



CONCRETE AND REBAR

The following information is provided by the Portland Cement Association (PCA) and the Concrete Reinforcing Steel Institute (CRSI). This newsletter updates the November-December 1994 issue on concrete and the July-August 1996 issue on concrete reinforcing steel.

Since U.S. construction metrication efforts began in the early 1990s, billions of dollars of concrete work have been designed and put in place using metric measurements.

The concrete and reinforcing steel industries have made significant strides in metricating their products, specifications, publications, and everyday activities. These changes are substantive and permanent.

As we enter the 21st century, the concrete and reinforcing steel industries, as well as the structural steel industry (see the 3rd Quarter 1999 newsletter) are ready and able to do business in the metric system.

Conversion Factors for Concrete

To convert*	To	Multiply by
inches	meters (m)	0.0254
feet	meters (m)	0.3048
pounds	kilograms (kg)	0.4535924
fluid ounces	milliliters (mL)	29.57353
gallons	liters (L)	3.7854118
psi	megapascals (MPa)	0.00689476
cubic yards	cubic meters (m ³)	0.7645549
pounds per cubic yard	kilograms per cubic meter (kg/m ³)	0.5933
pounds per cubic feet	kilograms per cubic meter (kg/m ³)	16.01846
Fahrenheit (F)	Celsius (C)	5/9 x (F - 32)
pound force	newton (N)	4.448222

* To convert from metric units to inch-pound units, divide instead of multiply by the factors in the third column.

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Typical Concrete Values

Typical value	Inch-pound	Metric
Weight of bag of cement	94 lb.	42 kg
Rebar designations (see p. 4)	#3 to #18	#10M to #57M
Vapor barrier thickness	6 mils	150 : m
Concrete design strength	3000 psi	21 MPa
High-strength concrete	over 6000 psi	over 41 MPa
Cement content, 6-bag mix	564 lb/cu yd	335 kg/m ³
Density of concrete	145 lb/cu ft	2320 kg/m ³
Ready mix truck capacity	9 cu yd	7 m ³
This much site-added water Increases slump by:	1 gal/cu yd 1 in	5 L/m ³ 25 mm
Slump	3 to 4 in	75 to 100 mm
Slab thickness	5 in	125 mm
Temperature of fresh concrete as mixed	50 to 90 /F	10 to 32 /C

Comparison of Batch Quantities in Inch-Pound and Metric Units

(medium consistency concrete, 75 to 100 mm slump)

Typical value	Inch-pound	Metric
Water-cement ratio	0.45	0.45
Coarse aggregate, max size	3/4 in	19 mm
Air content	6%	6%
Water per volume	300 lb/cu yd	180 kg/m ³
Cement per volume	665 lb/cu yd	395 kg/m ³
Fine aggregate per volume	1040 lb/cu yd	620 kg/m ³
Coarse aggregate per volume	1800 lb/cu yd	1070 kg/m ³

Notes on Concrete Metrication:

Conversion and Rounding. Neither the original units nor the conversion factors are rounded before multiplying; only the product is rounded. The rounded metric value should have about the same degree of accuracy as the original inch-pound value. For instance, to convert 564 pounds per cubic yard of cement to kilograms per cubic meter, multiply 564 by 0.5933 to obtain 334.6212 and round to 335 kg/m³.

Rounding requires common sense and experience. Reporting the above value to four decimal places would be a mistake because it implies that cement is batched to the nearest 0.0001 kilogram. Since the cement batching tolerance is 1 percent, or about 2.6 kilograms for the example given, 335 kg/m³ is the more appropriate value.

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A simple rule is to retain the value that neither sacrifices nor exaggerates the implied accuracy of the number.

Getting Comfortable with the Metric System. A concern of many professionals is that errors are not as readily recognizable when expressed in metric units. For instance, an erroneously calculated concrete elastic modulus of 30,000 psi is an easily recognized error, but an erroneous elastic modulus of 207 MPa may not be as evident.

Memorizing equivalent values in the two systems isn't feasible, but using the figures given in the above tables can serve as an interim aid in developing the needed feel for reasonable metric values.

