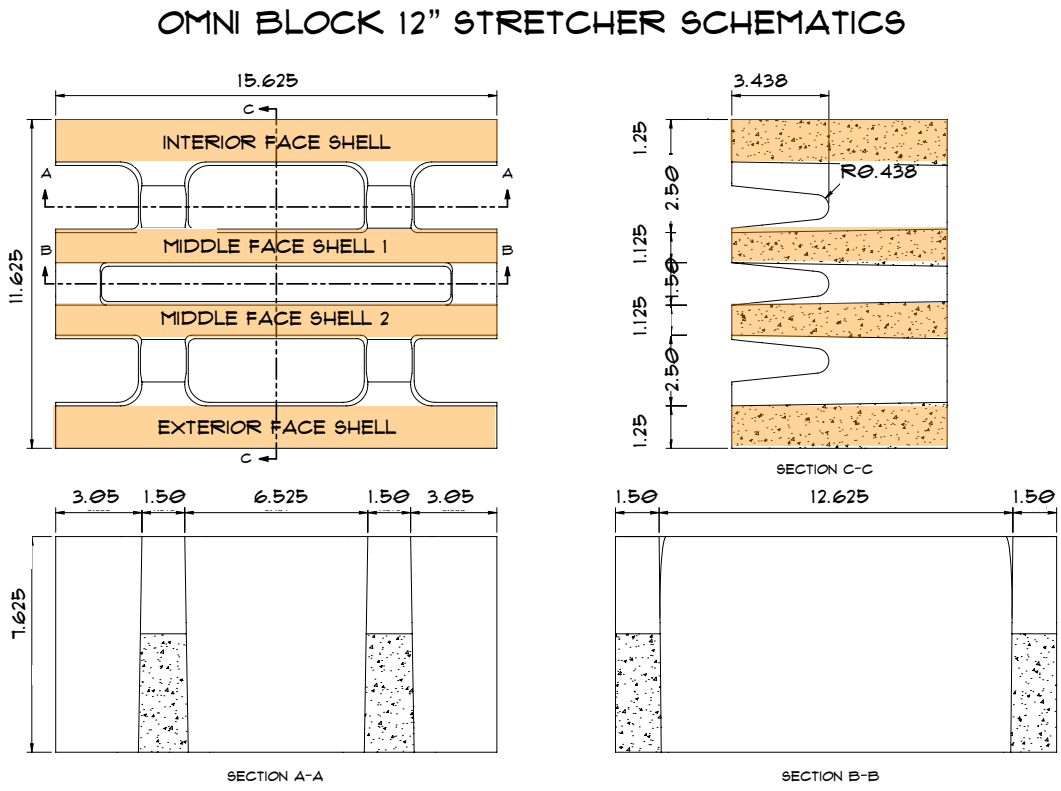
Given:

$15^{5/8}$ = width of Omni Block face shell, in inches
$7^{5/8}$ = height of Omni Block face shell, in inches
$1^{1/2}$ = depth of Omni Block face shell, in inches
4 = quantity of Omni Block face shells

Then:

15.625 w x 7.625 h x 1.50 d = 178.71 cubic inches per face shell
178.71 x 4 = 714.84 total cubic inches of four Omni Block 12" stretcher face shells

Block Face Shell Configuration Section - continued



The objective of this section is to calculate the additional thermal resistance (or delayed thermal conductance) provided by additional face shells.

Given:

357.42 = total cubic inches of two standard 12" CMU face shells

714.84 = total cubic inches of four Omni Block 12" stretcher face shells

Then:

(714.84 / 357.42) - 1 = 1.00

Omni Block 12" stretcher has 100% more or 2 times the resistance (or delayed thermal conductance) of standard 12" CMU due to additional face shells.

Resulting empty cores calculation of an Omni Block 12" stretcher:

Given:

(hrft^2°F/Btu) = R-value of standard 12" CMU per associated density of concrete, all other variables remain constant (NCMA TEK 6 2-B)

2.00 = additional resistance (or reduced thermal conductance)

Then:

(hrft^2°F/Btu)(2.00) = additional resistance (or delayed thermal conductance) provided by additional face shells of an Omni Block 12" stretcher

Block Cross Web Configuration Section

Cross Web - Standard nominally dimensioned 12” x 8” x 16” CMU typically has three (3) full-height direct cross webs from one face shell to the other face shell.

