CONCRETE TECHNOLOGY LABORATORY

DEPARTMENT OF CIVIL ENGINEERING
CHULALONGKORN UNIVERSITY

Tested by ..... ID No. .....
Date ..... Graded by .....

TEST No. C-4

MIXING, CASTING AND PROPERTIES OF FRESH CONCRETE (I)

Part A Mix Design and Mixing of Concrete by Mechanical Mixer

Objective — To determine the appropriate mix proportion of normal concrete at specified properties and to prepare the specimens for future testing.

Materials — Fine aggregate, coarse aggregate and cement available in the laboratory.

References — ASTM Designation : C 192
BS (British Standard) 1881
Recommended practice for selecting proportions for concrete (ACI 613)
Any text books on Concrete Technology

Apparatus
(1) Concrete mixer
(2) Balance
(3) Molds (or forms) for casting of the test specimens for future testing.

Procedures

1. Determine the mix proportion for concrete at specified strength, durability and consistency (may be given by the instructor). It is advisable to divide the materials and mix them into two or more batches.

2. To mix the concrete, first put some percentage[1] of the required amount of water in the mixer then add cement and sand and thoroughly mix about 1½ min. Finally add coarse aggregate, the rest amount of water and continue mixing[2] until a uniform and consistent mix is obtained.

3. Pour the freshly mixed concrete from the mixer into pan. Thoroughly mix the concrete with the aid of trowels and shovels (if necessary). Divide the concrete for the determination of slump, air content and variation of constituents. Then, determine the slump value, the amount of air content and the variation of constituents (as will be explained in Part B and C) and also inspect the texture of fresh concrete. These determinations must be performed for all mixing batches.

4. Fill the concrete in the molds or forms (Part D) with the aid of tamping rod or vibrator. After the filling is completed, smooth out the surface with trowels. The concrete specimens should be kept for one day before the forms are removed.

Part B Workability of Fresh Concrete

Part B(1) Slump Test

Objective — To determine the relative consistency of freshly mixed concrete by the use of slump test.

Material — Freshly mixed concrete.

References — ASTM Designation : C 143
BS (British Standard) 1881
JIS (Japan Industrial Standard) A 1101

Apparatus — (1) Slump mold : The mold shall be in the form of the lateral surface of the frustum of a cone with the base 8 in. (203 mm) in diameter, the top 4 in (102 mm) in diameter, and the height 12 in (305 mm). The base and the top shall be open and parallel to each other and at right angles to the axis of the cone. The mold shall be provided with foot pieces and handles.

[1] 80% for concrete with w/c 0.40 or less
70% for concrete with w/c 0.41-0.54
60% for concrete with w/c greater than 0.55

[2] not less than 1½ min is recommended.

(2) Tamping Rod : The tamping rod shall be round, straight steel rod 5/8 in (16 mm) in diameter and approximately 24 in (600 mm) in length, having a tamping end rounded to a hemispherical tip the diameter of which 5/8 in (16 mm).

Significance and Use

1. This test method was originally developed to provide a technique to monitor the consistency of unhardened hydraulic cement concrete. The slump is generally found to increase proportionally with the amount of water content of the given concrete mixture, and thus to be inversely related to concrete strength.

2. This test method is considered applicable to plastic concrete having coarse aggregate upto 1.5" (37.5 mm) in size. If the coarse aggregate is larger than 1.5" (37.5 mm) in size, the test method is applicable when it is made on the fraction of concrete passing a 1.5" (37.5 mm) sieve, with the larger aggregate being removed.

3. This test method is not considered applicable to non-plastic and non-cohesive concrete.

Procedures

1. Dampen the mold and place it on a flat, moist, nonabsorbent (rigid) surface. It shall be held firmly in place during filling by the operator standing on the two foot pieces. Immediately fill the mold in three layers, each approximately one third the volume of the mold.

2. Rod each layer with 25 strokes of the tamping rod. Uniformly distribute the strokes over the cross section of each layer.

3. In filling and rodding the top layer, heap the concrete above the mold before rodding start. If the rodding operation results in subsidence of the concrete below the top edge of the mold, add additional concrete to keep an excess of concrete above the top of the mold at all time.

