Concrete Mix Design Guide

The following is a design guide for selecting proportions for initial concrete mix design for normal weight concrete. This guide references ACI 211.1-91 (Reapproved 2009), "Standard Practice for Selecting Proportions for Normal, Heavy weight, and Mass Concrete", specifically Chapter 6, "Procedure" and Appendix 1, "Metric (SI) System Adaptation. This guide is to be used in conjunction with the CECALC.com Concrete Mix Design calculation for selecting proportions for initial concrete mix design.

General: There are two methods for selecting the concrete mix proportions, by *Weight Basis* and by *Absolute Volume Basis.* The Absolute Volume Basis will result in lower proportions by weight for some of the mix ingredients but requires further assumptions or known characteristics of those ingredients such as the specific gravity of the course aggregate and fine aggregate. Regardless either approach will result in a relatively close mix proportion to be used for batching and further refinement by testing and making adjustments prior to final production.

Step1, Choice of Slump: If the slump for the mix is not specified, determine the appropriate maximum slump from the table below, the minimum slump of 1 in (25 mm) is already assumed.

Recommended slumps for various types of construction		
Types of construction	**Maximum Slump in. (mm)**	**Minimum Slump in. (mm)**
Reinforced foundation walls and footings	3 (75)	1 (25)
Plain footings, caissons, and substructure walls	3 (75)	1 (25)
Beams and reinforced walls	4 (100)	1 (25)
Building columns	4 (100)	1 (25)
Pavements and slabs	3 (75)	1 (25)
Mass concrete	2 (50)	1 (25)

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Step 2, Choice of maximum aggregate size: If the maximum aggregate size is not specified, determine the maximum aggregate size for the mix. Take into consideration space between reinforcement, space between forms and reinforcement and other clearances, as well as workability, consolidation etc.

Step 3, Estimate mixing water and air content: Building on the previous choices, use the table below to select the corresponding water weight and entrained air for the concrete mix design.

Approximate mixing water and air content requirements for different slumps and nominal maximum sizes of aggregates								
Water, lb/cy (Kg/m^3), of concrete for indicated nominal maximum sizes of aggregate								
Slump, in (mm)	3/8 in (9.5)	1/2 in (12.5)	3/4 in (19)	1 in (25)	1–1/2 in (37.5)	2 in (50)	3 in (75)	6 in (150)
Non-air-entrained concrete								
1 to 2 (25 to 50)	350 (207)	335 (199)	315 (190)	300 (179)	275 (166)	260 (154)	220 (130)	190 (113)
3 to 4 (75 to 100)	385 (228)	365 (216)	340 (205)	325 (193)	300 (181)	285 (169)	245 (145)	210 (124)
6 to 7 (150 to 175)	410 (243)	385 (228)	360 (216)	340 (202)	315 (190)	300 (178)	270 (160)	--
> 7 (> 175)	--	--	--	--	--	--	--	--
Entrapped air	3	2.5	2	1.5	1	0.5	0.3	0.2
Air-entrained concrete								
1 to 2 (25 to 50)	305 (181)	295 (175)	280 (168)	270 (160)	250 (150)	240 (142)	205 (122)	180 (107)
3 to 4 (75 to 100)	340 (202)	325 (193)	305 (184)	295 (175)	275 (165)	265 (157)	225 (133)	200 (119)
6 to 7 (150 to 175)	365 (216)	345 (205)	325 (197)	310 (184)	290 (174)	280 (166)	260 (154)	--
> 7 (> 175)	--	--	--	--	--	--	--	--
Recommended Averages total air content, % 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

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Step 4, Select the water-cement or water cementitious materials ratio: From the table below select the water-cement or water-cementitious materials ratio. Using the next table check to insure the selected water-cement or water-cementitious materials ratio is less than or equal to the maximum permitted ratio.

