NCMA TEK

National Concrete Masonry Association
an information series from the national authority on concrete masonry technology

INTERNATIONAL ENERGY CONSERVATION CODE AND CONCRETE MASONRY

TEK 6-12C
Energy & IAQ (2007)

Keywords: ASHRAE, commercial buildings, energy codes, energy software, heat capacity, insulation, International Energy Conservation Code, R-value, thermal mass

INTRODUCTION

The *International Energy Conservation Code* (IECC) (refs. 1, 2) serves as a written model for states, counties, cities or other jurisdictions to develop local codes for energy efficient building design.

For commercial buildings, the IECC provides three alternatives for demonstrating building compliance, using: prescriptive criteria; a whole-building performance analysis; or demonstrating compliance with ASHRAE/IESNA Standard 90.1, *Energy Standard for Buildings Except Low-Rise Residential Buildings* (ref. 3). Although not specifically referenced in the code, the COM*check* software program (ref. 4) developed by the U. S. Department of Energy is a commonly accepted compliance tool.

The prescriptive criteria present an independent requirement for each building envelope component.

The whole-building performance compliance option is based on an analysis which simulates a full year of building operation, accounting for virtually all aspects of building energy use. Detailed energy analysis software, such as DOE-2 (ref. 5), is typically used when employing this option. This compliance path offers the maximum design flexibility, but requires a fairly rigorous and detailed analysis.

The third compliance option simply refers the reader to ASHRAE Standard 90.1. Standard 90.1 includes software that allows the user to trade off the performance of one building component for that of another, thus offering more design flexibility than the prescriptive option, while still being easier and quicker than comprehensive software analysis. Standard 90.1 also includes prescriptive requirements and a whole-building performance compliance option.

2003 IECC PRESCRIPTIVE COMPLIANCE

The IECC prescriptive tables were significantly reformatted between the 2003 and 2006 editions of the code. In the 2003 IECC, the thirty-seven prescriptive compliance tables represent thirty-seven climate zones as defined in Chapter 9 of the code. Each table is further subdivided into four sets of requirements based on the building's percentage glazing. Each table includes minimum requirements for windows and glass doors, skylights, slab or below-grade walls, roofs, above-grade walls, and floors over outdoor air or unconditioned space. Each of these elements must independently meet the stated requirement in order for the building to comply using prescriptive compliance. In other words, if the building's roof insulation does not meet the code minimum, the building does not comply, even if other elements exceed the minimum requirements.

The charging paragraph for above grade walls, code section 802.2.1, states: "Concrete masonry units (CMU) at least 8 inches (203 mm) nominal in thickness with essentially equal amounts of mass on either side of the insulation layer are considered as having integral insulation; however, the thermal resistance of that insulation shall not be considered when determining compliance." The intent of this statement is to make the user aware that the R-value of masonry cell insulation has already been accounted for in determining the prescriptive requirements listed in the tables, and should not be counted towards meeting the code-mandated insulation R-value.

As an example, consider Table 1a which shows the above grade wall prescriptive requirements for commercial buildings in Chicago, Illinois. The requirements for CMU $\geq$ 8 in. (203 mm) with integral insulation and no framing are: R-value cavity = NA and R-value continuous = R-5. This means that to comply, a masonry wall, $\geq$ 8 in. (203 mm) nominal thickness, must have continuous R-5 minimum insulation in addition to the integral insulation to comply, i.e., the R-value of the integral insulation does not count toward meeting the R-5 requirement. In Atlanta (Table 1b), where R-value continuous = R-0, the integral insulation alone meets the code requirement. Examples of masonry walls that meet the various requirements are also shown in Table 1.

Concrete masonry walls without integral insulation, such as masonry cavity or fully grouted walls, are required to use the *Other Masonry Walls* row of the table for compliance.

Note also that the requirements for *R-value cavity* and *R-value continuous* are used in conjunction to determine compliance. In other words, if the table lists requirements for both cavity and continuous insulation, the wall must include both to comply. "NA" means that the stated condition does not apply. When R-0 appears in the table, it indicates that no additional insulation in required for the condition listed.

