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METRIC CONCRETE MASONRY CONSTRUCTION

TEK 3-10A
Construction (2008)

INTRODUCTION

The metric system (Systeme Internationale or SI system) is the standard international system of measurement, and the system that has been mandated by the *Metric Conversion Act* (ref. 1) for use in the construction of all United States Federal buildings. Essentially, the *Metric Conversion Act* requires building designs and construction drawings to be submitted in metric units and constructed according to metric specifications. The subsequent *Savings in Construction Act of 1996* (ref. 5) places strong limitations for Federal agencies requiring hard metric concrete masonry units and allows conventional concrete masonry units to be used in metric construction projects. Economical adjustments that have virtually no impact on the configuration of the final project can be made to accommodate inch-pound units on a job where the plans and specifications are in metric, as described here and in *Metric Design Guidelines for Concrete Masonry Construction* (ref. 3).

Complying with these government mandates requires a knowledge of the metric system of measurement and its conventions as well as an understanding of how construction materials, such as concrete masonry, are best incorporated into a metric building design.

Table 1—Metric Decimal Prefixes

Prefix	Symbol	Order of magnitude	Expression
milli	m	10^{-3}	one thousandth, 0.001
centi	c	10^{-2}	one hundredth, 0.01
deci	d	10^{-1}	one tenth, 0.1
deca	da	10	ten, 10
hecto	h	10^{2}	one hundred, 100
kilo	k	10^{3}	one thousand, 1000
mega	M	10^{6}	one million, 1,000,000

METRIC UNITS

The metric system uses several base units of measurement with various prefixes that indicate magnitude. For example, the base unit for length is the meter. When combined with the prefix kilo—meaning one thousand—the unit of measurement is kilometer (km), meaning one thousand meters. Table 1 lists the metric decimal prefixes and their magnitudes.

Just as the inch-pound system has preferred units of measurement (i.e., building dimensions are measured in feet, not in yards), the metric system also conforms to a preferred set of units. For design and construction in the United States, typically only the prefixes milli and kilo are used. For example, lengths are given in millimeters, meters, or kilometers, not in centimeters or hectometers.

Table 2 lists common inch-pound units used in building design and construction, their standard metric unit equivalents, and conversion factors. The metric units listed in Table 2 are the preferred units.

As with any form of communication, there are some basic rules that apply to the use of the metric system so that the meaning is consistent and clear, thereby minimizing the potential for errors during construction. The following sections summarize common metric conventions.

Abbreviations

The third column of Table 2 indicates the proper abbreviations for metric units. Note the use of capital and lower case letters. For example, megapascal is abbreviated MPa. If mPa were written instead, it would indicate millipascals rather than megapascals.

Symbols

When using inch-pound units, the use of symbols to represent feet (') and inches (") is second nature. No such symbols are used in the metric system; only the abbreviations listed in Table 2.

Related TEK:

Keywords: construction, dimensions, hard metric, metric, metric conversion, modular coordination, soft metric

Stating Metric Units

While mixing feet and inches is common practice, a similar practice is not used in the metric system. For example, if dual units are shown on a set of plans, the metric equivalent of 8' - 8" would be 2.64 m, not 2.4 m - 203 mm.

In addition, fractions are never used in the metric system, decimals are used instead. For example, a length of nine and one-half meters is written as 9.5 m, not as $9\,{}^{1}/_{2}$ m.

Rounding

Dimensions on building plans are rarely shown to less than ${}^{1}/_{8}$ in. (3 mm) because it is impractical to build to a tighter tolerance. Similarly, it is meaningless to state dimensions in decimals of millimeters. For example, a required tolerance of $\pm{}^{3}/_{8}$ in. thick becomes $\pm$10 mm, rather than $\pm$ 9.5 mm.

SOFT VERSUS HARD METRIC CONVERSION

The most common consequence of the metric conversion effort has been a simple relabeling of products with equivalent metric dimensions, with no physical change to the product dimensions. This is commonly called soft metric conversion. From a practical standpoint, soft metric conversion is easily accomplished.

