Concrete Mix Design ACI 211.1-91

Concrete Technology

Introduction

- Concrete is composed principally of aggregates, a portland or blended cement, and water, and may contain other cementitious materials and/or chemical admixtures.
- The selection of concrete proportions involves a balance between economy and requirements for **placeability**, **strength**, **durability**, **density**, and **appearance**.
- Proportions calculated by any method must always be considered subject to revision on the basis of experience with trial batches.

- Concrete proportions must be selected to provide necessary placeability, density, strength, and durability for the particular application.
- In addition, when mass concrete is being proportioned, consideration must be given to generation of heat.

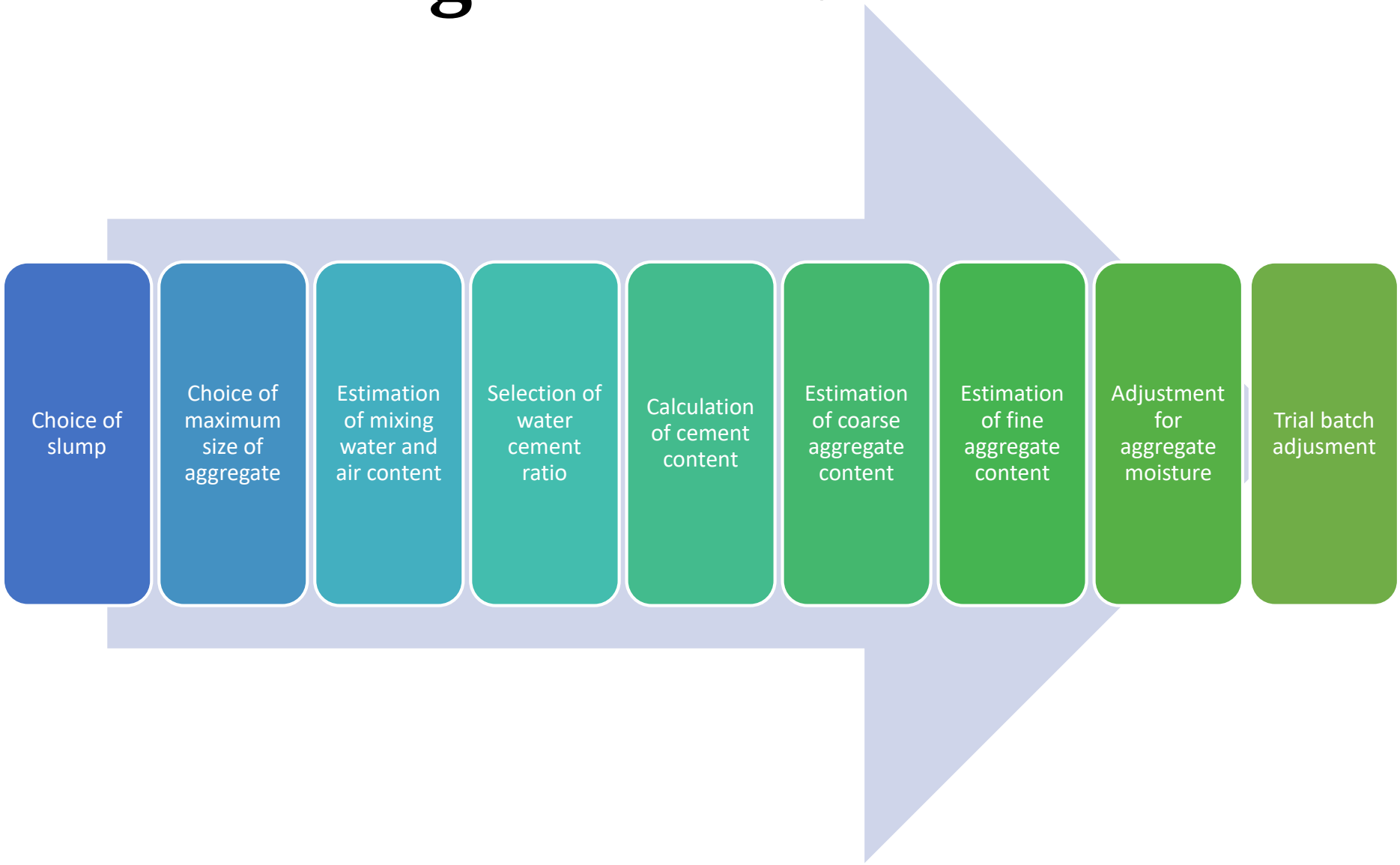
Background Data

- The following information for available materials will be useful:
  - Sieve analyses of fine and coarse aggregates
  - Unit weight of coarse aggregate.
  - Bulk specific gravities and absorptions of aggregates.
  - Mixing-water requirements of concrete developed from experience with available aggregates.
  - Relationships between strength and water-cement ratio or ratio of water-to-cement plus other cementitious materials, for available combinations of cements, other cementitious materials if considered, and aggregates.
  - Specific gravities of portland cement and other cementitious materials, if used.
  - Optimum combination of coarse aggregates to meet the maximum density gradings for mass concrete

