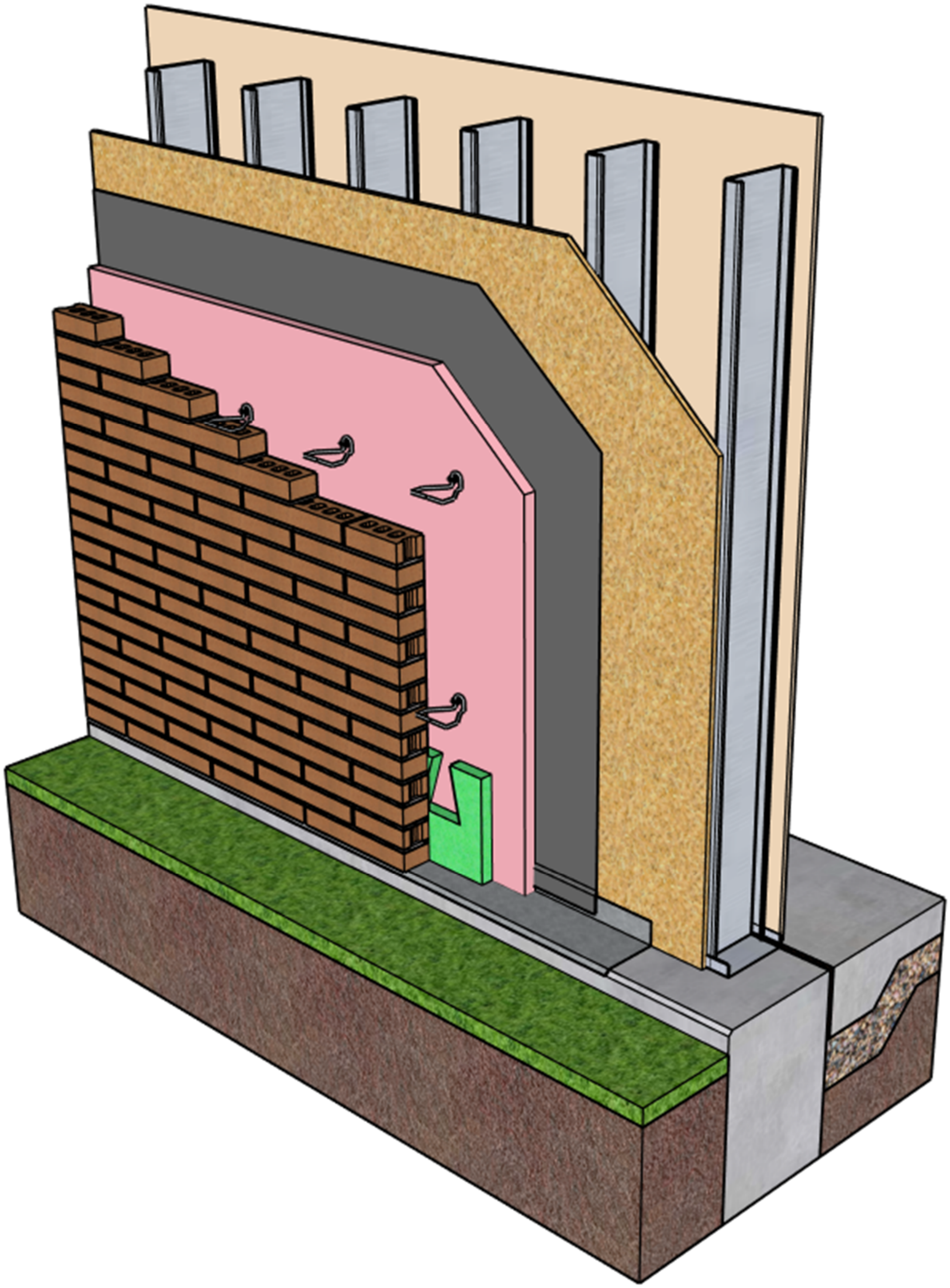
Guide to **COM***check*™ for Brick Veneer Walls

INTERSTATE® BRICK
More **Sizes**, More **Shapes**, More **Possibilities**



Brick Veneer Over Stud Framing as a Mass Wall: Energy Code Compliance **WITHOUT** Stud Cavity Insulation

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This document is a step-by-step guide to help the user of ***COMcheck* · *Web*™** (called **COM*check*™**) to assess energy code compliance of brick veneer cavity wall construction evaluated as a mass wall, as allowed by code.

Both the IECC (International Energy Conservation Code) and ASHRAE 90.1 (called "90.1") define a mass wall in terms of the the wall weight is pounds per square foot (psf), the unit weight of the wall assembly (wall density in pounds per cubic foot (pcf)) and the heat capacity (HC) of the wall assembly. The criteria is explained at the end of the document.

The R-values (heat flow resistance of insulation) and HC values have been calculated and appear in tables near the end of this guide for various wood stud and steel stud framing sizes and stud layout spacings along with the use of XPS rigid exterior continuous insulation (*c.i.*) of various thicknesses ranging from 0" to 4".

R-Values and the HC values included herein have been determined using the software program called M.A.T.S.S. (Masonry Assembly Thermal Simulation Software), a thermal conductivity analysis program used within the masonry industry which was developed by the National Brick Research Center affiliated with Clemson University based on published papers rehearsing the experimental testing of various brick cavity wallassemblies, and single wythe structural masonry wall assemblies, using "Hot Box" methods to measure heat flow and resistance to heat flow.

[Other thermal analysis programs may generate slightly different results based on the inherent assumptions used to develop the analysis engine of the analysis software.]

Let's begin….

