TEK NOTE

July 2016

Masonry Requirements of Northwest Energy Codes

There are two questions often asked regarding energy code compliance for concrete masonry (CMU) walls. They will be addressed in this technical note along with additional information on energy efficient design with masonry. The following information is based on the 2012 and 2015 editions of the Washington State Energy Code (WSEC) and the 2014 Oregon Energy Efficiency Specialty Code (OEESC).

Do concrete masonry walls require continuous insulation?

No. This is a common misconception. Although one particular prescriptive compliance path requires insulation to be continuous, there are several other options that do not require continuous insulation of concrete masonry walls. **It is recommended to use either the U-factor alternative prescriptive method, the component performance (envelope trade-off) method, or whole building analysis to optimize the energy-efficient design of masonry walls.**

Can integral-insulated, single-wythe CMU walls comply with northwest energy codes?

Yes. In many cases they can. Both the WSEC and OEESC contain exceptions within the prescriptive compliance path for core-insulated concrete masonry walls. The interior and exterior surfaces of these walls can be left exposed to utilize many of the benefits of CMU construction such as durability, fire-resistance, and attractive appearance (Figure 1). There is also the sustainable design benefit of using less materials in the construction and maintenance of building walls.

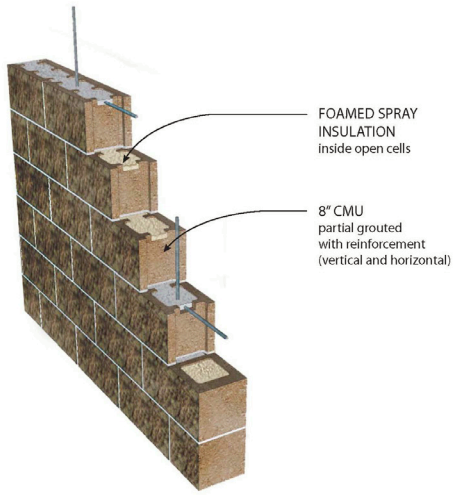


Figure 1 - Integral Insulated CMU Wall

This important exception applies to certain building types/uses listed in the code. These are buildings where the beneficial properties of exposed masonry walls are desired and it is not cost-effective to require excessive amounts of surface insulation on these walls in our northwest climate. The exception can be found in the code sections noted below.

WSEC Table C402.1.3, footnote (c)
(2015) Table C402.1.4, footnote (d)

OEESC Table 502.1.2, footnote (b)

The CMU exception requires at least 50% of the block cores to be filled with insulation. Some cores will be filled with reinforcement and grout for wind or seismic resistance. See Table 1 to determine the grouted area percentages and ungrouted area available for core insulation based upon reinforcement/grout spacing. Core insulation can be loose-fill, foam-in-place, or rigid inserts.

Table 1 - Percent Ungrouted Area/Percent Grouted Area

Horizontal Grout Spacing, Inches	Vertical Grout Spacing, Inches			
	48”	**40”**	**32”**	**24”**
48”	69 / 31	67 / 33	63 / 37	56 / 44
40”	67 / 33	64 / 36	60 / 40	53 / 47
32”	63 / 37	60 / 40	56 / 44	50 / 50
24”	56 / 44	53 / 47	50 / 50	44 / 56

MASS WALLS

Masonry walls are "mass walls". Such walls are defined in energy codes as having a minimum weight per square foot of surface area or having a minimum heat capacity.[1] The commercial building provisions of the 2012 and 2015 Washington State Energy Code, 2012 and 2015 International Energy Conservation Code (IECC), and 2014 Oregon Energy Efficiency Specialty Code define mass walls as follows:

"Mass walls" shall include walls weighing at least:
(1) 35 pounds per square foot of wall surface area or
(2) 25 pounds per square foot of wall surface area if the material weight is not more than 120 pounds per cubic foot (pcf).

The WSEC and the IECC include the following additional definitions:
(3) Walls having a heat capacity exceeding 7 Btu/ft² - °F or
(4) Walls having a heat capacity exceeding 5 Btu/ft² - °F where the material weight is not more than 120 pcf.

Thermal mass – the energy saver in masonry buildings

Table 2 lists typical concrete masonry wall weights. All exceed 35 pounds per square foot. Table 3 lists heat capacity values for various masonry walls.

Table 2 - Typical Concrete Masonry Wall Weights (PSF)

Vertical Grout Spacing (assumes 48" o.c. horiz. grouting)	CMU Wall Thickness			
	6"	8"	10"	12"
48" o.c.	37	50	58	72
32" o.c.	39	53	62	77
Solid grout	55	76	95	121

The concept that massive walls absorb and retain heat, to be later released, has been understood since the time of the world's earliest structures, many of which were built to benefit from the delaying effect of mass on the transfer of heat. This physical property, combined with the dynamic temperature cycles a building is subjected to, allows masonry materials to be utilized effectively in the design of energy efficient buildings. The benefits of thermal mass have been partially incorporated into modern energy code requirements permitting masonry wall assemblies to have less insulation than lightweight frame systems.

