CONCRETE TECHNOLOGY LABORATORY

DEPARTMENT OF CIVIL ENGINEERING
CHULALONGKORN UNIVERSITY

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

TEST No. C-7

NON-DESTRUCTIVE TEST OF HARDENED CONCRETE

Part A Pulse Velocity Through Concrete

Objective To determine the pulse velocity of propagation of compressional waves in concrete, for the purpose of comparatively determining the condition of concrete.

Reference ASTM Designation : C 597

Apparatus A set of Portable Ultrasonic Non-destructive Digital Indicating Tester (PUNDIT)
(a) Pulse Generator Circuit and Transducer
(b) Receiving Circuit and Transducer
(c) Time Measuring Circuit and Display Unit

Significance and Use

1. This method covers the determination of the pulse velocity of propagation of compressional waves in concrete. For the purpose of comparatively determining the condition of the concrete. This method can also be used to advantage to access the uniformity of field concrete, to indicate changes in characteristics in concrete, and in the survey of field structures to estimate the severity of deterioration, cracking or both.

2. The results obtained by the use of this method should not be considered as a means of measuring strength nor as an adequate test for establishing the compliance of the modulus of elasticity of the field concrete with that assumed in design. The procedure is applicable in both field and laboratory testing regardless of size or shape of the specimen, within the limitations of available pulse energy sources.

3. The method concerns itself with the measurement of the velocity to propagation of groups of compressional waves in concrete and does not apply to the propagation of other vibrations within the material. The pulse velocity is independent of the dimension of the body provided that reflected waves from boundaries do not complicate the determination of the arrival time of the directly transmitted pulse.

Procedures

1. Determination of Calibration Correction

Where time intervals are measured, check the accuracy of the measurement against a calibration circuit. Any difference between the reading and the calibration circuit indication (this is a calibration correction) must be included in the determination of the traveling time. Check the calibration over a range including both the zero correction reading (2) and the received pulse reading.

2. Determination of Zero Correction

Apply zero time correction to the measured time intervals. The zero correction is equal to the travel time between the transmitting and receiving transducers with zero thickness of concrete between the two. A control is provided to set the output to zero when the transducers are held face to face or when setting to a reference bar.

3. Determination of Travel Time in Concrete[1]

Press the faces of the transducers against the faces of the concrete after establishing contact through a coupling medium. Wetting the concrete with water, oil or other viscous materials may be used to exclude entrapped air from between the contact surfaces of the diaphragms of the transducer and the surface of concrete. Measure the length of the shortest direct path between the centers of the diaphragms and the time of travel between the transmitted and received pulse.

(a) Because the effective beam width of the transducers is wide they need not be pointing at each other. Transmission times can be measured across corners of structures or along one face, although in the latter case the maximum range is reduced.

(b) For greater accuracy in the time measurement increase the amplifier gain until the wave front of the received signal is as nearly vertical as possible, to provide best delineation of the received signal. The error due to rounding off the received wave is then minimized.

(c) Where pulse velocity measurements on large structures require the use of long interconnecting cables. The accuracy of the measurement may be reduced.

3. Determination of Velocity

The pulse velocity through concrete can be calculated as follows:

$$V = \frac{L}{T} = \sqrt{\frac{gE_d(1-\mu)}{\rho(1+\mu)(1-2\mu)}}$$

[1]In this test, you may use concrete cylinders casted in Test C-7 as test specimens.

Where V is pulse velocity, L is path length, T is effective time (measured time minus zero time correction), E_d is dynamic elastic modulus[2], μ is Poisson's ratio[3] and ρ is density of concrete.

4. Determination of Compressive Strength

The compressive strength of can be indirectly estimated from the relationship between dynamic elastic modulus and static elastic modulus (Young's modulus) as follows:

$$E_c = 1.25E_d - 19$$

where E_d is dynamic elastic modulus, E_c is static elastic modulus and unit in GPa. Since the static elastic modulus has been estimated, the compressive strength of concret can also be estimated from the relationship between elastic modulus and strength which is generally known.

Part B Rebound Number of Hardened Concrete

Objective — To determine the rebound number of hardened concrete which has close relation with compressive strength of concrete by using a spring-driven steel hammer (Schmidth Hammer).

Reference — ASTM Designation : C 805

Apparatus
(1) Rebound Hammer (Schmidth Hammer)
(2) Abrasive stone

Significance and Use

1. The rebound number determined by this method may be used to access the uniformity of concrete in situ, to delineate zones or regions (areas) of poor quality or deteriorated concrete in structures, and to indicate changes with time in characteristics of concrete such as those caused by the hydration of cement so that it provides useful information in determining when forms and shoring may be removed.