There are a few important points to note about the information in the table on batch quantities. Water in a concrete mixture is measured using weight and mass (pounds and kilograms), not volume (gallons and liters). Admixture dosages, if listed, would be shown in milliliters (mL) instead of fluid ounces. Batch quantities are converted to round, easy-to-use numbers in this table.

Be careful when working with multiple units. A common mistake when converting pounds of cement per cubic yard is to convert pounds to kilograms but to neglect converting cubic yards to cubic meters. Use the factor 0.5933 for a one-step conversion.

Some Rounding Pitfalls. As mentioned, rounding requires careful consideration of consequences. For example, 4000-psi concrete has been converted to 30-MPa concrete in some documents. A 30-MPa concrete is actually a 4350-psi concrete with a strength nearly 9 percent higher than 4000-psi concrete. Thus, concretes proportioned for a 4000-psi design strength may not have an adequate overdesign to meet the acceptance requirements for 30-MPa concrete. A design value of 28 MPa is closer to the 4000-psi value and is the better choice.

Another example involves existing criteria for satisfactory strength levels for a class of concrete. ACI 318, *Building Code Requirements for Reinforced Concrete*, requires taking steps to increase the average strength of a class of concrete if it falls below the designated design strength by more than 500 psi. Since 500 psi converts to 3.45 MPa, rounding this value to 3 MPa would produce a more stringent requirement and result in more test failures while rounding it to 4 MPa would relax the requirement and compromise structural safety. The best compromise is to use 3.5 MPa as the metric value; this is, in fact, the value used in the metric version of ACI 318.

Concrete-Related Resources. For those involved in maintenance and repair, Construction Technology Laboratories (CTL) has a handy crack comparison card that shows widths in both millimeters and inches. Contact CTL at 708-965-7500 for a free card.

The Portland Cement Association publishes the *Design and Control of Concrete Mixtures -- Canadian Metric Edition*, EB101T. Contact PCA's Order Processing at 1-800-868-6733 to purchase a copy.

The American Concrete Institute publishes ACI 318M/318RM, *Building Code Requirements for Reinforced Concrete and Commentary*, Metric Edition, and ACI 318.1M/318.1RM, *Building Code Requirements for Structural Plain Concrete and Commentary*, Metric Edition. Contact ACI at 313-532-2600.

CONSTRUCTION METRICATION COUNCIL

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The National Institute of Building Sciences is a non-profit, nongovernmental organization authorized by Congress to serve as an authoritative source on issues of building science and technology.

The Council is an outgrowth of the Construction Subcommittee of the Metrication Operating Committee of the federal Interagency Council on Metric Policy. The Construction Subcommittee was formed in 1988 to further the objectives of the 1975 *Metric Conversion Act*, as amended by the 1988 *Omnibus Trade and Competitiveness Act*. To foster effective private sector participation, the activities of the Subcommittee were transferred to the Council in April 1992.

Membership in the Council is open to all public and private organizations and individuals with a substantial interest in and commitment to the Council's purposes. The Council publishes the *Metric Guide for Federal Construction* and this newsletter. It is funded primarily by contributions from federal agencies but also receives private sector support.

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Concrete Reinforcing Steel

ASTM A615 M-96a and A706M-96a Metric Bar Sizes	Nominal Diameter	ASTM A615-96a and A706-96a Inch-Pound Bar Sizes
#10	9.5 mm/0.375"	#3
#13	12.7 mm/0.500"	#4
#16	15.9 mm/0.625"	#5
#19	19.1 mm/0.750"	#6
#22	22.2 mm/0.875"	#7
#25	25.4 mm/1.000"	#8
#29	28.7 mm/1.128"	#9
#32	32.3 mm/1.270"	#10
#36	35.8 mm/1.410"	#11
#43	43.0 mm/1.693"	#14
#57	57.3 mm/2.257"	#18

Notes on Rebar Metrication:

Virtually all reinforcing bars produced in the United States are now labeled in metric units. The Concrete Reinforcing Steel Institute's technical report EDR 42, *Using Soft Metric Reinforcing Bars in Non-Metric Construction Products*,

includes a discussion of the major metric provisions in the ASTM specifications, design issues, and bar detailing. It is available on the CRSI Web site, www.crsi.org, or from CRSI (Dept. DPG), 933 N. Plum Grove Road, Schaumburg, IL 60173-4758; fax number 847-517-1206.