



**STUDY GUIDE  
WACEL  
CONCRETE I**

**JUNE 2011**

## **CONCRETE I STUDY GUIDE**

### **Scope:**

A technician who successfully earns the WACEL Concrete I certification has demonstrated in writing and in practice his or her ability to conduct basic quality control testing for concrete. In addition, he or she will have a basic understanding of how concrete as a construction material works. This includes concrete materials, the hydration and strength-gain process, water-cementitious materials ratio, admixtures, air entrainment, and ready-mixed concrete specifications.

### **Examinations:**

The Concrete I written examination is based on the following references. It will be 2 hours in length and is a closed-book examination. A grade of 80 percent or better is required for passing. A calculator is authorized. Scratch paper will be provided, and it must be turned in at the completion of the examination.

In addition, the Concrete I technician candidate must successfully pass a practical examination that demonstrates his or her ability to properly conduct the following quality control tests: obtaining a composite sample, temperature, slump, density (unit weight), air content (pressure and volumetric method), and casting compressive strength cylinders. The practical examination is graded on a pass/fail basis.

Both written and the practical examinations must be successfully passed within 90 calendar days of each other for the Concrete I certification to be issued.

### **Required References:**

- A. ASTM C 31-09, Making and Curing Concrete Test Specimens in the Field.
- B. ASTM C 94-09a, Specifications for Ready-Mixed Concrete.
- C. ASTM C 143-10, Slump of Hydraulic Cement Concrete.
- D. ASTM C 138-09, Density (Unit Weight) of Concrete.
- E. ASTM C 172-08, Sampling Freshly – Mixed Concrete.
- F. ASTM C 173-10, Air Content of Freshly Mixed Concrete by the Volumetric Method.
- G. ASTM C 231-09b, Air Content of Freshly Mixed Concrete by the Pressure Method.
- H. ASTM C 1064-08, Temperature of Freshly-Mixed Portland Cement Concrete.
- I. Concrete Inspection Handbook, Fourth Edition, Portland Cement Association, 2005.
- J. Design and Control of Concrete Mixtures, Portland Cement Association, 14<sup>th</sup> Edition, 2002 (Chapters 1, 8, 12, 13, 14 and 16).

**Learning Objectives: (see WACEL skills matrix for Concrete Inspectors)**

- I. Fundamentals of Concrete (ASTM C94, References I and J).
  - A. Knows that the basic ingredients used in making concrete are cement, water, coarse aggregate, and fine aggregate.
  - B. Has a basic understanding of the various quality indicators that can be used to evaluate either freshly-mixed or hardened concrete with an emphasis on compressive strength.
  - C. Understand that hydration is a complex chemical process that produces heat.
  - D. Knows that for hydration or the strength gain of the concrete to be maximized, temperature, moisture, and vibrations must be controlled.
  - E. Understands the importance of the water-cement ratio in predicting the ultimate strength of the concrete.
    - 1. Knows to sample after job-site water, if, any, is added.
    - 2. Is aware of the importance of reporting the amount of job-site water added.
    - 3. Provided the necessary testing information with aggregate in saturated surface dry condition, can calculate a basic water-cement ratio.
  - F. Is familiar with the effects of and the reasons for the use of air-entraining admixtures.
    - 1. Knows the expected range of air content in non-air entrained concrete will generally be less than 2 percent.
    - 2. Knows that slump, temperature, and air content tests must be taken whenever compressive strength cylinders are prepared.
    - 3. Is knowledgeable of the effects of air entrainment on increasing workability, decreasing bleeding, increasing freeze-thaw resistance, and decreasing compressive strength.
  - G. Understands the purpose and content of approved concrete mix designs and how to determine what approvals are required.
  - H. Knows what information is or should be available on the batch ticket with particular attention to mix designations and batch time.
    - 1. Can demonstrate an ability to locate specified batch-to-placement time limitations.
    - 2. Knows how to correctly compute batch-to-placement time.
    - 3. Knows what to do if an unapproved mix designation is found on a batch ticket.
  - I. Has basic understanding of the need for the proper curing of concrete to include cold weather and hot weather concreting as defined by the American Concrete Institute (ACI) and often local code requirements.
- II. Knows how to properly sample freshly-mixed concrete (ASTM C 172).
  - A. Understands the meaning of composite samples.
  - B. Knows how to determine the frequency and randomness of obtaining representative samples for testing.

- C. Can properly obtain a composite sample from a ready-mixed truck.
- D. Understands why sampling is not started until job-site water and admixtures, if any, are added.
- E. Knows the time limitations associated with sampling and testing as contained in ASTM C 172.
- F. Knows how to determine the size of the composite sample to be taken based on the required tests and the quantity of compressive strength cylinders to be made (minimum 1 cubic foot, if compressive strength cylinders are being made).
- G. Knows how to protect the composite sample.

III. Can properly take concrete temperature (ASTM C 1064).

- A. Understands that temperature measuring devices require calibration at least annually.
- B. Knows that the acceptable temperature ranges for freshly-mixed concrete are defined by the American Concrete Institute and/or project specifications.
- C. Is aware of the minimum concrete cover and time requirements when taking the temperature of concrete.
- D. Knows that the temperature measuring device must be left in the fluid concrete for at least 2 minutes but not more than 5 minutes for an acceptable reading.
- E. Knows to wait until temperature readings have stabilized before recording the result.
- F. Knows the accuracy to which temperature readings are taken and recorded.

IV. Can properly perform a slump test (ASTM C 143).

- A. Understands the purpose of testing the slump of plastic concrete.
- B. Knows where to find the allowable range of slump values for a particular type of concrete.
- C. Knows what equipment is needed to properly conduct a slump test.
- D. Can correctly follow the testing procedure prescribed in ASTM C 143.
- E. Knows how to properly measure the slump of concrete to include the required accuracy.
- F. Knows what to do if the concrete subsides below the top of the mold while rodding the top layer.
- G. Is aware of the time limitation for the conduct of this test.