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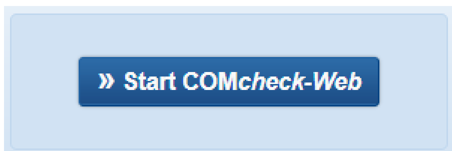
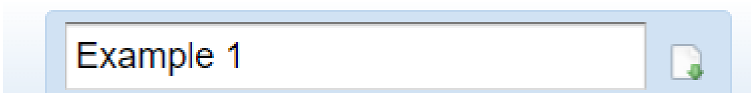
Step 1

Open a web session of **COM***check*™
https://energycode.pnl.gov/COMcheckWeb

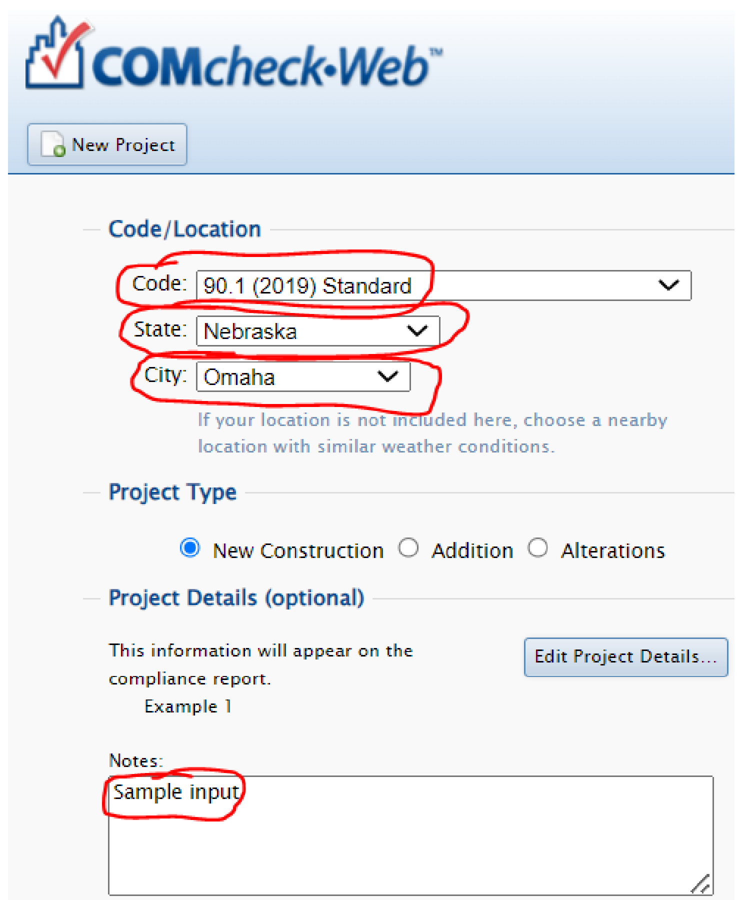


and input project name/title, middle top of web page…..
Project Title "Example 1"



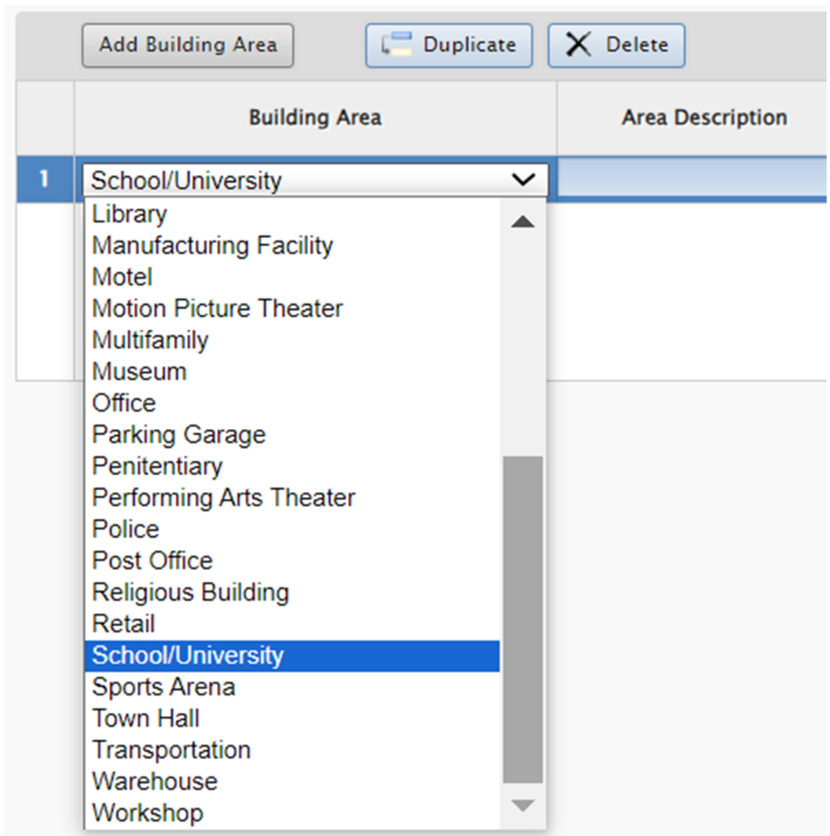
Then:
Code: (and date)
State:
City:
And Project Type:
New/Addition/Alteration

[Note: Location for this example is in **Climate Zone 5** – Therefore, **Steel framed wall** requires R-13 + R-11.4 *c.i.* Per 90.1-2019]



Step 2

Start defining the Building Area (function; **School** in this example):

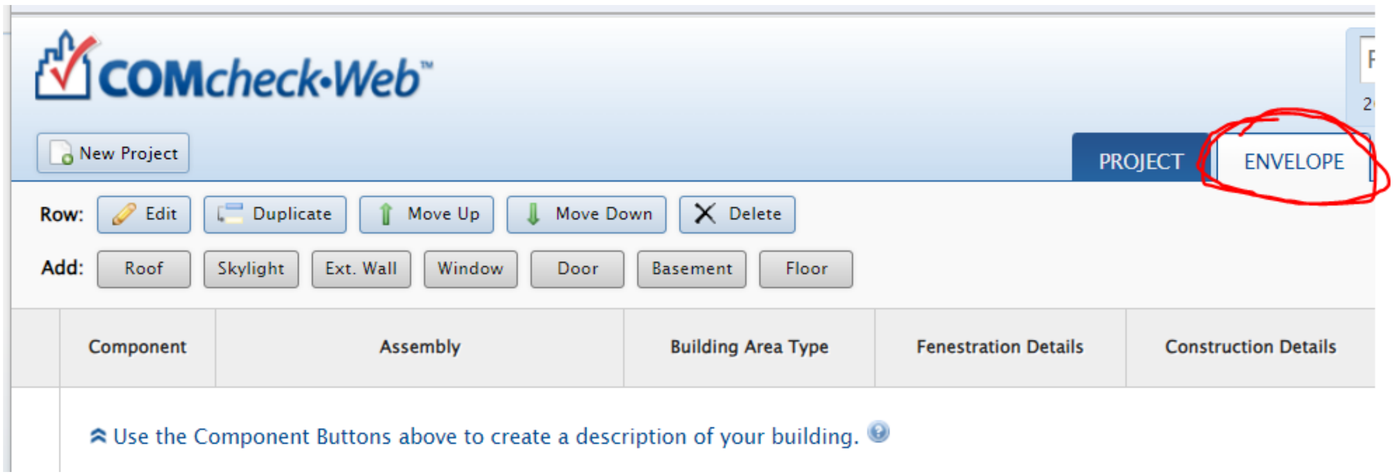


Then input the Space Conditioning: **Nonresidential**,
Then input the floor Area: **12,000** ft^2 (60 ft x 200 ft assumed) in this example:

Energy use (W/ft^2) is predetermined, based on the facility type.

