

## ACI 214.4R - 10 Method

Bibliography (4) – 2010

ACI 318-11 (Chapter 20) requires estimation of equivalent strength  $f'_c$  through ACI 214.4R-10, on which should be considered some correction factors related to test effects, geometry and moisture of cores, as follows

$$f_{ci,eq} = f_{c,i} * F_{l/d} * F_{dia} * F_{dril} * F_{mc}$$

Where :

$f_{ci,eq}$  : in situ equivalent strength of each concrete core (N/mm<sup>2</sup>)

$f_{c,i}$  : measured strength of each core (N/mm<sup>2</sup>)

$F_{l/d}$  : correction coeff. for height/diameter ratio of core (-)

$F_{dia}$  : correction coeff. due to core diameter (-)

$F_{dril}$  : correction coeff. for damage because of drilling (-)

$F_{mc}$  : correction coeff. due to moisture condition (-)

**Table 9.1—Magnitude and accuracy of strength correction factors for converting core strengths into equivalent in-place strengths**

	Factor	Mean value	Coefficient of variation $V$ , %
$F_{l/d}$ : $l/d$ ratio <sup>†</sup>	Standard treatment <sup>‡</sup> :	$1 - \{0.130 - \alpha f_{core}\} \left(2 - \frac{l}{d}\right)^2$	$2.5 \left(2 - \frac{l}{d}\right)^2$
	Soaked 48 hours in water:	$1 - \{0.117 - \alpha f_{core}\} \left(2 - \frac{l}{d}\right)^2$	$2.5 \left(2 - \frac{l}{d}\right)^2$
	Dried <sup>§</sup> :	$1 - \{0.144 - \alpha f_{core}\} \left(2 - \frac{l}{d}\right)^2$	$2.5 \left(2 - \frac{l}{d}\right)^2$
$F_{dia}$ : core diameter	2 in. (50 mm)	1.06	11.8
	4 in. (100 mm)	1.00	0.0
	6 in. (150 mm)	0.98	1.8
$F_{mc}$ : core moisture content	Standard treatment <sup>‡</sup> :	1.00	2.5
	Soaked 48 hours in water:	1.09	2.5
	Dried <sup>§</sup> :	0.96	2.5
$F_{di}$ : damage due to drilling		1.06	2.5

<sup>\*</sup>To obtain equivalent in-place concrete strength, multiply the measured core strength by appropriate factor(s) in accordance with a.m.Eq.

<sup>†</sup>Constant  $\alpha$  equals  $3(10^{-6})$  1/psi for  $f_{core}$  in psi, or  $4.3(10^{-4})$  1/MPa for  $f_{core}$  in MPa.

<sup>‡</sup>Standard treatment specified in ASTM C42/C42M.

<sup>§</sup>Dried in air at 60 to 70°F (16 to 21°C) and relative humidity less than 60% for 7 days.

After correction of the compressive strength of each core, the ACI 214.4R-10 recommends two methods to obtain the final equivalent specified compressive strength of concrete :

§ 9.4.1 – **Tolerance factor method** (Hindo/Bergstrom 1988)

§ 9.4.2 – **Alternate method** (Bartlett/MacGregor 1995)

### TOLERANCE FACTOR METHOD

$$f'_{c,eq} = \bar{f}_c - \sqrt{(K * s_c)^2 + (Z * s_a)^2}$$

Where :

sample in situ mean strength

$$\bar{f}_c = \frac{1}{n} * \sum_{i=1}^n f_{ci}$$

sample standard deviation of the in situ strength

$$s_c = \sqrt{\sum_{i=1}^n \frac{(f_{ci} - \bar{f}_c)^2}{(n-1)}}$$

standard deviation of in situ strength due to empirical nature of strength correction factors (from table 9.1)

$$s_a = \bar{f}_c * \sqrt{V_{l/d}^2 + V_{dia}^2 + V_{mc}^2 + V_{dril}^2}$$

**Table 9.2—K-factors for one-sided tolerance limits on the 10% fractile (Natrella 1963)**

n	Confidence level		
	75%	90%	95%
3	2.50	4.26	6.16
4	2.13	3.19	4.16
5	1.96	2.74	3.41
6	1.86	2.49	3.01
8	1.74	2.22	2.58
10	1.67	2.06	2.36
12	1.62	1.97	2.21
15	1.58	1.87	2.07
18	1.54	1.80	1.97
21	1.52	1.75	1.90
24	1.50	1.71	1.85
27	1.49	1.68	1.81
30	1.48	1.66	1.78
35	1.46	1.62	1.73
40	1.44	1.60	1.70

Note: n = number of specimens tested.

**Table 9.3—Z-factors (Natrella 1963)**

Confidence level, %	Z
75	0.67
90	1.28
95	1.64

## ALTERNATE METHOD

Equivalent specified strength

$$f'_{c,eq} = C * (\bar{f}_c)_{CL}$$

Where :

lower-bound estimate of the in situ mean strength

$$(\bar{f}_c)_{CL} = \bar{f}_c - \sqrt{\left(\frac{T * s_c}{n}\right)^2 + (Z * s_a)^2}$$

**Table 9.4—One-sided T-factors  
(Natrella 1963)**

<i>n</i>	Confidence level		
	75%	90%	95%
3	0.82	1.89	2.92
4	0.76	1.64	2.35
5	0.74	1.53	2.13
6	0.73	1.48	2.02
8	0.71	1.41	1.90
10	0.70	1.38	1.83
12	0.70	1.36	1.80
15	0.69	1.34	1.76
18	0.69	1.33	1.74
21	0.69	1.33	1.72
24	0.69	1.32	1.71
30	0.68	1.32	1.70

Note: *n* = number of specimens tested.

**Table 9.5—C-factors for use in Eq. (9-9)**

Structure composed of:		One member	Many members
One batch of concrete		0.91	0.89
Many batches of concrete	Cast-in-place	0.85	0.83
	Precast	0.88	0.87

NOTE : in tables 9.1 , 9.2 , 9.3 and 9.4 the linear interpolation is allowed