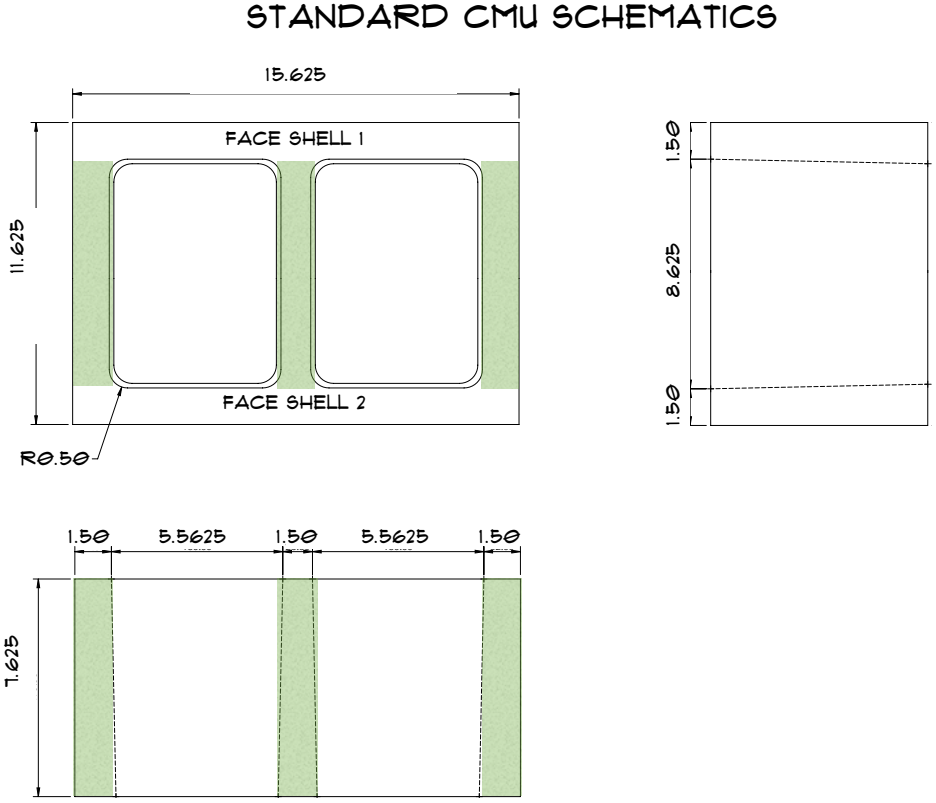
III. Determine cubic inches of standard 12” CMU direct cross web cubic inches:

Given:

$1^{1/2}$ = width of CMU cross web, in inches
$7^{5/8}$ = height of CMU cross web, in inches
$8^{5/8}$ = depth of CMU cross web (excluding interior and exterior face shell sections), in inches
3 = quantity of CMU cross webs

Then:

1.5 w x 7.625 h x 8.625 d = 98.65 cubic inches of cross web
98.65 x 3 = 295.95 total cubic inches of three standard 12” CMU cross webs



Cross Web - The nominally dimensioned Omni Block 12” stretcher has six (6) indirect, reduced-height, cross webs; two are from the interior face shell to the middle face shell one; two from the middle face shell one to the middle face shell two; and two from the middle face shell two to the exterior face shell.

IV. Determine cubic inches of two (2) Omni Block 12” stretcher interior face shell to middle face shell one cross webs:

Given:

$1^{1/4}$ = width of Omni Block interior cross web, in inches
$4^{1/4}$ = height of Omni Block interior cross web, in inches
$2^{1/2}$ = depth of Omni Block interior cross web (interior face shell to 1st middle face shell), in inches
2 = quantity of Omni Block interior cross webs

Then:

1.25 w x 4.25 h x 2.50 d = 13.28 cubic inches of interior cross web
13.28 x 2 = 26.56 total cubic inches of two Omni Block 12” stretcher interior cross webs

