



# CONCRETE MANUAL WORKBOOK

2015 IBC® AND ACI 318-14



# Concrete Manual Workbook

## Based on the 2015 IBC and ACI 318-14

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## INTRODUCTION

This workbook is intended to provide practical learning assignments for independent study of the *Concrete Manual*. The independent study format provides a method for the student to complete the study program in an unlimited amount of time. Proceeding through the workbook, students can measure their level of knowledge by using the quizzes in each study session.

All study sessions contain specific learning objectives, a list of statements and questions summarizing the key points for study, and quizzes designed to assess the student's retention of technical knowledge. Therefore, before beginning the quizzes, students should thoroughly review the corresponding chapters of the *Concrete Manual* concerning the learning objectives and key points.

The quizzes are designed to encourage students to develop the habit of carefully reading the text for a clear understanding of the subject material. The questions are not intended to be tricky or misleading. The following three formats are used to vary the method of evaluation:

1. Multiple choice—Each statement is followed by a unique group of possible responses from which to choose.
2. True/False—Each statement is either true or false.
3. Completion—Each statement must be correctly completed by inserting the proper *Concrete Manual* text.

The workbook is structured so that every question is followed by the opportunity for students to record their responses and the corresponding text reference. The correct responses are indicated at the back of the workbook in the answer key so that students can assess their knowledge immediately.



## **ACKNOWLEDGMENTS**

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Mr. Hunsicker was the Assistant Building Official with the City of Visalia, California. He has been active in the construction field for more than 25 years, with more than 15 years dedicated to the field of building inspection. Mr. Hunsicker holds degrees in Building Inspection Technology and Vocational Education. His writing credits include two other inspection-related workbooks published by ICC.

Since initial publication, the Concrete Manual Workbook has been updated by Gerald B. Neville, author of the Concrete Manual, to reflect later editions of the IBC and ACI 318.



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# CHAPTER 1

## FUNDAMENTALS OF CONCRETE

**Objectives:** To outline a brief history of cement and concrete, describe the hydration process, identify the characteristics of concrete, introduce the role of admixtures and the water-cement ratio, define “good, durable concrete” and the causes of distress or failure, and briefly discuss the five fundamentals of concrete.

**Lesson Notes:** Special attention should be given to the nine properties of good, durable concrete (they will be discussed in detail in subsequent chapters) and their relationship to the five fundamentals of concrete construction.

### Key Points:

- From where does the term *pozzolan* originate?
- Who first developed Portland cement?
- What led to the large-scale production of cement?
- What is the first basic law of concrete technology?
- Describe the hydration process.
- For how long will the hydration process continue?
- What affects the rate of hydration?
- What is generated during hydration?
- Describe the difference between concrete, mortar and grout.
- What are the characteristics of fresh concrete?
- Define green concrete.
- Describe the water-cement ratio law.
- What factors contribute to concrete strength and durability?
- In what ways do admixtures modify concrete’s properties?
- Define the properties of “good, durable concrete.”
- Name three general reasons for the distress or failure of concrete.
- What facts should be considered when investigating a concrete failure?
- Name the five fundamentals of concrete construction.
- What is the most probable cause of distress in concrete?
- What does the term *workmanship* mean?
- How does maintenance affect a structure?



## CHAPTER 1—QUIZZES

### I Multiple Choice

1. Who developed the first Portland cement by burning limestone and clay at high temperatures?
- a. Romans
  - b. Aspdin
  - c. Eddystone
  - d. Smeaton
  - e. Greeks

Response \_\_\_\_\_ Reference \_\_\_\_\_

2. Which one of the following is not one of the five fundamentals of durable concrete?
- a. material selection
  - b. proper structure design
  - c. reasonable cost
  - d. site investigation
  - e. workmanship

Response \_\_\_\_\_ Reference \_\_\_\_\_

3. Fresh concrete is \_\_\_\_\_.
- a. green
  - b. plastic
  - c. newly placed
  - d. self-supporting
  - e. none of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

4. Hydration produces \_\_\_\_\_.
- a. heat
  - b. water
  - c. drying
  - d. cooling
  - e. shrinkage

Response \_\_\_\_\_ Reference \_\_\_\_\_

5. The first law of concrete to be researched and observed is the \_\_\_\_\_.
- a. hydration rate
  - b. admixture reaction
  - c. drying time/strength
  - d. volume stability
  - e. water-cement ratio

Response \_\_\_\_\_ Reference \_\_\_\_\_

## II True/False

6. Admixtures provide a means to achieve certain properties in fresh and hardened concrete.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
7. Good workmanship includes proper material selection.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
8. Deterioration of concrete is a maintenance concern only.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
9. Investigation of materials for the Hoover Dam resulted in development of low-heat of hydration cement.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
10. Portland cement is composed of lime and clay only.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_

## III Completion

11. Concrete with low strength and high moisture content, and that is only a few hours or days old, is referred to as \_\_\_\_\_ concrete.  
Reference \_\_\_\_\_
12. The property of concrete that resists attack by weather or substances is called \_\_\_\_\_.  
Reference \_\_\_\_\_
13. The forces of weather can be destructive to concrete through \_\_\_\_\_ and \_\_\_\_\_, which produce cracks, followed by the entrance of \_\_\_\_\_ into the cracks.  
Reference \_\_\_\_\_
14. Burnt \_\_\_\_\_ was first developed in early Egypt.  
Reference \_\_\_\_\_
15. The \_\_\_\_\_ process of cement manufacture led to large scale production of cement worldwide.  
Reference \_\_\_\_\_

## CHAPTER 2

### THE FRESH CONCRETE

**Objectives:** To obtain an understanding of the significance of workability, how it is measured, the factors affecting it and the concurrent properties of segregation, bleeding, unit weight and air content.

**Lesson Notes:** *Consistency*, *cohesiveness* and *plasticity* are terms that are interrelated but describe different aspects of concrete's workability. Consistency is a measure of wetness or fluidity. Cohesiveness indicates whether concrete is harsh (low adhesion), sticky (high adhesion) or plastic (good adhesion and not easily segregated). Plasticity is the quality of fresh concrete that allows concrete to be molded or formed into a final configuration without segregation when properly handled.

#### Key Points:

- Define the terms *workability* and *plasticity*.
- What three terms are used to describe the workable aspects of concrete?
- Define consistency.
- What test measures consistency?
- What effect does temperature have on slump?
- What is meant by the term *cohesiveness*?
- What does a harsh concrete mix lack?
- Where might a harsh concrete mix be desirable?
- What is a common occurrence in a sticky concrete mix?
- Identify the factors that can affect workability.
- What is meant by the term *false set*?
- What is meant by the term *flash set*?
- How does aggregate affect workability?
- How might admixtures affect workability?
- Define the term *segregation*.
- In hardened concrete, what can be the result of segregation?
- Which type of concrete mixes tend to segregate?
- What is bleeding, and where does it occur most frequently?
- What can influence bleeding?
- Name the detrimental effects of too much bleeding.
- What is laitance?
- How would laitance affect a joint?
- Identify the causes of laitance.
- Define the terms *unit weight* and *yield of concrete*.
- Name the three ways to measure air content.
- How does air-entrainment affect concrete?



## CHAPTER 2—QUIZZES

### I Multiple Choice

1. The amount of air in nonair-entrained concrete is \_\_\_\_\_ percent.
- between one and two
  - at least three
  - as much as five
  - a maximum of eight
  - as high as ten

Response \_\_\_\_\_ Reference \_\_\_\_\_

2. The element of workability that indicates whether fresh concrete is plastic, sticky or harsh is \_\_\_\_\_.
- cohesiveness
  - consistency
  - slump
  - air content
  - water content

Response \_\_\_\_\_ Reference \_\_\_\_\_

3. Which one of the following is not a result of segregation?
- rock pockets
  - laitance
  - sand streaks
  - bleeding
  - scaling

Response \_\_\_\_\_ Reference \_\_\_\_\_

4. A harsh and unworkable concrete mix can result from \_\_\_\_\_.
- finely ground cement
  - fine aggregate
  - adding pozzolans
  - low cement content
  - rounded or subrounded aggregates

Response \_\_\_\_\_ Reference \_\_\_\_\_

5. A sticky concrete mix usually contains a high \_\_\_\_\_ content.
- air
  - aggregate
  - cement or rock dust
  - water and pozzolans
  - pozzolans

Response \_\_\_\_\_ Reference \_\_\_\_\_

## II True/False

6. One of the most important properties of fresh concrete is workability.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
7. The type of structural element does not determine workability.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
8. Grading of coarse aggregate is more critical than grading of fine aggregate.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
9. Entrained air can cause segregation.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
10. A well-graded sand usually produces a low bleeding rate in concrete.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_

## III Completion

11. Air-entrainment can improve workability, lower \_\_\_\_\_ and reduce \_\_\_\_\_.  
Reference \_\_\_\_\_
12. The weight of 1 cubic foot of concrete is referred to as \_\_\_\_\_.  
Reference \_\_\_\_\_
13. Concrete that is fluid enough to flow into place without \_\_\_\_\_ or \_\_\_\_\_ will \_\_\_\_\_.  
Reference \_\_\_\_\_
14. Low-slump concrete mixes are commonly used for \_\_\_\_\_, \_\_\_\_\_ and \_\_\_\_\_.  
Reference \_\_\_\_\_
15. \_\_\_\_\_, especially in flat slabs, is accompanied by a slight settlement of solid particles.  
Reference \_\_\_\_\_



## CHAPTER 3 THE STRENGTH OF CONCRETE

**Objectives:** To understand the importance of strength, the kinds of strength, how strength is measured and the various factors affecting strength.

**Lesson Notes:** Concrete is well known for its compressive strength. However, there are many factors that may affect this strength. By examining Table 3.3, you will gain an understanding into the causes and effects of some of these factors.

### **Key Points:**

- At what age is concrete usually tested?
- What is the basis for acceptance or rejection of concrete?
- Other than strength, what properties of concrete can be significant?
- What is the standard size cylinder for testing compressive strength of concrete?
- Define the “modulus of rupture.”
- What test is a good indicator of tensile strength in concrete?
- What are the four basic methods by which concrete can be tested?
- What is a job-molded specimen?
- How does a Swiss hammer work?
- Describe how a Windsor probe tests concrete strength.
- What is one problem with strength tests?
- How does a high-water content affect concrete?
- How do aggregates affect strength?
- When are larger aggregates used?
- When are smaller aggregates used?
- Identify the three relationships between aggregates and concrete strength.
- What are considered to be the maximum amounts of rock dust or other fine materials acceptable in coarse and fine aggregate?
- How should organic matter be dealt with?
- How does aggregate moisture affect concrete batching?
- What types of chemicals are not acceptable in concrete mixing water?
- Is the volumetric measurement of ingredients good practice? Name the batching errors that may contribute to reduced concrete strength.
- What is considered the optimum temperature for placing concrete?
- Describe how freezing affects concrete strength.
- When is rapid strength development advantageous?
- Name the five methods to accelerate concrete strength.
- What type of cement is high-early, and how does it differ from other cements?
- When is calcium chloride not acceptable as an admixture in concrete?
- How might insulating forms contribute to curing?
- Where is high-temperature curing most frequently used?
- How would an overdose of a retarder admixture affect concrete strength?
- What occurs when concrete is placed and kept at near freezing?
- At what psi is concrete considered high strength?
- Where might high-strength concrete be used?

- At what age are specimens of 10,000 psi concrete usually tested?
- In what way can fire damage concrete?

## CHAPTER 3—QUIZZES

### I Multiple Choice

1. For valuation and acceptance of concrete, compressive strength tests are usually done when the specimens have been aged for \_\_\_\_\_ days.
- a. 7
  - b. 14
  - c. 21
  - d. 28
  - e. 56

Response \_\_\_\_\_ Reference \_\_\_\_\_

2. Other factors aside, the best range of temperature for placing concrete is between \_\_\_\_\_ °F.
- a. 20 to 40
  - b. 40 to 80
  - c. 50 to 90
  - d. 60 to 90
  - e. 40 to 120

Response \_\_\_\_\_ Reference \_\_\_\_\_

3. High-early-strength cement is made by increasing the amount of tricalcium silicate and \_\_\_\_\_.
- a. calcium chloride
  - b. hydration
  - c. air-entrainment
  - d. high-temperature curing
  - e. finer grinding of the cement

Response \_\_\_\_\_ Reference \_\_\_\_\_

4. MSA stands for \_\_\_\_\_.
- a. modified-strength admixture
  - b. maximum size aggregate
  - c. modulus of shear axial
  - d. minimum size aggregate

Response \_\_\_\_\_ Reference \_\_\_\_\_

5. Mineral admixtures used to achieve strengths between 8,000 and 20,000 psi are \_\_\_\_\_.
- a. pozzolans and chert
  - b. chert and ground manganese
  - c. caliche and rock dust
  - d. fly ash and silica fume
  - e. calcium and aluminum silicate

Response \_\_\_\_\_ Reference \_\_\_\_\_

6. A type of aggregate that should be avoided on account of its effects on strength is \_\_\_\_\_.
- a. crushed quartz
  - b. any of glacial origin that contains organic matter
  - c. any with a high specific gravity
  - d. granite
  - e. all of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

7. Test specimens are valuable in that they give a measure of \_\_\_\_\_ and other properties of the concrete.
- a. specific gravity
  - b. strength potential
  - c. density
  - d. durability resistance
  - e. all of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

8. A source of batching errors is \_\_\_\_\_.
- a. careless operation
  - b. allowance for moisture variables in aggregates
  - c. scales returning to zero between batches
  - d. placing methods
  - e. all of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

9. Compressive strength of precast and prestressed concrete elements is typically specified to \_\_\_\_\_.
- a. below 2,000
  - b. 2,500 to 3,500
  - c. 3,000 to 4,000
  - d. d.4,000 to 7,000

Response \_\_\_\_\_ Reference \_\_\_\_\_

10. The strength of concrete most commonly measured is \_\_\_\_\_.

- a. compressive strength
- b. flexural strength
- c. tensile strength
- d. none of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

11. As compared to the compressive strength of a 6-inch by 12-inch cylinder, the compressive strength of a 4-inch by 8-inch cylinder will generally be \_\_\_\_\_.

- a. significantly lower
- b. slightly lower
- c. about the same
- d. higher

Response \_\_\_\_\_ Reference \_\_\_\_\_

12. The modulus of rupture of concrete is a measure of the \_\_\_\_\_.

- a. compressive strength
- b. tensile strength
- c. flexural strength
- d. shear strength

Response \_\_\_\_\_ Reference \_\_\_\_\_

13. Tensile strength of concrete can be measured indirectly by a \_\_\_\_\_.

- a. compressive strength test
- b. flexural strength test
- c. split cylinder test
- d. direct tension test

Response \_\_\_\_\_ Reference \_\_\_\_\_

14. Cores taken from near the top of a column will generally indicate \_\_\_\_\_ strength, compared with cores taken from near the bottom of the same column.

- a. higher
- b. lower
- c. about the same
- d. slightly higher

Response \_\_\_\_\_ Reference \_\_\_\_\_

15. Commonly, the major causes of compressive strength test variation are \_\_\_\_\_.

- a. cement composition variations
- b. water-cement ratio variations
- c. cement temperature variations
- d. mixing speed variations

Response \_\_\_\_\_ Reference \_\_\_\_\_

16. Concrete proportioned at the same water-cement ratio and made with well-graded aggregates having a maximum size of \_\_\_\_\_ will have the higher strength.

- a.  $\frac{3}{8}$  inch
- b.  $\frac{3}{4}$  inch
- c.  $1\frac{1}{2}$  inches
- d. 3 inches

Response \_\_\_\_\_ Reference \_\_\_\_\_

17. To gain strength rapidly during the first few days after placing, which one of the following can be used?

- a. high-early-strength cement
- b. an accelerating admixture
- c. curing at high temperature
- d. any of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

18. Concrete will gain strength slowly if \_\_\_\_\_.

- a. it contains an overdose of a water-reducing admixture
- b. it contains an overdose of a retarder
- c. it contains an overdose of an accelerator
- d. the concrete and air temperature are 80°F

Response \_\_\_\_\_ Reference \_\_\_\_\_

19. Concrete heated to 800°F for a long period of time and then cooled will have a permanent strength reduction of \_\_\_\_\_ percent.

