Lab 4: Concrete Mix
Lab 5: Concrete Cylinder Test

CIVE 2700

Civil Engineering Materials

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Outline

- Lab 4:
  - Concrete Mix Design
  - Concrete Mixing
  - Slump Test
- Lab 5:
  - Concrete Cylinder Test
- Final Report

Concrete Mix Design

- Purpose:
  - To design the following values for concrete mixing:

$$\begin{cases} C = \text{ weight of cement per unit volume } (\text{kg/m}^3) \\ FA_W = \text{ weight of fine aggregates per unit volume } (\text{kg/m}^3) \\ CA_W = \text{ weight of coarse aggregates per unit volume } (\text{kg/m}^3) \\ W = \text{ weight of water per unit volume } (\text{kg/m}^3) \end{cases}$$

- Known:
  - Concrete properties: $\begin{cases} f_c \ \ (\text{MPa}) \\ slump \ \ (\text{mm}) \end{cases}$
  - Aggregates properties and cement type
  - Design procedures

Design Procedures

- Step 3:
  - Slump = 90 mm; dmax = 40 mm; non-air-entrained concrete.
  - Interpolating ➔ W = 175 kg/m^3

TABLE A1.5.3.3 — APPROXIMATE MIXING WATER AND AIR CONTENT REQUIREMENTS FOR DIFFERENT SLUMPS AND NOMINAL MAXIMUM SIZES OF AGGREGATES (SI)

Slump, mm	Water, Kg/m^3 of concrete for indicated nominal maximum sizes of aggregate							
	9.5*	12.5*	19*	25*	37.5*	50†*	75†‡	150†‡
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, %	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, % 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**††

Design Procedures (contd)

- Step 4:
  - f_c = 25 MPa → W/C = 0.61
- Step 6:
  - dmax = 40 mm; FM = 2.8
  - Interpolating → V_{CA} = 0.72

TABLE A1.5.3.4(a) — RELATIONSHIPS BETWEEN WATER-CEMENT 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

TABLE A1.5.3.6 — 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 modulit 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

Design Results

- Submit design results to your TA for correction 1 or 2 days before the mixing of concrete.
- In the submission, provide the key values that you are designing for and your detailed calculations.
- Groups: 6-7 students per group.

Concrete Mixing

- Purpose: procedure to mix concrete and prepare test samples.
- Related Standards: ASTM C192
- Equipment for hand mixing: barrow, shovel, hand scoop, pan and tamping rod.

Mixing Procedures

- Clean mixing apparatus and accessories.
- Weigh the ingredients (cement, aggregates and water) needed for mixing.
- Mix cement and fine aggregates first, then add course aggregates and add water.
- Fully mix until the concrete is homogeneous in appearance.

Slump Test

- Purpose: To determine the slump of plastic concrete
- Related Standards: ASTM C143, C172
- Equipment: Slump mold, tamping rod, pan, scale, shovel and hand scoop.

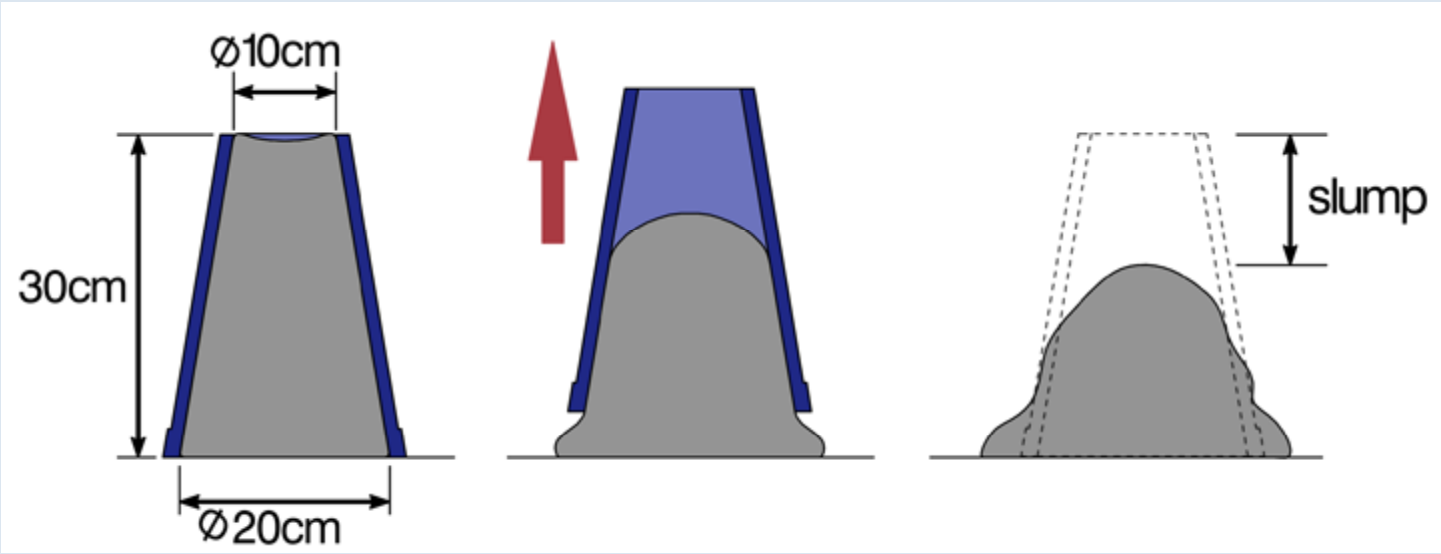
Slump Test (contd)