Block Cross Web Configuration Section - continued

V. Determine cubic inches of two (2) Omni Block 12" stretcher middle face shell one to middle face shell two cross webs:

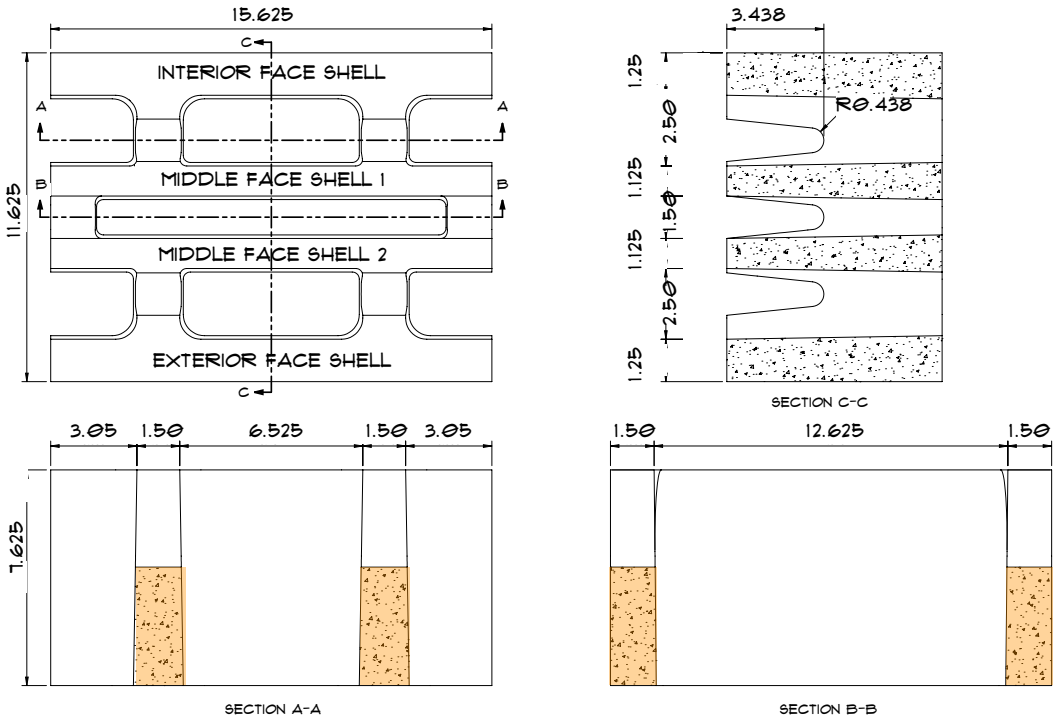
Given:

$1^{1/4}$ = width of Omni Block middle cross web, in inches
$4^{1/4}$ = height of Omni Block middle cross web, in inches
$1^{3/8}$ = depth of Omni Block middle cross web (1st middle face shell to 2nd middle face shell), in inches
2 = quantity of Omni Block middle cross webs

Then:

1.25 x 4.25 x 1.375 = 7.30 cubic inches of middle cross webs
7.30 x 2 = 14.60 total cubic inches of two Omni Block 12" stretcher **middle** cross webs

OMNI BLOCK 12" STRETCHER SCHEMATICS



VI. Determine cubic inches of two (2) Omni Block 12" stretcher middle face shell two to exterior face shell cross webs:

Given:

$1^{1/4}$ = width of Omni Block exterior cross web, in inches
$4^{1/4}$ = height of Omni Block exterior cross web, in inches
$2^{1/2}$ = depth of Omni Block exterior cross web (2nd middle face shell to exterior face shell), in inches
2 = quantity of Omni Block exterior cross webs

Then:

1.25 w x 4.25 h x 2.50 d = 13.28 cubic inches of exterior cross web
13.28 x 2 = 26.56 total cubic inches of two Omni Block 12" stretcher **exterior** cross webs

Given:

26.56 = total cubic inches of Omni Block 12" stretcher interior cross webs
14.60 = total cubic inches of Omni Block 12" stretcher middle cross webs
26.56 = total cubic inches of Omni Block 12" stretcher exterior cross webs

Then:

26.56 + 14.60 + 26.56 = 67.42 total cubic inches of Omni Block 12" stretcher cross webs

Block Cross Web Configuration Section - continued

The objective of this section is to calculate the additional thermal resistance (or delayed thermal conductance) provided by the indirect, reduced-height, cross webs of an Omni Block 12" stretcher.

Given:
295.95 = total cubic inches of three standard 12" CMU cross webs
67.42 = total cubic inches of six Omni Block 12" stretcher cross webs
Then:
67.42 / 295.95 = 0.228
Omni Block 12" stretcher has a cross web volume equal to 22.8% of standard 12" CMU cross web volume.

Given:
0.228 = percent of Omni Block 12" stretcher cross web volume to standard 12" CMU cross web volume
8.625 = total standard 12" CMU cross web, in inches
11.625 = total standard 12" CMU block width, in inches
Then:
8.625 / 11.625 = 0.742 = standard 12" CMU cross web volume (less face shells) within total standard 12" CMU block volume
0.742 x 0.228 = 0.169 = Omni Block 12" stretcher cross webs to total standard 12" CMU block volume
1 - (0.169 / 0.742) = 0.772
Omni Block 12" stretcher has a total of 77.2% additional effective resistance (or delayed thermal conductance) due to indirect, reduced-height, cross webs.