- a. less than ten
- b. 10 to 40
- c. about 50
- d. 50 to 95

Response \_\_\_\_\_ Reference \_\_\_\_\_

20. HSC stands for \_\_\_\_\_.

- a. high-strength cement
- b. high-strength concrete
- c. hydrogen-sulfate cement
- d. high-shrinkage cement

Response \_\_\_\_\_ Reference \_\_\_\_\_

21. For structural concrete, the minimum specified compressive strength should not be less than \_\_\_\_\_ psi.

- a. 1500
- b. 2000
- c. 2500
- d. 3000

Response \_\_\_\_\_ Reference \_\_\_\_\_

22. Specified compressive strength of concrete above about \_\_\_\_\_ psi is considered high-strength concrete.

- a. 4000
- b. 6000
- c. 8000
- d. 10,000

Response \_\_\_\_\_ Reference \_\_\_\_\_

## II True/False

23. There is no field test for direct determination of tension under axial loading.

T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_

24. When concrete has to be cored to verify strength, damage to reinforcement is not of concern when the specified concrete strength is below 3,000 psi.

T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_

25. A common accelerator admixture that is added to the batch in solution is calcium chloride.

T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_

26. In general, load-bearing concrete members exposed to continuous heat in excess of 500°F should be avoided.

T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_

27. Watertightness is important in nearly all hydraulic structures.

T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_

28. Irregularly shaped natural gravel or cube-shaped crushed rock with a rough and slightly porous surface will give the best bond with the cement paste.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
29. Concrete that will be continuously exposed to temperatures greater than 150°F should be laboratory tested to determine if the expected temperature will be detrimental.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
30. Concrete made and cured at 50°F will have lower strength at three days but higher strength at 28 days than concrete made and cured at 90°F.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
31. Concrete strengths in the range of 6,000 to 10,000 psi at 56 days require new technology.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_

### III Completion

32. If concrete is placed and kept at a near-freezing temperature, the hydration process and strength gain will be \_\_\_\_\_.  
Reference \_\_\_\_\_
33. The \_\_\_\_\_ of \_\_\_\_\_ is a measure of flexural strength and can be determined by testing a beam specimen in flexure with a concentrated load at each of the \_\_\_\_\_ points. This beam is usually \_\_\_\_\_ by \_\_\_\_\_ inches in cross section.  
Reference \_\_\_\_\_
34. Five basic methods to accelerate the early strength of concrete are \_\_\_\_\_ cement, \_\_\_\_\_ admixtures, \_\_\_\_\_ heat of hydration, \_\_\_\_\_ curing and rapid-setting \_\_\_\_\_.  
Reference \_\_\_\_\_
35. Aggregates with a specific gravity less than \_\_\_\_\_, or having an absorption rate exceeding \_\_\_\_\_ percent, are usually deficient in strength.  
Reference \_\_\_\_\_
36. Two nondestructive instruments for checking the strength of hardened concrete are a \_\_\_\_\_ and a \_\_\_\_\_.  
Reference \_\_\_\_\_



## CHAPTER 4 THE DURABILITY OF CONCRETE

**Objectives:** To understand the property of concrete known as *durability* and the agencies of destruction that affect durability. Also considered are the effects of a marine environment and of hydraulic structures on durability, as well as the typical problems associated with slabs on ground and prevention of deterioration.

**Lesson Notes:** When concrete is found to lack durability, the most common cause by far is inferior workmanship—specifically the use of too much mixing water. A high water content can lead to segregation, laitance, rock pockets, cracking, weak permeable layers and porous concrete. Emphasis should be placed on using only the amount of water specified for the mix.

### Key Points:

- Define *durability*.
- To what properties of concrete is durability closely related?
- What are the six factors that affect durability?
- Name the three methods of measuring durability.
- Identify the four general categories of destructive agents.
- What are the necessary steps to protect concrete from destructive agents?
- What does petrographic examination reveal?
- What substances found in aggregates contaminate or weaken concrete?
- How might selection of cement type affect durability?
- How important is workmanship to durable concrete?
- In what way might mix proportions affect durability?
- List the substances that attack concrete.
- How does sea water deteriorate concrete?
- Identify a type of structure or exposure condition where each item listed in Table 4.1 might occur.
- How do acids affect concrete?
- What are some of the sources of acids?
- Why is calcium chloride an agent of deterioration?
- Which de-icing agents are best and worst for use on concrete?
- Explain how corrosion of steel reinforcement affects concrete.
- What are the effects of high temperatures on concrete's durability?
- What might be early indications of structural damage?
- What are the chief causes of structural damage?
- What are the factors that affect sulfate resistance?
- Name the types of aggregate that can be alkali-silica reactive.
- Describe the effect of alkali-silica reaction on concrete.
- What is the effect of freezing on fresh concrete?
- How does frost damage concrete?
- How can frost resistance of concrete be improved?
- How does good workmanship help concrete resist environmental attack?
- What are the main causes of slab-on-ground cracking?

- Define *scaling*, *spalling*, *subsidence*, *pumping* and *blowups* and the causes of each type of defect.
- Why is air-entrainment of concrete important?
- How is air-entrainment accomplished?
- What two points must be remembered about entrained air with respect to durability?

## CHAPTER 4—QUIZZES

### I Multiple Choice

1. Cavitation can be caused by \_\_\_\_\_.
  - a. surface depressions
  - b. surface projections
  - c. sharp bends
  - d. sudden changes in cross section
  - e. all of the aboveResponse \_\_\_\_\_ Reference \_\_\_\_\_
2. Concrete continually exposed to high temperature is affected primarily by \_\_\_\_\_.
  - a. frequent spalling
  - b. accelerated hardening
  - c. a reduction of strength
  - d. exhaust gases
  - e. high- and low-temperature extremesResponse \_\_\_\_\_ Reference \_\_\_\_\_
3. Concrete that expands and contracts abnormally may be caused by \_\_\_\_\_.
  - a. unsound aggregates
  - b. temperature changes
  - c. reaction between aggregates and cement
  - d. all of the above
  - e. none of the aboveResponse \_\_\_\_\_ Reference \_\_\_\_\_
4. Freezing of concrete in the plastic state will reduce durability, weather resistance and strength by as much as \_\_\_\_\_.
  - a. one-fourth
  - b. one-half
  - c. three-fourths
  - d. one-third
  - e. two-thirdsResponse \_\_\_\_\_ Reference \_\_\_\_\_

5. Poor durability in concrete is rarely caused by \_\_\_\_\_.

- a. water
- b. cement
- c. aggregate
- d. workmanship
- e. mix proportions

Response \_\_\_\_\_ Reference \_\_\_\_\_

6. Which one of the following is considered a reactive aggregate?

- a. feldspar
- b. quartz
- c. chert
- d. granite
- e. silica

Response \_\_\_\_\_ Reference \_\_\_\_\_

7. Of the following de-icing agents, which one is not recommended?

- a. calcium chloride
- b. urea
- c. sodium chloride
- d. ammonium sulfate
- e. all of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

## II True/False

8. Concrete slabs placed in the late fall can be exposed to de-icing salts during the first winter of exposure, provided adequate curing is accomplished.

T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_

9. Aluminum is attacked by caustic alkalies when exposed to moist concrete.

T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_

10. When a slab is placed directly on a fine-grained, plastic, impervious soil, the presence of moisture may create a condition known as pumping.

T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_

11. Normal weathering may cause a slight roughening of the surface or rounding of the edges but is not harmful to durable concrete.

T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_

12. One strength of concrete is its ability to strongly resist acids.

T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_

13. Entrained air does not improve the durability and other characteristics of concrete exposed to weather in severe climates.

T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_

14. Streams may not be a good source of water for concrete if the water contains sulfates, tannic acid, organic materials or sugar.

T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_

### III Completion

15. \_\_\_\_\_ and \_\_\_\_\_ improve the appearance of a structure, and sharp arris, which is subject to spalling and chipping from moving objects, is avoided.

Reference \_\_\_\_\_

16. The three types of waves that concrete structures should be designed for are \_\_\_\_\_, \_\_\_\_\_ and \_\_\_\_\_.

Reference \_\_\_\_\_

17. Movement of paving slabs or blocks on the face of an embankment of reservoirs, sea walls or dams may be caused by \_\_\_\_\_ back pressure upon sudden \_\_\_\_\_ of the water level.

Reference \_\_\_\_\_

18. When dealing with potential attack by chemical elements, either proper attention to produce \_\_\_\_\_ concrete or some sort of \_\_\_\_\_ should be provided to separate the concrete from the aggressive materials.

Reference \_\_\_\_\_

19. The six factors that affect the durability of concrete are the \_\_\_\_\_ characteristics, \_\_\_\_\_ properties, \_\_\_\_\_ conditions, imposed \_\_\_\_\_, \_\_\_\_\_ practices and \_\_\_\_\_.

Reference \_\_\_\_\_

20. \_\_\_\_\_ salts are destructive to concrete because, in the alkaline environment of concrete, they release \_\_\_\_\_ gas and \_\_\_\_\_ ions that must be placed by dissolving calcium from the concrete, resulting in a leaching action similar to a(n) \_\_\_\_\_ attack.

Reference \_\_\_\_\_



## CHAPTER 5

### VOLUME CHANGES AND OTHER PROPERTIES

**Objectives:** To understand the effects and control of shrinkage, the role of reinforcement, thermal properties, watertightness and the cause of fatigue. Also discussed are the acoustical, electrical and elastic properties of concrete.

**Lesson Notes:** Expansion and contraction are important to the dimensional stability of the structure, and creep or plastic flow may cause an undesirable change in the stresses distributed through the structure. Water is once again at the heart of most problems. As you are studying this chapter, note how factors such as shrinkage, bleeding and watertightness are directly or indirectly affected by the amount of water in the mix.

#### **Key Points:**

- At what point is concrete subject to shrinkage?
- Why does concrete shrink?
- Name the factors that affect shrinkage.
- Besides water loss, why else might concrete shrink?
- What is the most important factor in minimizing shrinkage?
- How would a water-reducing admixture affect shrinkage?
- What percent of sand should pass a 100-mesh screen? A 50-mesh screen?
- What is the recommended slump for slabs?
- How is water lost from concrete?
- Define *plastic* shrinkage.
- What happens when there is a rapid loss of bleed water?
- Describe the effects of low humidity and wind on plastic shrinkage.
- Can a minor change in weather have a great effect on evaporation? Explain using Figure 5-3.
- When is bleeding detrimental to concrete, and what are the negative effects?
- What is drying shrinkage?
- What has the greatest effect on drying shrinkage?
- How much drying shrinkage will occur with 300 pounds of water per cubic yard?
- What is the range of drying shrinkage?
- Name the factors that can help limit drying shrinkage.
- How does the volume of concrete change when it gets warm or cool?
- What can happen when concrete is restrained from movement?
- Do volume changes caused by temperature affect concrete differently than those caused by moisture?
- How does reinforcement affect shrinkage?
- Describe the chemical methods of drying shrinkage control.
- Why should aluminum powder not be used to control shrinkage.
- How could a volume change be measured?
- What is meant by the term *coefficient of expansion*?
- What is conductivity?
- Does concrete have a fairly high “*k*” value?
- Name the three things that influence concrete’s conductivity.

- What is the Btu range for concrete?
- Identify the ways in which the “*k*” value of concrete is important.
- Define *specific heat* and *diffusivity*.
- Define *modulus of elasticity*.
- What is the stress-strain curve of hardened concrete?
- What might the elastic modulus tell us about concrete?
- How is the modulus of elasticity related to compressive strength?
- Define *creep*.
- What is the difference between creep and plastic flow?
- What is the rate of creep in relationship to time?
- Name the two components of creep.
- Define *permeability*.
- On what does the permeability of concrete depend?
- How is porosity affected by the water-cement ratio?
- Name the three factors that are most important to the watertightness of concrete.
- List the six principles and precautions for obtaining watertightness of concrete.
- Describe two methods for minimizing moisture problems on enclosed slabs.
- Summarize the best way to obtain impermeable concrete.
- Is concrete an insulator or conductor?
- Define *yield*.
- Identify the factors that can contribute to loss of yield.



## CHAPTER 5—QUIZZES

### I Multiple Choice

1. Lack of watertightness in concrete can almost always be traced to \_\_\_\_\_ .
- a. porous aggregates
  - b. improper cement/aggregate proportions
  - c. poor construction practices
  - d. creep
  - e. waterproofing admixtures
- Response \_\_\_\_\_ Reference \_\_\_\_\_
2. When used as an accelerator \_\_\_\_\_ causes an increase in shrinkage.
- a. pozzolan
  - b. fly ash
  - c. calcium chloride
  - d. tricalcium aluminate
  - e. sandstone
- Response \_\_\_\_\_ Reference \_\_\_\_\_
3. Which one of the following does not affect shrinkage in concrete?
- a. water-cement ratio
  - b. aggregate grading
  - c. weather conditions
  - d. cement content
  - e. quality of curing
- Response \_\_\_\_\_ Reference \_\_\_\_\_
4. Moisture problems associated with slabs-on-ground can be minimized by \_\_\_\_\_ .
- a. installing a vapor barrier
  - b. laying a 1-inch sand base sub-base
  - c. using an admixture that helps to retain water
  - d. air-entrainment
  - e. using less water in the mix design
- Response \_\_\_\_\_ Reference \_\_\_\_\_

5. The rate at which a material conducts heat through a 1-inch thickness per unit of area is known as\_\_\_\_\_.
- a. Btu
  - b. diffusivity
  - c. "k" value
  - d. modulus
  - e. coefficient of expansion

Response \_\_\_\_\_ Reference \_\_\_\_\_

6. The property of concrete that indicates its ability to change in volume with changes in temperature is known as its \_\_\_\_\_.
- a. conductivity
  - b. coefficient of expansion
  - c. diffusivity
  - d. modulus of elasticity
  - e. dynamic creep

Response \_\_\_\_\_ Reference \_\_\_\_\_

7. Which one of the following factors will not help limit shrinkage in concrete?
- a. smallest size aggregate possible
  - b. proper consolidation
  - c. good workmanship
  - d. proper curing
  - e. intelligent use of admixtures

Response \_\_\_\_\_ Reference \_\_\_\_\_

## II True/False

8. Yield is defined as the volume of concrete per cubic yard.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
9. A critical factor for minimizing shrinkage in concrete is the total water per cubic yard.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
10. Reinforcing steel is rarely used to help control shrinkage.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
11. Concrete does not start losing water for about 15 to 20 minutes after placement unless Type III cement is used or concrete is in contact with earth.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
12. Creep is a time-dependent deformation of concrete under varying loads.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_

13. Entrained air decreases drying shrinkage, but because air entrainment requires the use of more water, the effect on shrinkage is negligible.

T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_

14. A small amount of bleeding is not detrimental to concrete and, in fact, can result in a slightly stronger paste.

T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_

### III Completion

15. \_\_\_\_\_ humidity in the air and \_\_\_\_\_ are the principle causes of high evaporation. However, \_\_\_\_\_ temperature can also be significant.

Reference \_\_\_\_\_

16. Aluminum is not an acceptable method to control shrinkage and should not be used in normal construction because of \_\_\_\_\_ and the possible \_\_\_\_\_ of strength.

Reference \_\_\_\_\_

17. Concrete is a \_\_\_\_\_ conductor of sound because it is a \_\_\_\_\_ material.

Reference \_\_\_\_\_

18. When water loss is fairly slow, the concrete can adjust to the reduction in \_\_\_\_\_, whereas a rapid loss of \_\_\_\_\_ water from the surface of a slab will introduce a \_\_\_\_\_ stress in the surface layer.

Reference \_\_\_\_\_

19. The modulus of elasticity is the \_\_\_\_\_ of a substance and is known by the letter \_\_\_\_\_.

Reference \_\_\_\_\_

20. Volume change is the \_\_\_\_\_ and \_\_\_\_\_ of concrete that results from temperature changes or \_\_\_\_\_ and drying. These changes are \_\_\_\_\_.

Reference \_\_\_\_\_



## CHAPTER 6

### CRACKS AND BLEMISHES

**Objectives:** To become familiar with the causes and prevention of cracks and blemishes and to obtain an understanding of how repairs to concrete are made.