Table 3 - Heat Capacity Values (Btu/ft² – °F)

Structural Walls	Partial Grout	Solid Grout
8" CMU	9.65	15.00
12" CMU	14.50	23.60
8" Brick	10.90	16.40
Brick/CMU Cavity Wall	15.00	20.35
Veneer Walls	**No Grout**	
4" brick (wood studs)	7.8	–
4" brick (metal studs)	7.5	–
4" CMU @115 pcf (unit only)	5.6	–

INSULATION (R-Value) IMPACT

It is important to note that R-values alone do not fully describe the thermal performance of a concrete masonry wall. Masonry's thermal performance depends upon its steady-state thermal characteristics (described by R-value or U-factor) as well as the thermal mass properties of the wall assembly. Because of its comparatively high density and specific heat, masonry provides very effective thermal storage. Masonry walls remain warm or cool long after the heat or air-conditioning has shut off. This reluctance of the wall to change temperature (thermal flywheel effect) reduces peak heating and cooling loads, moderates indoor temperature swings, and shifts heating and cooling loads to off-peak hours. Due to these significant benefits of thermal mass, concrete masonry buildings can provide similar energy performance to more heavily insulated frame buildings.

Although in general higher R-values reduce heat flow through a building element, you can quickly reach a point where R-values have a diminishing impact upon the overall building envelope energy use. Adding excessive amounts of insulation to a mass wall for example, is not cost-effective for most nonresidential buildings in the northwest. Payback periods for the building owner are far too long. At some point it makes more sense to invest in energy efficiency measures other than wall insulation. Figure 2 illustrates an example of the diminishing return of additional wall insulation for a typical elementary school.

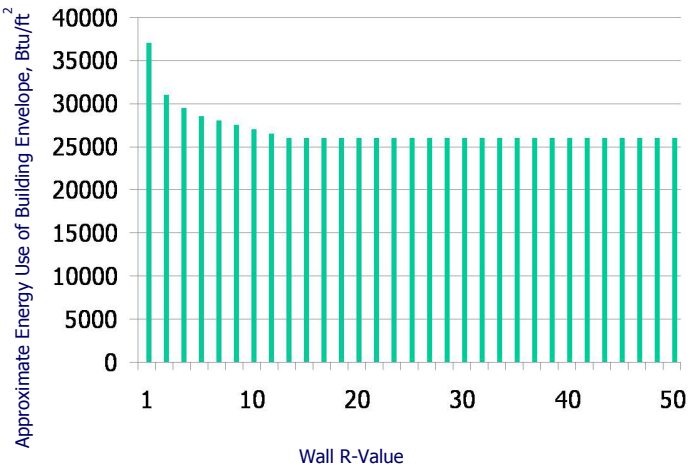


Figure 2 - Diminishing Return of Added Wall Insulation

[1] The amount of heat necessary to raise the temperature of a given mass 1° F, or the product of wall weight times specific heat

The masonry industry conducted a recent study looking specifically at masonry building energy use in the northwest climate. Several building types were modeled using EnergyPlus, a US DOE supported whole building analysis program. All design variables were identical with the exception of the concrete masonry wall R-value (U-factor).

In a high school gymnasium for example, a single-wythe, integral core-insulated CMU wall was compared to a more highly insulated CMU wall with surface insulation. **It was found that the annual energy use of the gymnasium did not change when the more highly insulated CMU wall was used.** From a cost-effectiveness standpoint the simple payback period for the higher insulated wall was infinite. Additionally, a 50-year life-cycle cost analysis determined a savings of $183,000 by selecting the integral-insulated concrete masonry wall. Other typical masonry building types and other studies have shown similar results.

CONCLUSION

The masonry (mass) wall provisions of northwest energy codes allow greater design flexibility and properly recognize the benefits of thermal mass. Most common masonry wall systems will qualify as "mass walls" meeting the wall weight or heat capacity requirements. They are eligible to comply with the codes using the lower mass wall insulation requirements in the prescriptive compliance tables. **They are not required to have continuous insulation.** Surface insulated masonry walls or preinsulated CMU can comply with the U-factor requirements. Furthermore, the single-wythe concrete masonry exception allows integrally-insulated walls to comply with the code for many building types/uses (Figure 3).