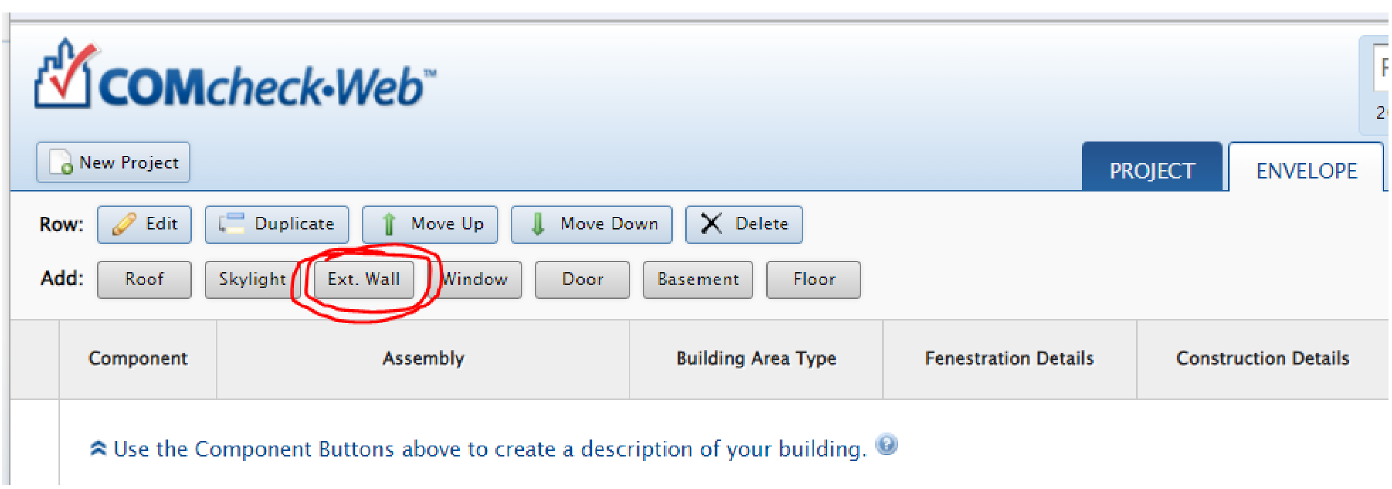
Step 3

Select the ENVELOPE tab…



… and the web page changes…

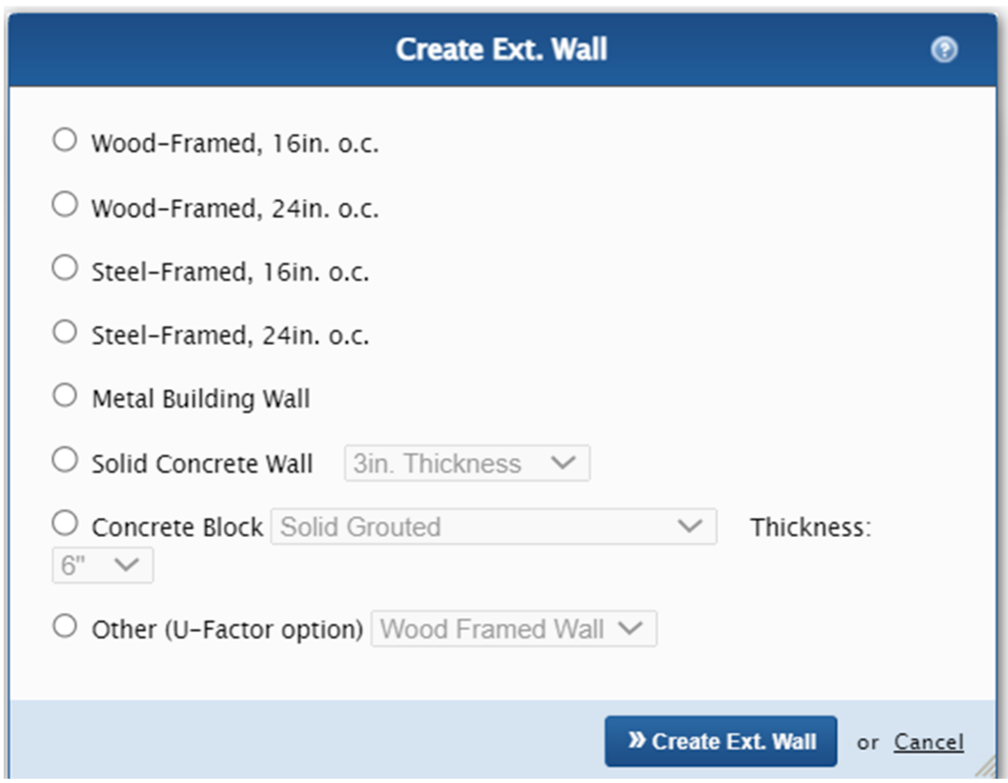
Then to the left and down, Select Ext. (exterior) Wall button…



…and a pop-up window appears….

Step 3, continued…

A pop-up window appears…

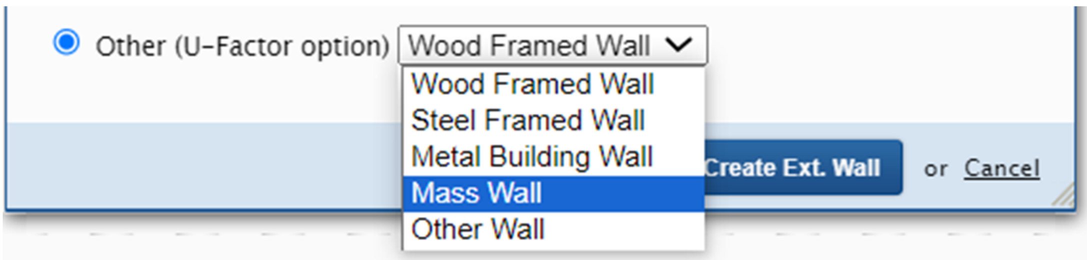


Brick veneer over steel studs is **<u>not,</u>** at present, a preset option, so you must select "Other":