Resulting reduced cross web calculation of an Omni Block 12" stretcher:
Given:
($hrft^2°F/Btu$) = R-value of standard 12" CMU per associated density of concrete, all other variables remain constant (NCMA TEK 6 2-B)
77.2% additional effective resistance (or delayed thermal conductance) due to indirect, reduced-height, cross webs
Then:
($hrft^2°F/Btu$)(1.772) = additional resistance (or reduced thermal conductance) provided by indirect, reduced-height, cross webs of an Omni Block 12" stretcher

Block Face Shell Configuration and Cross Web Configuration Effect on Omni Block Stretcher R-Value

Summation of the additional resistance (or reduced thermal conductance) that must be factored for the Omni Block 12" stretcher when all cores are empty:
Given:
($hrft^2°F/Btu$)(2.00) = additional resistance (or delayed thermal conductance) provided by additional face shells of an Omni Block 12" stretcher
($hrft^2°F/Btu$)(1.772) = additional resistance (or reduced thermal conductance) provided by indirect, reduced-height, cross webs of an Omni Block 12" stretcher
Then:
($hrft^2°F/Btu$)(2.00)+($hrft^2°F/Btu$)(1.772) = ($hrft^2°F/Btu$)(2.00+1.772) = ($hrft^2°F/Btu$)(3.772)
Omni Block 12" stretcher has 3.772 times the R-value of standard 12" CMU

Continuous Interior Insert Insulation Correction Section

Interior Continuous Insulation Correction - Omni Block 12" stretcher interior continuous insulation has two (2) partial "breaks" (due to constricted block cross webs).

The objective of this calculation is to dertimine the percent that should be deducted from the R-value of the interior insulation inserts due to the cross web areas of each block.

VII. Determine cubic inches of Omni Block 12" stretcher **interior** EPS foam inserts:

Given:

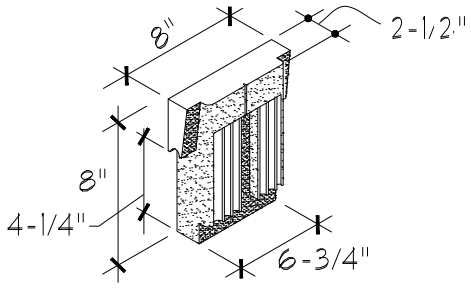
16 = total width of foam, in inches

8 = total height of foam, in inches

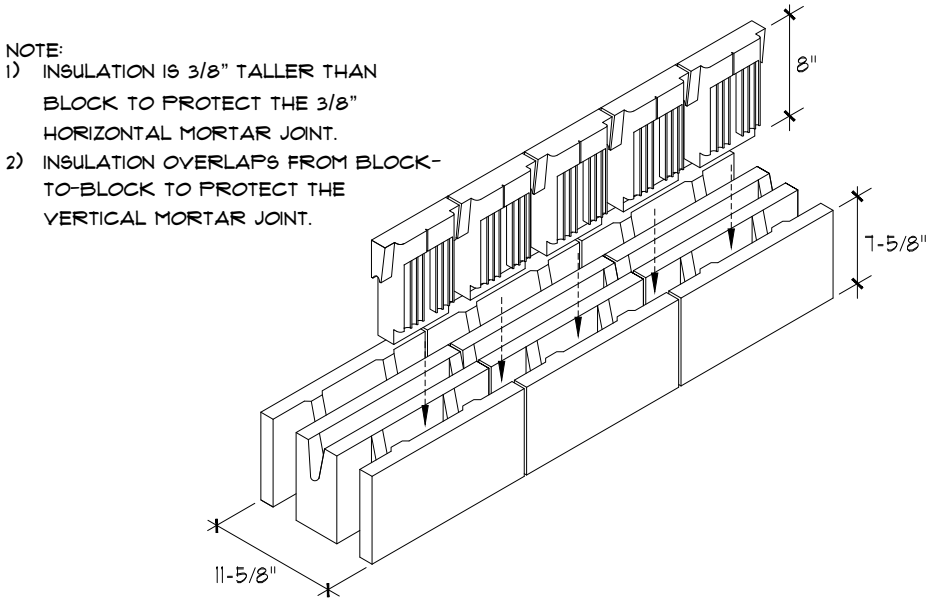
$2^{1/4}$ = exterior insert depth, in inches

