ACI Tables for Concrete Mix Design

Table 1. Recommended Slump for Various Types of Construction

Types of Construction	Slump (mm)	
	Maximum*	Minimum
Reinforced foundation walls and footings	75	25
Plain footings, caissons, and substructure walls	75	25
Beams and reinforced walls	100	25
Building columns	100	25
Pavements and slabs	75	25
Mass concrete	50	25

* May be increased by 25 mm for consolidation methods other than vibration.

Table 2. Approximate Mixing Water and Air Content Requirements for Different Slumps and Nominal Maximum Sizes of Aggregates

Water (kg/m^3) of concrete for indicated nominal maximum size of aggregates (mm)								
Slump (mm)	9.5	12.5	19	25	37.5	50	75	150
Non-Air-Entrained Concrete								
25-50	207	199	190	179	166	154	130	113
75-100	228	216	205	193	181	169	145	124
150-175	243	228	216	202	190	178	160	-
Approximate amount of entrapped air (%)								
	3	2.5	2	1.5	1	0.5	0.3	0.2
Air-Entrained Concrete								
25-50	181	175	168	160	150	142	122	107
75-100	202	193	184	175	165	157	133	119
150-175	216	205	197	184	174	166	154	-
Recommended entrained air (%) for level of exposure								
Mild Exposure	4.5	4.0	3.5	3.0	2.5	2.0	1.5	1.0
Moderate Exposure	6.0	5.5	5.0	4.5	4.5	4.0	3.5	3.0
Severe Exposure	7.5	7.0	6.0	6.0	5.5	5.0	4.5	4.0

Table 3A. Relationship Between Water-Cement Ratio and Compressive Strength of Concrete

28-day Compressive Strength (MPa)	Water-Cement Ratio, by weight	
	Non-Air-Entrained Concrete	Air-Entrained Concrete
40	0.42	-
35	0.47	0.39
30	0.54	0.45
25	0.61	0.52
20	0.69	0.60
15	0.79	0.70

Table 3B. Recommendations for Normal Weight Concrete Subject to Sulfate Attack

Exposure	Water Soluble Sulfate (SO_4) in soil, (%)	Sulfate (SO_4) in water (ppm)	Cement	Maximum Water-Cement Ratio
Mild	0.00-0.10	0-150	-	-
Moderate	0.10-0.20	150-1500	II, IP	0.50
Severe	0.20-2.00	1500-10000	V	0.45
Very Severe	> 2.00	> 10000	V+poz and/or slag	0.45

Table 4. Volume of Coarse Aggregate Per Unit Volume of Concrete

Maximum size of aggregate (mm)	Volume of dry-rodded coarse aggregate per unit volume of concrete for different fineness moduli of fine aggregate			
	2.40	2.60	2.80	3.00
9.5	0.50	0.48	0.46	0.44
12.5	0.59	0.57	0.55	0.53
19	0.66	0.64	0.62	0.60
25	0.71	0.69	0.67	0.65
37.5	0.75	0.73	0.71	0.69
50	0.78	0.76	0.74	0.72
75	0.82	0.80	0.78	0.76
150	0.87	0.85	0.83	0.81

Table 5. First Estimate of Unit Weight of Fresh Concrete

Maximum Size of Aggregate (mm)	First Estimate of Fresh Concrete Unit Weight (kg/m^3)	
	Non-Air-Entrained Conc.	Air-Entrained Conc.
9.5	2280	2200
12.5	2310	2230
19	2345	2275
25	2380	2290
37.5	2410	2350
50	2445	2375
75	2490	2405
150	2530	2435

Example 1.

Job Specifications:

Type of Construction	Reinforced concrete footing
Exposure	Mild (below ground, not exposed to freezing or sulfate)
Maximum aggregate size	37.5mm
Slump	75-100mm
Specified 28-day compressive strength	25MPa

Characteristics of the Materials Selected

	Cement (I)	Fine Agg.	Coarse Agg.
BSG	3.15	2.60	2.70
Dry-rodded UW (kg/m^3)	-	-	1600
Fineness Modulus	-	2.8	-
Surface Moisture og Agg.(%)	-	2.5	0.5

Step 1. Determination of Slump:

Given: 75-100mm. Otherwise, use Table 1.

Step 2. Determination of D_{max}

Given: 37.5mm. Otherwise, consider the limitations.

Step 3. Estimation of Mixing Water Content and Air Content:

Table 2. Approximate Mixing Water and Air Content Requirements for Different Slumps and Nominal Maximum Sizes of Aggregates

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Moderate Exposure	6.0	5.5	5.0	4.5	4.5	4.0	3.5	3.0
Severe Exposure	7.5	7.0	6.0	6.0	5.5	5.0	4.5	4.0

Step 4. Estimation of W/C:

Required average compressive strength (MPa) (take the larger one)
$f'_{cr} = f'_c + 1.34S$
$f'_{cr} = f'_c + 2.33S - 3.5$

If adequate statistical data are not available, use

Specified Compressive Strength (MPa)	Req. Average Comp. Strength (MPa)
< 20	f'c + 7
20-35	f'c + 8.5
>35	f'c + 10

Specified strength is 25MPa. Since no statistical data are available, average compressive strength that we will use is 33.5MPa. **(So that the probability of specimens having strength less than the specified is 1/100)**

Table 3A. Relationship Between Water-Cement Ratio and Compressive Strength of Concrete

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Interpolation yields W/C = 0.49.

Step 5. Estimation of Cement Content:

C = W/(W/C) = 181/0.49 = 369 kg.