- V. Can properly test for concrete density (unit weight) (ASTM C 138).
  - A. Is familiar with the differences between normal weight and lightweight concrete.
  - B. Knows what tools and equipment are required to properly conduct a density (unit weight) test.
  - C. Is aware of the calibration requirements for unit weight equipment.
  - D. Knows how to determine acceptable ranges of the density (unit weight) of fresh concrete.
  - E. Knows how to determine the correct size of container to use based on the nominal, maximum size of coarse aggregates (in particular for 1 inch and 2 inch coarse aggregate).
  - F. Can properly complete the specified steps in ASTM C 138 to correctly conduct a unit density (unit weight) test.
  - G. Provided with the necessary test information, can correctly compute unit weight.
  - H. Knows the accuracy to which density (unit weight) results are reported. (63)
  - I. Can compute the weight of a cubic yard of concrete given its density (unit weight).
  
- VI. Can correctly test for air entrainment (Pressure Method: ASTM C 231 and Volumetric Method: ASTM C 173).
  - A. Pressure Method (ASTM C 231)
    - 1. Knows that testing for air by the Pressure Method can only be used for normal weight concrete.
    - 2. Knows where to find acceptable range of air content values for the concrete being tested.
    - 3. Can correctly follow the testing procedures prescribed in ASTM C 231.
    - 4. Understands what "Initial Pressure" is and how it is determined.
    - 5. Knows the accuracy to which the air content is read.
    - 6. Understands the reason for an "Aggregate Correction Factors"; how it is determined; and, if provided or computed, how it effects the recorded air content of the concrete being tested.
  
  - B. Volumetric Method (ASTM C 173)
    - 1. Knows the principle by which this test works and why it can be used for either lightweight or normal weight concrete.
    - 2. Can correctly and completely follow the required testing procedures listed in ASTM C 173.
    - 3. Knows the accuracy to which the air content is read.
    - 4. Knows that, even if provided, an Aggregate Correction Factor is not used to adjust the results of this test.

- VII. Can properly cast, store, and transport concrete cylinders (ASTM C 31).
- A. Knows the two standard cylinder mold sizes authorized by ASTM C 31 and the limits on the nominal maximum coarse aggregate size for each.
  - B. Can determine how many test specimens are required for a given test. Knows how many are to be designated as field-cured and how many laboratory-cured.
  - C. Knows how to determine if a particular set of compressive strength test specimens are to be consolidated by rodding or vibration.
  - D. Knows the allowable range of temperatures for the initial curing of test specimens.
  - E. Knows how to properly prepare test specimens as prescribed in ASTM C 31. This includes the procedural differences when using 6x12 inch molds or 4x8 inch molds.
  - F. Is aware of the criticality of properly marking test specimens so they can be traced to the concrete placement they represent.
  - G. Understands the reasons for and the handling differences between field-cured and laboratory-cured test specimens.
  - H. Knows the time limits for and the handling limitations for transportation of laboratory-cured specimens.
- VIII. Can prepare thorough and legible field reports.

## WACEL CONCRETE/MASONRY INSPECTORS SKILLS MATRIX

Skill	Concrete I	Concrete II	Structural Concrete/ Masonry Inspector
1. Understands the fundamentals of concrete at the basic level:	X	X	
a. Components	X	X	
b. quality indicators	X	X	
c. Hydration	X	X	
d. water-cement ratio	X	X	
e. air entrainment	X	X	
f. approved mix designs	X	X	
g. batch tickets	X	X	
h. curing to include cold and hot weather concreting	X	X	
2. Can determine specified testing requirements.	X	X	
3. Knows how to properly sample freshly mixed concrete.	X	X	
4. Can properly take concrete and air temperature.	X	X	
5. Can properly perform a slump test.	X	X	
6. Can properly test for concrete density (unit weight).	X	X	
7. Can test for air entrainment (pressure and volumetric).	X	X	
8. Can properly cast, store and transport concrete cylinders.	X	X	
9. Can properly cast, store and transport concrete beams.	X	X	
10. Can prepare thorough and legible field reports.	X	X	
11. Knowledge of ACI and ASTM concrete requirements.		X	
12. Can properly monitor and test grout and mortar.		X	
13. Can inspect simple reinforced masonry (storage & placement of materials, mixing, grout and mortar, reinforcement and anchorage).		X	
14. Can inspect batch plant operations.		X	
15. Can interpret plans, specifications, shop drawings and details for material, dimension, size and location.		X	
16. Can perform visual inspection of reinforcing steel placement.		X	
17. Has knowledge of proper handling and placement of epoxy-coated rebar.		X	
18. Can inspect basic vertical and horizontal formwork.		X	
19. Can perform post-tensioned concrete inspections.			X
20. Can inspect complex reinforced masonry above the basic level (post-tensioned, non-standard details, etc.).			X
21. Can perform observations,, inspections, and testing for tilt-up concrete structures.			X

22. Understands advanced topics for concrete as a construction material:			X
a. Density			X
b. Permeability			X
22. Understands advanced topics for concrete as a construction material:			X
c. Freeze-thaw resistance			X
d. Alakali-silica reactivity (ASR)			X
e. Cement properties			X
f. Aggregates for concrete			X
g. Air entrainment			X
h. Chemical admixtures			X
i. Mixing, transportation & handling			X
j. Proper placement			X
k. Consolidation			X
l. Slabs on grade			X
m. Patching, finishing and cleaning			X
n. Curing			X
o. Hot weather concreting			X
p. Cold weather concreting			X
q. Advanced control tests			X
r. Special types of concrete			X

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