For soft metric conversion of concrete masonry, the metric equivalents of concrete masonry unit dimensions are simply the exact metric conversions of the inch-pound unit dimensions. Table 3 lists the inch-pound and metric equivalent dimensions for typical concrete masonry units of various sizes.

Hard metric conversion means the product is resized to metric modular dimensioning. Hard metric conversion is principally applied to modular products where dimensional

Table 2—Inch-Pound To Metric Conversions

Quantity	to convert from these inch-pound units...	to these metric units...	multiply the inch-pound units by:
Length	mile (mi) foot (ft) foot (ft) inch (in)	kilometer (km) meter (m) millimeter (mm) millimeter (mm)	1.609344 0.3048 304.8 25.4
Area	square yard (yd^2) square foot (ft^2) square inch (in^2)	square meter (m^2) square meter (m^2) square millimeter (mm^2)	0.83612736 0.09290304 645.16
Volume	cubic yard (yd^3) cubic foot (ft^3) cubic inch (in^2)	cubic meter (m^3) cubic meter (m^3) cubic millimeter (m^3)	0.764555 0.0283168 16,387.064
Mass	pound (lb) kip (k)	kilogram (kg) metric ton (t)	0.453592 0.453592
Mass density	pounds/cubic foot (lb/ft^3 or pcf)	kilogram/cubic meter (kg/m^3)	16.0185
Force	pound (lb) kip (k)	newton (N) kilonewton (kN)	4.44822 4.44822
Force per unit length	pound/foot (lb/ft or plf) kip/foot (k/ft)	newton/meter (N/m) kilonewton/meter (kN/m)	14.5939 14.5939
Force per unit area	pound/square inch ($lb/in.^2$ or psi) kip/square inch ($k/in.^2$ or ksi) pound/square foot (lb/ft^2 or psf)	megapascal (MPa) megapascal (MPa) pascal (Pa)	0.00689476 6.89476 47.8803
Bending moment	foot-pound (ft-lb) foot-kip (ft-k) inch-pound per foot (in.-lb/ft)	newton · meter (N· m) kilonewton · meter (kN· m) newton · meter per meter (N·m/m)	1.35582 1.35582 0.370686
Thermal resistance (R-Value)	square foot-hour-degree Fahrenheit/British thermal unit (ft^2-h-°F/Btu)	square meter · degree Kelvin/ Watt ($m^2 \cdot K/W$)	0.176
Thermal conductance (U-Factor)	British thermal unit/square foot-hour-degree Fahrenheit (Btu/h-ft^2-°F)	Watt/square meter · degree Kelvin ($W/m^2 \cdot K$)	5.678
Temperature	degrees Fahrenheit (°F) degrees Fahrenheit (°F)	degrees Celsius (°C) degrees Kelvin (K)	°C = (°F - 32)/1.8 K = (°F + 459.67)/1.8

Example: The specified length of a concrete masonry unit is typically $15\,{}^{5}/_{8}$ in. To convert this length to millimeters, use the conversion factor 25.4. The converted actual length = 15.625 x 25.4 = 397 mm.

Table 3—Typical Concrete Masonry Unit Dimensions

Nominal unit size		Specified unit size		Faceshell thickness[a]		Web thickness[a]	
Inch-pound (in.)	Soft metric (mm)	Inch-pound (in.)	Soft metric (mm)	Inch-pound (in.)	Soft metric (mm)	Inch-pound (in.)	Soft metric (mm)
4 x 8 x 16	102 x 203 x 406	3 5/8 x 7 5/8 x 15 5/8	92 x 194 x 397	3/4	19	3/4	19
6 x 8 x 16	152 x 203 x 406	5 5/8 x 7 5/8 x 15 5/8	143 x 194 x 397	1	25	1	25
8 x 8 x 16	203 x 203 x 406	7 5/8 x 7 5/8 x 15 5/8	194 x 194 x 397	1 1/4	32	1	25
10 x 8 x 16	254 x 203 x 406	9 5/8 x 7 5/8 x 15 5/8	244 x 194 x 397	1 3/8	35	1 1/8	29
12 x 8 x 16	305 x 203 x 406	11 5/8 x 7 5/8 x 15 5/8	295 x 194 x 397	1 1/2	38	1 1/8	29

(a) Dimensions are minimums required by *Standard Specification for Loadbearing Concrete Masonry Units* (ref. 4).