Next……

Step 3, continued…

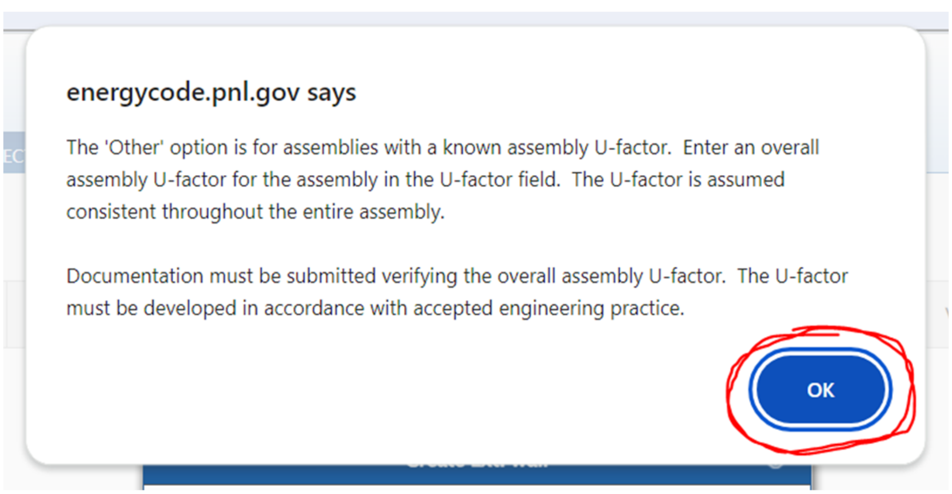
… a drop-down menu appears:



Select Mass Wall.

Then click "Create Ext. Wall" button.

Then this window pops up:



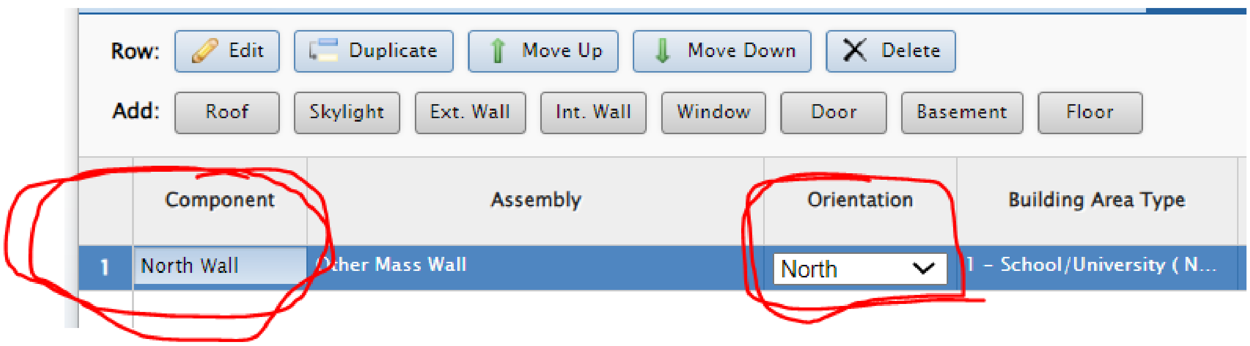
Interstate Brick (and perhaps other manufactures or Design Professionals) can provide the needed documentation [see tables later in this guide].

Select "OK".

Step 4

Define the components.

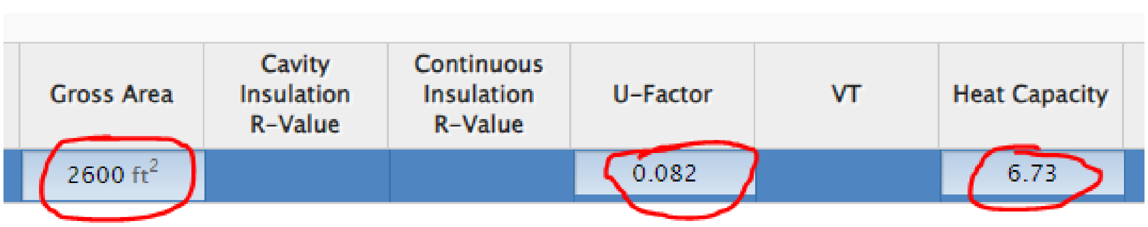
First identify the wall by typing in the Component designation (**North Wall** in this case) and select Orientation (drop down menu - North in this example)



Then input the Gross Area of the first wall (assuming a solid wall – no openings), the U-factor, and the Heat Capacity.

From the earlier input we have assumed the building is 60 ft x 200 ft in plan. Next, assume the walls are 13 ft high, with the long axis of the building going East-West. Therefore, the North Wall area is:
200 ft x 13 ft = **2600** ft^2. Input that as Gross Area of the first wall.

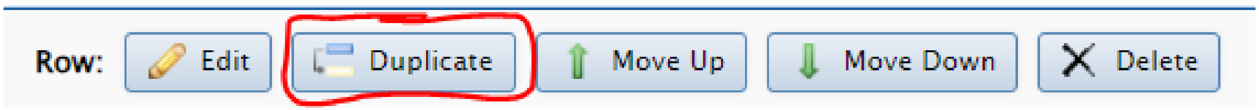
Input U-factor of **0.082*** (6" steel studs at 16" o.c. w/ 1.5" XPS exterior *c.i.* assumed; *c.i.* ≈ R-7.50).
Input HC of **6.73***;



*: See table on page 12 for U-factors and HC; interpolated for 1.5" XPS.

Step 4, continued…

Define the rest of the walls (four walls assumed in this example).
[For faster input, one can use the "Duplicate" and/or other buttons…



…and then, edit as needed by highlighting and changing the values that need to change.] All the walls assumed to have the same assembly.

	Component	Assembly	Orientation	Building Area Type
1	Ext. Wall	Other Mass Wall	North	1 - School/University (No…
2	Ext. Wall	Other Mass Wall	East	1 - School/University (No…
3	Ext. Wall	Other Mass Wall	South	1 - School/University (No…
4	Ext. Wall	Other Mass Wall	West	1 - School/University (No…

East and West 'end walls' are:
60 ft x 13 ft = **780** sf

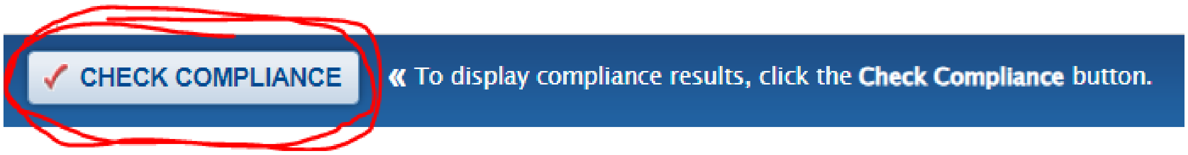
Gross Area	Cavity Insulation R-Value	Continuous Insulation R-Value	U-Factor	VT	Heat Capacity
2600 ft^2			0.082		6.73
780 ft^2			0.082		6.73
2600 ft^2			0.082		6.73
780 ft^2			0.082		6.73

Keep track of the correct wall areas in the appropriate orientations.