**Lesson Notes:** The properties of concrete are all interrelated. When one symptom appears, we can be sure that other properties will be affected. Cracks and blemishes seen on the surface usually indicate a problem below the surface that cannot be seen.

#### Key Points:

- Cracking:
- Cracks and blemishes can result from a deficiency in which properties of concrete?
- Can cracking be prevented?
- Why does concrete crack?
- What are the main causes of cracking?
- What are plastic shrinkage cracks?
- How do plastic shrinkage cracks differ from cracks in hardened concrete?
- Where do plastic shrinkage cracks usually occur?
- Describe how weather can influence plastic shrinkage cracking?
- How can plastic shrinkage cracking be minimized?
- How does evaporation affect plastic shrinkage cracking?
- Identify the ways that plastic shrinkage cracking can occur prior to hardening.
- Describe how settlement or movement in the concrete, forms, subgrade and soil can contribute to cracking.
- What is the cause of drying shrinkage cracks?
- What role does restraining of concrete play in drying shrinkage cracking?
- Name the other important factors that contribute to drying shrinkage cracks.
- How does tensile strength of concrete relate to cracking?
- What is a structural crack?
- What are the job conditions that can cause structural cracks?
- What is the result of reactive aggregates in hardened concrete?
- Describe how rusting of reinforcing steel can cause concrete cracking.
- Define *thermal shock*.
- How does thermal shock occur and what is the result?
- Where do weathering cracks occur most frequently?
- At what point do freezing and thawing cycles no longer affect concrete?
- Define *crazing*.
- When is crazing most noticeable?
- Identify the three general causes of crazing.

#### Blemishes:

- What is meant by the term *dusting*?
- How can a dusting surface be made hard?
- Why is tannin harmful to concrete?
- In what way might heaters have a negative effect on plastic concrete?
- What is the most frequent cause of dusting?

- How does a lack of curing create dusting?
- What causes bugholes?
- Do bugholes create structurally unsound concrete?
- What are the ways to eliminate or reduce bugholes?
- Name the causes of bubbles and blisters.
- What are rock pockets, and how do they form?
- What are the principle causes of rock pockets?
- How can you prevent concrete from sticking to forms?
- How might a blemish occur at a horizontal construction joint?
- List the types of materials that may stain or discolor concrete.
- When using white cement, what materials should be avoided?
- Why should dry cement NOT be used to absorb water?
- Name the possible causes for irregular dark areas in slabs.
- What procedures can be used to minimize dark spots in slabs?
- Define *efflorescence*.
- How is efflorescence formed?
- How can efflorescence be reduced?
- Describe how efflorescence is removed.
- What is laitance?
- What are the causes of laitance?
- Define *scaling*.
- What are the causes of scaling?
- Identity the best preventative measures for scaling when concrete is exposed to freezing and thawing.
- Define *spalling*.
- List the causes of spalling.
- How is spalling avoided?
- What is popout and what are the causes?
- What is usually present when popouts occur?
- How are popouts prevented?
- Can popouts be repaired?

### **Repair of Defects:**

- Describe the differences between structural and cosmetic repairs.
- What are the methods used to repair concrete?
- Do all patches require wetting of the old concrete?
- When is dry pack used?
- Of what materials and proportions does dry pack consist?
- Describe how dry pack is installed.
- What is the procedure for repairing with an overlay?
- What types of materials can be used to fill cracks?
- How are large cracks filled?
- How can mortar bond be improved?
- Describe the epoxy process for filling cracks in both vertical and horizontal elements.
- How are bonding agents applied?
- Describe the process of joining concrete with adhesives.

## CHAPTER 6—QUIZZES

### I Multiple Choice

1. Which one of the following is not a crack that occurs while concrete is still plastic?
- a. green
  - b. plastic shrinkage
  - c. pre-set
  - d. drying shrinkage
  - e. none of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

2. Sudden changes in temperature that can stress concrete and cause cracks are called \_\_\_\_\_.
- a. reactive thermoset
  - b. thermal shock
  - c. frost action
  - d. freezing and thawing cycles
  - e. drying shrinkage

Response \_\_\_\_\_ Reference \_\_\_\_\_

3. Joint dowels in slabs on ground should be \_\_\_\_\_.
- a. coated with a lubricant
  - b. perpendicular to the subgrade
  - c. secured against slippage
  - d. placed off center
  - e. all of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

4. A deposit of crystalline salts on hardened concrete brought by water and deposited on the concrete surface through evaporation is called \_\_\_\_\_.

- a. laitance
- b. spalling
- c. scaling
- d. efflorescence
- e. drying scale

Response \_\_\_\_\_ Reference \_\_\_\_\_

5. The minimum thickness of a bonded overlay for slab repairs should not be less than \_\_\_\_\_.
- a. 1 inch
  - b. 2 inches
  - c. 3 inches
  - d. 1<sup>1</sup>/<sub>2</sub> inches
  - e. 2<sup>1</sup>/<sub>2</sub> inches

Response \_\_\_\_\_ Reference \_\_\_\_\_

6. Unvented heaters used for heating an enclosure during cold weather will cause a reaction when \_\_\_\_\_ come(s) in contact with the surface of green concrete.
- a. hydrogen ions
  - b. ferruginous concretions
  - c. chloride salts
  - d. silica
  - e. carbon dioxide

Response \_\_\_\_\_ Reference \_\_\_\_\_

7. The breaking away of a small piece of concrete in the shape of a cone on the surface of a concrete slab is called a \_\_\_\_\_.
- a. scale
  - b. spall
  - c. popout
  - d. pit
  - e. void

Response \_\_\_\_\_ Reference \_\_\_\_\_

8. \_\_\_\_\_ cracks are caused primarily because of loss of water from new concrete after it has hardened.
- a. plastic shrinkage
  - b. spalling
  - c. drying shrinkage
  - d. hydration
  - e. contraction

Response \_\_\_\_\_ Reference \_\_\_\_\_

## II True/False

9. Concrete in structures consisting of a large amount of concrete in huge blocks or masses is called *mass concrete*.

T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_

10. Contraction joints should be spaced not more than about 30 feet apart.

T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_



11. When concrete is first placed in forms, it contains large amounts of entrapped air that cause voids called air pockets, which can be removed if proper vibration is applied.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
12. Discoloration of concrete can be caused by certain plywoods, hardboards, form oils and iron pyrites.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
13. The dry pack method of repairing concrete requires special knowledge and can only be applied by certified installers.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
14. Concrete surfaces to be bonded by adhesives must be sound and thoroughly wetted prior to application.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
15. Preparation for repair of concrete begins with removal of unsound and disintegrated concrete.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
16. Concrete cracks are due to compressive forces that pull the concrete apart before tensile strength is adequate.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_

### III Completion

17. Settlement of concrete may be obstructed by \_\_\_\_\_, \_\_\_\_\_ in the concrete or large \_\_\_\_\_, causing \_\_\_\_\_ in the concrete over these obstructions.  
Reference \_\_\_\_\_
18. Diagonal cracks at corners of door and window \_\_\_\_\_ can be controlled by the use of sufficient \_\_\_\_\_.  
Reference \_\_\_\_\_
19. Isolation joints should be provided whenever concrete abuts \_\_\_\_\_ concrete in \_\_\_\_\_, \_\_\_\_\_ or footings.  
Reference \_\_\_\_\_
20. The first step in repairing concrete is to \_\_\_\_\_ the damage, including determination of the \_\_\_\_\_ and the \_\_\_\_\_.  
Reference \_\_\_\_\_

21. Cracking of precast concrete can be minimized if units are \_\_\_\_\_, avoiding variable \_\_\_\_\_ and providing adequate \_\_\_\_\_.

Reference \_\_\_\_\_

22. One of the worst blemishes in a horizontal concrete surface is a sloughing away or \_\_\_\_\_ of the surface in thin flakes called \_\_\_\_\_.

Reference \_\_\_\_\_

23. Large cracks can be filled with epoxy mortar consisting of epoxy \_\_\_\_\_ mixed with \_\_\_\_\_ in the proportion of \_\_\_\_\_ part \_\_\_\_\_ to \_\_\_\_\_ parts \_\_\_\_\_ by volume.

Reference \_\_\_\_\_

24. Often appearing as circular or oval depressions on concrete surfaces, \_\_\_\_\_ is a deeper surface defect than scaling, and can be \_\_\_\_\_ or more in depth and \_\_\_\_\_ or more in diameter.

Reference \_\_\_\_\_

## CHAPTER 7 PORTLAND CEMENT

**Objectives:** To obtain a basic understanding of the way cement is manufactured; its composition, properties and characteristics; and the methods of its transportation and storage.

**Lesson Notes:** For a better understanding of how cement is made, study Figure 7-3 as you read Section 7.2.

### **Key Points:**

- What is meant when it is said that cement is hydraulic in nature?
- Of what raw materials is cement made?
- What is the process of making cement called?
- Describe the first phase of cement manufacture.
- After the blended material is stored, what are the two possible processes prior to its being sent to the kiln?
- Describe the burning and finishing process.
- What are clinkers?
- What materials are added during finish grinding?
- Describe each of the five main types of cement, including the characteristics and uses of each.
- What are the three types of air-entrained cements?
- What is blended cement?
- What is added to cement to make each of the following types? IS, IS-A, P, IP, S, I(SM) and I(PM)
- What is masonry cement?
- How does white cement differ from gray cement?
- Name some uses of white cement.
- What is added to cement to make plastic cement, and what are its most common uses?
- How does expansive cement differ from other cements?
- Where is expansive cement used most effectively?
- Calcium aluminate cement is used for what applications?
- Can aluminous cement be used for structural concrete?
- How is magnesite made, and where is it used?
- Where is rapid-setting cement used most frequently?
- What are the two basic types of hauling equipment used to transport cement?
- What is warehouse set?
- How is bulk cement usually stored?
- What are two concerns when storing cement?
- Why is it important for all equipment used in handling cement to be weathertight?



## CHAPTER 7—QUIZZES

### I Multiple Choice

1. The specific gravity of Portland cement is about \_\_\_\_\_.
- a. 2.75
  - b. 2.92
  - c. 3.15
  - d. 3.25
  - e. 3.40

Response \_\_\_\_\_ Reference \_\_\_\_\_

2. Type IV cement is a special cement that generates less heat during hydration and is used only in mass concrete such as \_\_\_\_\_.
- a. high-rise buildings
  - b. large parking structures
  - c. large dams
  - d. tilt-up buildings
  - e. water treatment plants

Response \_\_\_\_\_ Reference \_\_\_\_\_

3. The process of making cement is called \_\_\_\_\_.
- a. hydration
  - b. hydraulic kiln refining
  - c. clinker
  - d. pyroprocessing
  - e. heat steuration

Response \_\_\_\_\_ Reference \_\_\_\_\_

4. Type \_\_\_\_\_ cement is used when high early strengths are desired.
- a. I
  - b. II
  - c. III
  - d. IV
  - e. V

Response \_\_\_\_\_ Reference \_\_\_\_\_

5. Which one of the following is not a property or characteristic of cement?
- a. fineness
  - b. setting time
  - c. color
  - d. workability
  - e. soundness

Response \_\_\_\_\_ Reference \_\_\_\_\_

6. The two basic classes of fly ash are \_\_\_\_\_.

- a. A and B
- b. B and D
- c. C and F
- d. D and G
- e. A and D

Response \_\_\_\_\_ Reference \_\_\_\_\_

7. Pozzolans are used to improve \_\_\_\_\_ and reduce \_\_\_\_\_.

- a. plasticity, air-entrainment
- b. durability, water volume
- c. workability, bleeding
- d. hydration, heat loss
- e. drying shrinkage, cohesiveness

Response \_\_\_\_\_ Reference \_\_\_\_\_

## II True/False

8. In the manufacture of Portland cement, the divergence of the dry and wet process ends when the kiln feed is put into storage.

T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_

9. Cement sacks can be stacked directly on a warehouse floor, provided there is no moisture coming through the floor.

T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_

10. Shipments of cement to the customer are made either in bulk or in 94-pound bags, the latter of which equal about  $\frac{1}{2}$  cubic foot.

T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_

11. Color is an indication of cement quality.

T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_

12. One problem with storing cement in silos is a tendency for a hollow core to develop in the center when the cement is withdrawn from the bottom.

T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_

13. In the dry process of making cement, grinding and blending operations are done with the materials mixed with water in a slurry form.

T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_

14. Air-entrained concrete is commonly made by using air-entraining Portland cements.

T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_

15. Silica fume is a material that is used as a pozzolanic admixture.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
16. One source of pozzolans is calcined or burnt shales and slates, heated in a stationary kiln and crushed and ground after cooling.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_

### III Completion

17. Type V cement is a special \_\_\_\_\_ cement. It is used where concrete is exposed to \_\_\_\_\_ or \_\_\_\_\_ water that is high in \_\_\_\_\_ content.  
Reference \_\_\_\_\_
18. Greater cement fineness increases the rate at which cement \_\_\_\_\_ and \_\_\_\_\_ strength development.  
Reference \_\_\_\_\_
19. Portland blast-furnace slag cement can be either Type \_\_\_\_\_ or \_\_\_\_\_; slag cement is Type \_\_\_\_\_; and Portland-pozzolan cement can be either Type \_\_\_\_\_ or \_\_\_\_\_.  
Reference \_\_\_\_\_
20. During finish grinding of cement, a small amount of \_\_\_\_\_ is interground with the cement to control \_\_\_\_\_.  
Reference \_\_\_\_\_
21. White Portland cement contains no \_\_\_\_\_ and meets the requirements for Type \_\_\_\_\_ Portland cement. It is pure white in color and allows for a great amount of variety in \_\_\_\_\_ or \_\_\_\_\_ concrete.  
Reference \_\_\_\_\_
22. When working with fresh concrete, care should be taken to avoid \_\_\_\_\_ or \_\_\_\_\_.  
Reference \_\_\_\_\_
23. Some of the most common natural pozzolans are \_\_\_\_\_, \_\_\_\_\_, \_\_\_\_\_ and \_\_\_\_\_.  
Reference \_\_\_\_\_
24. Dependent on other material costs, fly ash is more economical, as well as more resistant to \_\_\_\_\_ and \_\_\_\_\_ reaction, and has a \_\_\_\_\_ of hydration.  
Reference \_\_\_\_\_





## CHAPTER 8 AGGREGATES

**Objectives:** To identify the different types and sources of rock used as aggregate, as well as the characteristics, processing, stockpiling and testing of aggregate materials. The special kinds of aggregates will be studied in a brief overview.

**Lesson Notes:** Aggregates are normally inert materials and do not react with concrete; however, there are some aggregates to which this generally does not apply. Throughout this chapter, note the types of aggregates that may react with the concrete.

### Key Points:

- How much of the volume of concrete is occupied by aggregates?
- What class of rock makes the most consistently good aggregate?
- Describe the differences between the three rock classes.
- How is aggregate quality determined?
- List the seven properties that affect aggregate quality.
- How are aggregate soundness and stability determined?
- How is cleanness determined?
- Name the materials that can negatively affect aggregate quality.
- How is aggregate hardness determined?
- By what name is a common grading test known?
- How is the fineness modulus of sand determined?
- What is the most desirable grading curve?
- Review Section 3.11 on the maximum size aggregate (MSA). What effect does the MSA have on concrete?
- What is the main influence on aggregate shape?
- Describe the differences between aggregate shape and texture.
- Which aggregate texture is most desirable?
- Why is a petrographic analysis of aggregate important?
- Define *specific gravity*.
- How can the specific gravity of aggregate affect concrete?
- Describe how absorption affects aggregate quality.
- Why must the absorption of an aggregate be known?
- Identify the four possible aggregate moisture content conditions.
- Why is knowing the moisture content necessary?
- Define *unit weight*.
- What is void content, and why is it important?
- Why is it rare to find aggregate that is dug out of the ground ready to be used in concrete?
- How is poor grading remedied?
- What should be removed from coarse aggregate before primary crushing?
- What equipment is used for initial, intermediate and final crushing?
- Describe the purposes of a revolving scrubber, a log washer and a screw washer.
- Define *fine aggregate*.
- How is sand grading accomplished?