Table 1—Sample 2003 IECC Prescriptive Requirements and Complying Concrete Masonry Above Grade Walls (ref. 1)

Table 1a: For Chicago, Illinois

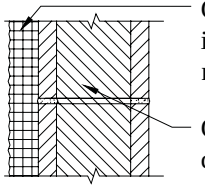
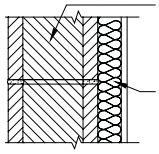
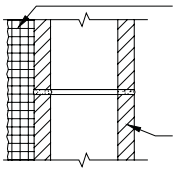
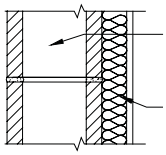
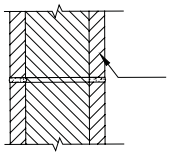
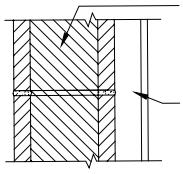
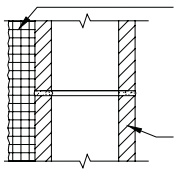
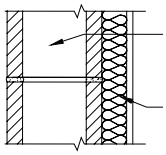
Wall:	No framing		Metal or wood framing	
CMU, ≥ 8 in., w/integral insulation R-value cavity R-value continuous	IECC requirement NA R-5	Example of complying wall  Continuous insulation, R5, min. CMU ≥ 8 in., cores insulated	IECC requirement R-11 R-0	Example of complying wall  CMU ≥ 8 in., cores insulated Insulation between framing, R11 min.
Other masonry walls R-value cavity R-value continuous	NA R-5	 Continuous insulation, R5, min. CMU ≥ 8 in.	R-11 R-0	 CMU ≥ 8 in. Insulation between framing, R11 min.

Table 1b: For Atlanta, Georgia

Wall:	No framing		Metal or wood framing	
CMU, ≥ 8 in., w/integral insulation R-value cavity R-value continuous	IECC requirement NA R-0	Example of complying wall  CMU ≥ 8 in., cores insulated	IECC requirement R-0 R-0	Example of complying wall  CMU ≥ 8 in., cores insulated Framing
Other masonry walls R-value cavity R-value continuous	NA R-5	 Continuous insulation, R5, min. CMU ≥ 8 in.	R-11 R-0	 CMU ≥ 8 in. Insulation between framing, R11 min.

Source: 2003 IECC Tables 802.2(18) and 802.2(32)

The IECC terminology is slightly different from commonly accepted masonry terminology. As an example, "cavity" in the IECC refers to the space between framing or furring, thus "NA" appears under the *No framing* column for all *R-value cavity* entries. Table 2 lists the terms as used in the IECC and defines their applicability to masonry walls.

The IECC prescriptive table requirements apply to the following concrete masonry assemblies.

1) Walls greater than or equal to 8 in. (203 mm) nominal thickness with integral insulation.
2) Walls greater than or equal to 8 in. (203 mm) nominal thickness and weighing at least 35 psf (171 kg/m^2) (ref. 6 lists concrete masonry wall weights). Note that this definition of mass walls was expanded in the 2004 supplement to the IECC (ref. 7) to also include walls weighing 25 psf (122 kg/m^2) if the material weight is not more than 120 lb/ft^3 (1,900 kg/m^3). This additional provision clarifies that lightweight concrete masonry walls are governed by the same criteria as other concrete masonry walls.

Buildings with thinner walls, or other concrete masonry walls not meeting these descriptions, must use either the COM*check* compliance software or ASHRAE/IESNA Standard 90.1, *Energy Standard for Buildings Except Low-Rise Residential Buildings* to verify compliance.

Note that the prescriptive requirements of Standard 90.1, while similar to those in the IECC, include an option for compliance with an overall wall U-factor in addition to adding a certain insulation R-value to the wall (as shown in Table 1). This may be a good option for concrete masonry walls with proprietary inserts, or other walls that have better thermal performance than that assumed in the code.

2006 IECC PRESCRIPTIVE COMPLIANCE

The prescriptive wall requirements for commercial buildings, listed in IECC Table 502.2(1), were significantly simplified in the 2006 edition of the IECC. The number of climate zones was reduced to eight, wall requirements are now independent of the amount of glazing and all concrete masonry walls must now comply with a single requirement.

As defined in the 2004 IECC supplement, *Mass walls* in the 2006 IECC are those weighing at least 35 psf (171 kg/m^2)

as well as those walls weighing 25 psf (122 kg/m^2) if the material weight is not more than 120 lb/ft^3 (1,900 kg/m^3). The minimum 8-in. (203-mm) thickness is no longer a requirement to qualify as a mass wall.