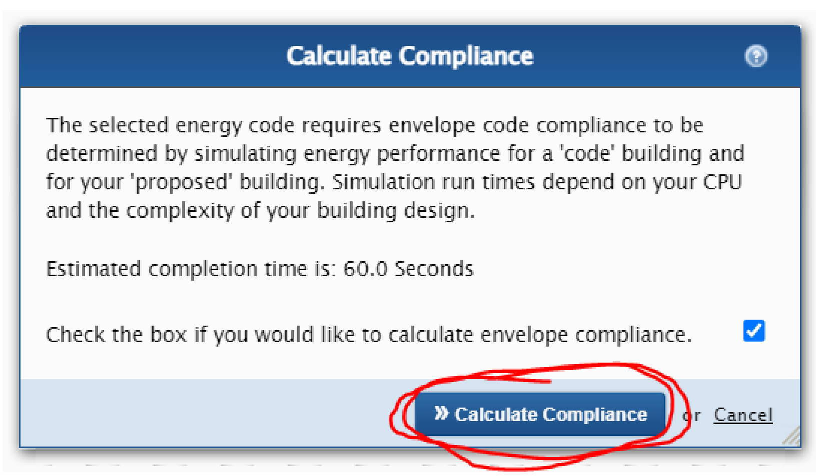
It is also possible to have different U-factors and Heat Capacities for different portions of the same wall – perhaps more insulation above the ceiling, as an example. Just make sure that the incremental wall areas total the correct total areas for the walls being defined.

Step 5

When you are done defining the walls (the walls are assumed to have no openings at this stage) then select the Check Compliance button at the bottom left of the page:

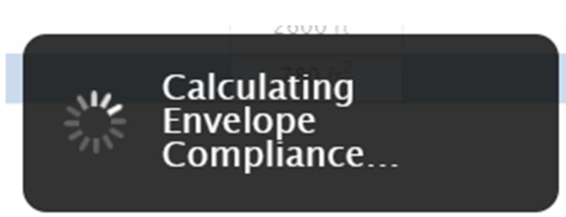


Depending on which code was selected a pop-up window may appear, such as this for ASHRAE 90.1-2019:



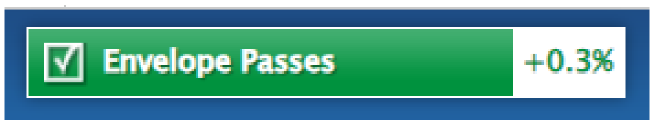
Select "Calculate Compliance"

This pops up:



Step 6

Evaluate the calculated result and modify as needed:



<u>In this example the walls, as defined, have sufficient energy performance to comply with code.</u> Note that only R-7.50 was added as *c.i.* to the wall compared to R-11.4 *c.i.* as prescribed for the R-Value approach. This U-factor approach using HC represents a savings of R-24.4 – R-7.5 = R-16.9

If the walls did not comply, then additional insulation would need to be added for the full surface, or only a portion, of the wall. Insulation can, at times, be added only to the upper portion of the wall (above the ceiling, possibly) to reach conformance.

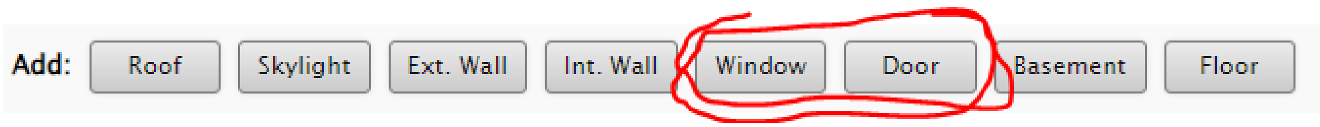
<u>Keeping all of the insulation outboard of the wall framing and outboard of the WRB almost guarantees that the dew point will occur outboard of the WRB – which is highly desirable to keep the interior of the building dry.</u>

A roof element can be added, which can be a benefit to the building performance model.

In situations where wall is slightly underperforming, insulation can be added to the roof (easily) to enhance the overall building performance – averaging in effect of the walls combined with the roof. **COM***check*™ will do this averaging when checking compliance.

Step 7

Once conformance of the wall (plus roof,) system has been reached, doors and windows are added to the walls as in the case for all other typical wall types.



Reasonably high-thermal-performance window systems and high-thermal-performance door systems are generally required to meet energy use conformance.

Rule of thumb for wall performance:

"More mass, less glass"

Tables; Steel Stud Wall Assembly Values:

C216 brick veneer cavity wall assemblies - 1.5" air cavity Steel Studs - 16GA.						
framing	stud spcg (in)	*c.i.* (in - XPS)	R'-value	R-value	U-factor	HC
4" steel studs	16	0.0	4.14	4.99	0.200	6.62
	16	1.0	9.37	10.22	0.098	6.67
	16	2.0	14.39	15.24	0.066	6.71
	16	3.0	19.43	20.28	0.049	6.76
	16	4.0	24.48	25.33	0.039	6.80
4" steel studs	24	0.0	4.15	5.00	0.200	6.58
	24	1.0	9.37	10.22	0.098	6.63
	24	2.0	14.40	15.25	0.066	6.67
	24	3.0	19.43	20.28	0.049	6.72
	24	4.0	24.46	25.31	0.040	6.76
6" steel studs	16	0.0	4.25	5.10	0.196	6.66
	16	1.0	9.47	10.32	0.097	6.71
	16	2.0	14.49	15.34	0.065	6.75
	16	3.0	19.53	20.38	0.049	6.80
	16	4.0	24.57	25.42	0.039	6.84
6" steel studs	24	0.0	4.22	5.07	0.197	6.61
	24	1.0	9.45	10.30	0.097	6.65
	24	2.0	14.47	15.32	0.065	6.70
	24	3.0	19.50	20.35	0.049	6.74
	24	4.0	24.53	25.38	0.039	6.79

Table values are based on Interstate Brick brick materials. Material from other manufacturers will vary.