- Review the effect of sand grading on concrete.
- How can the defects of pit-run sand be corrected?
- What is aggregate beneficiation?
- How can segregation be minimized when stockpiling coarse aggregate?
- How does sand differ from coarse aggregate in regard to segregation?
- How is moisture in sand usually measured?
- Why is sampling from a stockpile difficult?
- How should a sample be obtained from a conveyor belt?
- When is the quartering method used for aggregate sampling?
- Describe the quartering method of aggregate sampling.
- What is slag?
- How is slag processed?
- How does slag compare to natural aggregate?

## CHAPTER 8—QUIZZES

### I Multiple Choice

1. The greater the size range within a gravel stockpile, the greater the danger of harmful \_\_\_\_\_ .

- a. beneficiation
- b. hydration
- c. segregation
- d. scrubbing
- e. rounding

Response \_\_\_\_\_ Reference \_\_\_\_\_

2. Which one of the following is not a characteristic of an aggregate?

- a. cleanness
- b. durability
- c. texture
- d. reactivity
- e. absorption

Response \_\_\_\_\_ Reference \_\_\_\_\_

3. When taking a sample of sand for testing, the sample size should be \_\_\_\_\_ pounds.

- a. 10
- b. 20
- c. 30
- d. 40
- e. 50

Response \_\_\_\_\_ Reference \_\_\_\_\_

4. The limit of deleterious substances in aggregate should not be more than \_\_\_\_\_ percent by weight, depending on the substance.

- a. one to two
- b. two to three
- c. three to four
- d. four to five
- e. five to eight

Response \_\_\_\_\_ Reference \_\_\_\_\_

5. The particle shape of an aggregate that will tend to make a harsh concrete mix is \_\_\_\_\_.
- a. angular
  - b. rounded
  - c. subrounded
  - d. crushed
  - e. circular

Response \_\_\_\_\_ Reference \_\_\_\_\_

6. Unsatisfactory grading of aggregates can be corrected by \_\_\_\_\_.
- a. breakage
  - b. segregating
  - c. crushing and screening
  - d. scalping
  - e. spalling

Response \_\_\_\_\_ Reference \_\_\_\_\_

7. Coarse aggregate samples should be reduced in size by using \_\_\_\_\_.
- a. a sample splitter
  - b. the quartering method
  - c. dry selection
  - d. wet selection
  - e. beneficiation

Response \_\_\_\_\_ Reference \_\_\_\_\_

8. Sand or fine aggregate for concrete consists of material that will pass a No. \_\_\_\_\_ screen.
- a. 4
  - b. 5
  - c. 6
  - d. 7
  - e. 8

Response \_\_\_\_\_ Reference \_\_\_\_\_

## II True/False

9. A useful number when studying aggregate gradation is the fineness modulus.  
T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_
10. Aggregates in concrete are frequently called *filler material* because they occupy between 60 and 80 percent of concrete volume.  
T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_

11. The quality of rock in a quarry is fairly consistent, especially for limestone and granite rock.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
12. Aggregates for structural concrete can be either natural or artificial and may weigh as little as 75 pounds per cubic foot.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
13. Natural aggregates used in concrete come either from solid bedrock or deposits of sand and gravel.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
14. Sand and gravel are most frequently dug out of the ground and used directly in concrete.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
15. Segregation of materials in a gravel stockpile can be minimized by having a greater size range.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
16. The average specific gravity of sand or gravel is 2.65, which means it is 2.65 times as heavy as water.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
17. When different size aggregates are combined, the spaces between the aggregate particles decrease.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_

### III Completion

18. Aggregate samples are taken from a conveyor belt by stopping the belt, taking at least \_\_\_\_\_ portions and combining them to form a sample. \_\_\_\_\_ templates shaped to fit across the belt must be inserted and all material between the templates, including \_\_\_\_\_ and \_\_\_\_\_, removed.  
Reference \_\_\_\_\_
19. Of the several varieties of slag, slag that comes from a \_\_\_\_\_ is the most suitable for use in concrete.  
Reference \_\_\_\_\_
20. There are \_\_\_\_\_ basic classes of rock. They are \_\_\_\_\_, \_\_\_\_\_ and \_\_\_\_\_.  
Reference \_\_\_\_\_

21. Hard, dense stone such as granite may have an absorption rate of only \_\_\_\_\_ percent, whereas the absorption rate of a shale or porous chert is as high as \_\_\_\_\_ percent. The absorption rate for sand should not exceed \_\_\_\_\_ percent.  
Reference \_\_\_\_\_
22. The limits for deleterious substances in fine aggregate for concrete is about \_\_\_\_\_ percent for clay lumps and between \_\_\_\_\_ and \_\_\_\_\_ percent for coal and lignite.  
Reference \_\_\_\_\_
23. There are four commonly used methods of beneficiation. They are \_\_\_\_\_ separation, \_\_\_\_\_, \_\_\_\_\_ and \_\_\_\_\_  
Reference \_\_\_\_\_
24. Aggregate scrubbing is required when adherent coatings of \_\_\_\_\_ and \_\_\_\_\_ cannot be removed from aggregate by washing and screening. The three methods of scrubbing are (1) use of a \_\_\_\_\_ scrubber, (2) a \_\_\_\_\_ or (3) a \_\_\_\_\_.  
Reference \_\_\_\_\_
25. To avoid segregation of materials when stockpiling aggregate, the following precautions should be observed. Handle as \_\_\_\_\_ times as possible, avoid \_\_\_\_\_, \_\_\_\_\_ shaped piles, stockpile in \_\_\_\_\_, handle in \_\_\_\_\_ graded sizes and remove from the stockpile in \_\_\_\_\_ slices.  
Reference \_\_\_\_\_
26. A \_\_\_\_\_ texture is desirable in aggregates, as it provides better bond with the \_\_\_\_\_, making concrete of better strength compared with \_\_\_\_\_ surfaced aggregates.  
Reference \_\_\_\_\_

## CHAPTER 9

### WATER AND ADMIXTURES

**Objectives:** To understand the effects of water, various admixtures, pozzolans and fly ash on plastic, fresh and hardened concrete.

**Lesson Notes:** Water is absolutely necessary. It lubricates and makes concrete plastic and workable, and provides the catalyst for the reaction with the cement. However, when the amount of water exceeds the specified limits, the benefits of water become liabilities. As the water-cement ratio rises, strength, durability, workability and other properties of concrete diminish.

Admixtures, when used, must conform to American Society for Testing and Materials (ASTM) standards and the manufacturer's specifications. To avoid defects in the concrete, the effects of an admixture on the other concrete materials and the site conditions must be known before introduction into a mix.

#### Key Points:

- Name two things that water does to cement.
- Why is increasing the water-cement ratio not good for concrete?
- Up to how much dirt or silt is acceptable for water used for concrete?
- Define *ppm* and *TDS*.
- Without testing, how can contaminated water be identified?
- Describe the possible effects of sea water if used in concrete.
- What effect does sea water have on steel reinforcement?
- What are the three general classes of admixtures and the seven types of chemical admixtures?
- Name some concerns when choosing an admixture.
- Why use admixtures?
- How should an admixture be tested?
- What three concerns should be kept in mind when selecting an admixture?
- How are liquid admixtures measured?
- When using an admixture, what capabilities should the dispensing system have?
- Why should an admixture in a dry or powdered state never be introduced into concrete?
- Name some methods for dispensing admixtures.
- Should admixtures be intermixed prior to mixing?
- Is the time frame for adding admixtures ever critical?
- What does an accelerator do to concrete?
- What are the benefits of an accelerator?
- How and in what manner should calcium chloride be added to concrete?
- Identify the effects of calcium chloride on fresh and hardened concrete.
- How does a water reducer affect concrete?
- What are the advantages of water reducers?
- How does a retarder affect concrete?
- How is a retarder evaluated?
- How might temperature affect a retarder?

- Identify the benefits of air-entrainment.
- Describe how the disadvantages of air-entrainment can be offset.
- When is the best time to add air-entraining agents to the concrete mix?
- What factors can change the amount of entrained air?
- Name the most frequent causes of water leakage through concrete.
- Identify the types of bonding agents most frequently used for concrete.
- What type(s) of compounds can be used as antifreeze agents?
- What are the best workability agents?
- How can shrinkage be chemically controlled?
- Name the four kinds of finely divided mineral admixtures.
- When can a superplasticizer be used in concrete?
- How does a superplasticizer react with concrete?
- What benefits can be obtained from using a superplasticizer?
- Define *pozzolan*.
- Name the three general classes of pozzolans.
- What are the two classes of fly ash, and how are they produced?
- What are the benefits of including fly ash in a concrete mix?



## CHAPTER 9—QUIZZES

### I Multiple Choice

1. A retarder is an admixture that \_\_\_\_\_ the chemical process of hydration.
- increases
  - slows
  - accelerates
  - stops
  - none of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

2. The reason for using an admixture is to \_\_\_\_\_ of concrete so that it will be more suitable for a particular usage.
- change the slump
  - reduce segregation
  - enhance the chemical properties
  - reduce the cracking
  - modify the properties

Response \_\_\_\_\_ Reference \_\_\_\_\_

3. A superplasticizer admixture is used in concrete to \_\_\_\_\_.
- reduce the amount of water
  - reduce cement content without reducing strength
  - produce a flowing, self-leveling concrete
  - all of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

4. The total air content for concrete exposed to freezing and thawing conditions in a moderate exposure when the MSA is  $\frac{3}{4}$  inch should be \_\_\_\_\_ percent.
- six
  - five
  - four
  - four and one-half
  - three

Response \_\_\_\_\_ Reference \_\_\_\_\_

5. Which one of the following is an acceptable source for concrete mixing water?
- a. a private well
  - b. the sea water
  - c. a stagnant pool
  - d. a brackish body of water
  - e. a swamp

Response \_\_\_\_\_ Reference \_\_\_\_\_

### II True/False

6. An accelerator speeds up setting time and increases the rate of early strength development.  
T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_
7. Entrained air in concrete increases bleeding and reduces segregation tendencies.  
T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_
8. There is no material that can be put into a batch of fresh concrete to lower the freezing point without damaging the concrete.  
T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_
9. In general, sugar in mixing water is not objectionable.  
T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_
10. Expansion producing admixtures compensate for drying shrinkage of concrete and are usually incorporated in expansive cement.  
T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_
11. Admixtures used to make high-slump flowing concrete are often called *superplasticizers*.  
T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_

### III Completion

12. When using more than one admixture, they should not be \_\_\_\_\_ prior to introduction into the mixer unless the \_\_\_\_\_ state that it is permissible.  
Reference \_\_\_\_\_
13. Bonding agents can be applied to the \_\_\_\_\_ to be bonded or used as admixtures, and can be made from \_\_\_\_\_ or \_\_\_\_\_ rubber or \_\_\_\_\_.  
Reference \_\_\_\_\_

14. Stearates, used as a permeability-reducing admixture, reduce \_\_\_\_\_ and retard \_\_\_\_\_ but are of little or no value if the water is under pressure.

Reference \_\_\_\_\_

15. Coloring admixtures should be \_\_\_\_\_ in sunlight, \_\_\_\_\_ in the presence of alkalis, and have no adverse effects on \_\_\_\_\_ or \_\_\_\_\_ development.

Reference \_\_\_\_\_

16. The two general classes of admixtures are \_\_\_\_\_ admixtures and \_\_\_\_\_ agents.

Reference \_\_\_\_\_



## **CHAPTER 10**

### **ACCESSORY MATERIALS**

**Objectives:** To understand the use, purpose and installation of sealants, resins, bonding agents and other coatings.

**Lesson Notes:** New materials are continually being introduced. It is important that these materials be tested for their intended use prior to installation. An untested product can quickly become a detriment to what otherwise would be good quality concrete.

#### **Key Points:**

- Name the various kinds of field-molded sealants.
- Describe each of the following sealants as to composition and where used: mastics, hot-applied thermoplastics, chemically curing thermosetting sealants, solvent-release thermosetting sealants and rigid materials.
- What are preformed sealants?
- Name the three types, grades and classes of epoxy resin systems.
- Where are epoxy resin systems used?
- What are the temperature ranges, conditions, surfaces and applications of epoxy resin systems?
- What two components are usually part of an epoxy resin system?
- Name the advantages of bonding agents.
- As what are bonding agents usually classified?
- Describe the types of paints that can be used to improve durability, decorate concrete and make concrete water tight .
- What materials can be used for waterproofing and damp-proofing concrete?
- Why should plaster of paris not be used as a patching compound?
- Where would a surface retarder be used?



## CHAPTER 10—QUIZZES

### I Multiple Choice

1. \_\_\_\_\_ are thick liquids used where small joint movement is expected.
- Mastics
  - Solvent-release thermosetting sealants
  - Epoxies
  - Thermoplastics
  - Patching compounds

Response \_\_\_\_\_ Reference \_\_\_\_\_

2. Epoxy resins will not normally adhere to \_\_\_\_\_ surfaces.
- wet
  - metal
  - wood
  - concrete
  - greased

Response \_\_\_\_\_ Reference \_\_\_\_\_

3. Some rapid-setting cements contain \_\_\_\_\_, which causes a set within a few minutes.
- dehydrated gypsum
  - hydrated lime
  - epoxy resin
  - mastic
  - calcium chloride

Response \_\_\_\_\_ Reference \_\_\_\_\_

4. Which one of the following materials is not a chemically-curing thermosetting sealant?
- polysulfide
  - epoxy
  - urethane
  - silicone
  - neoprene

Response \_\_\_\_\_ Reference \_\_\_\_\_

5. Which one of the following is not an application in which epoxy resins are normally used with concrete?
- a. producing a skid-resistant surface
  - b. bonding hardened concrete to other materials
  - c. waterproofing and waterstops
  - d. bonding plastic concrete to hardened concrete
  - e. filling cracks

Response \_\_\_\_\_ Reference \_\_\_\_\_

### II True/False

6. Polyvinyl acetate, which improves the bond of concrete to old concrete, is a type of epoxy resin.

T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_

7. A job-mixed paint to make concrete watertight is composed mainly of white Portland cement and calcium stearate.

T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_

8. One method of exposing aggregate on the surface of concrete is to use a surface retarder.

T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_

### III Completion

9. Two methods of installing preformed sealants are to \_\_\_\_\_ the sealant in the concrete or by \_\_\_\_\_ the sealant into the joint slot.

Reference \_\_\_\_\_

10. Sealants that are cured by release of a solvent include \_\_\_\_\_, \_\_\_\_\_ and \_\_\_\_\_.

Reference \_\_\_\_\_

11. Epoxy resins are usually composed of two components, the basic \_\_\_\_\_ and a \_\_\_\_\_.

Reference \_\_\_\_\_

12. Rigid waterstops are usually made of \_\_\_\_\_; flexible waterstops are usually made of natural and synthetic \_\_\_\_\_ and \_\_\_\_\_.

Reference \_\_\_\_\_



## CHAPTER 11 FORMWORK

**Objective:** To gain an understanding of the various materials used for forms and of the requirements for formwork, including bracing, shoring, form oils, cleanliness and removal.

**Lesson Notes:** All too frequently, failure that is due to inadequate formwork causes major loss of life or property. Not included in the latter are the unsightly conditions that occur when only part of a formwork is deficient. There is no substitute for well-designed forms.

### Key Points:

- Name the 18 most common deficiencies that lead to the failure of forms.
- How could unsatisfactory alignment and concrete vibration affect forms?
- When are chamfer strips used?
- In what dimension is plywood strongest?
- How should tie rods and metal ties be placed?
- Describe how horizontal construction joints should be formed.
- Why camber forms?
- What is the most stable type of lumber for forms?
- Why not use green or kiln-dried lumber?
- What is coated plywood?
- In formwork, what is the most common use of glass fiber-reinforced plastic?
- What are the advantages of using plastic and rubber liners?
- What are the most common uses for steel forms?
- Of what are sonotube fiber forms made?
- Describe waste molds, their uses and the precautions necessary for good concrete.
- What is the most common form fastener?
- Describe each of the following and how they are used: form clamp, snap tie, coil tie, she-bolt and inserts.
- Why are forms treated with oil?
- Name the different types of materials used as form coatings.
- Name the two general classes of form coatings.
- How are chemically active coatings applied to forms?
- Define *falsework*, *permanent shores* and *reshores*.
- What criteria should govern the installation of reshores?
- Define *slipform*.
- Identify the two types of prefabricated forms and the materials of which they are made.
- Prior to placing concrete, what should be done to forms?
- What are the concerns related to metal chairs?
- What are the benefits of careful form removal after placing concrete?
- When can forms be removed?