Then:

16 w x 8 h x 2.25 d = 288 total cubic inches of Omni Block 12" stretcher **interior** foam inserts



INTERIOR INSULATION INSERT



INTERIOR INSULATION INSTALLATION

Continuous Interior Insert Insulation Correction Section - continued

VIII. Determine cubic inches of two (2) Omni Block 12" stretcher **interior** cross webs :

Given:

$1^{1/4}$ = width of Omni Block interior cross web, in inches
$4^{1/4}$ = height of Omni Block interior cross web, in inches
$2^{1/2}$ = depth of Omni Block interior cross web (interior face shell to middle face shell), in inches
2 = quantity of Omni Block interior cross webs

Then:

1.25 w x 4.25 h x 2.50 d = 13.28 cubic inches of Omni Block 12" stretcher interior cross web
13.28 x 2 = 26.56 total cubic inches of two Omni Block 12" stretcher **interior** cross webs

Given:

288 = total cubic inches of Omni Block interior foam
26.56 = total cubic inches of two Omni Block 12" stretcher interior cross webs

Then:

26.56 / 288 = 0.092 percent of total Omni Block 12" stretcher interior cross web volume to total interior EPS foam insert volume
1 - .092 = 0.908
Omni Block 12" stretcher has 90.8% of continuous insulation value of **interior** foam insert R-value.

Resulting calculation provides the continuous insulation correction of the interior foam inserts:

Given:

2.25 = EPS foam depth, in inches
4.00 = R-value per inch of 1.35 lb. EPS foam (ICC ESR-1498 and ASTM C 578)
0.908 = percent of continuous insulation value of interior foam insert

Then:

[(2.25)(4.00)](0.908) = 8.17 additional interior continuous insulation R-value of an Omni Block 8" stretcher in relation to non-insulated standard 8" CMU.

Continuous Middle Insert Insulation Correction Section

Middle Continuous Insulation Correction - Omni Block 12" stretcher middle continuous insulation has two (2) partial "breaks" (due to constricted block cross webs).

The objective of this calculation is to determine the percent that should be deducted from the R-value of the middle insulation inserts due to the cross web areas of each block.

IX. Determine Omni Block 12" stretcher **middle** EPS foam inserts cubic inches:

Given:

$15^{5/8}$ = total width of foam area, in inches
8 = total height of foam area, in inches
$1^{3/8}$ = middle insert thickness, in inches

Then:

15.675 w x 8 h x 1.375 d = 172 total cubic inches of Omni Block **middle** foam inserts

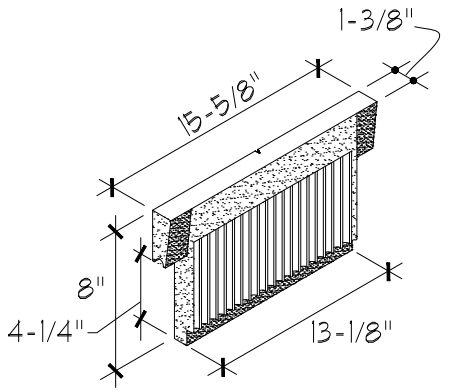
X. Determine cubic inches of two (2) Omni Block 12" stretcher **middle** cross webs:

Given:

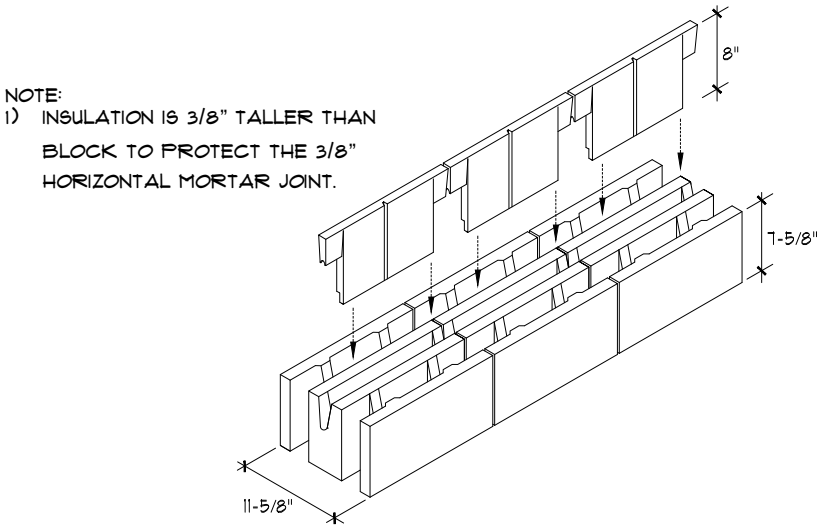
$1^{1/4}$ = width of Omni Block middle cross web, in inches
$4^{1/4}$ = height of Omni Block middle cross web, in inches
$1^{3/8}$ = depth of Omni Block middle cross web, (1st middle face shell to 2nd middle face shell) in inches
2 = quantity of Omni Block middle cross webs