2. This test method is not intended as an alternative for strength determination of concrete.

3. Optimally, rebound number should be correlated with core testing information. Due to the difficulty of acquiring the appropriate correlation data in a given instance, the rebound number is most useful for rapidly surveying large areas of similar concretes in the construction under consideration.

---

[2]Dynamic modulus of elasticity, E_d is the modulus which can be dynamically determined. However, the physical meaning is exactly the same as static modulus of elasticity, E_c. It is usually used in the calculation of wave's velocity in solid media.

[3]0.15-0.24 for normal concrete, however, 0.20 is recommended.

Procedures

1. Calibration of Hammer

Carefully calibrate hammer every time before use. Follow the instruction manual of each hammer.

2. Selection of the Test Surface

Concrete member to be tested shall be at least 100 mm (4 in) thick and fixed within a structure. Smaller specimens must be rigidly supported. Area exhibiting honeycombing, scaling, rough texture or high porosity should be avoided.

For convenience, you may use concrete cylinders casted in Test C-7 as test specimens.

3. Preparation of Test Surface

A test area shall be at least 150 mm (6 in) in diameter. Heavily textured, soft or surfaces with loose mortar shall be ground smooth with the abrasive stone. Smooth-formed or troweled surfaces shall be tested without grinding.

4. Testing

a) Firmly hold the instrument in a position that allows the plunger to strike perpendicularly to the tested surface. Gradually increase the pressure on the plunger until the hammer impacts.

b) After impact, record the rebound number. Take ten reading from each test area. No two impact test shall be closer together than 25 mm (1 in). Examine the impression made on the surface after impacted, and disregard the reading if the impact impact crushes or breaks through a near surface air void.

c) Discard readings differing from the average of 10 readings by more than 7 units and determine the average of the remaining readings. If more than 2 readings differ from the average by 7 units, discard the entire set of readings.

d) The rebound number used for estimation of concrete strength should be calculated from

$$R = (C * Rdg) + Q$$

where R is rebound number (to the nearest 0.5), C is coefficient of the hammer (Nominal value/Calibration value), Rdg is nominal impact reading and Q is correction for the inclination of impact as shown in the following table:

Rdg	Upward		Downward	
	+90 degree	+45 degree	-45 degree	-90 degree
10	NA.	NA.	+2.4	+3.2
20	-5.4	-3.5	+2.5	+3.4
30	-4.7	-3.1	+2.3	+3.1
40	-3.9	-2.6	+2.0	+2.7
50	-3.1	-2.1	+1.6	+2.2
60	-2.3	-1.6	+1.3	+1.7

Part C Rebar Location

Objective — To determine the location of rebars, measuring the concrete cover and bar's diameter by Rebar Locator.

Apparatus — A set of Rebar Locator.

Procedures — Follow the instruction of PROFOMETER 3.

Sketch all necessary figures about the test

Experimental Data and Results

Part A Pulse Velocity Through Concrete

Sample	Path	Length (cm)	Travel Time (sec)	Velocity (m/s)
Cylinder No. 1				
	Average velocity (m/s)			
	Dynamic elastic modulus (GPa)			
	Static elestic modulus (ksc)			
	Estimated compressive strength (ksc)			
Cylinder No. 2				
	Average velocity (m/s)			
	Dynamic elastic modulus (GPa)			
	Static elestic modulus (ksc)			
	Estimated compressive strength (ksc)			
Cylinder No. 3				
	Average velocity (m/s)			
	Dynamic elastic modulus (GPa)			
	Static elestic modulus (ksc)			
	Estimated compressive strength (ksc)			
Average compressive strength (ksc)				

Part B Rebound Number of Hardened Concrete

Schmidth Hammer Test

No.	Calibration Test (Standard steel)	Concrete cylinders test		
		No.1	No.2	No.3
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
Average				
Coefficient of hammer, C				
Correction for inclination, Q				
Rebound number, R				
Cylinder strength (ksc)				

Direct Compressive Strength Test (Destructive Test)

	Concrete cylinders		
	No.1	No.2	No.3
Weight (kg)			
Diameter (cm)			
Area (cm2)			
Height (cm)			
Density (kg/cu.m)			
Maximum load (kg)			
Comp. Strength (ksc)			

Sample of Calculations

Discussion and Conclusion

Summary of Results

	Compressive strength of concrete from different test method		
	Pulse Velocity	Hammer Test	Compression Test
No.1			
No.2			
No.3			
Average			

Sketch of the rebar location (Part C)