Step 6. Estimation of CA content:

Table 4. Volume of Coarse Aggregate Per Unit Volume of Concrete

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25	0.71	0.69	0.67	0.65
37.5	0.75	0.73	0.71	0.69
50	0.78	0.76	0.74	0.72
75	0.82	0.80	0.78	0.76
150	0.87	0.85	0.83	0.81

$CA_{dry} = 0.71 \times 1600 = 1136$ kg.

Step 7. Estimation of FA Content:

Weight Basis:

Table 5. First Estimate of Unit Weight of Fresh Concrete

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25	2380	2290
37.5	2410	2350
50	2445	2375
75	2490	2405
150	2530	2435

$FA_{dry} = 2410-181-369-1136 = 724$ kg.

Volume Basis:

$V_{FA} = 1- (181/1000) – (369/3150) - (1136/2700) – (0.01) = 0.28\ m^3$
$FA_{dry} = 0.28 \times 2600 = 730$ kg.

Step 8: Moisture Adjustment:

Both aggregates are wet.

Surface moisture on CA = $1136 \times 0.005 = 5.68$ kg
$CA_{wet} = 1136 + 5.68 = 1142$ kg

Surface moisture on FA = $730 \times 0.025 = 18.25$ kg
$FA_{wet} = 730 + 18.25 = 748$ kg

Thus, batch weights are

Cement	369 kg
Water	181 – 5.68 – 18.25 = 157 kg
CA_{wet}	1142 kg
FA_{wet}	748 kg

Step 9. Trial Batch Adjustment:

Example 2

A reinforced concrete wall. No severe weather condition nor sulfate attack.
σ_{28} = 20 MPa.
Slump = 80 mm.

Materials:

PC 32.5, density is 3.10 g/cm^3.
Coarse Aggregate
Dry bulk specific gravity of CA = 2.68
% Absorption = 0.5
D_{max} = 25 mm
Dry-rodded unit weight = 1610 kg/m^3
Fine aggregate
Dry Bulk specific gravity of FA = 2.64
% Absorption = 0.7%
FM = 2.90

Step 1. Slump = 80 mm (given)
Step 2. D_{max} = 25 mm (given)
Step 3. Water and Air Contents:

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Severe Exposure	7.5	7.0	6.0	6.0	5.5	5.0	4.5	4.0

W = 193 kg
A = 1.5%

Step 4. Water-Cement Ratio

The standard deviation of strength is 3 MPa from past experience with these materials.

$f'_{cr} = f'_c + 1.34S = 24$ MPa

$f'_{cr} = f'_c + 2.33S - 3.5 = 23.5$ MPa

Thus, use 24 MPa as required strength.

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25	0.61	0.52
20	0.69	0.60
15	0.79	0.70

Therefore, W/C = 0.63, by interpolation.

Step 5. Cement Content

C = 194/0.63 = 308 kg.

Step 6. Coarse Aggregate Content

Table 4. Volume of Coarse Aggregate Per Unit Volume of Concrete

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37.5	0.75	0.73	0.71	0.69
50	0.78	0.76	0.74	0.72
75	0.82	0.80	0.78	0.76
150	0.87	0.85	0.83	0.81

$CA_{dry} = 0.66 \times 1610 = 1063$ kg.

Step 7. Fine Aggregate Content

$V_{FAdry} = 1 - 308/3100 - 193/1000 - 1063/2680 - 0.015 = 0.296\ m^3$

$FA_{dry} = 0.296 \times 2640 = 781.4$ kg.

Step 8. Mositure correction

$CA_{SSD} = 1063 \times 1.005 = 1068.3$ kg

$FA_{SSD} = 781.4 \times 1.007 = 787$ kg

$W = 194 + (1068.3-1063) + (787-781.4) = 205$ kg.

Step 9. Trial Batch Adjustment

Example 3

Specification for a concrete work dictates

1. C = 350 kg for 1 m^3 of concrete.
2. W/C = 0.50 (net)
3. Fine aggregate-to-total aggregate ratio = 0.45 (by weight, SSD)

Material properties:

Density of cement = 3.15 g/cm^3
Abs. Capacity of both FA and CA is 2%
Total moisture of FA = 5%
Total moisture of CA = 1%
SSD BSG of FA = 2.40
SSD BSG of CA = 2.60
Entrapped Air = 1% (assumed)

Calculate the batch weights.

$V_{agg} = 1 - (350/3150) - ((350 \times 0.50)/1000) - 0.01 = 0.704\ m^3$. (SSD)

$$\frac{V_{FA} \cdot 2.40}{(V_{FA} \cdot 2.40) + (V_{CA} \cdot 2.60)} = 0.45 \Rightarrow V_{CA} = 1.128 V_{FA}\ \text{(SSD)}$$

$2.128\ V_{FA} = 0.704$
$V_{FA} = 0.33\ m^3$ (SSD)
$V_{CA} = 0.37\ m^3$ (SSD)

Thus,
C = 350 kg.
W = 175 kg (net)
FA (SSD) = 0.33 x 2400 = 792 kg
CA (SSD) = 0.37 x 2600 = 962 kg

FA IS WET, CA IS DRY!
Moisture correction:

$$FA_{wet} = \frac{792}{1.02}(1.05) = 815kg$$

$$CA_{dry} = \frac{962}{1.02}(1.01) = 953kg$$

Finally, the batch weights are

C = 350 kg
W = 175 – (815-792) + (962-953) = 161 kg
FA (wet) = 815 kg
CA 8dry) = 953 kg.