R'-values are without interior and exterior air film effects.

R-value includes interior and exterior air film effects (R-0.85, total).

U-factor is derived from 1/(R-value).

For ½" increments of insulation interpolate between table values.

See next page for wall assembly materials.

[De-rating of insulation performance as required in some jurisdictions requires additional calculations but is generally around a 3% to 6% reduction in the thermal performance of the insulation when using thermally broken ties.]

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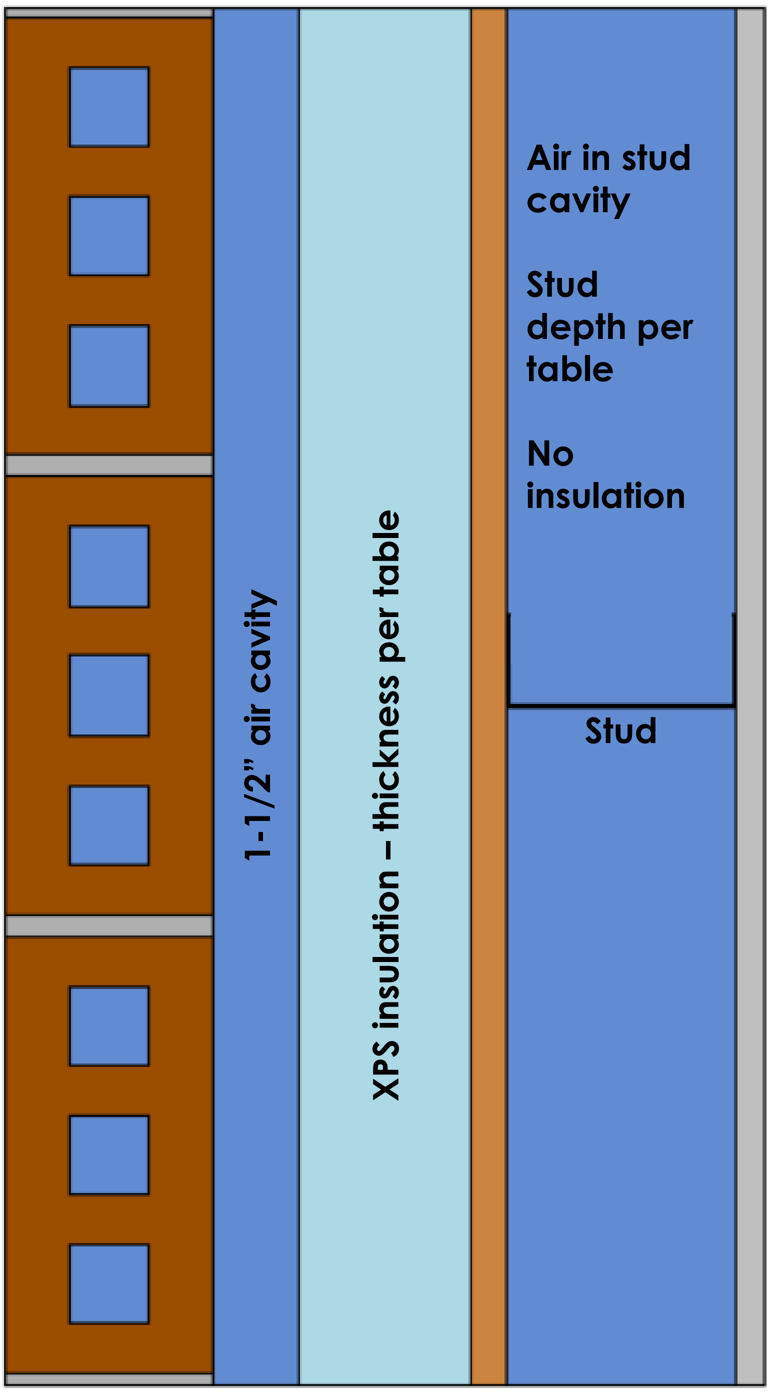
Tables; Steel Stud Wall Assembly (plan view):

5/8" OSB ext. sheathing

3-5/8" deep ASTM C216 Face Brick with 25% voids (voids filled with air)

3/8" head joints filled with mortar



4" (shown) and 6" 16-ga steel "C" studs at spacing per table (24" o.c. shown).

Stud flange lips (not shown) do not contribute to the energy performance of the wall

Brick ties and WRB not shown or modeled as they have negligible impact on R-values and HC

1/2" sheetrock

Tables; Wood Stud Wall Assembly Values:

C216 brick veneer cavity wall assemblies - 1.5" air cavity Wood Studs						
framing	stud spcg (in)	*c.i. (in* - XPS)	R'-value	R-value	U-factor	HC
2x4 wood studs	16	0.0	4.39	5.24	0.191	6.73
	16	1.0	9.61	10.46	0.096	6.78
	16	2.0	14.64	15.49	0.065	6.82
	16	3.0	19.66	20.51	0.049	6.87
	16	4.0	24.69	25.54	0.039	6.91
2x4 wood studs	24	0.0	4.30	5.15	0.194	6.67
	24	1.0	9.53	10.38	0.096	6.71
	24	2.0	14.55	15.40	0.065	6.74
	24	3.0	19.58	20.43	0.049	6.79
	24	4.0	24.62	25.47	0.039	6.83
2x6 wood studs	16	0.0	4.51	5.36	0.186	6.87
	16	1.0	9.74	10.59	0.094	6.92
	16	2.0	14.76	15.61	0.064	6.96
	16	3.0	19.79	20.64	0.048	7.00
	16	4.0	24.82	25.67	0.039	7.05
2x6 wood studs	24	0.0	4.38	5.23	0.191	6.75
	24	1.0	9.61	10.46	0.096	6.79
	24	2.0	14.63	15.48	0.065	6.84
	24	3.0	19.66	20.51	0.049	6.88
	24	4.0	24.69	25.54	0.039	6.93

Table values are based on Interstate Brick brick materials. Material from other manufacturers will vary.

R'-values are without interior and exterior air film effects.

R-value includes interior and exterior air film effects (R-0.85 total).