Prescriptive Path Compliance Options:

1. Meeting a mass wall assembly U-factor requirement (U=0.104 WA and U=0.150 OR). As long as the wall as a whole (not the insulation alone) meets this U-factor, the wall complies with the code, or

2. Using continuous insulation with the insulation alone meeting the R-value requirement. **This is an option, mass walls are not required to use continuous insulation, or**

3. **Using the concrete masonry exception for certain building use types. This exception allows an integral-insulated, partial-grouted concrete masonry wall to comply.**

   Use of this exception requires the following two items:

   a. At least 50 percent of the ASTM C-90 block cores must be filled with insulation. See Table 1 for grout spacing that will comply.

   b. 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, restroom/concession, mechanical/ electrical structure, motor vehicle service facility.**

      Contact your local building official for permission to use this exception for similar building uses not listed above.

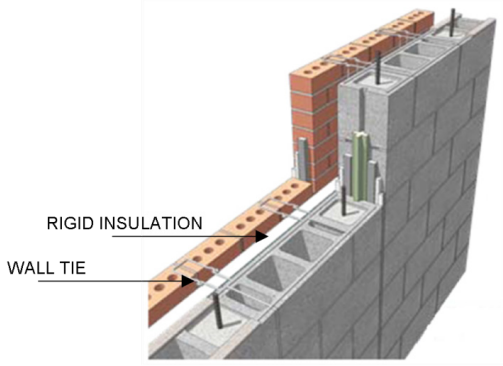
NOTE: U-factors for mass walls can be found in Table A 103.3.7.1(1) in Appendix A of the WSEC, in the *Thermal Catalog of Concrete Masonry Assemblies* published by the National Concrete Masonry Association, or per the ASHRAE *Handbook of Fundamentals.*

Figure 3 - Prescriptive Path Compliance Options

Other code compliance paths for mass walls include component performance (envelope trade-off) and total building performance/whole building analysis. Table 4 lists the optional design methods and recommends which method(s) is preferable based upon masonry wall type. The **prescriptive path** choices are listed in the first three columns and are easiest to use. Within the prescriptive options, either the U-factor alternative or CMU single-wythe exception are preferred as they account for the full masonry assembly, not just the insulation. Next is the **envelope trade-off** approach where one envelope component can exceed the prescriptive U-factor requirement if another component makes up the difference. **Mass walls with their higher U-factor requirement allow designers more trade-off potential than lightweight walls.** Last is the **whole building analysis** method which can accurately model thermal mass effects and allows the greatest design flexibility. **Use a comprehensive energy analysis program with hour-by-hour simulation and allowance for inputting custom mass wall properties.**

Regardless of a project's energy efficiency and sustainable design goals, concrete masonry walls can help meet these goals. In addition to the thermal mass benefits discussed in this technical note, concrete masonry block is a locally-produced construction material that has superior durability minimizing the need for repair or replacement. It also provides attractive appearance, structural strength, and will not burn. Build to last…Build Better with Block.

Exposed single-wythe CMU wall in gymnasium

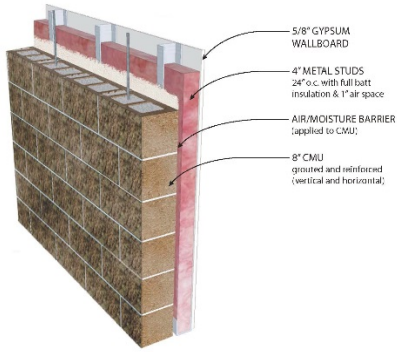


Cavity walls can easily comply with the code via the U-factor or R-value prescriptive options.

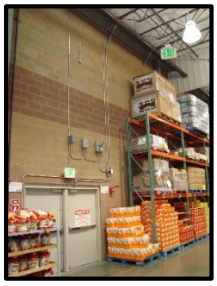
Table 4 - Design Method Choices

Masonry (Mass) Wall Type	Code Compliance Path				
	Prescriptive Path U-Factor	CMU Exception	Prescriptive Path R-Value	Component Performance (Envelope Trade-Off)	Total (Whole) Building Performance
Single-Wythe Wall	P	P	O	O	P
Cavity Wall	P	N.A.	O	O	P
Masonry Veneer Over Frame Wall	P	N.A.	O	O	P

P = preferred design methods; O = optional design methods; N.A. = not applicable



The U-factor alternative path accounts for all components of the wall assembly not just the insulation.



Durable, noncombustible CMU wall interior of big-box retail building.

Insulation on the surface of these CMU walls would not save energy for this motor vehicle service facility.

For further information on how to put concrete masonry to work for you contact:

Basalite Concrete Products, LLC
www.basalite.com

Central Pre-Mix Concrete Products Co.
www.centralpremix.com

Mutual Materials Co.
www.mutualmaterials.com

Western Materials
www.westernmaterials.com

White Block Co.
www.whiteblockcompany.com

Willamette Graystone, Inc.
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