General Procedure

See SNI 2847:2013 page 37/255 for details

Mix Design Procedure



Tabel 5.3.2.1 Kekuatan tekan rata-rata perlu bila data tersedia untuk menetapkan deviasi standar benda uji

Kekuatan tekan disyaratkan, MPa	Kekuatan tekan rata-rata perlu, MPa
$f'_c \le 35$	Gunakan nilai terbesar yang dihitung dari Pers. (5-1) dan (5-2) $f'_{cr} = f'_c + 1,34s_s$ (5-1) $f'_{cr} = f'_c + 2,33s_s - 3,5$ (5-2)
$f'_c > 35$	Gunakan nilai terbesar yang dihitung dari Pers. (5-1) dan (5-3) $f'_{cr} = f'_c + 1,34s_s$ (5-1) $f'_{cr} = 0,90f'_c + 2,33s_s$ (5-3)

Choice of Slump

TABLE A1.6.3.1—RECOMMENDED SLUMPS FOR VARIOUS TYPES OF CONSTRUCTION (SI)

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 25 mm for methods of consolidation other than vibration.

See SNI 7576:2012 Tabel 1 for comparison

Choice of maximum size of aggregate, estimation of mixing water and air content

TABLE A1.6.3.3 — APPROXIMATE MIXING WATER AND AIR CONTENT REQUIREMENTS FOR DIFFERENT SLUMPS AND NOMINAL MAXIMUM SIZES OF AGGREGATES (SI)

	Water, kg/m³ of concrete for indicated nominal maximum sizes of aggregate							
Slump, mm	9.5 mm*	12.5 mm*	19 mm*	25 mm*	37.5 mm*	50 mm*†	75 mm†‡	150 mm†‡
Non-air-entrained concrete								
25 to 50	207	199	190	179	166	154	130	113
75 to 100	228	216	205	193	181	169	145	124
150 to 175	243	228	216	202	190	178	160	—
Approximate amount of entrapped air in non-air-entrained concrete, percent	3	2.5	2	1.5	1	0.5	0.3	0.2
Air-entrained concrete								
25 to 50	181	175	168	160	150	142	122	107
75 to 100	202	193	184	175	165	157	133	119
150 to 175	216	205	197	184	174	166	154	—
Recommended average§ total air content, percent 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**††
Extreme exposure‡‡	7.5	7.0	6.0	6.0	5.5	5.0	4.5**††	4.0**††

See SNI 7576:2012 Tabel 2 for comparison

Selection of water cement ratio

TABLE A1.6.3.4(a)—RELATIONSHIP BETWEEN WATER-CEMENT OR WATER-CEMENTITIOUS MATERAL RATIO AND COMPRESSIVE STRENGTH OF CONCRETE (SI)

Compressive strength at 28 days, MPa*	Water-cement ratio, by mass	
	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

See SNI 7576:2012 Tabel 3 for comparison

TABLE A1.6.3.4(b)—MAXIMUM PERMISSIBLE WATER-CEMENT OR WATER-CEMENTITIOUS RATIO FOR CONCRETE IN SEVERE EXPOSURES (SI)*

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 5 mm cover over steel	0.45	0.40‡
All other structures	0.50	0.45‡

See SNI 7576:2012 Tabel 4 for comparison

Estimation of coarse aggregate content

TABLE A1.6.3.6—VOLUME OF COARSE AGGREGATE PER UNIT OF VOLUME OF CONCRETE (SI)

Nominal 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

See SNI 7576:2012 Tabel 5 for comparison

Trial batch adjusment

TABLE A1.6.3.7.1—FIRST ESTIMATE OF MASS OF FRESH CONCRETE (SI)

Nominal maximum size of aggregate, mm	First estimate of concrete unit mass, kg/m³*	
	Non-air-entrained concrete	Air-entrained concrete
9.5	2280	2200
12.5	2310	2230
19	2345	2275
25	2380	2290
37.5	2410	2350
50	2445	2345
75	2490	2405
150	2530	2435

See SNI 7576:2012 Tabel 6 for comparison

- Read Appendix 2 of ACI 211.1-91, Example Problem in Metric (SI) System
- We will continue our discussion based on that example

Home Work 07

- Your task is to make a mix design of a specific concrete compressive strength ($f'c$).
- Use your own data from previous laboratory test.
- Submit your work, 24 hours after the class.