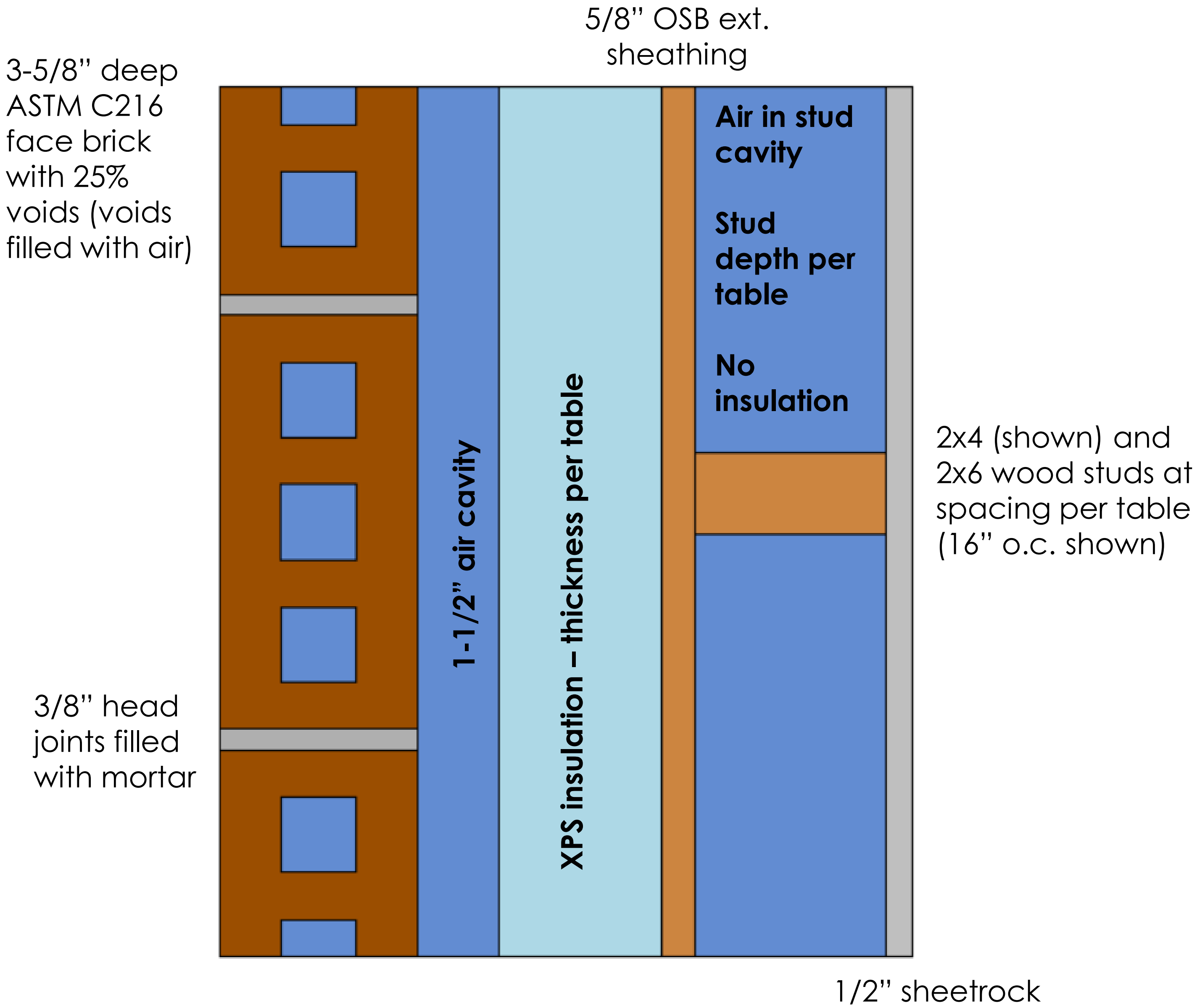
U-factor is derived from 1/(R-value).

For ½" increments of insulation interpolate between table values.

See next page for wall assembly materials.

[De-rating of insulation performance as required in some jurisdictions requires additional calculations but is generally around a 3% to 6% reduction in the thermal performance of the insulation when using thermally broken ties.]

Tables; Wood Stud Wall Assembly:



Brick ties and WRB not shown or modeled as they have negligible impact on R-values and HC

Mass wall code definitions:

Per IECC

Meet one of the following:

1. Weigh not less than 35 psf of wall surface area
2. Weight not less than 25 psf of wall surface area when material is not more than 120 pcf.
3. Have a heat capacity exceeding 7 Btu/ft^2 ·°F
4. Have a heat capacity exceeding 5 7 Btu/ft^2 ·°F where the material weight is not more than 120 pcf.

Per ASHRAE 90.1 (called, **"90.1"**)

Meet one of the following:

1. Have a heat capacity exceeding 7 Btu/ft^2 ·°F
2. Have a heat capacity exceeding 5 7 Btu/ft^2 ·°F where the material weight is not more than 120 pcf.

Given assembly (from outside face, inward) weight of materials:

3-5/8" ASTM C216 brick (with 25% voids) veneer cavity wall with ties + 1.5" air gap + zero exterior insulation + WRB + 5/8" OSB + 4" 16-ga studs at 24" o.c. + ½" sheet rock:

3-5/8" ASTM C216 Interstate Brick with 25% voids = **29 psf (min)**

Brick ties (1.0 psf assumed) = **1 psf**

Air gap = **0 psf**

Insulation (0.0 psf) + WRB (0.5 psf) = **0.5 psf**

5/8" OSB is approx. = **2 psf**

4" steel stud with 5/8" flanges and 3/8" flange lips weighs 1.8 lb/ft, spaced at 24" o.c. that is 0.85 psf; add top and bottom tracks at 1.5 lb/ft x 2 tracks / 9-ft wall = 0.5 psf = 1.35 psf for stud framing; say **1.5 psf**

1/2" sheetrock is approx. **2 psf**

Continued……

Mass wall code definitions, continued…

Total wall weight:

Weight = 29+1+0+0.5+2+1.5+2 = 36 psf (min) ≥ 35 psf

Weight complies with IECC option 1

Wall density:

The wall thickness for this brick cavity wall framed with 4" steel studs is: 3.625" + 1.5" air cavity + 0.0625" WRB + 0.625" OSB + 4" studs + 0.5" sheetrock = 10.3125"

Assembly density = 36 psf x 12 in/ft / 10.3125" = 41.9 pcf;
41.9 < 120 pcf; and wall weight at 36 psf > 25 psf

Density complies with IECC option 2

Heat Capacity:

Heat capacity is calculated at 6.58 < 7 (minimum); 6.58 ≥ 5 (See table data from page 12)
Does not comply with IECC option 3
Does not comply with 90.1 option 1
But, this **Heat Capacity complies with IECC options 1, 2 and 4**
And **Heat Capacity complies with 90.1 option 2**

As the criteria for a mass wall **only needs to meet one** of the given options for either code, this stud wall assembly qualifies as a mass wall.