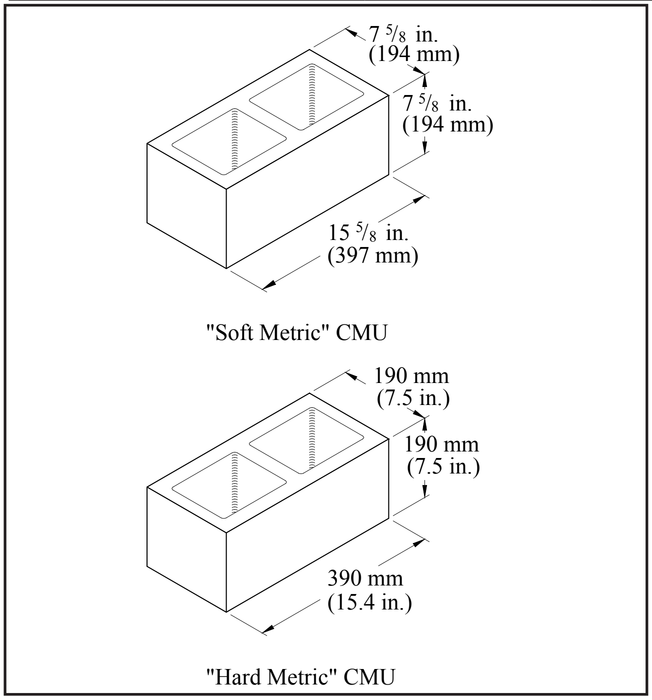

Figure 1—Specified Dimensions of Soft and Hard Metric Concrete Masonry Units

tolerances are critical. Hard metric concrete masonry units are manufactured to nominal widths of 100, 150, 200, 250, and 300 mm, nominal heights of 100 and 200 mm, and nominal lengths of 200 and 400 mm. Specified dimensions are 10 mm smaller than nominal to provide space for vertical and horizontal mortar joints.

The difference between soft and hard metric concrete masonry units is shown in Figure 1.

MODULAR COORDINATION

Modular design is based on the use of standardized components, which helps increase the efficiency and cost-effectiveness of construction. Modular components are mass-produced to exacting physical properties and dimensions.

Modular products are based on a 4-in. (102-mm) module in the inch-pound system and a 100-mm (3.9-in.) module in the metric system. Since 4 inches equals 101.6 mm, the inch-pound module is 1.6 percent larger than the 100 mm metric module. This seemingly small difference (about 1/16 in. or 1.5 mm), however is cumulative, becoming 1/4 in. in 16 in. and 3/4 in. in 4 ft (6 mm in 406 mm and 19 mm in 1.2 m), making the two modules incompatible.

When modular units are placed, they produce wall lengths, heights and thicknesses that are multiples of the given module. This allows building dimensions and wall openings to be placed and sized to minimize cutting on site.

However, when units of different modular dimensions are incorporated into the same wall, such as an 8-in. (203-mm) concrete masonry unit in a wall laid out on a 100-mm module, significant coordination and adjustment is needed.

When hard metric concrete masonry units are available for a metric project, modular coordination is straightforward, as the building is laid out on a 100-mm module, which corresponds to the nominal dimensions of the hard metric masonry units.

When hard metric concrete masonry units are not available for a metric job, two options are available: lay out the building using inch-pound modules, which are then converted to their metric equivalents, or use soft metric concrete masonry units in a building laid out using a 100-mm module. These are described in more detail below.

Metric Design Based on Soft Metric Building Modules

This option essentially applies a soft metric conversion to the project plans and specifications. From the beginning of the project, a module of 101.6 mm, rather than 100 mm, is used. In this case, soft metric concrete masonry units can be used without further adjustment. Structures designed based on soft metric conversions should incorporate windows and doors sized to the inch-pound module as well.

