CONCRETE TECHNOLOGY LABORATORY

DEPARTMENT OF CIVIL ENGINEERING
CHULALONGKORN UNIVERSITY

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

TEST No. C-6

PROPERTIES OF HARDENED CONCRETE

Part A Compressive Strength, Modulus of Elasticity and Poisson's Ratio

Objective To determine the compressive strength, modulus of elasticity and Poisson's Ratio of molded concrete cylinder specimens.

Material Concrete cylinders

References TIS (Thai Industrial Standard) 409
ASTM Designation : C 39, C 469
BS (British Standard) 1881
JIS (Japan Industrial Standard) A 1108, A 1127

Apparatus
(1) Universal Loading Machine
(2) Compressometer
(3) Extensometer
(4) Balance
(5) Measuring tape or ruller

Significance and Use

1. Care must be exercised in the interpretation of the significance of compressive strength determinations by this test method since strength is not a fundamental or intrinsic property of concrete made from givem materials. Values obtained will depend on the size and shape of the specimen, batching, mixing procedures, the methods of sampling, molding, and fabrication and the age, temperature, and moisture conditions during curing.

2. The results of this test method may be used as a basis for quality control of concrete proportioning, mixing, and placing operations; determination of compliance with specification; control for evaluating effectiveness of admixtures as similar uses.

3. This test method provides a stress to strain ratio value and a ratio of lateral to longitudinal strain for hardened concrete at whatever age and curing conditions may be designated.

4. The modulus of elasticity and Poisson's ratio values, applicable within the customary working stress range (0-40% of ultimate concrete strength), may be used in sizing of reinforced

and nonreinforced structural members, establishing the quantity of reinforcement, and computing stress for observed strain.

5. The modulus of elasticity values obtained will usually be less than moduli derived under rapid load application (dynamic or seismic rates, for example), and will usually be greater than values under slow load application or extended load duration, other test conditions being the same.

Procedures

1. Weigh the concrete cylinder and determine the average diameter to the nearest 0.1 in (0.25 mm). Cap the concrete cylinder.

2. Fix the compressometer and Extensometer to the specimen and attach the dial micrometer in order to measure the deformation of cylinder during loading in compression.

3. After the specimens has been set up in the testing machine, apply a slight initial load and set the dial micrometer to read zero.

4. Apply load continuously at slow speed approximately 150 ksc/min[1] without shock. Record the dial reading of both compressometer and extensometer at about 1000-2000 kg interval. Take care to remove the compressometer and extensometer when the specimen start to crack.

5. Plot the load-deformation curve to a suitable scale and determine the following results:

a) Crushing strength or ultimate strength, σ_c

$$\sigma_c = \frac{4P}{\pi d_{av}^2}$$

where P is maximum load and d_{av} is average diameter of cylinder specimen calculated from the diameter measured in two directions at right angles to each other at about mid height of specimen.

b) Compressive stress at elastic limit, σ_e

$$\sigma_e = 0.40(\sigma_c)$$

c) The initial tangent modulus, E_i

d) The tangent modulus at 40% of crushing strength, E_t

e) The secant modulus at 40% of crushing strength, E_s

$$E_s = \frac{\sigma_e - \sigma_o}{\varepsilon_e - 0.000050}$$

where σ_o is stress corresponding to a longitudinal strain, σ_o of 50 millionth and ε_e is longitudinal strain produced by stress σ_e.

[1] The loading rate should be held constant within the range of 2-3 ksc/sec or 120-180 ksc/min as recommended by JIS.

f) Poisson's Ratio, μ

$$\mu = \frac{\varepsilon_e^t - \varepsilon_o^t}{\varepsilon_e - 0.000050}$$

where ε_{et} is transverse strain at mid-height of the specimen produced by stress σ_e and ε_o^t is transverse strain at mid-height of the specimen produced by stress σ_o.

<u>Part B</u> Splitting Tensile Strength of Cylindrical Concrete Specimens

<u>Objective</u> To determine the splitting tensile strength of concrete cylinder.

<u>Material</u> Concrete cylinders

<u>References</u> ASTM Designation : C 496
BS (British Standard) 1881 Part 117
JIS (Japan Industrial Standard) A 1113

<u>Apparatus</u> (1) Universal Loading Machine
(2) Bearing Strips (Plywood strips)

<u>Significance and Use</u>

1. This test method measures the splitting tensile strength of concrete by the application of a diametral compressive force on a cylindrical concrete specimen placed with its axis horizontal between the platens of a testing machine.

2. Splitting tensile strength is simpler too determine than direct tensile strength.

3. Splitting tensile strength is used to evaluate the shear resistance provided by concrete in reinforced concrete members.

<u>Procedures</u>

1. Determine the diameter and length of test specimen to the nearest 0.1 in (0.25 mm) at not less than two places. The mean value shall be taken as the representatives.

2. Center one of the bearing strips along the center of the lower bearing block. Place the specimen on the strip in such a manner that the ends of the specimen are vertical and centered over the strip.

3. Place the second plywood strip lengthwise on the cylinder, centered on the specimen. The upper and lower strips shall be maintain parallel during loading.

4. Loading at slow speed without shock. The speed of application shall be such that the splitting tensile strength increases in the range of 4-5 ksc/min until failure of the specimen.

5. Calculate the splitting tensile strength, T as follows :

$$T = \frac{2P}{\pi dl}$$

where P is maximum applied load, d is average diameter of cylinder and l is the average length of the concrete specimen.

Part C Flexural Strength of Concrete

Objective To determine the flexural strength or Modulus of rupture of concrete by the use of simple beam.

Material Concrete prism.