Then:

1.25 x 4.25 x 1.375 = 7.30 cubic inches of Omni Block middle cross web
7.30 x 2 = 14.60 total cubic inches of two Omni Block **middle** cross webs



MIDDLE INSULATION INSERT



MIDDLE INSULATION INSTALLATION

Continuous Middle Insert Insulation Correction Section - continued

XI. Determine the cubic inches where Omni Block 12" stretcher **middle** insert does not protect the vertical mortar joint between blocks:

Given:

$^{3/8}$ = width of vertical mortar joint, in inches
8 = height of vertical mortar joint, in inches
$1^{3/8}$ = depth of unprotected vertical mortar joint, in inches

Then:

0.375 w x 8 h x 1.375 d = 4.13 cubic inches of the unprotected vertical mortar joint

Given:

14.60 = total cubic inches of two Omni Block middle cross webs
4.13 = cubic inches of the unprotected vertical mortar joint

Then:

14.60 + 4.13 = 18.73 total cubic inches without EPS insulation

Given:

18.73 = total cubic inches without EPS insulation
172 = total cubic inches of Omni Block middle insulation

Then:

18.73 / 172 = 0.109 percent of total Omni Block 12" stretcher middle cross web volume to total middle EPS foam insert volume

1 - 0.109 = 0.891

Omni Block 12" stretcher has 89.1% percent of continuous insulation value of **middle** foam insert R-value.

Resulting calculation provides the continuous insulation correction of the middle foam insert:

Given:

1.375 = EPS foam depth, in inches
4.00 = R-value per inch of 1.35 lb. EPS foam (ICC ESR-1498 and ASTM C 578)
0.891 = percent of continuous insulation value of middle foam insert

Then:

[(1.375)(4.00)](0.891) = 4.90 additional middle continuous insulation R-value of an Omni Block 12" stretcher in relation to non-insulated standard 12" CMU

Continuous Exterior Insert Insulation Correction Section

Exterior Continuous Insulation Correction - Omni Block 12" stretcher exterior continuous insulation has two (2) partial "breaks" (due to constricted block cross webs).

The objective of this calculation is to determine the percent that should be deducted from the R-value of the exterior insulation inserts due to the cross web areas of each block. Please note that this not a duplication as the exterior is the exact same as the interior.

XII. Determine cubic inches of Omni Block 12" stretcher **exterior** EPS foam inserts:

Given:

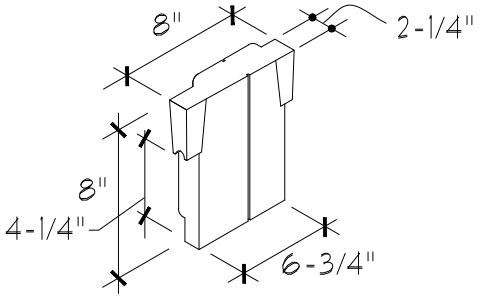
16 = total width of foam, in inches

8 = total height of foam, in inches

$2^{1/4}$ = exterior insert depth, in inches

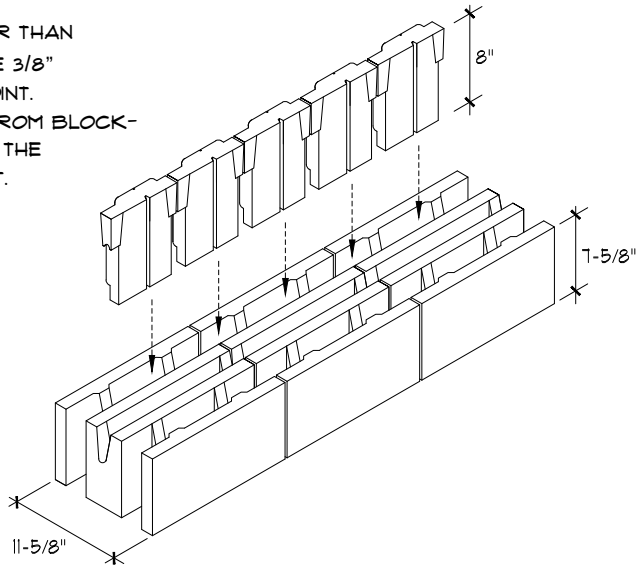
Then:

16 w x 8 h x 2.25 d = 288 total cubic inches of Omni Block 12" stretcher **exterior** foam inserts



EXTERIOR INSULATION INSERT

NOTE:
1) INSULATION IS 3/8" TALLER THAN BLOCK TO PROTECT THE 3/8" HORIZONTAL MORTAR JOINT.
2) INSULATION OVERLAPS FROM BLOCK-TO-BLOCK TO PROTECT THE VERTICAL MORTAR JOINT.



EXTERIOR INSULATION INSTALLATION

Continuous Exterior Insulation Insert Correction Section - continued

XIII. Determine cubic inches of two (2) Omni Block 12" stretcher **exterior** cross webs:

Given:

$1^{1/4}$ = width of Omni Block exterior cross web, in inches
$4^{1/4}$ = height of Omni Block exterior cross web, in inches
$2^{1/2}$ = depth of Omni Block exterior cross web, (2nd middle face shell to exterior face shell) in inches
2 = quantity of Omni Block exterior cross webs

Then:

1.25 w x 4.25 h x 2.50 d = 13.28 cubic inches of Omni Block 12" stretcher exterior cross web
13.28 x 2 = 26.56 total cubic inches of two Omni Block 12" stretcher exterior cross webs

Given:

288 = total cubic inches of Omni Block exterior foam
26.56 = total cubic inches of two Omni Block 12" stretcher exterior cross webs

Then:

26.56 / 288 = 0.092 percent of total Omni Block 12" stretcher exterior cross web volume to total exterior EPS foam insert volume
1 - .092 = 0.908
Omni Block 12" stretcher has 90.8% of continuous insulation value of **exterior** foam insert R-value.

Resulting calculation provides the continuous insulation correction of the exterior foam insert:

Given:

2.25 = EPS foam depth, in inches
4.00 = R-value per inch of 1.35 lb. EPS foam (ICC ESR-1498 and ASTM C 578)
0.908 = percent of continuous insulation value of exterior correction factor

Then:

[(2.25)(4.00)](0.908) = 8.17 = additional exterior continuous insulation R-value of an Omni Block 12" stretcher in relation to non-insulated standard 12" CMU

Continuous Interior Insulation Insert Correction and Continuous Middle Insulation Insert Correction and Continuous Exterior Insulation Insert Correction effect on Omni Block 12" Stretcher R-Value

Summation of the Omni Block 12" stretcher continuous insulation correction:

Given:

[(2.25)(4.00)](0.908) = 8.17 additional interior continuous insulation R-value of an Omni Block 12" stretcher
[(1.375)(4.00)](0.891) = 4.90 additional middle continuous insulation R-value of an Omni Block 12" stretcher
[(2.25)(4.00)](0.908) = 8.17 additional exterior continuous insulation R-value of an Omni Block 12" stretcher

Then:

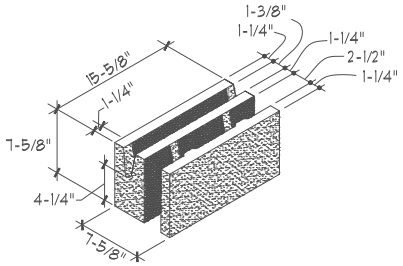
8.17 + 4.90 + 8.17 = 21.24
Omni Block 12" stretcher has 21.24 total additional continuous insulation R-value in relation to non-insulated standard 12" CMU.

Worksheet

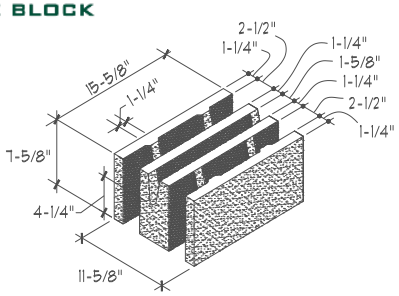
The table below illustrates the R-Value effects of the preceeding calculations of the Omni Block 12” stretcher Face Shell and Cross Web Correction Factors as well as the Continuous Insulation Correction.