The width of an opening in a concrete masonry wall should be a multiple of 8 in. (203 mm) plus the width of one mortar joint (3/8 in. or 10 mm). The height of the opening should be a multiple of 8 in. (203 mm). For example, a nominal 4 ft x 4 ft (1,219 x 1,219 mm) opening should have actual dimensions of 4 ft - 3/8 in. x 4 ft (1,229 x 1,219 mm). Similarly, the width of piers should be a multiple of 8 in. (203 mm) minus the width of one mortar joint (3/8 in. or 10 mm).

Soft Metric Units Used With Hard Metric Building Modules

This option uses soft metric concrete masonry units in a project laid out using 100-mm modules. Because soft metric units are approximately 2% larger in height and length than hard metric units, complications arise when they are incorporated into a structure designed according to the 100 mm module, or when other modular metric components, such as windows and doors, are not readily available.

Because soft metric units are longer, cutting around openings will be required. Cutting around door and window openings can be avoided by substituting soft metric door and window units in the masonry. Cutting can also be minimized by moving one side of the opening to the nearest inch-pound modular dimension, eliminating the need to cut units on both sides of the opening.

Vertical coursing can be adjusted by either of the two methods illustrated in Figure 2. The first method (Case A) is to use soft metric concrete masonry units with a $^3/_8$ in. (10 mm) mortar joint and allow each story to be slightly taller than specified. For example, consider a specified story height of 13 courses (2600 mm, 8 ft - 6 $^3/_8$ in.). Using soft metric units, the story height would increase to 2641 mm (8 ft - 8 in.), an increase of 1 $^5/_8$ in. (41 mm) per story height.

The second method (Case B) uses custom soft metric concrete masonry units manufactured to an actual height of 7 $^1/_2$ in. (191 mm) rather than 7 $^5/_8$ in. (194 mm) (unit height is more easily adjusted during manufacture than is unit length). In the example given above, the metric module is maintained for the entire wall height when 7 $^1/_2$ in. (191 mm) high units are used with standard $^3/_8$ in. (10 mm) horizontal mortar joints.

For more information on using soft metric units in 100-mm module construction, see *Metric Design Guidelines for Concrete Masonry Construction* (ref. 3).

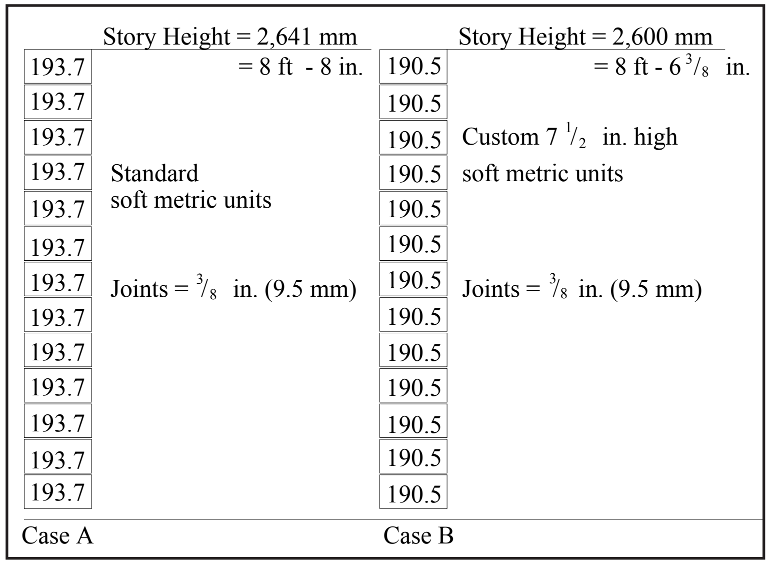

Figure 2—Vertical Coursing With Inch-Pound Concrete Masonry Units (ref. 3)

REFERENCES

1. *Metric Usage in Federal Government Programs*, Executive Order 12770, 1991.
2. *Metric Guide for Federal Construction*, First Edition. Washington, DC: National Institute of Building Sciences, 1991.
3. *Metric Design Guidelines for Concrete Masonry Construction*, TR 172. National Concrete Masonry Association, 2000.
4. *Standard Specification for Loadbearing Concrete Masonry Units*, ASTM C 90-03. ASTM International, 2003.
5. *Savings in Construction Act of 1996*, Public Law 104-298, 1996.

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