4. After the top layer has been rodded, strike off the surface of the concrete by means of screeding and rolling motion of the tamping rod.

5. Remove the mold immediately from the concrete by raising it carefully in the vertical direction. Raise the mold a distance of 12 in (300 mm) in 5 ± 2 sec by a steady upward lift with no lateral or torsional motion.

6. Immediately measure the slump by determining the vertical difference between top of the mold and the displaces original center of the top surface of the specimen. Complete the entire test from the start of the filling through removal of the mold without interruption and complete it within 2½ min.

7. If a decided falling away or shearing off of concrete from one side or portion of the mass occurs, disregard the test and make a new test on another portion of the sample. If two consecutive tests on a sample of concrete show a falling away or shearing off of a portion of concrete from the mass of specimen, the concrete lacks necessary plasticity and cohesiveness for the slump test to be applicable.

8. After completion of the test, the sample may be used for casting of the specimens for the future testing.

Part B(2) Ball Penetration Test

Objective — To determine the consistency of fresh concrete by Ball Penetration technique. The method covers determination of the depth of penetration of a metal weight into freshly mixed concrete.

Material — Freshly mixed concrete

Reference — ASTM Designation : C 360

Apparatus — (1) Kelly Ball (Metal Ball)
(2) Concrete container : The minimum depth of container shall be at least 3 times the maximum size of aggregate but not less than 8 in (203 mm). The minimum horizontal distance from the center line of the handle to the nearest edge of the level surface on which the test is to be made shall be 9 in (288 mm).

Significance and Use

This method is used primarily to determine the penetration of metal weight into freshly mixed concrete as a mean of determining the workability of concrete. After sufficient correlation data with results from the standard slump test is obtained, the results of the penetration reading may be used to determine compliance with slump requirements.

Procedures

1. Bring the surface of the concrete to a smooth and level condition by the use of a small wood float or screed, working the surface as little as possible to avoid formation of mortar layers. During the test, the adjoining concrete should not subjected to vibration, jarring or agitation.
2. Set the base of the apparatus on the leveled concrete surface, with the handle in a vertical position and free to slide through the frame. Lower the weight to the surface of concrete and release slowly.
3. After the weight has been released and has come to rest, read the penetration to the nearest ¼ in (6.4 mm). Take a minimum of three reading from a batch or location. These reading shall not be taken with the foot of the stirrup within 6 in (152 mm) of a point where the foot rested in a previous test.
4. If the difference between the maximum and minimum reading is more than 1 in (25 mm), make additional measurements until three successive readings have been obtained which agree within 1 in. Make no correction for any slight settlement of the stirrup.
5. The penetration shall be recorded in terms of inches (or millimeters). Take the average value of the three or more readings, which agree within 1 in. (25 mm). They shall be reported to the nearest ¼ in (6.4 mm).
6. Perform the slump test, compare the reading of the ball penetration with the slump.

Part B(3) Compacting Factor Test

Objective — To determine the consistency of freshly mixed concrete by Compacting factor apparatus.

Material — Freshly mixed concrete

References — Standard Practice for Selecting Proportions for No-Slump Concrete ACI 211.3
BS (British Standard) 1881

Apparatus
(1) Compacting Factor Apparatus
(2) Trowel
(3) Scoop about 150 mm long.
(4) Tamping Rod
(5) Balance capable of weighing up to 25 kg with the sensibility of 10 g.

Procedures

1. The internal surface of the hoppers and cylinder shall be thoroughly clean and free from superfluous moisture and any set of concrete commencing the test.

2. The sample of concrete to be tested shall be placed gently in the upper hopper using the scoop. The trap door shall be opened immediately after filling or approximately 6 min after water is added so that the concrete fails into the lower hopper. During this process the cylinder shall be covered.

3. Immediately after the concrete has come to the rest the cylinder shall be uncovered, the trap door of the lower hopper opened and the concrete allowed to fall to into the cylinder.

4. For some mixes have a tendency to stick in one or both of the hoppers. If this occurs the concrete shall be helped through by pushing the tamping rod gently into the concrete from the top.