## CHAPTER 11—QUIZZES

### I Multiple Choice

1. The most common material used for forms is \_\_\_\_\_.
- a. steel
  - b. wood
  - c. masonry
  - d. hardboard
  - e. sonotube

Response \_\_\_\_\_ Reference \_\_\_\_\_

2. A \_\_\_\_\_ is made from multiple layers of heavy paper bonded together and impregnated with resin or wax to become water-repellent.
- a. slipform
  - b. hardboard form
  - c. flexible liner
  - d. sonotube
  - e. waste mold

Response \_\_\_\_\_ Reference \_\_\_\_\_

3. Prefabricated forms that can be used for many applications are known as \_\_\_\_\_ forms.
- a. modular
  - b. job specific
  - c. slip
  - d. spreader
  - e. chamfer

Response \_\_\_\_\_ Reference \_\_\_\_\_

4. Which one of the following is not used as a form oil or compound?
- a. wax
  - b. lacquer
  - c. plastic coatings
  - d. motor oil
  - e. shellac

Response \_\_\_\_\_ Reference \_\_\_\_\_

5. A \_\_\_\_\_ is a movable form that is raised vertically as the concrete is placed.
- a. roller form
  - b. reshore form
  - c. self-adjusting form
  - d. slipform
  - e. none of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

6. An assembly for a wall form that is composed of two nut washers, two waler rods and a central tie is a \_\_\_\_\_.
- a. form clamp
  - b. snap tie
  - c. she-bolt
  - d. coil tie
  - e. reshore tie

Response \_\_\_\_\_ Reference \_\_\_\_\_

7. Overlay plywood can be used without \_\_\_\_\_.
- a. walers
  - b. form oil
  - c. chamfers
  - d. bulkheads
  - e. resin

Response \_\_\_\_\_ Reference \_\_\_\_\_

8. \_\_\_\_\_ should be placed in the corners of forms to produce beveled edges on permanently exposed concrete surfaces.
- a. edge protectors
  - b. chamfer strips
  - c. steel liners
  - d. form clamps
  - e. walers

Response \_\_\_\_\_ Reference \_\_\_\_\_

9. Vertical shoring under a beam or slab can be accomplished either with permanent shores or \_\_\_\_\_.
- a. slipshores
  - b. precast shores
  - c. reshores
  - d. waste shores
  - e. panel shores

Response \_\_\_\_\_ Reference \_\_\_\_\_

**II True/False**

10. A snap tie is made of a single piece of wire cut to length and headed at each end.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
11. A waste mold is usually made of casting plaster reinforced with fiber and supported on wood framework.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
12. Clamps and pins should hold forms rigidly together in place and allow removal without damage to the concrete.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
13. Forms should be constructed to withstand a hydraulic head from fresh concrete of at least 250 pounds per lineal foot.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
14. The quality of lumber that is usually specified to be used for formwork is utility grade.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
15. Except for prefabricated forms, forms usually are not designed for reuse.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_

**III Completion**

16. Forms for suspended slabs and beams are frequently cambered to allow for \_\_\_\_\_ or \_\_\_\_\_; a common allowance being \_\_\_\_\_ per 16 feet of \_\_\_\_\_.  
Reference \_\_\_\_\_
17. When placing a successive lift of concrete on previously placed and hardened concrete, the horizontal \_\_\_\_\_ between the two lifts is often a source of disfigurement that can be avoided by providing form \_\_\_\_\_ about \_\_\_\_\_ below the top of the \_\_\_\_\_.  
Reference \_\_\_\_\_
18. After stripping a form, it should have all \_\_\_\_\_, \_\_\_\_\_, \_\_\_\_\_, and \_\_\_\_\_ removed before reuse.  
Reference \_\_\_\_\_

19. When made, waste molds should be sized with \_\_\_\_\_ or \_\_\_\_\_ and coated with parting compound or \_\_\_\_\_ just prior to placing concrete.

Reference \_\_\_\_\_

20. Prefabricated forms are held together with \_\_\_\_\_ and can be \_\_\_\_\_ and \_\_\_\_\_ to form large areas.

Reference \_\_\_\_\_

## CHAPTER 12

### PROPORTIONING THE CONCRETE MIXTURE

**Objectives:** To understand how to proportion materials in a concrete mixture and how to adjust the mix to maintain the required quality, and how to review the properties of materials and understand the selection of mix characteristics when tests or history are not available.

**Lesson Notes:** Give additional attention to the steps used to estimate mix proportions in Section 12.3.

- Key Points:
- Study Table 12.1 and note how changing the MSA affects a concrete mix.
- How are the ingredients of concrete mixes selected?
- In good quality concrete, what percentage of total ingredients does the paste occupy?
- How should mixes be proportioned?
- Why should a mix be adjustable?
- Regardless of the mix selected, what are the special exposure requirements that may have to be met?
- Define the following terms: *specific gravity*, *bulk specific gravity*, *density*, *voids*, *unit weight* and *absolute volume*.
- List the steps in establishing a trial mix.
- What are the limits of the MSA?
- What is the most common aggregate size for structural concrete?
- Name the controlling conditions when water-cement ratio is not specified.
- What does slump measure?
- On what does the total amount of mixing water for the required slump depend?
- Review the mix design example given on page 225 of the *Concrete Manual*.
- When using trial mixes, how many mixes are to be made in order to establish strength versus water-cement ratio?
- Describe the final adjustments to be made to a proposed mix.
- Review the example on page 233 of the *Concrete Manual*. What is the variable when using air entrainment?
- What variables are involved when using superplasticizers and fly ash? Review Section 12.5.
- What are relative yield and actual yield?
- What information should be supplied when ordering ready-mixed concrete?
- What are gap-graded mixes?
- Where are gap-graded mixes typically used?
- What might be the advantages of using gap-graded mixes?





## CHAPTER 12—QUIZZES

### I Multiple Choice

1. If the MSA in non-air-entrained concrete is 1 inch, the air content is 1.5 percent, and the volume of sand is 41 percent, the amount of water per cubic yard will be approximately \_\_\_\_\_ pounds.
- a. 280
  - b. 300
  - c. 325
  - d. 340
  - e. 355

Response \_\_\_\_\_ Reference \_\_\_\_\_

2. Relative yield is the \_\_\_\_\_ divided by the designed sign of the batch.
- a. unit weight
  - b. actual yield
  - c. weight of all materials except admixtures
  - d. water-cement ratio
  - e. aggregate weight

Response \_\_\_\_\_ Reference \_\_\_\_\_

3. All aggregate particles in concrete should be \_\_\_\_\_ .
- a. surrounded by paste
  - b. moist prior to mixing
  - c. added to the mix last
  - d. clean, dry and segregated
  - e. none of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

4. Most aggregate is graded from the finest material to the MSA; in \_\_\_\_\_ grading, some sizes of aggregate are not used.
- a. gap
  - b. batch
  - c. selective
  - d. stepped
  - e. none of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

5. If enough test results are not available for a statistical analysis of field tests, then it is necessary to make \_\_\_\_\_ to determine the concrete proportions.
- a. structural models
  - b. strength value models
  - c. a field analysis
  - d. educated guesses
  - e. laboratory trial batches

Response \_\_\_\_\_ Reference \_\_\_\_\_

6. Which of the following material properties is not important when determining mix proportions?
- a. density
  - b. unit weight
  - c. voids
  - d. durability
  - e. specific gravity

Response \_\_\_\_\_ Reference \_\_\_\_\_

7. When the water-cement ratio is constant and sources of ingredients differ, concrete strengths \_\_\_\_\_.
- a. are constant
  - b. are higher
  - c. do not vary
  - d. are usually lower
  - e. may vary

Response \_\_\_\_\_ Reference \_\_\_\_\_

8. Non-air-entrained concrete with a maximum size aggregate of  $\frac{3}{4}$  inch will have about \_\_\_\_\_ percent air content.
- a. 1.0
  - b. 1.5
  - c. 2.0
  - d. 2.5
  - e. 3.0

Response \_\_\_\_\_ Reference \_\_\_\_\_

9. Concrete exposed to seawater must be made with Type \_\_\_\_\_ cement.
- a. I
  - b. II
  - c. III
  - d. V

Response \_\_\_\_\_ Reference \_\_\_\_\_

**II True/False**

10. The introduction of a high-range water reducer has not presented another variable in proportioning mixes.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
11. Each sack of ready-sacked concrete mix contains cement, fine aggregate and coarse aggregate; weighs either 60 or 100 pounds; and is ready to use by adding water.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
12. The normal procedures for mix proportioning can, in general, be applied when using no- slump concrete.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
13. Superplasticizers cannot be used successfully with fly ash.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
14. The ratio of the weight of a piece of aggregate of 1 cubic foot volume to the weight of 1 cubic foot of water is the bulk specific gravity.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
15. Two methods of arriving at the mix proportions for a job are the statistical method and the use of laboratory trial batches.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
16. The total amount of mixing water per cubic yard of concrete is significantly affected by the cement content but is not affected by temperature.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
17. The water-cement ratio selected for mix design must be the highest value required to meet anticipated exposure conditions.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_

**III Completion**

18. When test and history information is not available, estimates of mix proportions can be determined by following a number of steps, the first of which is to select the \_\_\_\_\_ from the specifications or based on the \_\_\_\_\_ conditions.  
Reference \_\_\_\_\_
19. There are two kinds of voids, those \_\_\_\_\_ the aggregate and those that are \_\_\_\_\_ aggregate particles.  
Reference \_\_\_\_\_
20. The MSA of any mix should not exceed one-third of the \_\_\_\_\_ of

a slab, \_\_\_\_\_ of the minimum clear reinforcement spacing or between reinforcing and the \_\_\_\_\_, nor \_\_\_\_\_ the narrowest dimension between form sides.

Reference \_\_\_\_\_

21. When selecting a mix using the aggregate content percentage method, \_\_\_\_\_ batches should have compressive strength tested with \_\_\_\_\_ cylinders at \_\_\_\_\_, \_\_\_\_\_ and \_\_\_\_\_ days.

Reference \_\_\_\_\_

22. When proportioning mixes, the effects of admixtures on \_\_\_\_\_ and \_\_\_\_\_ of concrete must be taken into consideration.

Reference \_\_\_\_\_

23. Concrete that will be exposed to seawater must be made with \_\_\_\_\_ cement, with a water-cement ratio not exceeding \_\_\_\_\_, with a corresponding minimum specified strength of \_\_\_\_\_.

Reference \_\_\_\_\_

## CHAPTER 13

### TESTING AND CONTROLLING THE CONCRETE

**Objectives:** To understand why testing is needed, the types of tests conducted on fresh concrete and how they are taken, the curing and testing of strength cylinders, methods of rapid strength gain, and the sampling and testing methods used on hardened concrete.

**Lesson Notes:** Although extensive knowledge of testing procedures for concrete is not necessary for everyone, the basics should be known so that we understand the importance and objectives of testing.

#### **Key Points:**

- What adjustments to a mix might be necessary under field conditions?
- What factors may contribute toward needing to adjust the amount of water in a mix so as to maintain a consistent slump?
- Define *sample*.
- What is the basic requirement when sampling concrete?
- What occurs when a sample is not representative of the concrete?
- What is the purpose of laboratory and field testing?
- Why are tests necessary?
- Why take more than one test?
- On page 242 of the *Concrete Manual* there are two statements: “Testing is a precise operation” and “An improperly made test is worse than no test at all.” Why are these statements true?
- When might a nonstandard test be appropriate?
- There are two groups of tests for concrete. Identify the tests that belong to each group.
- Describe the method for obtaining samples of fresh concrete.
- How often should samples be taken?
- What does a slump test determine?
- How is slump measured?
- List the steps in taking a slump test.
- Why take the temperature of fresh concrete?
- Where can the temperature test be made?
- When should air content tests be taken?
- Name the two types of air meters.
- What is the main source of errors in these meters, and how can errors be avoided?
- What information does a concrete strength specimen provide?
- What is the most common size of a specimen cylinder?
- After making strength specimens, how are the cylinders handled?
- Under what conditions can specimens be stored at a job site?
- Why might job-site curing be done?
- How are specimens stored in the laboratory?
- Describe the precautions to be observed when the cylinder is capped.
- When a specimen has a low strength, what visual observations might give an indication of the cause?

- Identify some of the methods of measuring strength gain.
- What do all these tests have in common in relationship to the 28-day strength?
- When are tests made on hardened concrete?
- What is the most common method of sampling hardened concrete?
- Describe the concerns when taking core samples.
- For what other purposes might core samples be taken?
- After core samples are obtained, how should they be treated and handled?
- How are cores dressed?
- Name the two methods of testing concrete in-place.
- How is a Swiss hammer calibrated?
- In what ways is the accuracy of a Swiss hammer affected?
- When using a Swiss hammer, how many readings are taken?
- Briefly describe how a Windsor probe works.

## CHAPTER 13—QUIZZES

### I Multiple Choice

1. In general, when total water in a mix is increased by \_\_\_\_\_ percent, the slump will increase about 1 inch.
- a. one
  - b. five
  - c. two
  - d. ten
  - e. three

Response \_\_\_\_\_ Reference \_\_\_\_\_

2. Which of the following is not included as a mixer performance test for uniformity of concrete?
- a. slump
  - b. unit weight
  - c. strength
  - d. air content
  - e. none of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

3. To properly perform a test, it is necessary to \_\_\_\_\_.
- a. follow standard methods
  - b. have it be performed by qualified persons
  - c. properly interpret the results
  - d. use the proper equipment
  - e. all of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

4. The most common size of a compressive strength cylinder is \_\_\_\_\_.
- a. 4-inch x 8-inch
  - b. 6-inch x 12-inch
  - c. 8-inch x 12-inch
  - d. 4-inch x 12-inch
  - e. 8-inch x 6-inch

Response \_\_\_\_\_ Reference \_\_\_\_\_

5. When taking a slump test, the slump cone should be filled in \_\_\_\_\_ equal volumes.

- a. two
- b. three
- c. four
- d. five
- e. none of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

6. The most common method of sampling hardened concrete is by \_\_\_\_\_ .

- a. sampling a broken piece from the structure
- b. using a Swiss hammer
- c. using a Windsor probe
- d. extracting cores
- e. none of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

7. Which of the following will aid in reducing the water-cement ratio?

- a. reduce the percentage of sand
- b. use larger-sized coarse aggregate
- c. use an air-entraining agent
- d. improve the sand grading
- e. all of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

8. When testing compressive strength cylinders in the laboratory, the cylinders should be \_\_\_\_\_ .

- a. at room temperature
- b. between 60°F and 80°F
- c. between 50°F and 80°F
- d. immersed in water
- e. treated with oil

Response \_\_\_\_\_ Reference \_\_\_\_\_

9. Compressive strength tests should be made at a location where they will be undisturbed for at least \_\_\_\_\_ hours.

- a. 8
- b. 12
- c. 24
- d. 36
- e. 48

Response \_\_\_\_\_ Reference \_\_\_\_\_



10. A Swiss hammer has an accuracy of between \_\_\_\_\_ percent, depending on how well it is calibrated.
- a. 2 and 3
  - b. 5 and 10
  - c. 10 and 20
  - d. 5 and 8
  - e. 15 and 20

Response \_\_\_\_\_ Reference \_\_\_\_\_

11. Maturity methods can be an effective means to determine adequate strength for \_\_\_\_\_ .
- a. form removal
  - b. post-tensioning work
  - c. sawing joints in slabs-on-grade
  - d. controlling accelerated heat curing methods
  - e. all of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

12. When the lab technician measures and reports 7-day versus 28-day strength data for concrete test cylinders, the technician is reporting \_\_\_\_\_ .
- a. durability data
  - b. frequency data
  - c. maturity data
  - d. petrographic data
  - e. none of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

13. The 4-inch by 8-inch test cylinder \_\_\_\_\_ .
- a. is easier to cast
  - b. requires less sample
  - c. is easier to handle
  - d. requires less field curing space
  - e. all of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

## II True/False

14. In general, the strength of extracted cores is lower than the strength of standard cylinders tested at an identical age.