Nominal Thickness	Concrete Density pcf	Standard CMU Cores Empty R-Value		Face Shell and Cross Web Correction Factor		Omni Block Stretcher Cores Empty R-Value		Continuous Insulation Correction Add		Omni Block Stretcher Cores with EPS Inserts R-Value
12”	85	2.6	X	3.772	=	9.8	+	21.24	=	31.0
12”	95	2.4	X	3.772	=	9.1	+	21.24	=	30.3
12”	105	2.3	X	3.772	=	8.7	+	21.24	=	29.9
12”	115	2.2	X	3.772	=	8.3	+	21.24	=	29.5
12”	125	2.1	X	3.772	=	7.9	+	21.24	=	29.2
12”	135	2.0	X	3.772	=	7.5	+	21.24	=	28.8

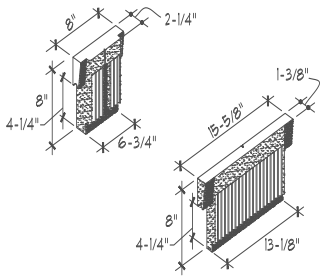
This data was used to complete the Tables on the following page.



STRETCHER - 8 x 8 x 16



STRETCHER - 12 x 8 x 16



INSULATION INSERTS

Table 1 - U-Factors (Btu/hrft²°F) and R-Values (hrft²°F/Btu) of Concrete Masonry Walls [A]

Nominal Wythe Thickness in. (mm)	Concrete Density pcf	Standard CMU Cores Empty		100% Solid Grouted [B]	
		U	R	U	R
8 in. (203mm)	85	0.402	2.5	0.525	1.9
	95	0.427	2.3	0.559	1.8
	105	0.452	2.2	0.592	1.7
	115	0.479	2.1	0.623	1.6
	125	0.507	2.0	0.654	1.5
	135	0.537	1.9	0.684	1.5
12 in. (305mm)	85	0.390	2.6	0.441	2.3
	95	0.411	2.4	0.466	2.1
	105	0.433	2.3	0.490	2.0
	115	0.455	2.2	0.515	1.9
	125	0.478	2.1	0.539	1.9
	135	0.503	2.0	0.564	1.8

Table 1 Source: Abbreviated NCMA TEK 6-2B

[A] (hrft²°F/Btu) (0.176) = m²K/W. Mortar joints are 3/8" (9.5 mm) thick, with face shell mortar bedding. Unit dimensions based on *Standard Specification for Loadbearing Concrete Masonry Units,* ASTM C 90. Surface air films are included.

[B] Grout density is 140 pcf (2,243 kg/m³). Lightweight grouts will provide higher R-values and may be used.

Table 2 - U-Factors (Btu/hrft²°F) and R-Values (hrft²°F/Btu) of Omni Block Walls [A]

Nominal Wythe Thickness in. (mm)	Concrete Density pcf	Stretcher Unit Cores Empty [C]		Cores With EPS Inserts [D,E]	
		U	R	U	R
8 in. (203mm)	85	0.123	8.2	0.047	21.2
	95	0.133	7.5	0.048	20.6
	105	0.139	7.2	0.049	20.2
	115	0.146	6.8	0.050	19.9
	125	0.153	6.5	0.051	19.6
	135	0.161	6.2	0.052	19.3
12 in. (305mm)	85	0.102	9.8	0.032	31.0
	95	0.110	9.1	0.033	30.3
	105	0.115	8.7	0.033	29.9
	115	0.121	8.3	0.034	29.5
	125	0.126	7.9	0.034	29.2
	135	0.133	7.5	0.035	28.8

Table 2 Source: Tom Norris, Architect (ICC Certified)

[C] 8 inch unit has an additional face shell and reduced cross-web conductance. Resulting formula: (hrft²°F/Btu)(1.50)+(hrft²°F/Btu)(1.76).
12 inch unit has two additional face shells and reduced cross-web conductance. Resulting formula: (hrft²°F/Btu)(2.00)+(hrft²°F/Btu)(1.772).

[D] Values apply when all cores are filled completely.

[E] Average continuous insulation correction factor is 10% less than total insert R-value.

Some table values are the same due to rounding.

Table 3 - Thermal Resistance of EPS Foam Insulation

EPS Type	Minimum Density (pcf) [F]	R-Value Per Inch of Thickness (F°•ft²•h/Btu)
II	135	4.00

Table 3 Source: ICC ESR - 1498 per ASTM C 578

[F] pcf = 16.02 kg/m³, 1°F ft²hr/Btu=0.176m²K/W, 1°F=1.8°C+32

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