Relationship between water-cementitious materials ratio and compressive strength of concrete		
Compressive strength at 28 days, psi (MPa)	Water-cement ratio, by weight	
	Non-air-entrained concrete US (SI)	Air-entrained concrete US (SI)
6000	0.41	--
(40)	(0.42)	
(35)	(0.47)	(0.39)
5000	0.48	0.40
(30)	(0.54)	(0.45)
4000	0.57	0.48
(25)	(0.61)	(0.52)
3000	0.68	0.59
(20)	(0.69)	(0.60)
(15)	(0.79)	(0.70)
2000	0.82	0.74

Maximum permissible water-cement or water-cementitious ratios for concrete in severe exposures		
Type of structure	Structure wet continuously or frequently and exposed to freezing and thawing	Structure exposed to sea water or sulfates
Thin sections (railings, curbs, sills, ledges, ornamental work) and sections with less than 1 in of cover over steel	0.45	0.40*
All other structures	0.50	0.45*

*If sulfate resisting cement, i.e. Type II or Type V, is used, value may be increased by 0.05.

Next enter the amount of pozzolanic materials to be used there are two methods for specifying the pozzolanic materials, weight equivalency and absolute volume to which the amount used in the mix can be specified as a percentage of cement by weight or by

absolute volume. If pozzolanic materials are used, the method of proportioning them in the mix, weight equivalency or absolute volume, should be selected, and then the method of specifying the amount in the mix, percent of cement by weight or by percent of absolute volume of cement, should be selected, and finally the percent of pozzolanic materials, whether by weight or volume should be entered and the specific gravity of the pozzolanic materials should be entered. In the CECALC.com Concrete Mix Design calculation the specific gravity for Type I cement, 3.15 is used.

Step 5, Calculation of cement content: This step is performed by the calculation and will be displayed in the output.

Step 6, Estimation of course aggregate: From the table below select the fineness moduli of the fine aggregate and the unit volume of course aggregate per unit volume of concrete. If Calculating mix design proportions by the Absolute Volume Basis, also enter the specific gravity of the course aggregate and the fine aggregate.

Volume of coarse aggregate per unit volume of concrete				
Nominal maximum size of aggregate, in (mm)	Volume of oven-dry-rodded coarse aggregate per unit volume of concrete for different fineness moduli of fine aggregate			
	2.40	2.60	2.80	3.00
3/8 (9.5)	0.5	0.48	0.46	0.44
1/2 (12.5)	0.59	0.57	0.55	0.53
3/4 (19)	0.66	0.64	0.62	0.60
1 (25)	0.71	0.69	0.67	0.65
1 1/2 (37.5)	0.75	0.73	0.71	0.69
2 (50)	0.78	0.76	0.74	0.72
3 (75)	0.82	0.80	0.78	0.76
6 (150)	0.87	0.85	0.83	0.81

Step 7 Estimation of fine aggregate content and Step 8 Adjustments for aggregate moisture: From the table below select the estimated weight of the initial concrete batch. Also enter the amount of total moisture in the course aggregate; the amount of total moisture in the fine aggregate; the course aggregate degree of moisture absorption and the fine aggregate degree of moisture absorption.

First estimate of weight of fresh concrete		
Nominal maximum size of aggregate in (mm)	First estimate of concrete weight, lb/cy (kg/m^3)	
	Non-air-entrained concrete	Air-entrained concrete
3/8 (9.5)	3840 (2280)	3710 (2200)
1/2 (12.5)	3890 (2310)	3760 (2230)
3/4 (19)	3960 (2345)	3840 (2275)
1 (25)	4010 (2380)	3850 (2290)
1 1/2 (37.5)	4070 (2410)	3910 (2350)
2 (50)	4120 (2445)	3950 (2345)
3 (75)	4200 (2490)	4040 (2405)
6 (150)	4260 (2560)	4110 (2435)

Step 9 water reducing admixture: If water reducing admixture is used enter the values for the percent of water reducing admixture to use, whether by weight of cement or weight of cementitious materials and the percentage of water reduced by using the water reducing admixture as per the manufacturer's instructions.