slump mold

tamping

removing mold

measuring



Concrete Cylinder Casting

- Purpose: To prepare concrete cylinders for strength tests.
- Related Standards: ASTM C39, C192 and C617
- Equipment for Casting: concrete molds, tamping rod, pan, mallet, trowel and hand scoop.
- Cast 8 cylinders; cylinder size: 10cm (dia.) by 20cm (H)

Casting

Each time, fill the mold with 1/3 level, tamp the concrete with the steel rod 25 times and vibrate the concrete by tamping the mold with the mallet.

Finish the top surface, cover the specimens with plastic covers.

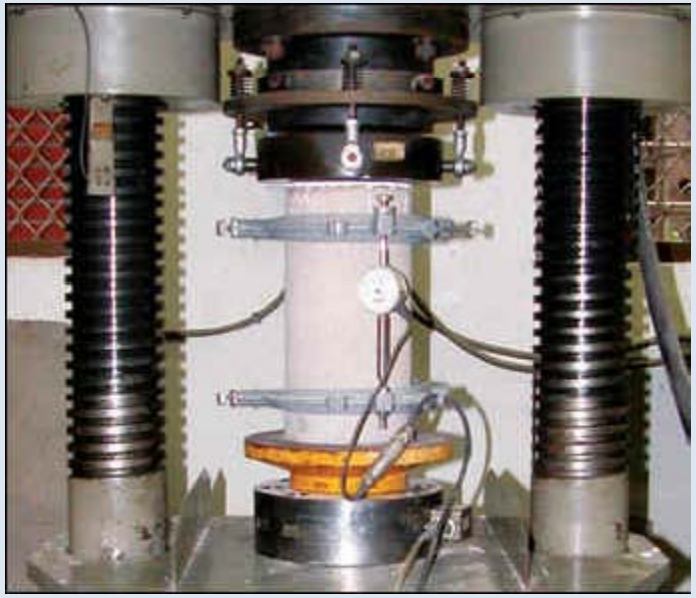
After Casting

- Mark the 8 specimens.
- Moist-cure the specimens in the curing room.
- Remove the specimens from the molds between 20 and 48 hrs after casting.
- Waiting for 2 weeks for cylinder tests.

Cylinder Test

- Purpose: To determine the compressive strength and tensile strength of the concrete specimens.
- Related Standards: ASTM C39
- Equipment: universal loading machine, compressometer.
- 3 cylinders for compressive tests and 3 cylinders for tensile tests.

Compressive Test



Test setup

Compressometer

After test

$$\sigma_c = F / A$$

Tensile Test

- No a true tensile test, but a splitting tension test: a diametral compression force on a horizontally placed cylinder.

$$\sigma_t = \frac{2P}{\pi DL}$$

Theoretically:

$$\sigma_t = 0.1\sigma_c$$

Final Report

- Part I, Mix Design:

  detailed calculations, mixing procedures, slump test and cylinder preparation

- Part II, Cylinder Test:
  - test data, analysis and results
- **Note: the mark of this lab report is equivalent to two lab reports.**

Final Report and Marking Scheme

1. Neatness of report (5)
2. Introduction (10):
   - Use of concrete as building material (2)
   - Concrete mix (2)
   - Purpose of concrete mix design (2)
   - Curing (2)
   - Cylinder strength test (2)
3. Description of experiment and specimen (20):
   - Concrete mix design (10)
   - Apparatus (5)
   - Specimen (5)
4. Experimental procedures (20)
   - Mixing concrete (5)
   - Slump test (5)
   - Making test samples (5)
   - Testing cylinder samples (5)

Final Report and Marking Scheme

4. Results (20)
   - slump test (4)
   - cylinder tests (strength values, show tables and graphs) (12)
   - failure modes (explain, or show pictures) (4)
5. Discussion (20)
   - Measured slump vs. design slump (5)
   - Test strengths vs. design strengths (5)
   - Failure modes (5)
   - Sources of error (5)
6. Conclusion (10)

Summary

- 1st submission: mix design calculations; due prior to the mixing.
- 2nd submission: a final report, due 2 weeks after the cylinder test.