T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_

15. Tests do three things: they reveal the quality of a product, they show how uniform the product is, and they verify the total volume.

T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_

16. A Windsor probe will measure hardness to a greater depth than a Swiss hammer.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
17. There are two types of air meters in regular use: pressure and volumetric.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
18. When using a Swiss hammer, it is usual practice to take 15 readings and average them together.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
19. An abnormally low unit weight indicates either a high air content or excessive water.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
20. Most procedures for rapid strength measurement rely on heat to accelerate hydration.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
21. Before maturity of job-placed concrete can be determined, a maturity curve for the specific concrete mix must be developed in the laboratory.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
22. The difference in compressive strength between the 4-inch by 8-inch and 6-inch by 12- inch test cylinder size is insignificant.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
23. Concrete cylinders cast in place in cylinder molds provide a means for determining the in-place compressive strength of concrete.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_

### III Completion

24. Slump is measured in \_\_\_\_\_; a \_\_\_\_\_ slump indicates a stiff or dry consistency, a \_\_\_\_\_ slump indicates a soft or wet consistency.  
Reference \_\_\_\_\_
25. Because important decisions are based on tests results, strict and undeviating \_\_\_\_\_ of the specific procedures will achieve \_\_\_\_\_ and \_\_\_\_\_ .  
Reference \_\_\_\_\_

26. A change in coarse aggregate grading may affect the percentage of \_\_\_\_\_ and the rodded \_\_\_\_\_ of the aggregate, which is reflected in a change in the amount of sand required.  
Reference \_\_\_\_\_
27. Concrete used in an air meter in which water is used to fill the container should not be used for \_\_\_\_\_ tests or \_\_\_\_\_ specimens.  
Reference \_\_\_\_\_
28. Tests performed on hardened concrete are made in order to \_\_\_\_\_ or \_\_\_\_\_ the quality of the hardened concrete.  
Reference \_\_\_\_\_
29. The basic requirement of any sampling procedure is to obtain a truly \_\_\_\_\_ sample of the concrete.  
Reference \_\_\_\_\_



## CHAPTER 14

### BATCHING AND MIXING THE CONCRETE

**Objectives:** To understand how materials for concrete are to be handled, the types of batching and control systems in current use, and the types of mixers. Also reviewed are the history, operation and control of ready-mixed concrete, as well as the responsibilities of those involved in all aspects of concrete construction.

**Lesson Notes:** Size is not a qualifier for the quality mixing of concrete. Quality control may in fact be easier to achieve with smaller batches as opposed to a large operation in which one mistake can result in hundreds of yards of defective concrete.

#### **Key Points:**

- Define *fine aggregate*.
- What is the difference between natural and manufactured sand?
- What is the purpose of finish screening?
- How might coarse aggregate be contaminated?
- Why should special precautions be taken when taking aggregates from the bottom of a pile?
- How should admixtures be stored?
- At what point are superplasticizers usually introduced into a mix?
- How are pozzolans handled?
- Describe the types of control systems used at a batch plant.
- Of what does a partially automated batching system consist?
- Of what does a semiautomatic batching system consist?
- Describe the operation of an automatic batching system.
- What is the function of a recorder?
- Name the types of recorders.
- How accurate does a recorder have to be?
- In addition to the recording of plant operations, what other information can be obtained from a recorder?
- Describe the steps in calibrating a moisture meter.
- What is another name for a consistency meter?
- How does a consistency meter work?
- Why is weighing the cement first on a cumulative scale unacceptable?
- Identify the ways in which batching can be done.
- Describe the various ways that an admixture is batched.
- On what should the batch weights of aggregate be based?
- Name the causes of slump variations.
- What is the reason for having a batching sequence?
- Why is it important to check the accuracy of scales and batchers?
- Define *suspense material*.
- Name the different types of mixers and how they operate.
- What type of mixer is a turbine mixer?
- Name the advantages of a turbine mixer.
- Can a mixer be overloaded?

- List the causes of cement balls.
- Name the causes of incomplete mixing.
- Why install a timing device on a mixer?
- Define *ready-mixed concrete*.
- List the factors that are significant in batching and mixing of ready-mixed concrete.
- Name the three types of truck mixers.
- Which of these is a nonagitating type?
- What are the maintenance concerns of a mixer?
- Describe the operation of a mobile batcher.
- What are the advantages of a mobile batcher?
- Define *ribbon loading* and how it works.
- Describe what the sequence should be when adding materials to a mixer.
- During the trip to the job site, what is the speed of the truck mixer?
- Why is overmixing detrimental?
- Define what is meant by *agitating speed*.
- What is included when considering the total water?
- Should wash water be allowed as part of mixing water?
- Describe how water should be added after a truck has left the batch plant. When during or after discharge may water be added to a batch?
- List the information that should be included on a load ticket.
- Does air content increase or decrease with extended mixing?
- What is the generally agreed-on maximum time frame for mixing?
- How is delayed mixing accomplished?
- Give a brief description of the producer's and contractor's responsibilities, as well as their joint responsibilities.

## CHAPTER 14—QUIZZES

### I Multiple Choice

1. Aggregates at the bottom of a pile may be unsuitable because of the intrusion of \_\_\_\_\_.

- a. water
- b. foreign matter
- c. paste
- d. other aggregates
- e. e.fines

Response \_\_\_\_\_ Reference \_\_\_\_\_

2. A moisture meter usually consists of \_\_\_\_\_ electrode(s).

- a. one
- b. two
- c. three
- d. four
- e. none of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

3. Which one of the following is not required on the load ticket?

- a. serial number of the ticket
- b. amount of concrete
- c. MSA
- d. name of the contractor
- e. job name and location

Response \_\_\_\_\_ Reference \_\_\_\_\_

4. The primary function of a recorder is to \_\_\_\_\_ .

- a. check the mix design
- b. make a permanent record of plant operation
- c. verify the quality of materials
- d. indicate the accuracy of the weight and amount of cement
- e. provide quality control

Response \_\_\_\_\_ Reference \_\_\_\_\_

5. One of the concrete producer's responsibilities is to \_\_\_\_\_ .

- a. perform required tests
- b. organize placement and prompt discharge
- c. proportion and batch to meet specifications
- d. provide information on quantity required
- e. all of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

6. The use of ready-mixed concrete became widespread after \_\_\_\_\_.

- a. 1909
- b. 1920
- c. 1930
- d. 1940
- e. 1960

Response \_\_\_\_\_ Reference \_\_\_\_\_

7. The main advantage of a mobile batch mixer is \_\_\_\_\_.

- a. accurate mixing
- b. quality control of materials
- c. ease of delivery
- d. portability
- e. all of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

8. Fine aggregate is material that passes a No. \_\_\_\_\_ sieve.

- a. 4
- b. 5
- c. 8
- d. 9
- e. 12

Response \_\_\_\_\_ Reference \_\_\_\_\_

9. A mixer with a rotating drum that charges, mixes and discharges with its drum axis horizontal is a \_\_\_\_\_.

- a. plant mixer
- b. vertical shaft mixer
- c. horizontal shaft mixer
- d. tilting mixer
- e. nontilting mixer

Response \_\_\_\_\_ Reference \_\_\_\_\_

10. The agreed upon length of time that cement can be exposed to moisture in a mixer is \_\_\_\_\_.

- a. one hour
- b. one and one-half hours
- c. two hours
- d. two and one-half hours
- e. three hours

Response \_\_\_\_\_ Reference \_\_\_\_\_



**II True/False**

11. Aggregates at the bottom of a stockpile located on ground can be used without concern.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
12. Batch plants that handle more than one type of cement should have each type in a separate compartment.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
13. A ready-mixed concrete producer provides the personnel and equipment to ensure continuous production at a rate that meets the needs of the work.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
14. When used, a superplasticizer must be introduced into the mixer immediately before discharge of the concrete into the receiving equipment.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
15. Trucks used to supply ready-mixed concrete to the job site must be cleaned so that concrete will not accumulate on the drum or around the mixing blades.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
16. If water is not added, long-time mixing will not affect slump or stiffness.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
17. The suggested mixing time for a 4 cubic-yard stationary mixer is about three minutes.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
18. The direction of rotation of the drum on a truck-mixer is reversed to discharge the concrete.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_

**III Completion**

19. The method of \_\_\_\_\_ and \_\_\_\_\_ the cement and aggregates into the \_\_\_\_\_ has a very important influence on the efficiency of mixing.  
Reference \_\_\_\_\_
20. When batching, cement must be weighed \_\_\_\_\_ ; aggregates may be \_\_\_\_\_, weighing each in turn; and if weighed, water should be weighed on \_\_\_\_\_.  
Reference \_\_\_\_\_

21. Control systems range from manually controlled individual batchers that depend on the operator's visual observation of a \_\_\_\_\_ or \_\_\_\_\_ to fully automated systems that are actuated by a single starting \_\_\_\_\_ and that stop automatically when the \_\_\_\_\_ has been reached.

Reference \_\_\_\_\_

22. Total water in concrete includes free water on the \_\_\_\_\_, \_\_\_\_\_ in admixtures, \_\_\_\_\_ used in hot weather and water added to the batch.

Reference \_\_\_\_\_

23. To promote thorough mixing inside a drum mixer, the \_\_\_\_\_ should be designed to move the concrete from \_\_\_\_\_ end of the drum to the \_\_\_\_\_, with many crossing of \_\_\_\_\_.

Reference \_\_\_\_\_

24. There are two potential sources of trouble when aggregate is delivered to the plant by \_\_\_\_\_: placing the \_\_\_\_\_ material in a pile, and \_\_\_\_\_ and \_\_\_\_\_ being carried into the pile by the truck.

Reference \_\_\_\_\_

25. A few of the items that are included on a ready-mixed load ticket are the date, \_\_\_\_\_ number, name of the \_\_\_\_\_ and the \_\_\_\_\_, amount of \_\_\_\_\_, and time \_\_\_\_\_.

Reference \_\_\_\_\_

26. Scales and batching equipment should be kept \_\_\_\_\_. Binding of \_\_\_\_\_ or \_\_\_\_\_ knife edges and \_\_\_\_\_ causes serious weighing errors.

Reference \_\_\_\_\_

27. The three methods of mixing ready-mixed concrete are \_\_\_\_\_, \_\_\_\_\_, and \_\_\_\_\_.

Reference \_\_\_\_\_

## CHAPTER 15

### HANDLING AND PLACING THE CONCRETE

**Objectives:** To understand the preparation needed prior to placing concrete, the various ways of conveying and pumping concrete, and the proper placement and consolidation of concrete.

**Lesson Notes:** When depositing concrete in the forms, the term most commonly used is *pouring*; however, *placing* is the more correct term and is more accurate insofar as pouring applies only to a liquid. The use of the word *pouring* originated in the days when wet, sloppy concrete was permitted to flow into place.

#### **Key Points:**

- What are the three phases of placing concrete?
- How are cast-in-place piles and caissons inspected?
- When may a construction joint be required?
- Is roughness necessary for a good construction joint?
- Does reinforcing usually continue through a construction joint?
- How is a shear key formed?
- Describe the factor that can cause laitance at a construction joint.
- When may embedded items be placed in plastic concrete?
- What factors must be considered when choosing conveying equipment?
- Identify the advantages and disadvantages of direct discharge.
- What is one of the chief considerations when placing concrete?
- How should concrete be discharged vertically?
- Name the three types of concrete pumps.
- How does aggregate grading affect pumping?
- List the admixtures that improve pumpability.
- What is the best slump for pumping concrete?
- What is the most common aggregate size when pumping concrete?
- How does pumping affect slump?
- What concerns are associated with keeping concrete in a pump hopper?
- What are the causes of line blockage, and how can they be avoided?
- Describe the problems with downhill pumping.
- What is the main problem in pumping lightweight concrete?
- From where does the term *pouring* originate?
- State the basic rule of placing concrete.
- Name the types of equipment used to deposit concrete.
- How quickly should concrete be placed?
- Describe how concrete should be placed in walls of considerable height.
- How should concrete be placed in deep footings or piles?
- Give a brief description of how best to place monolithic columns and slabs.
- Why should concrete not be placed during a heavy rain?
- What precautions are necessary when placing concrete after rain has started?
- Name the two kinds of vibrators.
- Is vibration always required?

- Against what should a vibrator not be placed?
- How would you handle concrete that has segregated?
- Is overvibration ever a problem?
- When can concrete be revibrated?

## CHAPTER 15—QUIZZES

### I Multiple Choice

1. A good concrete mix for pumping is a plastic, workable mix with a slump range between \_\_\_\_\_ inches.
- a. 3 to 6
  - b. 4 to 6
  - c. 4 to 8
  - d. 5 to 7
  - e. 2 to 5

Response \_\_\_\_\_ Reference \_\_\_\_\_

2. Chutes can be made of \_\_\_\_\_ .
- a. wood
  - b. metal
  - c. plastic
  - d. aluminum
  - e. any of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

3. One problem associated with belt conveyors is \_\_\_\_\_ .
- a. segregation
  - b. consolidation
  - c. mortar leakage
  - d. motor failure
  - e. all of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

4. Forms should be clean, tight and \_\_\_\_\_ .
- a. wet
  - b. staked
  - c. properly braced
  - d. supported by earth
  - e. all of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

5. Vibrators can be grouped into two classes: \_\_\_\_\_ .
- a. mechanical and electrical
  - b. external and internal
  - c. pneumatically driven and electrical
  - d. pan and screed
  - e. table and shaft

Response \_\_\_\_\_ Reference \_\_\_\_\_

6. The most commonly used aggregate in a pump mix is \_\_\_\_\_ inch(es).

- a.  $\frac{3}{4}$  or 1
- b. 1 or  $1\frac{1}{4}$
- c. 1 or  $1\frac{1}{2}$
- d.  $1\frac{1}{2}$  or 2
- e. pea gravel

Response \_\_\_\_\_ Reference \_\_\_\_\_

7. High-frequency vibration for consolidation of concrete was introduced around \_\_\_\_\_ .

- a. 1950
- b. 1945
- c. 1940
- d. 1935
- e. 1930

Response \_\_\_\_\_ Reference \_\_\_\_\_

8. Prior to placing concrete when using a pump, the hose should be \_\_\_\_\_ .

- a. primed with water
- b. straight and without radius, bends or kinks
- c. kept at pump level
- d. lubricated with form oil
- e. primed with mortar

Response \_\_\_\_\_ Reference \_\_\_\_\_

9. When using a wheelbarrow to transport concrete, the maximum horizontal distance should be \_\_\_\_\_ feet.

- a. 100
- b. 150
- c. 175
- d. 200
- e. 250

Response \_\_\_\_\_ Reference \_\_\_\_\_

10. Conveyor belts for placing concrete have an average capacity of about \_\_\_\_\_ cubic yards per hour.
- a. 20 to 30
  - b. 30 to 40
  - c. 40 to 50
  - d. 50 to 60
  - e. 60 to 70

Response \_\_\_\_\_ Reference \_\_\_\_\_

11. Proper consolidation of concrete decreases \_\_\_\_\_ .
- a. cold joints
  - b. honeycombing
  - c. entrapped air
  - d. segregation
  - e. all of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

12. Concrete is properly vibrated when \_\_\_\_\_ .
- a. concrete surface takes on a sheen
  - b. large air bubbles no longer appear at surface
  - c. vibrator changes pitch or tone
  - d. large aggregate blends into surface
  - e. all of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

## II True/False

13. Revibration occurs when the vibrator, in consolidating a layer of concrete, penetrates into the layer below to unite the two layers.  
T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_
14. When pumping concrete during an extended delay, it is not good practice to run the pump every few minutes.  
T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_
15. There are two types of piston pumps: hydraulic and mechanical.  
T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_
16. When using a bucket to place concrete, the bucket should have a capacity of at least one batch.  
T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_
17. Prior to placing concrete, excavations for foundations should extend into sound, undisturbed soil or rock.  
T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_

