Protection is a concrete idea.

The International Energy Code and Masonry Construction

The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) developed and published Standard 90 in 1975, shortly after the 1973 Oil Embargo took place. At that time, it became evident crude oil had become a serious threat to the future well-being of the entire world. The ASHRAE Standard 90 established the Energy Efficient Requirements for all Buildings Except Low-Rise Residential Construction. Part of this Standard covered the thermal efficiency of Walls and Ceilings.

Since its original issue, Standard 90 has undergone numerous revisions. The current issue is now used by many states as the basis for their Energy Construction Codes for all buildings Except Low-Rise Residential Construction. [Low-Rise being defined as single-family, multi-family three stories or fewer above grade, manufactured houses (mobile homes and modular)].

In 1998, the International Energy Conservation Code (IECC) was developed covering both residential and commercial building construction. This Code has also been refined and updated to its current version known as the 2006 IECC Code. This Code has also been adopted as the basis for many state building codes as well.

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Member of NCMA and EPSMA

In order to determine which Code is applicable to a specific state, the United States Department of Energy has developed a website to provide current information on State Energy Codes. Their website is www.energycodes.gov.

Both the ASHRAE Standard 90 and the IECC show various methods of meeting the thermal requirements for both residential and commercial building construction. The use of these standards will have a significant impact in reducing the heating and cooling costs for new building construction, which coupled with the other energy saving items covered in the standards, will have a major reduction in the future consumption of oil in our country.

There are two (2) NCMA publications showing a detailed analysis of just how the International Energy Code relates to masonry. The documents are attached here for your review.

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CMU walls comply with energy codes for commercial buildings in many climates WITHOUT the addition of continuous insulation

Here are compliance options for above grade, non residential, single wythe CMU walls —

Prescriptive
Using IECC* Table 502.2(1)[1]

While the first option indicated in the table for mass walls specifies continuous insulation for Climate Zones 3, 4 , 5, 6, 7, and 8, footnotes to the table provide for the following options which might be preferred.

Climate Zones 1 and 2: No insulation is required for mass walls.

Climate Zones 3 and 4:
Fill ungrouted cells with insulation such as vermiculite, perlite, or foamed in place, with Conductivity $\leq$ 0.44 BTU-in/hr- ft^2 ^{0}F (R/inch $\geq$ 2.27). Note that insulation is not required in Climate Zone 3B nor is it required below the Warm-Humid Line in Climate Zone 3A. See Climate Zone Map.

Climate Zones 5-8:

1. choose the prescriptive R option for assemblies with continuous insulation,**

OR 2.⇩ show that wall assembly complies with ASHRAE 90.1 Maximum U Value,
OR 3.⇨ use Compliance Software,
OR 4.⇨ use Whole Building Analysis.

*2006 IECC —International Energy Conservation Code
** R=7.6 Zone 5; R= 9.5 Zone 6; R=11.4 Zone 7; R= 13.3 Zone 8

ASHRAE 90.1 2004[7] Table 5.5 -1 thru -8

Zone	1 & 2	3 & 4	5	6	7	8
U_{MAX}	0.58	0.151	0.123	0.104	0.090	0.080

Compliance Software
COMcheck[2] and ENVSTD[3]

Compliance software, developed specifically to demonstrate code compliance, is relatively straightforward to learn and use. Two of the most commonly used programs are ENVSTD and COMcheck. ENVSTD is applicable only to ASHRAE Standard 90.1. COMcheck is applicable to many energy standards, and it is the more widely used. Built into both programs are thermal property constants for various wall, roof and floor systems including masonry. Within COMcheck, various wall design options are offered according to which energy code is selected by the user. For example, a user demonstrating compliance with one of the ASHRAE 90.1 versions will see different drop-down lists of masonry walls than will a user demonstrating compliance with one of the many IECC versions available. A concern with this approach is that user-defined masonry walls may not be getting the full thermal mass benefits that default masonry walls receive. NCMA is investigating this further.