In climate zones 1 and 2, concrete masonry walls do not require any insulation. While the first option indicated in IECC Table 502.2(1) table for mass walls specifies continuous insulation in climate zones 3 through 8, footnotes to the table provide the following options. In climate zones 3 and 4, concrete masonry walls with ungrouted cells filled with insulation such as vermiculite, perlite or foamed-in-place (with a thermal conductivity less than or equal to 0.44 Btu-in./h·ft$^{2.}$ ^{o}F, or R-value per inch $\geq$ 2.27 (63.4 W·mm/m$^{2.o}$C)) comply, as long as the amount of grouting does not exceed 32 in. (813 mm) o.c. vertically and 48 in. (1,219 mm) o.c. horizontally.

Also note that insulation is not required for concrete masonry walls in climate zone 3 Dry (B) nor is it required below the warm-humid line in climate zone 3 Moist (A), as defined in IECC Figure 301.1.

In climate zones 5 through 8, there are several options for compliance:

- choose the applicable prescriptive option for continuous insulation from IECC Table 502.2(1), or
- demonstrate compliance using ASHRAE Standard 90.1 (see following section), or
- use compliance software (see following section), or
- use the whole-building performance compliance option.

TRADE-OFF COMPLIANCE USING COM*check*

Using either the 2003 or 2006 IECC, the trade-off option allows the user to demonstrate compliance based on the building envelope as a whole, rather than on the prescriptive component-by-component basis. These trade-offs are most often implemented using easily-implemented software, such as COM*check*.

There are two main benefits to using trade-off software for compliance, rather than prescriptive tables. First, the user gains design flexibility because parameters such as increased glazing area can be offset by increasing roof or wall insulation. Second, once the basic building data is entered into the program and saved, design changes or the building location can be quickly modified, and compliance immediately redetermined.

More detailed information on using COM*check* for concrete masonry buildings can be found in TEK 6-4A, *Energy Code Compliance Using COMcheck* (ref. 8).

Table 2—Insulation Definitions Used in the 2003 IECC

Integral insulation: Insulation installed such that there is essentially an equal amount of mass on both sides of the insulation, such as insulation installed in the cores of masonry units or insulation installed in the cavity of a masonry cavity wall. Masonry core insulation is typically molded polystyrene inserts, expanded perlite or vermiculite granular fills or foams. Rigid board insulation is typically used in multi-wythe masonry wall installations, although expanded perlite, vermiculite and foams have also been used.

R-value cavity: R-value of insulation installed between framing members, hence "NA" appears in the IECC Chapter 8 requirements under the "no framing" column for all "R-value cavity" entries. Does not refer to insulation installed in the cavities or cores of hollow masonry units, nor in the cavity of a multi-wythe masonry wall.

R-value continuous: R-value of continuous insulation (without thermal bridges), i.e. insulation not installed in masonry cores or interrupted by framing members; such as cavity insulation in a masonry cavity wall.

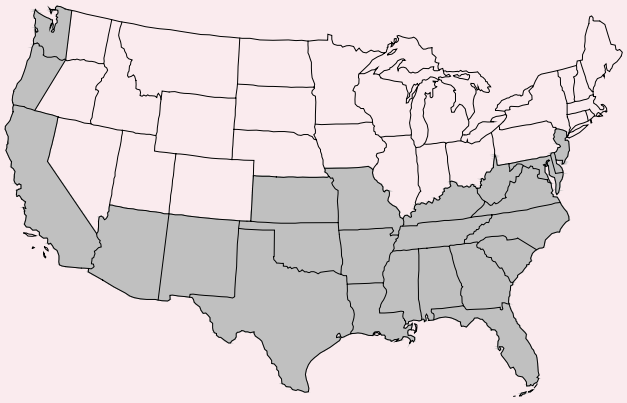


Figure 1—Areas Where ASHRAE 90.1 Prescriptive Exception Applies for Nonresidential Buildings (shading indicates that the exception applies)

Table 3—Sample ASHRAE 90.1 Prescriptive Requirements for Above Grade Walls in Atlanta (ref. 3)

	Nonresidential		Residential		Semiheated	
Above grade walls	Assembly maximum	Insulation min. R-value	Assembly maximum	Insulation min. R-value	Assembly maximum	Insulation min. R-value
Mass	U-0.151[a]	R-5.7 ci[a, b]	U-0.123	R-7.6 ci[b]	U-0.580	NR[c]
Metal building	U-0.113	R-13.0	U-0.113	R-13.0	U-0.184	R-6.0
Steel framed	U-0.124	R-13.0	U-0.084	R-13.0 + R-3.8 ci[b]	U-0.352	NR[c]
Wood framed & other	U-0.089	R-13.0	U-0.089	R-13.0	U-0.089	R-13.0