18. The most common width of a conveyor belt used to place concrete is about 24 inches.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
19. When using wood forms for blockouts, the wood should be clean and dry prior to placing the concrete.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
20. If it begins to rain before concrete placement has been completed, cover the work area with tarps until the concrete has set.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
21. Vibrators that are attached to forms and that vibrate the concrete by vibrating the forms are external-type vibrators.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
22. Sites that are especially suited for pumping of concrete are those where access is limited or that are crowded with materials.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
23. A thin coating of rust on reinforcing steel is detrimental, and dried mortar splashed on the steel must be removed.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
24. Hauling buckets on trucks for a considerable distance can cause segregation of the concrete.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
25. When vibrating formed concrete, the vibrator should be tilted slightly after contacting bottom of form.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
26. To avoid over vibration, a vibrator should be lifted rapidly from the concrete after each insertion.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
27. Revibration of concrete is acceptable if the vibrator can easily be pushed into the concrete.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_

### III Completion

28. Roughness is not essential to a good construction joint. A better joint is achieved if the surface of the old concrete is \_\_\_\_\_ and \_\_\_\_\_.  
Reference \_\_\_\_\_



29. Essential to any system of moving concrete from a mixer to forms is to minimize \_\_\_\_\_, prevent loss of \_\_\_\_\_ and avoid excessive loss of \_\_\_\_\_ .  
Reference \_\_\_\_\_
30. In difficult locations, such as on a steep hillside, a pump can easily move the concrete over \_\_\_\_\_ that would be difficult for a truck to reach.  
Reference \_\_\_\_\_
31. Cause of line blocks are slump to \_\_\_\_\_; harsh, unworkable \_\_\_\_\_; a mix that is too \_\_\_\_\_; bleeding of the concrete; a long line exposed to the \_\_\_\_\_; and a long interruption in \_\_\_\_\_ .  
Reference \_\_\_\_\_
32. A vibrator should not come into contact with the \_\_\_\_\_ or held against the \_\_\_\_\_ .  
Reference \_\_\_\_\_
33. With few exceptions, placing of \_\_\_\_\_, \_\_\_\_\_, \_\_\_\_\_, and \_\_\_\_\_ should be done prior to concrete placement.  
Reference \_\_\_\_\_
34. Pumps are currently available with capacities in excess of \_\_\_\_\_ cubic yards per hour, \_\_\_\_\_ feet vertically and \_\_\_\_\_ feet horizontally.  
Reference \_\_\_\_\_
35. Vibrators should be placed at points that are uniformly \_\_\_\_\_ close enough together to ensure \_\_\_\_\_ and for \_\_\_\_\_ seconds duration per insertion.  
Reference \_\_\_\_\_



## CHAPTER 16

### SLABS ON GROUND

**Objectives:** To gain an understanding of the requirements for correct placing of concrete on all types of slabs, including suspended slabs.

**Lesson Notes:** One does not know concrete unless one knows “Slabs on ground”. They are never problem free... shrinkage, not strength, is the primary problem. If the reader deals primarily with construction of slabs on ground, a thorough understanding of the following “Key Points” is essential.

#### Key Points:

- What is the most important property of a slab on ground?
- How must the subgrade be prepared?
- What types of soils should be avoided in the subgrade?
- How essential is good drainage to sidewalks, floors and patio slabs?
- What is a screed?
- What is the difference between a screed and a wet screed?
- What is the recommended slope for interior and exterior slabs requiring drainage?
- When is a vapor barrier required?
- What material is normally used as a vapor barrier?
- How should a vapor barrier be installed?
- When would a vapor barrier not be required?
- When should slab on ground concrete be air-entrained?
- Describe the condition of the subgrade prior to placing concrete.
- When is concrete ready for final finishing?
- What are a darby, bullfloat, tamper and jitterbug?
- When should a tamper or jitterbug not be used?
- What is the primary function of joints in slabs?
- Name the three types of joints and their purpose.
- When are construction joints used?
- What is used when a bond across a joint is required?
- What can happen if dowels are not placed perpendicular to the bulkhead?
- When are contraction joints used?
- What is another name for contraction joints?
- Describe four methods for placing contraction joints.
- When a mix has normal shrinkage characteristics, at what distance should contraction joints be placed?
- When are isolation joints used?
- What is another name for an isolation joint?
- How is an isolation joint installed?
- Define *light-duty floor*.
- Describe the acceptable ways of installing wire mesh in medium-duty slabs.
- What are the strength and slump requirements for a medium-duty floor?
- Define *two-course heavy-duty floors*.
- How is wear resistance obtained for a heavy-duty floor?

- What is expansive soil, and how does it react with water?
- Define *suspended slabs*.
- How do the placing procedures for a suspended slab differ from those for a ground slab?

## CHAPTER 16—QUIZZES

### I Multiple Choice

1. A concrete floor that is not exposed to heavy loads or to an aggressive environment is a \_\_\_\_\_ floor.
- a. light-duty
  - b. medium-duty
  - c. heavy-duty
  - d. special-duty
  - e. none of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

2. The maximum recommended slump of a medium-duty floor is \_\_\_\_\_ inches.
- a. 2
  - b. 3
  - c. 4
  - d. 5
  - e. 6

Response \_\_\_\_\_ Reference \_\_\_\_\_

3. The subgrade must be prepared by removing \_\_\_\_\_ .
- a. grass
  - b. roots
  - c. organic matter
  - d. soft soil
  - e. all the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

4. A floor slab where industrial vehicular traffic is anticipated should have a \_\_\_\_\_ finish.
- a. single trowel
  - b. float
  - c. broom
  - d. hard steel trowel
  - e. rake

Response \_\_\_\_\_ Reference \_\_\_\_\_

5. Isolation joints allow a slab to \_\_\_\_\_.

- a. move vertically
- b. move horizontally
- c. move vertically and horizontally
- d. expand
- e. none of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

6. An interior floor slab should \_\_\_\_\_ if moisture is present under it.

- a. be built on a vapor barrier
- b. have a 2-inch sand barrier
- c. be built with Type V cement
- d. have adequate subdrains
- e. none of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

7. When placing concrete, the final compacting following the strike-off is accomplished by the use of a \_\_\_\_\_.

- a. screed
- b. bullfloat
- c. rake
- d. jitterbug
- e. tamper

Response \_\_\_\_\_ Reference \_\_\_\_\_

8. When installing contraction joints, the groove edges should be \_\_\_\_\_.

- a. squared
- b. slightly rounded
- c. tapered
- d. angled
- e. any of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

9. Where installed in a slab, reinforcing should be supported by \_\_\_\_\_.

- a. pieces of stone
- b. metal stakes
- c. wood supports
- d. chairs
- e. any of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

10. Spacing of contraction joints should not exceed \_\_\_\_\_ times the slab thickness where normal shrinkage is anticipated.
- 20
  - 30
  - 40
  - 50
  - 60
- Response \_\_\_\_\_ Reference \_\_\_\_\_

## II True/False

11. When a new slab is placed adjacent to existing concrete, there must be a separation to allow for movement relative to the old concrete.  
T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_
12. When a slab is water soaked for much of the time, a nonpermeable layer should be installed for a depth of 6 inches.  
T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_
13. Rakes, shovels and hoes are acceptable for spreading concrete.  
T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_
14. The thickness of a medium-duty, one-course floor slab is determined on the basis of the strength and slump of the concrete used.  
T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_
15. After a good floor has been properly cured, its durability cannot be improved by further drying.  
T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_
16. A floor in a dwelling that is intended to be covered by carpet should be of the same hardness quality as a warehouse floor.  
T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_
17. The primary function of most joints in concrete is to control or minimize cracking and other volume changes, or to permit relative movement of adjacent portions in a structure.  
T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_
18. The drying shrinkage of the concrete in a large slab will cause random cracks in the slab unless means are provided to relieve this stress.  
T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_
19. Premolded material in an expansion joint must be at least one-half as wide as the slab is thick and may extend slightly above the slab.  
T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_

20. A deep keyway for keyed construction joints is preferable to ensure complete filling of the keyway when the second run of concrete is placed.

T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_

### III Completion

21. A suspended slab is one that does not require support by the \_\_\_\_\_ and must meet the structural requirements of the \_\_\_\_\_ .

Reference \_\_\_\_\_

22. A wet screed is a strip of concrete about \_\_\_\_\_ inches wide that is placed just before placing concrete for the slab.

Reference \_\_\_\_\_

23. Prior to placing a concrete slab, the subgrade should be saturated for \_\_\_\_\_ before and \_\_\_\_\_ at the time concrete is to be placed.

Reference \_\_\_\_\_

24. When floors must be sloped for drainage, interior slabs should have a slope of at least \_\_\_\_\_ inch per \_\_\_\_\_ , and exterior slabs should have at least \_\_\_\_\_ inch per \_\_\_\_\_. Anything less is likely to result in \_\_\_\_\_ .

Reference \_\_\_\_\_

25. In locations where concrete placing is discontinued, a \_\_\_\_\_ should be installed and a \_\_\_\_\_ made. The location of construction joints on a large slab should be \_\_\_\_\_ .

Reference \_\_\_\_\_

26. The effect of adequate cement on the durability of a floor can be nullified by a lack of \_\_\_\_\_ , high \_\_\_\_\_ , over-vibration or working the surface when \_\_\_\_\_ is present.

Reference \_\_\_\_\_



## CHAPTER 17

### FINISHING AND CURING THE CONCRETE

**Objectives:** To understand the proper application and use of concrete finishing tools and the wear resistance, special treatments and decorative finishes for floors. The materials, time and methods of curing will be reviewed as well.

**Lesson Notes:** Improper curing can ruin what otherwise would be good quality concrete. Unfortunately, it is often neglected or done improperly, thus reducing durability and structural adequacy. Conscientiously following proper curing procedures will result in good, durable concrete. Additionally, finishing, if hurried, can turn an attractive product into an unsightly mess.

#### **Key Points:**

- When should slab finishing operations begin?
- State the basic law of finishing concrete.
- Do all slabs require edging?
- Describe the purpose of edging.
- At what point is grooving begun?
- Name the important points of the correct method of grooving.
- What is the third step in finishing?
- When should floating start?
- What is the purpose of floating?
- Which material is best for floats?
- Name the last step in finishing concrete.
- What is the best type of finishing trowel.
- How is the first troweling done?
- How can smoothness of the concrete surface be improved?
- How should bubbles and blisters be treated when troweling?
- Describe the methods, besides brooming or brushing, of applying a nonslip finish to concrete.
- What is the hardness factor of concrete?
- Define *dusting*.
- What are the causes of dusting?
- Describe the chemical treatment processes for hardening of a concrete floor that is dusting.
- What is meant by a *dry shake coat*?
- What is the purpose of a dry shake coat?
- Name the materials used in dry shake coatings.
- How do liquid hardeners work?
- Should liquid hardeners be considered for any floor slab?
- Name two ways a travertine surface can be obtained.
- Describe how simulated flagstone is made.
- Identify the three methods for imparting color to concrete.
- Name the materials involved in the dry shake method of coloring concrete.
- Describe the two methods employed for creating exposed aggregate concrete.

- Briefly describe how to obtain exposed aggregate concrete using the integral and seeding methods.
- Why would a retarder be used in the integral method?
- What should be the MSA in an exposed aggregate slab when the seeding method is used?
- What is terrazzo?
- Describe how a sand-cushion terrazzo concrete floor is installed.
- What are the similarities and differences between a sand-cushion and a bonded terrazzo floor?
- How do dividers control cracking?
- What can occur if concrete is not properly cured?
- What does curing do?
- Over what period of time should concrete curing extend?
- Name the four methods of curing.
- What is the minimum thickness of polyethylene film used for curing concrete?
- Why is continual stirring of sealing compounds required?
- What time period is most crucial in concrete curing?
- What are the minimum curing times for various cements?
- What are the two general categories of curing methods? Which method is best?
- Give the positive and negative aspects of the methods of curing that supply added moisture.
- Briefly describe how wet burlap, spray pipes, flooding, wet earth and cotton mats are used to cure concrete.
- Name four common materials used for wet curing with blankets or mats.
- When is brush application of sealing materials acceptable?
- What is *Confilm*, and how is it applied?
- What is the usual temperature range of high-temperature curing?
- Identify the concerns when using high-temperature curing.
- What is steam curing?

## CHAPTER 17—QUIZZES

### I Multiple Choice

1. Prior to being subjected to high-temperature curing, concrete should undergo a presetting period after casting of between \_\_\_\_\_ at normal temperatures.
- a. 1 to 2 hours
  - b. 2 to 3 hours
  - c. 24 to 48 hours
  - d. 48 to 72 hours
  - e. 1 to 2 weeks

Response \_\_\_\_\_ Reference \_\_\_\_\_

2. When exposing aggregate, which of the following should not be done?
- a. using calcium chloride in the concrete
  - b. using a surface retarder
  - c. testing a sample panel under field conditions
  - d. using uniform materials
  - e. none of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

3. When a heavy-duty topping is required and placement has been delayed, the base slab should be \_\_\_\_\_ .
- a. clean
  - b. moist
  - c. dry
  - d. both a and b
  - e. both a and c

Response \_\_\_\_\_ Reference \_\_\_\_\_

4. Curing methods that prevent loss of moisture entail use of \_\_\_\_\_ .
- a. retarders
  - b. insulators
  - c. sealing materials
  - d. mats and blankets
  - e. none of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

5. After floating, the next step in the finishing process is \_\_\_\_\_.
- a. troweling
  - b. grooving
  - c. edging
  - d. brooming
  - e. none of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

6. The best use of liquid hardeners is on \_\_\_\_\_.
- a. cured floors
  - b. new floors
  - c. above-grade slabs
  - d. older floors
  - e. all of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

7. After grinding, a standard terrazzo topping should have a minimum thickness of at least \_\_\_\_\_ inch(es).
- a. 1 1/4
  - b. 1
  - c. 3/4
  - d. 5/8
  - e. 3/8

Response \_\_\_\_\_ Reference \_\_\_\_\_

8. The normal range of temperatures for high temperature curing is \_\_\_\_\_ °F.
- a. 120 to 160
  - b. 100 to 125
  - c. 150 to 200
  - d. 125 to 170
  - e. 175 to 225

Response \_\_\_\_\_ Reference \_\_\_\_\_

9. \_\_\_\_\_ solutions are not to be used for curing concrete.
- a. Potassium chloride
  - b. Sodium sulfate
  - c. Calcium chloride
  - d. Sodium silicate
  - e. all of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

10. All concrete must be \_\_\_\_\_ .

- a. finished
- b. cured
- c. edged
- d. treated
- e. all of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

11. Unformed concrete surfaces include \_\_\_\_\_ .

- a. floors
- b. slabs
- c. sidewalks
- d. driveways
- e. all of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

12. One result of dusting a partly hardened slab with dry cement can be \_\_\_\_\_.

- a. retarded setting
- b. dry shaking
- c. increased hardness
- d. bubbles
- e. all of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

**II True/False**

13. Dusting is caused by weak and soft concrete that results from overfinishing, the use of overly fluid mixes or working the surface while bleed water is present.

T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_

14. In a heavy-duty slab, joints in the base slab must be continuous through the wearing course; otherwise the topping will crack.

T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_

15. A basic law of finishing concrete is to never use any tools on the fresh concrete while bleed water is present on the surface.

T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_

16. Two of the optimum conditions for high-temperature steam curing are dry steam and a slow temperature rise of not over 60°F per hour.