5. The excess of concrete remaining above the level of the top of the cylinder shall then be cut off by holding a trowel in each hand, with the plane of the blades horizontal, and moving them simultaneously one from each side across the top of the cylinder, at the same time keeping them pressed on the top edge of the cylinder. The outside of the cylinder shall then be wiped clean. This entire process shall be carried out at a place free from vibration or shock.

6. Determine the weight of concrete to the nearest 10 g. This is known as "weight of partially compacted concrete", W_p.

7. Refill the cylinder with concrete from the same sample in layers approximately 50 mm depth. The layers being heavily rammed with the compacting rod or vibrated to obtain full compaction. The top surface of the fully compacted concrete shall be carefully struck off and finished level with the top of the cylinder. Clean up the outside of the cylinder.

8. Determine the weight of concrete to the nearest 10 g. This is known as "weight of fully compacted concrete", W_f.

9. The compacting factor, F_c can be calculated as follows:

$$F_c = \frac{W_p}{W_f}$$

Part C Air Content and Variability of Constituents of Freshly Mixed Concrete

Part C(1) Air content of Freshly mixed Concrete (Pressure Method)

Objective — To determine the amount of air in freshly mixed concrete from observation of the change in volume of concrete with a change in pressure.

Material — Freshly mixed concrete

References — ASTM Designation : C 231
BS (British Standard) 1881
JIS (Japan Industrial Standard) A 1128

Apparatus
(1) Air meters (ASTM Type B)
(2) Measuring Bowl
(3) Tamping Rod
(4) Trowel

Significance and Use

1. This test method covers the determination of the air content, of freshly mixed concrete. The test is intended to determine the air content of freshly mixed concrete exclusive of any air that may be inside voids within aggregate oarticles. For this reason, it is applicable to concrete made with relatively dense aggregate particles and requires determination of the aggregate correlation factor.

2. This method is unsuitable for concrete or mortar using porous aggregate such as artificial lightweight aggregate, aggregate correction factor cannot be accurately determined.

3. The amount of air content of hardened concrete may be either higher or lower than that determined by this test method. This depends upon the methods and amount of consolidation effort applied to the concrete from which the hardened concrete specimen is taken.

Procedures

1. The air meter should be calibrated (container, initial pressure and graduation of air content) periodically as specified by ASTM Designation or JIS.

2. Measureing of Aggregate Correction Factor

(a) The weight of fine and coarse aggregates contained in the sample concrete of the volume, V to be tested for obtaining the air content shall be calculated by the following formula:

$$w_f = \frac{V}{B}(W_f)$$

$$w_c = \frac{V}{B}(W_c)$$

where w_f, w_c is the weight of fine aggregate and coarse aggregate in concrete sample respectively, V is volume of concrete sample, B is compacted volume (air-free concrete) of concrete of one batch and W_f, W_c is weight of fine aggregate and coarse aggregate used in one batch respectively.

(b) Typical sample of fine aggregate and coarse aggregate, w_f, w_c shall be collected and immersed in water[3] to make the moisture condition of the sample aggregate particles equivalent to that in concrete sample.

(c) Feed the sample into the container which approximately one third filled with water. During feeding, a scoopful of the fine aggregate shall be put in the container and to be followed by two scoops of the coarse aggregate, and this sequence shall be repeated. Caution shall be taken to assure that the amount of air entering with the aggregates is minimized, and that all aggregates are completely immersed. To rerelease air, the side of container shall be tapped and whenever the fine aggregate is added, the tamping rod shall be plunged approximately 10 times into it to a depth of 25 mm.

(d) Remove all air bubbles on the surface of water, cleanly wipe the flanges of container and clamp the cover onto the container. Then pour water until air trapped between the back side of the cover and the water level is discharged.

(e) Adjust The pressure in the air chamber to the initial pressure (usually zero). After approximately 5 seconds, fully open the actuating value, and tap the side of the container with a rubber hammer for making the pressure act on every part of sample.

(f) Read the graduation of air content on the pressure gauge after waiting for the gauge needle to stabilize. This reading shall be used as aggregate correction factor, G.