[a] prescriptive exception applies (see text and Figure 1)

[b] "ci" refers to continuous insulation without thermal bridges other than fasteners and service openings

[c] "NR" means no requirement, i.e. the wall complies with no added insulation

COMPLIANCE USING ASHRAE STANDARD 90.1

Standard 90.1 Prescriptive Compliance

The prescriptive compliance tables in Standard 90.1 are organized by climate zone, as they are in the IECC. Tables list requirements for each building envelope element by building type: nonresidential, residential or semiheated (see Table 3). The bottom half of each table contains glazing requirements based on the percentage glazing area, similar to the 2003 IECC. Unlike the 2003 IECC, however, only the glazing U-factor and solar heat gain coefficient (SHGC) requirements vary with the building's percentage of glazed area; other building envelope requirements are independent of glazed area.

Separate requirements are listed for each of the four above-grade wall construction classes: mass walls, such as concrete masonry; metal building; steel frame; and wood frame. For each wall and building type, the user may comply by using either the minimum R-value of the insulation added to the wall, *or* using the wall assembly U-factor.

For example, Table 3 indicates that mass walls must either have a maximum U-factor of 0.151 Btu/h ft^2 ^{o}F (R-6.6) (0.86 W/m^2 ^{o}C) or continuous R-5.7 (1.00 m^2 ^{o}C/W) insulation to comply with the prescriptive requirements for nonresidential buildings. The asterisk, however, indicates an exception for concrete masonry walls: "Alternatively, for mass walls, where the requirement in the table is for a maximum assembly U-0.151 followed by an asterisk only, ASTM C90 concrete block walls, ungrouted or partially grouted at 32 in. or less on center vertically and 48 in. or less horizontally, shall have ungrouted cores filled with material having a maximum thermal conductivity of 0.44 Btu in./h ft^2 ^{o}F." (ref. 3) This maximum thermal conductivity corresponds to a minimum R-value per inch of 2.27 ft$^{2\cdot o}$F·h/Btu·in. (63.4 W·mm/m$^{2\cdot o}$C). Materials meeting this threshold include vermiculite, perlite and cellulosic loose fills, as well as most rigid and foam insulations.

In general, this exception applies to nonresidential buildings located in the shaded area of Figure 1. In essence, the exception allows the majority of single wythe ungrouted and partially grouted concrete masonry walls containing insulation in the ungrouted cells to comply with Standard 90.1, and hence with the IECC, regardless of that wall's R-value.

For the unshaded areas in Figure 1, concrete masonry walls must meet either the continuous insulation requirement, or a wall R-value of 6.6 h·ft$^{2\cdot o}$F/Btu (U-0.151) (1.16 m$^{2\cdot o}$C/W), as for other mass walls.

Standard 90.1 Trade-Off Compliance

The Standard 90.1 building envelope trade-off option uses the EnvStd (ref. 9) software to determine compliance. Similar to COM*check*, the user essentially "builds" the project by entering building envelope thermal characteristics. The software combines this input with embedded weather data to perform a location-specific analysis, accounting for more design variables than can be included in the prescriptive tables.

REFERENCES

1. *International Energy Conservation Code*. International Code Council, 2003.
2. *International Energy Conservation Code*. International Code Council, 2006.
3. *Energy Standard for Buildings Except Low-Rise Residential Buildings*, ASHRAE/IESNA Standard 90.1. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. and Illuminating Engineering Society of North America, 2001 and 2004.
4. COM*check*, version 3.4.1. United States Department of Energy, http://www.energycodes.gov/comcheck/ez_download.stm, 2007.
5. DOE-2.1E, available through various sources, see http://gundog.lbl.gov/dirsoft/d2whatis.html.
6. *Concrete Masonry Wall Weights*, TEK 14-13A. National Concrete Masonry Association, 2002.
7. 2004 *International Energy Conservation Code Supplement*. International Code Council, 2004.
8. *Energy Code Compliance Using* COM*check*, TEK 6-4A. National Concrete Masonry Association, 2007.
9. [free download] EnvStd, http://www.archenergy.com/products/tools/envstd//.