When insulation is added, the wall weight goes up a little, the wall density reduces a little, if the stud spacing reduces to 16" the weight goes up, and the HC also goes up a little, all which helps maintain the mass wall requirements.

Conclusion:
Brick veneer cavity wall construction assemblies meet the necessary IECC and 90.1 code requirements to be classified as a **mass wall**.

Tables; 2" *c.i.* comparisons:

C216 brick veneer cavity wall assemblies - 1.5" air cavity Insulation Comparison						
framing	**stud spcg (in)**	**2" *c.i.***	**R'-value**	**R-value**	**U-factor**	**HC**
4" stl studs	16	XPS	14.39	15.24	0.066	6.71
	16	Polyurethane	17.57	18.42	0.054	6.74
	16	Polyiso	16.32	17.17	0.058	6.74
	16	Mineral wool	12.17	13.02	0.077	6.71
6" stl studs	16	XPS	14.49	15.34	0.065	6.75
	16	Polyurethane	17.66	18.51	0.054	6.78
	16	Polyiso	16.42	17.27	0.058	6.78
	16	Mineral wool	12.27	13.12	0.076	6.75
6" stl studs	24	XPS	14.47	15.32	0.065	6.70
	24	Polyurethane	17.63	18.48	0.054	6.73
	24	Polyiso	16.40	17.25	0.058	6.73
	24	Mineral wool	12.25	13.10	0.076	6.69
2x4 wood	16	XPS	14.64	15.49	0.065	6.82
	16	Polyurethane	17.80	18.65	0.054	6.85
	16	Polyiso	16.56	17.41	0.057	6.85
	16	Mineral wool	12.42	13.27	0.075	6.82
2x6 wood	16	XPS	14.76	15.61	0.064	6.96
	16	Polyurethane	17.93	18.78	0.053	6.99
	16	Polyiso	16.69	17.54	0.057	6.99
	16	Mineral wool	12.56	13.41	0.075	6.95
2x6 wood	24	XPS	14.63	15.48	0.065	6.84
	24	Polyurethane	17.80	18.65	0.054	6.86
	24	Polyiso	16.56	17.41	0.057	6.87
	24	Mineral wool	12.42	13.27	0.075	6.83

This table is intended to demonstrate that there is comparatively minimal change (about 0.5%) in **Heat Capacity (HC)** associated with the type of insulation used for a given thickness.

Conclusion: the **HC** values provided for XPS insulation (pages 12 and 14) are reasonably accurate regardless of the insulation type.

Notes

For the data tables on pages 12 and 14, R'-Value, R-Value, U-factor, and HC are based on XPS insulation having R-5 per inch of thickness.

To determine the **R-value** for insulation other than XPS of an assembly, start with determine the **R'-value** for the assembly with XPS insulation. Subtract the R-value of the XPS insulation of the given thickness in the assembly at R-5 per inch. Add back the R-value of the alternate insulation for the given thickness, then add the R-value of the air films [R-0.17 for ext. & R-0.68 for int = R0.85].

Example: data adjustment for *2x4 studs at 16" o.c. with 2" of mineral wool*;
From the table on page 14 take the noted R'-value of R'-14.64 for the 2x4 at 16" o.c. with 2" XPS insulation.
Subtract 2" x R-5 per inch for the XPS insulation (R-10) to get R'-4.64 without insulation.
Then add in the R-value of the alternate insulation (mineral wool, for instance, at R-4 per inch), so 2 x R-4 = R-8, plus R'-4.64 = R'-12.64.
Lastly, add in the R-value for the interior and exterior air film; R-0.85 total, to get R-12.64 + R-.085 = **R-13.49**.
The **U-factor** is then 1/13.49 = **0.074** (rounded up).

This gets to a reasonably accurate approximation of the R-value and U-factor of the alternate insulation material without an in-depth wall assembly computer analysis.

As noted on page 18, the **HC** will hardly change with a change to the insulation, so the table value for HC with XPS insulation (**HC = 6.82**) will be reasonably accurate for the mineral wool in this example.

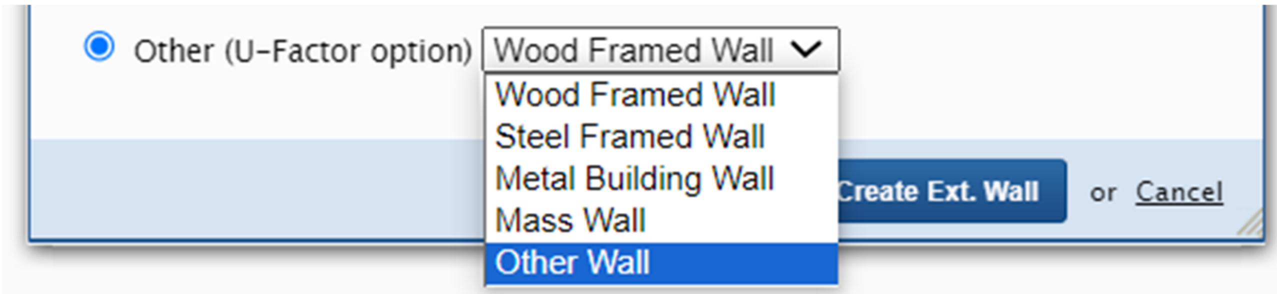
Notes

Some insulation materials change insulative properties with age and some insulation materials change insulative properties with temperature.

The R-values published herein are derived from a 2D finite element simulation/modeling based on the insulation versus temperature performance curve for the given material insulation material (XPS).

Step 3, alternative … (to page 6)

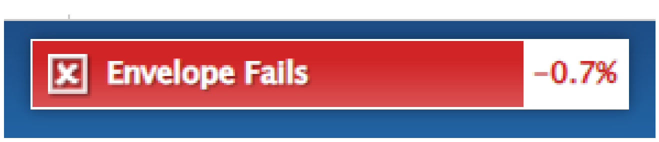
… a drop-down menu appears:



One can also select Other Wall,

Then click "Create Ext. Wall" button.

Then follow the guide as before, creating inputting data for each wall – Area and U-factor – as on pages 7 and 8 above **but** this path has no option to input the **Heat Capacity** as it is **not** the Mass Wall path, and the end result for the same U-factor input in the example above is….



This "Other, Other" input path would require additional insulation to reach compliance as the Heat Capacity of the wall is not recognized and the wall is not treated as a Mass Wall.

Guide to **COM***check*™ for Brick Veneer Walls

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