References ASTM Designation : C 78
BS (British Standard) 1881
JIS (Japan Industrial Standard) A 1106

Apparatus Universal Loading Machine

Procedures

1. Turn the test specimen on its side with respect to its position as molds and center it on the support block. The test span length should not shorter than three time of the depth of specimen[2]. The load application block shall contact the specimen at third points of the span in case of third point loading or at the center of span in case of center point loading.

2. Load the specimen continuously and without shock. The loading rate should be the rate that constantly increase the extreme fiber stress between 8-10 ksc/min[3].

3. Continue loading until failure occurs. Determine the dimension of test specimen at failure section. The flexural tensile strength or modulus of rupture can be calculated as follows:

$$\sigma_b = \frac{Mc}{I} = \frac{6M}{bd^2}$$

where M is maximum applied moment, b is average width of specimen at the point of fracture and d is average depth of specimen at the point of fracture.

[2] Test span length, L equal to three times of the depth (3d) is recommended.

[3] The comparatively high loading speed may be applied up to about 50% of the maximum load.

Part D Concrete Bond Test

Objective: To determine the resistance to withdrawal of round bar and deformed bar embedded in concrete block by pull-out test.

Material: Concrete blocks 20 by 20 by 20 cm embedded with 19 mm deformed bar and round bar.

Reference: ASTM Designation : C 234

Apparatus:
(1) Loading Machine
(2) Bond test apparatus
(3) Dial Micrometer
(4) Steel rule
(5) Micrometer

Significance and Use

1. This test method is not intended for establishing bond values for structural design purposes. However, this test is adaptable to use for research purposes by varying the conditions as desired but no attempt to do so has been included in this method.

2. This test method may also be used to determine the conformance of a product or a treatment with a requirement relating to its effect on the bond developed between concrete and reinforcing steel.

Procedures

1. Determine the compressive strength of concrete cylinder and keep the broken parts of cylinder for the future test. Measure the diameter of the bar by micrometer and the embedded length (if possible) in concrete block by steel rule. Make a small hole at the middle of the short end of the bar by center punch.

2. Suspend the bond-test apparatus from the upper cross head of the testing machine by using the 25 mm diameter grips.

3. Mount the concrete cube in position in the bond-test apparatus with the long end of the bar projecting downward and adjust the block to central position on the square base. Lower the upper cross-head until the bar is gripped by the lower grip.

4. Apply a slight initial load and adjust the dial pointer to zero. Place the dial micrometer in position and adjust the micrometer so that the spindle is resting in the hole at middle of the bar.

5. Set the pointer of the micrometer at zero mark by adjusting the trump screw at the top of the instrument.

6. Apply the load to the reinforcing bar at a rate not greater than 2,240 kg/min (22 kN/min). Record the applied load and dial gage reading every 0.02 mm slip. Stop recording the load when maximum load is reached.

7. Further applying the load until the nearly constant load is indicated on the dial. Then stop applying the load and use the cross head switch to lift the concrete block completely from the steel bar.

8. Plot the load-slip curve to appropriate scale, using load as ordinate and slip as abscissa. Calculate the maximum bond stress by dividing maximum load by surface area of steel bar in contact with concrete. Also determine bond stress corresponding to slip of 0.5 mm and 1 mm if possible.

9. Compare the results of round bar and deformed bar.

Sketch all necessary figures about the test

Experimental Data and Results

Part A Compressive Strength, Modulus of Elasticity and Poisson's Ratio

Gage length of Compressometer	
Gage length of Extensometer	

Specimen No.	Area (cm^2)	Weight (kg)	Age (days)	Crushing load (kg)	Crushing strength (ksc)
1					
2					
3					

Specimen No.	σ_e (ksc)	σ_c (ksc)	E_i (ksc)	E_t (ksc)	E_s (ksc)	μ
1						
2						
3						
Average						

Part B Splitting Tensile Strength of Cylindrical Concrete Specimens

Specimen No.	Age (days)	d (cm)	l (cm)	P (kg)	T (ksc)	T_{av} (ksc)
1						
2						
3						

Part C Flexural Strength of Concrete

Age of specimens (days)						
Span length (cm)						
Loading condition						
Specimen No.	P (kg)	M (kg-cm)	Width # 1 (cm)	Width # 2 (cm)	σ_b (ksc)	σ_{av} (ksc)
1						
2						
3						

Specimen No. 1					Specimen No. 2					Specimen No. 3				
Load (kg)	Compresometer		Extensometer		Load (kg)	Compresometer		Extensometer		Load (kg)	Compresometer		Extensometer	
	Dial Rdg	Def$^{\underline{n}}$	Dial Rdg	Def$^{\underline{n}}$		Dial Rdg	Def$^{\underline{n}}$	Dial Rdg	Def$^{\underline{n}}$		Dial Rdg	Def$^{\underline{n}}$	Dial Rdg	Def$^{\underline{n}}$

Revised by BST, Department of Civil Engineering, Chulalongkorn University @ 2005

Part D Concrete Bond Test

	No.1	No.2	No.3	No.4
Compressive Strength, f_c' (ksc)				
Type of reinforcement				
Diameter of bar, cm				
Embedded length, cm				
Age of concrete, days				

Specimen No.	Maximum Bond Stress (kg/cm^2)	Bond Stress at 0.5 mm slip (kg/cm^2)	Bond Stress at 1 mm slip (kg/cm^2)
1			
2			
3			
4			

Sample of Calculations

Specimen No. 1				Specimen No. 2				Specimen No. 3				Specimen No. 4			
Slip (mm)	Load (kg)	Slip (mm)	Load (kg)	Slip (mm)	Load (kg)	Slip (mm)	Load (kg)	Slip (mm)	Load (kg)	Slip (mm)	Load (kg)	Slip (mm)	Load (kg)	Slip (mm)	Load (kg)

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