3. Measureing of Air Content of Concrete

(a) Place the concrete in the measuring bowl in three layers of approximately equal volume. Consolidate each layer by 25 strokes of the tamping rod evenly distributed over the cross section[4].

(b) After each layer is rodded, tap the sides of the measure smartly 10 to 15 times with the mallet or rubber hammer to close any voids left by the tamping rod and to release any large bubbles of air.

(c) After the final layer has been finished, strike off the top surface by sliding the strike-off bar across the top flange or rim of the measuring bowl with a sawing motion until the bowl is just level full.

(d) Thoroughly clean the flanges or rims of the bowl and the cover assembly so that when the cover is clamped in place a pressure-tight seal will be obtained.

(e) Remove all air bubbles on the surface of water, cleanly wipe the flanges of container and clamp the cover onto the container. Then pour water until air trapped between the back side of the cover and the water level is discharged.

(f) Adjust The pressure in the air chamber to the initial pressure (usually zero). After approximately 5 seconds, fully open the actuating value, and tap the side of the container with a rubber hammer for making the pressure act on every part of concrete sample.

(g) Read the graduation of air content on the pressure gauge after waiting for the gauge needle to stabilize. This reading shall be taken as apparent air content of concrete, A'.

(h) The amount of air content, A can be calculated as follows:

$$A = A' - G$$

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[3] 5 minutes will be appropriate for the immersion perioed.

[4] Rod the bottom layer throughout its depth, but the rod shall not forcibly strike the bottom of the measure. In rodding the second and final layers, use only enough force to cause the rod to penetrate the surface of the previous layer about 1 in or 25 mm.

Part C(2) Variation of Constituents in Freshly Mixed Concrete

Objective — To determine the variability of unit weight of air-free mortar and unit weight of coarse aggregate in freshly mixed concrete.

Material — Freshly mixed as obtain from Part B.

Reference — JIS (Japan Industrial Standard) A 1119

Apparatus
(1) Balance with the accuracy of 0.1% of the net weight of concrete sample.
(2) Sieve : No.4 sieve (5.0 mm)

Procedures

1. Determine the amount of air content as described in Part C(1). The weights of concrete fully filled in the container shall be measured.
2. The sample used for the test of air content shall be poured on a 5 mm sieve, and the particles of less than 5 mm shall be removed by washing with water.
3. The aggregates retained on 5 mm sieve shall be weighed in saturated surface-dry condition. The surface dry specific gravity shall be known from the previous test (Test No. C-3).
4. The unit weight of air-free mortar shall be calculated as follows:

$$M = \frac{W - W_s}{V - (V_a + \frac{W_s}{B})} * 1000$$

where M is unit weight of air-free mortar (kg/m^3), W is weight of concrete sample obtained by the test of air content, W_s is aggregate retained on 5 mm sieve, V is the volume of container used in air content test, V_a is computed volume of air computed by multiplying the volume of container, V, by percent of air divided by 100 and B is 1 kg/l multiplied by surface-dry specific gravity of coarse aggregate (kg/l).

5. The variation in unit weight of air-free mortar (s_m,%) can be calculated as follows:

$$\sigma_m = (\frac{M_1 - M_2}{M_1 + M_2}) * 100$$

where M_1 and M_2 are the highest and the lowest values of M respectively.

6. The unit weight of coarse aggregate shall be calculated as follows:

$$G = (\frac{W_s}{V}) * 1000$$

where G is unit weight of coarse aggregate in concrete (kg/m^3)

7. The variation in unit weight of coarse aggregate in concrete (s_G,%) can be calculated as follows:

$$\sigma G = \frac{G_1 - G_2}{G_1 + G_2} * 100$$

where G_1 and G_2 are the highest and the lowest value of G respectively.

8. If the variation in unit weight of mortar is less than 0.8% and the variation on unit weight of coarse aggregate in concrete is less than 5%, it is considered that uniform mix has been carried out.

Part D Casting of Concrete Specimens

Objective To prepare the test specimens for the future testing.

Material Freshly mixed concrete.