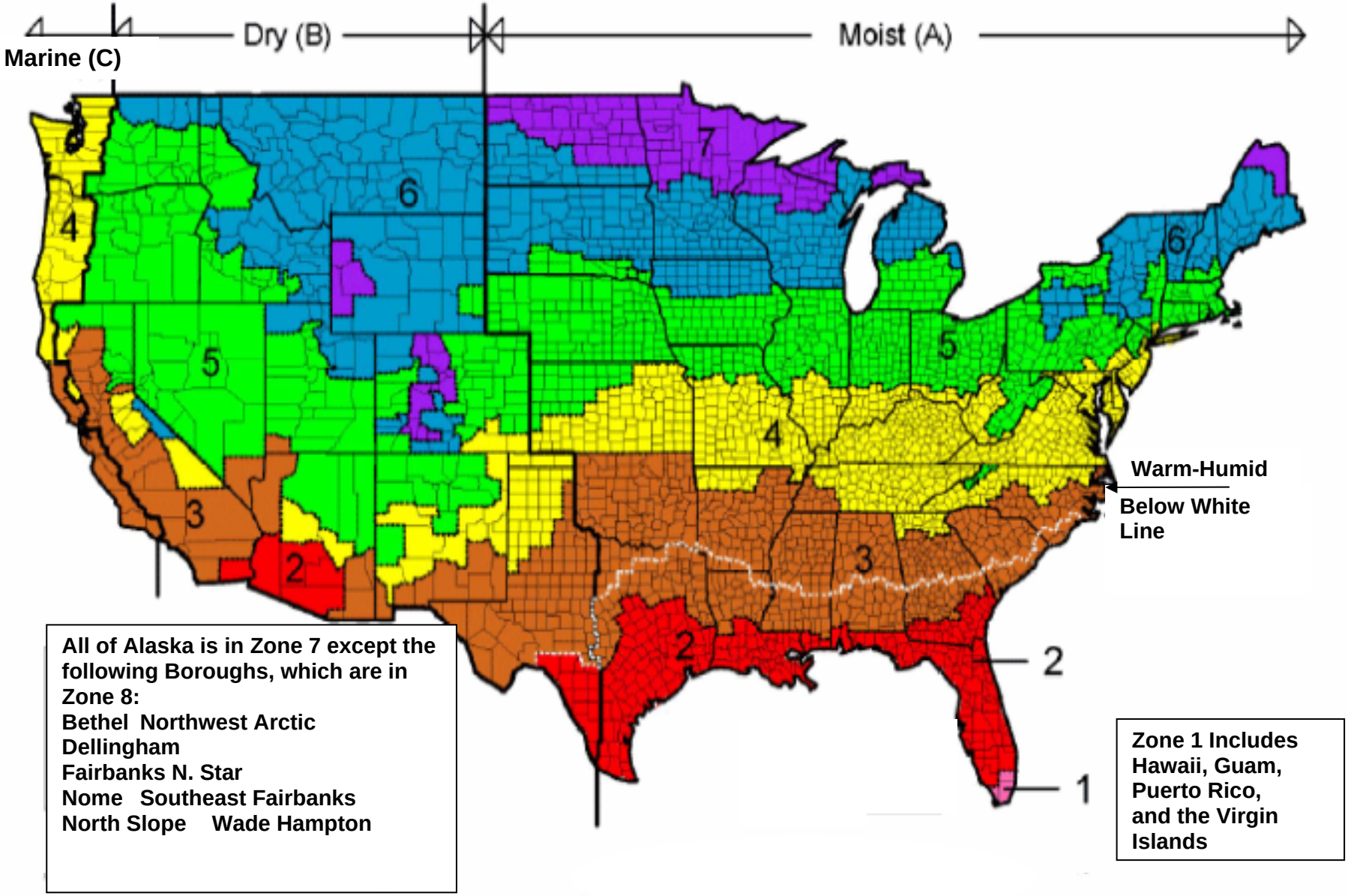
For integrally-insulated (masonry cell insulation) in single wythe walls, the U-factors embedded in the programs assume conventional CMU with both vertical and horizontal partial grout. Hence, the U-factor displayed is conservative in many cases. For a wall with better thermal properties than the default values provided in the programs, a user can define a unique wall system, although the user must then provide additional information to justify the data entered.

