

An ACI and TMS Standard

# Thermal Properties of Concrete and Masonry for Use in Determining Energy Code Compliance Except for Low- Rise Residential Buildings— Code Requirements and Commentary

Reported by Joint ACI-TMS Committee 122



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*This Code prescribes minimum design and construction requirements for energy efficiency of building envelopes of new buildings and additions to buildings. It applies to buildings having concrete walls, roofs, or floors; masonry walls; and masonry veneer, including veneer attached to frame walls as part of the building envelope. It also provides minimum thermal properties for these assemblies for code compliance.*

*This Code is applicable to commercial and mid- to high-rise residential buildings that use either electricity from any generation source or fossil fuel. It can be used with applicable energy codes and standards such as ASHRAE 90.1 and the International Energy Conservation Code (IECC).*

**Keywords:** energy efficiency; specific heat; thermal conductivity; thermal diffusivity; thermal resistance; thermal transmittance.

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**PREFACE**

This Code provides procedures that can be used to meet the requirements of energy efficiency codes and standards that have been adopted by the authority having jurisdiction. This Code has three alternative paths: 1) a prescriptive path; 2) a building envelope trade-off methodology; and 3) a whole building energy simulation trade-off methodology.

## CODE

## COMMENTARY

## CHAPTER 1—GENERAL

## R1—GENERAL

**1.1—Scope**

**1.1.1** This Code provides design and construction requirements to establish a minimum level of energy efficiency in new buildings and additions to buildings constructed with building envelopes of concrete or masonry construction. This Code is only applicable to commercial and mid- to high-rise residential buildings. For low-rise residential buildings, refer to [ACI/TMS CODE-122.2](#), “Thermal Properties of Concrete and Masonry for Use in Determining Energy Code Compliance for Low-Rise Residential Buildings—Code Requirements and Commentary.” This Code also lists thermal properties for these assemblies for use in code compliance. This Code shall be used with all applicable energy-efficiency codes and standards.

**1.2—General**

**1.2.1** The provisions of this Code apply to:

- (a) Portions of buildings having above-grade and below-grade walls consisting of concrete; masonry; or masonry veneer, including veneers attached to frame walls
- (b) Portions of buildings having concrete floors above unconditioned space and slab-on-ground floors

**1.2.2** The provisions of this Code do not apply to:

- (a) Single-family houses and residential structures with three stories or less above grade
- (b) Buildings that do not use electricity or fossil fuel

**1.3—Purpose**

The purpose of this Code is to establish the minimum energy efficiency requirements for buildings with concrete and masonry envelope components. This purpose is accomplished by providing the following for compliance with energy codes and standards:

- (a) Criteria for prescriptive and performance methods applicable to concrete and masonry
- (b) Thermal properties of concrete and masonry
- (c) A method of determining thermal properties of concrete and masonry by test or calculation

**1.4—Applicability**

**1.4.1** This Code shall not be used to circumvent any safety, health, or environmental requirements contained in other applicable codes or ordinances.

**1.4.2** This Code does not address moisture control or provide criteria to prevent moisture migration.

**R1.1—Scope**

**R1.1.1** This Code applies to buildings having concrete walls, roofs, or floors; masonry walls; or masonry veneer, including veneer attached to frame walls.

This Code applied to commercial and mid- to high-rise residential buildings that use either electricity from any generation source or fossil fuel. It can be used with applicable energy codes and standards such as [ASHRAE 90.1](#) or the [International Energy Conservation Code \(IECC\)](#).

Criteria covered includes above-grade walls, below-grade walls, and floors above unconditioned space and slab-on-ground floors.

**R1.2—General**

The code compliance of concrete and masonry walls and floors, with or without insulation, is complex because heat loss and heat gain through the building envelope depend on thermal inertia (thermal mass) as well as thermal resistance.

This Code does not consider the potential for moisture or condensation on or within the assemblies that comply nor does it provide criteria to prevent moisture migration or condensation. Condensate has the potential to accumulate between some dissimilar materials in some climate conditions. In addition, some insulation materials are moisture-sensitive. When these insulation materials become wet due to condensation or moisture infiltration, their rated R-value may decrease, the insulation may degrade, or both. A separate analysis is recommended to ensure that the assemblies used in design do not have the potential for condensation or moisture-related issues. The [ASHRAE Handbook—Fundamentals](#) provides guidance on methods of analysis.

**CODE**

**COMMENTARY**

**1.4.3** Construction means and methods are not addressed by this Code.

**1.5—Interpretation**

**1.5.1** The official version of this Code is the English language version using inch-pound units published jointly by the American Concrete Institute and The Masonry Society

**1.5.2** In case of conflict between the official version of the standard and other versions of the standard, the official version governs.



CODE

COMMENTARY

CHAPTER 2—NOTATION AND DEFINITIONS

R2—NOTATION AND DEFINITIONS

2.1—Code notation

The terms in this list are used in the code and as needed in the commentary.

- $a_{np}$  = fractional area of material heat flow path  $n'$  in thermal layer  $p$  in the CMU, ft<sup>2</sup>
- $a_{wallX}$  = area of the wall assembly attributed to  $U_{wallX}$ , ft<sup>2</sup>
- $C$  =  $C$ -factor (thermal conductance), Btu/h·ft<sup>2</sup>·°F
- $F$  =  $F$ -factor; the perimeter heat loss for slab-on-ground floors, Btu/h·ft·°F
- $R$  =  $R$ -value (thermal resistance), h·ft<sup>2</sup>·°F/Btu
- $R_{min}$  = minimum insulation  $R$ -value, h·ft<sup>2</sup>·°F/Btu
- $R_1, R_2, \dots R_n$  =  $R$ -value of each individual material layer, h·ft<sup>2</sup>·°F/Btu
- $R_i$  =  $R$ -value of the indoor air film, h·ft<sup>2</sup>·°F/Btu
- $R_{np}$  = thermal resistance of material heat flow path  $n$  in thermal layer  $p$  in the CMU, h·ft<sup>2</sup>·°F/Btu
- $R_o$  =  $R$ -value of the exterior or outdoor air film, h·ft<sup>2</sup>·°F/Btu
- $R_T$  = CMU thermal resistance, including surface air films, h·ft<sup>2</sup>·°F/Btu
- $R_{total}$  = total  $R$ -value of the assembly, h·ft<sup>2</sup>·°F/Btu
- $U$  =  $U$ -factor (thermal transmittance), Btu/h·ft<sup>2</sup>·°F
- $U_{max}$  = maximum assembly  $U$ -factor, Btu/h·ft<sup>2</sup>·°F
- $U_{mv}$  =  $U$ -factor of the clay masonry veneer and air space layers from Table 8.1d
- $U_{pp}$  = area-weighted average  $U$ -factor calculated using the parallel-path method, Btu/h·ft<sup>2</sup>·°F
- $U_{wallX}$  =  $U$ -factor of the portion of the wall assembly attributed to  $a_{wallX}$ , Btu/h·ft<sup>2</sup>·°F

2.2—Code definitions

The following terms are defined for general use in this Code.

**assembly**—the finished construction consisting of one or more components that are fitted together to form a portion of the building envelope.

**building envelope**—the wall, roof, slab, or other component(s) that in combination separate conditioned space (heated, cooled, or both) from outdoor air or unconditioned space.

**concrete**—the plastic or hardened material comprised of aggregate, cement, and water, with or without other materials.

R2.2—Commentary definitions