References ASTM Designation : C 31, C 172, C 192, C 470
ACI (American Concrete Institute) 613
JIS (Japan Industrial Standard) A 1115, A 1132, A 1138

Apparatus (1) Molds or Forms with sufficient number
(2) Tamping rod or vibrator
(3) Trowel

Procedures

1. General

(a) Molds for specimens shall be made with nonabsorbent material, non reactive with concrete. Molds shall conform to the dimensions and tolerances required.

(b) Place the molds as near as practicable to the place where they are to be stored during the first 24 hr. Place the molds on the rigid surface free from vibration and other disturbances. Avoid jarring, striking, tilting or scarring of the surface of the specimens.

(c) The inside of the molds shall be lightly coated with mineral oil or a suitable nonreactive release material.

2. Concrete Cylinder

(a) At least 9 specimens are required for the future test. The molds may be either 100 by 200 mm or 150 by 300 mm.

(b) Place the concrete in the mold in three approximately equal layers. Compact each layer with the tamper for 25 strokes or vibrator.

(c) After the top layer has been compacted, strike off the concrete flush with the top of the mold. Smooth out the surface with a trowel.

(d) Immediately after completing molding, cure the test specimens in the molds in a moist cabinet.

(e) Remove the specimens from the molds at the age of 23½ ± ½ hr after the addition of water to the cement during mixing operation. Using the demolding device to remove specimens from the molds.

(f) Upon removal of the specimens from the molds, place them in curing room or keep all specimens under moist clothes until the time of testing.

3. Concrete Prism and Concrete Block

(a) Four or five specimens are required for concrete prism and four concrete blocks are required for concrete bond test. The molds for concrete prism shall be 100 by 100 by 500 mm and the concrete blocks for concrete bond test shall be 200 by 200 by 200 mm with the steel reinforcement embedded at the required length.

(b) Place the concrete in the mold in two approximately equal layers. Compact each layer with the tamper (25 strokes) in order to put mortar into the corners and along the surface of the mold until a homogeneous specimen is obtained.

(c) Follow the above procedures for concrete cylinder from items (c) to (f).

Sketch all necessary figures about the test

Experimental Data and Results

Part A Mix Design and Mixing of Concrete by Mechanical Mixer

Data for the calculating of the mix proportion

Compressive strength at 28 days	
Slump	
Type of cement	
Specific gravity of cement	
Type of sand	
Specific gravity of sand	
Absorption of sand	
Moisture condition of sand	
Fineness modulus	
Type of coarse aggregate	
Specific gravity of coarse aggregate	
Absorption of coarse aggregate	
Moisture condition of coarse aggregate	

Calculations of Mix Proportion

Part B Workability of Fresh Concrete

Mix proportion for Part B, C and D (May be given by Instructor)

Mix proportion of concrete	For 1 cubic meter of concrete	For one batch of mixing
Coarse aggregate (kg)		
Fine aggregate (kg)		
Cement (kg)		
Water (kg)		
S/A		
w/c		
Admixture		

Part B(1) Slump Test

Batch No.	Determination			Average
	No.1	No.2	No.3	
1				
2				
3				
Average slump (cm)				

Part B(2) Ball Penetration Test

Batch No.	Penetration Depth					Slump	Ratio
	1	2	3	4	Average		
1							
2							
3							

Part B(3) Compacting Factor Test

	No. 1	No. 2	No. 3
Cylinder			
Partially compacted concrete + cylinder			
Fully compacted concrete + cylinder			
Partially compacted concrete, W_p			
Fully compacted concrete, W_f			
Compacting factor, F_c			
Average			

Part C Air Content and Variability of Constituents of Freshly Mixed Concrete

Part C(1) Air Content of Freshly Mixed Concrete (Pressure Method)

Batch No.	Determination			Factor, G (%)	Air content (%)
	No.1	No. 2	Average		
1					
2					
3					
Average air content (%)					

Part C(2) Variability of Constituents in Freshly Mixed Concrete

Sample	W (kg)	W_s (kg)	V (l)	V_a (l)	B (kg/l)	M (kg/m^3)	G (kg/m^3)
1							
2							
3							
4							
5							
6							
The variation in unit weight of air-free mortar (%)							
The variation in unit weight of coarse aggregate (%)							

Sample of Calculations

Summary of Results (in Tabular Form), Discussion and Conclusion