Whole Building Analysis
Energy 10[4], ENERGY+[5] and DOE-2[6]

Buildings can comply to the IECC using whole-building analysis software (IECC section 806), such as Energy-10, Energy Plus or DOE-2. These programs were developed to analyze annual total energy use, rather than simply to demonstrate compliance to energy codes, as compliance software typically does. The user must demonstrate that the *energy costs* of their building will be less than or equal to those of a standard building. This is a more rigorous analysis than for COMcheck: the user must include not only building envelope characteristics, but also information on mechanical and lighting. Climate variables are embedded within the program. Of the programs listed above, Energy 10 is probably the easiest to learn, followed by Energy Plus.

For additional information call
(703) 713 1900

NATIONAL CONCRETE MASONRY ASSOCIATION



References:

1) 2006 *International Energy Conservation Code®* International Code Conference, Inc.
2) *COMcheck™ Software Version 3.4.1* U.S. Department of Energy
3) *ENVSTD Version 4.0 Energy Software* U.S. Department of Energy
4) Energy-10™ Version 1.8, Copyright Midwest Research Institute
5) EnergyPlus Version 2.0.0, U.S. Department of Energy
6) DOE-2 Version 2.1 E, U.S. Department of Energy
7) ASHRAE Standard 90.1 Energy Standard for Buildings Except Low-Rise Residential 2004. American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc.

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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 ≥ 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, ≥ 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

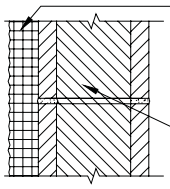
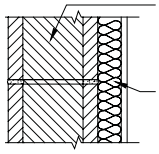
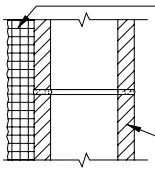
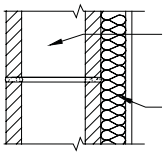
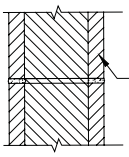
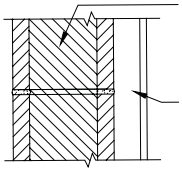
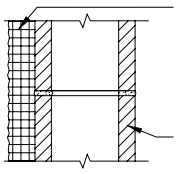
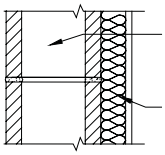
Wall:	No framing		Metal or wood framing	
CMU, ≥ 8 in., w/integral insulation R-value cavity R-value continuous	IECC requirement NA R-5	Example of complying wall  Continuous insulation, R5, min. CMU ≥ 8 in., cores insulated	IECC requirement R-11 R-0	Example of complying wall  CMU ≥ 8 in., cores insulated 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$^{2\cdot}$ ^{o}F, or R-value per inch $\geq$ 2.27 (63.4 W·mm/m$^{2\cdot o}$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.

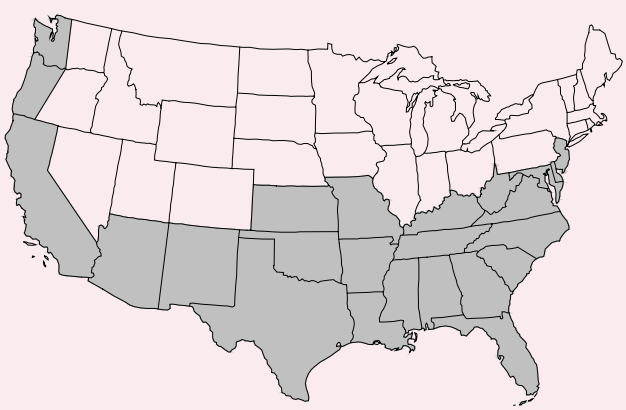


Figure 1—Areas Where ASHRAE 90.1 Prescriptive Exception Applies for Nonresidential Buildings (shading indicates that the exception applies)

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 °F (R-6.6) (0.86 W/m^2 °C) or continuous R-5.7 (1.00 m^2 °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 °F." (ref. 3) This maximum thermal conductivity corresponds to a minimum R-value per inch of 2.27 ft^2·°F·h/Btu·in. (63.4 W·mm/m^2·°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·°F/Btu (U-0.151) (1.16 m^2·°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.
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9. [free download] EnvStd, http://www.archenergy.com/products/tools/envstd//.

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