T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_

17. Curing compounds are dry mixed when they arrive on the job and should not be agitated after initial mixing.

T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_

18. Lean concrete in massive structures requires about four weeks for curing if pozzolans are not used. Normal concrete is best cured for seven days.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
19. When exposing aggregate, care must be taken to clean the aggregates without undercutting or loosening them. The maximum exposure is about  $\frac{1}{16}$  to  $\frac{1}{4}$  inch.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
20. Varnish, lacquers, shellac and surface waxes should not be used on terrazzo.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
21. When giving a rock salt finish, the salt is spread on the surface of the concrete at a rate of between 5 and 20 pounds per 100 square feet of area after the slab is finished in the normal manner.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
22. A new trowel is difficult to use until it has been broken in for a few weeks.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
23. It is not unusual to construct a floor that is exposed to especially severe conditions of traffic and abrasion in two layers.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
24. Polyethylene film used to cure concrete should consist of two sheets at least 4 mils in thickness and be black in color.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
25. Color can be imparted to concrete by paints, stains and pigments incorporated into the concrete when it is mixed.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
26. A concrete surface is ready for final finishing operations when all bleedwater has evaporated.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
27. Slab edging is required along all isolation and construction joints.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_

### III Completion

28. \_\_\_\_\_ produces a radius or rounded edge to the concrete that protects the concrete from \_\_\_\_\_ or other \_\_\_\_\_.  
Reference \_\_\_\_\_

29. The dry shake method of coloring concrete consists of \_\_\_\_\_ cement, \_\_\_\_\_ and specially graded \_\_\_\_\_.  
Reference \_\_\_\_\_
30. Trowels are made of heat-treated \_\_\_\_\_ steel or stainless steel and are \_\_\_\_\_ to \_\_\_\_\_ inches long and \_\_\_\_\_ to \_\_\_\_\_ inches wide.  
Reference \_\_\_\_\_
31. Curing methods that supply moisture include \_\_\_\_\_, \_\_\_\_\_ and other moisture-retaining \_\_\_\_\_.  
Reference \_\_\_\_\_
32. A dry shake or dust coat can be applied to a one-course slab to give it a high resistance to \_\_\_\_\_ and \_\_\_\_\_. Application of a dry shake is spread on the floated slab \_\_\_\_\_ the bleed water has \_\_\_\_\_.  
Reference \_\_\_\_\_
33. Materials that can be used for curing concrete include \_\_\_\_\_, \_\_\_\_\_ compounds, and various \_\_\_\_\_ and \_\_\_\_\_.  
Reference \_\_\_\_\_
34. A grooving tool is usually made of \_\_\_\_\_, \_\_\_\_\_ or \_\_\_\_\_, and is usually \_\_\_\_\_ inches long with ends \_\_\_\_\_ slightly to facilitate its use.  
Reference \_\_\_\_\_
35. Aggregate for heavy-duty floors must be \_\_\_\_\_ and \_\_\_\_\_, consisting of \_\_\_\_\_, \_\_\_\_\_ or similar natural rock particles, or a manufactured product.  
Reference \_\_\_\_\_
36. When using sealing compounds to cure concrete, the compounds should be of a consistency suitable for \_\_\_\_\_, should be relatively \_\_\_\_\_, should adhere to a vertical or horizontal \_\_\_\_\_ concrete surface, and should not react \_\_\_\_\_ with the concrete.  
Reference \_\_\_\_\_
37. Moist curing after steaming improves \_\_\_\_\_ and \_\_\_\_\_, and should be utilized if possible. The greatest advantage of steaming occurs during the \_\_\_\_\_ and soon reaches a point of diminishing return.  
Reference \_\_\_\_\_





## CHAPTER 18

### THE REINFORCEMENT

**Objectives:** To give a general overview of the kinds of reinforcing used, how it is fabricated, and its placing, handling and inspection. Also, to provide a brief look at fiberglass and stainless steel reinforcement.

**Lesson Notes:** Perhaps the most important aspect of placement of reinforcement is that it must be installed exactly per the approved plans and engineering details. Substitution of sizes, cutting, bending, splicing and relocation should never be permitted unless approved by the engineer and the building official.

#### Key Points:

- Why is reinforcement used in concrete?
- At what locations in a beam is reinforcement usually placed?
- Of what configuration are stirrups, and how are they placed?
- What are the nominal diameters of #4, #6 and #9 bars?
- What are the equivalent metric numbers for #4, #6 and #9 bars?
- What does the grade of steel indicate?
- What is the specified yield strength of a Grade 60 bar?
- Define *yield point* and *ultimate tensile strength*.
- Review Figure 18-4, and identify what each of the marks on a reinforcing bar indicate.
- Describe what each of the numbers and letters mean in WWR 6 x 12-W1 6 x W26.
- What is the substitute letter for deformed wire?
- What is a bar mat?
- What is a sand plate?
- What are the three classes of metal bar supports?
- Define *placing drawings*.
- What is contained in placing drawings?
- What is a bar list?
- Of what does a reinforcing schedule consist?
- How is steel bent?
- Review the rebar placing tolerances in Tables 18.7 and 18.8.
- What are bundled bars?
- What information should the tag on bundled bars contain?
- What is a manifest?
- What is contained in a manifest?
- How should reinforcing bars be stored at the job site?
- Of the following list, which item(s) is acceptable on reinforcing? Oil, grease, light rust, paint, mill scale.
- When may reinforcing be heated for bending?
- After heating, how should a bar be cooled?
- What should be inspected and verified on each shipment of reinforcing?
- When is welding of crossing bars allowed?
- When is field bending of partially embedded reinforcing acceptable?
- What is mill scale?

- What is the maximum amount of rust that is acceptable on steel?
- How are dowels held in place?
- Name the three general types of bar splices.
- How are splices in adjacent bars done?
- What criteria are followed when using a mechanical splice?
- What are the two types of welded splices?
- Describe a potential problem of welded splices.
- What is meant by the term *dobies*?
- What is the purpose of tying reinforcing?
- Do all intersections have to be tied?
- Why is placing the steel within code tolerances important?
- What are the usual tolerances for stirrups and column ties?
- What is the purpose of providing concrete cover over reinforcing?
- How is welded wire reinforcement lapped?
- Specify the correct and incorrect placement procedures for welded wire reinforcement.
- Which fiber reinforcement is the one most commonly used?
- Are there any concerns with using galvanized reinforcing?
- Describe the special precautions necessary when using epoxy-coated steel.

## CHAPTER 18—QUIZZES

### I Multiple Choice

1. Excessive rusting of the reinforcement weakens the steel and also causes \_\_\_\_\_, which may result in spalling and cracking.
- a. small voids
  - b. an expansion in volume
  - c. a loss of water proofing
  - d. a loss of durability
  - e. all of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

2. Which of the following does not interfere with steel bonding to concrete?
- a. paint
  - b. grease
  - c. mill scale
  - d. oil
  - e. light rust

Response \_\_\_\_\_ Reference \_\_\_\_\_

3. Epoxy-coated reinforcement should be checked for \_\_\_\_\_.
- a. proper mechanical splices
  - b. rust
  - c. smoothness
  - d. damaged coating
  - e. all of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

4. A #5 bar has an approximate diameter of \_\_\_\_\_ inch.
- a.  $\frac{5}{8}$
  - b.  $\frac{5}{16}$
  - c.  $\frac{1}{2}$
  - d.  $\frac{3}{4}$
  - e. none of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

5. An advantage of using WWR is \_\_\_\_\_.
- a. lighter weight
  - b. ease of use in columns and beams
  - c. increased tensile strength
  - d. speed and ease of installation
  - e. ease of use in transverse structures

Response \_\_\_\_\_ Reference \_\_\_\_\_

6. Welded splices can be either lap welds or \_\_\_\_\_ welds.

- a. proprietary
- b. mechanical
- c. tied
- d. hooked
- e. butt

Response \_\_\_\_\_ Reference \_\_\_\_\_

7. To resist movement or displacement, reinforcing bars must be \_\_\_\_\_ .

- a. supported
- b. welded together
- c. tied together
- d. hooked
- e. any of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

8. Field bending is apt to result in \_\_\_\_\_ .

- a. loss of ductility
- b. loss in compressive strength
- c. loss of bond
- d. increased lap slices
- e. expansion

Response \_\_\_\_\_ Reference \_\_\_\_\_

9. Carbon-steel reinforcing bars are available in Grades \_\_\_\_\_ .

- a. 35, 40 and 50
- b. 40, 50 and 60
- c. 40, 60 and 75
- d. 40, 60 and 80
- e. 60, 75 and 90

Response \_\_\_\_\_ Reference \_\_\_\_\_

10. In addition to the two main ribs, a reinforcing bar may have a third rib. This indicates \_\_\_\_\_ .

- a. type of steel
- b. Grade 60
- c. Grade 75
- d. rail steel
- e. low-alloy steel

Response \_\_\_\_\_ Reference \_\_\_\_\_

11. Factory-made wire bar supports may be made of \_\_\_\_\_.

- a. plain wire
- b. galvanized wire
- c. stainless steel wire
- d. all of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

12. A reinforcing bar shipment from a fabricator will be accompanied by a list known as a \_\_\_\_\_.

- a. manifest
- b. invoice
- c. trip ticket
- d. delivery ticket
- e. none of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

13. The most widely used reinforcing bars are \_\_\_\_\_.

- a. axle steel
- b. billet steel
- c. carbon steel
- d. low-alloy steel
- e. rail steel

Response \_\_\_\_\_ Reference \_\_\_\_\_

14. A #22 metric reinforcing bar is the same size as a \_\_\_\_\_ inch-pound reinforcing bar.

- a. #5
- b. #6
- c. #7
- d. #8
- e. none of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

15. The equivalent metric grade mark for the inch-pound grade mark 75 is \_\_\_\_\_.

- a. 3
- b. 4
- c. 5
- d. 42
- e. 52

Response \_\_\_\_\_ Reference \_\_\_\_\_

16. According to the placing drawing (Figure 18-15) of the *Concrete Manual*, the required number of stirrups at each end of grade beam GB1 is indicated as \_\_\_\_\_.

- a. 3@5 inch
- b. 3@6 inch
- c. 4@5 inch
- d. 4@6 inch
- e. none of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

17. According to the placing drawing (Figure 18-15) of the *Concrete Manual*, the required reinforcing (each way) for footing F2 is indicated as \_\_\_\_\_.

- a. 12#19
- b. 24#19
- c. 10#22
- d. 20#22
- e. 16#22

Response \_\_\_\_\_ Reference \_\_\_\_\_

18. According to the placing drawing (Figure 18-15) of the *Concrete Manual*, the footing dowels for column D1 may extend \_\_\_\_\_ vertically into the column and be within acceptable tolerance (+/- 2 inch).

- a. 2' 0"
- b. 2' 1"
- c. 2' 6"
- d. 2' 8"
- e. 2' 10"

Response \_\_\_\_\_ Reference \_\_\_\_\_

19. Suggested minimum spacing of supports for D9 WWR @14-inch wire spacing used in slab-on-ground applications is \_\_\_\_\_.

- a. 2 to 3 ft
- b. 3 to 4 ft
- c. 4 to 6 ft
- d. 6 to 8 ft
- e. none of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

20. If a mill test report is not available, welding of #6 carbon steel rebars is permitted if the bars are preheated to \_\_\_\_\_ °F.
- a. 100
  - b. 200
  - c. 300
  - d. 400
  - e. 500

Response \_\_\_\_\_ Reference \_\_\_\_\_

21. If a mill test report is not available, welding of #6 low-alloy steel rebars is permitted if the bars are preheated to \_\_\_\_\_ °F.
- a. 50
  - b. 200
  - c. 300
  - d. 500
  - e. no preheat required

Response \_\_\_\_\_ Reference \_\_\_\_\_

22. If the design drawings for an 8-inch concrete tilt-up panel indicate a 1<sup>1</sup>/<sub>2</sub>-inch cover to the vertical rebars, the minimum acceptable measured cover is \_\_\_\_\_ inch.
- a.  $\frac{3}{4}$
  - b. 1
  - c.  $1\frac{1}{8}$
  - d.  $1\frac{1}{4}$
  - e. none of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

23. If the design drawings for a 24-inch deep spandrel beam at the perimeter of an elevated slab indicate a clear cover of 1<sup>1</sup>/<sub>2</sub> inches to the bottom reinforcing bars, the minimum acceptable measured cover is \_\_\_\_\_ inch(es).
- a. 1
  - b.  $1\frac{1}{8}$
  - c.  $1\frac{1}{4}$
  - d.  $1\frac{3}{8}$
  - e. none of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

24. If the design drawings for a structural slab indicate that the bottom bars of the end span are to be located 3 feet from the center of the interior column support, the minimum acceptable measured distance is \_\_\_\_\_ .
- a. 2 feet, 8 inches
  - b. 2 feet, 9 inches
  - c. 2 feet, 10 inches
  - d. 2 feet, 11 inches
  - e. 3 feet, 0 inches

Response \_\_\_\_\_ Reference \_\_\_\_\_

25. The equivalent metric designation for inch-pound WWR sheet 6 x 6 - W4 x W4 is \_\_\_\_\_.
- a. 102 x 102 - MW9 x MW9
  - b. 102 x 102 - MW26 x MW26
  - c. 152 x 152 - MW9 x MW9
  - d. 152 x 152 - MW19 x MW19
  - e. 152 x 152 - MW26 x MW26

Response \_\_\_\_\_ Reference \_\_\_\_\_

## II True/False

26. Bar mats are similar to WWR except that they are made with reinforcing bars.  
T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_
27. All bends are made with the steel at normal room temperature except in cold weather, in which case hot bending is permitted.  
T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_
28. Tying the steel is done after it has been placed and spaced properly.  
T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_
29. The primary purpose of concrete cover for reinforcing steel is to protect the steel from weathering.  
T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_
30. Heavy welded wire reinforcement comes in flat sheets and is used primarily as structural reinforcement.  
T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_
31. A light coating of rust can decrease bond as well as cause spalling and cracking.  
T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_



32. Welded wire reinforcement is identified by denoting smooth wire with the letter "F," followed by a number indicating the cross-sectional area in hundredths of a square inch.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
33. Class 1 metal supports are plastic protected steel wire bar supports intended for use in moderate to severe exposure of the concrete surface.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
34. Bar supports for epoxy-coated reinforcing bars should be coated with a dielectric material such as plastic.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
35. A standard hook can be a 180-degree bend plus  $4_{db}$ , but not less than a  $2\frac{1}{2}$ -inch extension at the free end of the bar.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
36. It is sometimes advantageous to assemble the steel into *cages* in which the bars, stirrups and other elements can be tied together at a convenient assembly location.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
37. If a reinforcing bar appears to have rusted excessively, a sample should be cleaned and weighed to determine compliance with the specified weight.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
38. Reinforcing bars are cold rolled into bar size and deformations.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
39. USA-produced metric reinforcing bars are approximations of the inch-pound bar diameter in meters (m).  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
40. If the structural drawings indicate a #9 reinforcing bar, and the iron worker is placing a bar marked 19, the inspector should notify the contractor of the incorrect bar size.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
41. If the structural drawings indicate a Grade 75, #14 reinforcing bar, and the iron worker is placing a bar marked 43 with a grade mark 5, the inspector should notify the contractor of the incorrect bar.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_

42. USA-produced reinforcing bars furnished on the construction project most likely will be soft metric.

T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_

43. Epoxy coating of reinforcement is an acceptable surface condition of reinforcement.

T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_

44. FRP rebar significantly improves the longevity of concrete structures where corrosion is a major factor.

T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_

45. Flat sheet *width* dimension for WWR includes end overhangs.

T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_

46. Flat sheet *length* dimension for WWR includes end overhangs.

T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_

### III Completion

47. The minimum yield designation for Grade 60 reinforcing can be marked on the bar by either \_\_\_\_\_ longitudinal line or the number \_\_\_\_\_. Grade 75 can be marked by either \_\_\_\_\_ longitudinal lines or the number \_\_\_\_\_.

Reference \_\_\_\_\_

48. When wire fabric is supplied to the job in rolls, it is rolled out, then draped from a position near the top of the slab over the \_\_\_\_\_ to the bottom of the slab at \_\_\_\_\_, keeping the required \_\_\_\_\_ at each location.

Reference \_\_\_\_\_

49. Epoxy-coated reinforcing was initially developed for use in highway bridge decks where concrete is subjected to severe exposures from \_\_\_\_\_, \_\_\_\_\_ and \_\_\_\_\_.

Reference \_\_\_\_\_

50. Steel should be stored on \_\_\_\_\_ or other \_\_\_\_\_ off the ground to protect it from \_\_\_\_\_ and \_\_\_\_\_ on the jobsite and in locations where it may be splattered with \_\_\_\_\_. Long storage periods will result in excessive \_\_\_\_\_ or contamination.

Reference \_\_\_\_\_

51. A bar list is a bill of materials or a list of \_\_\_\_\_ covering a portion of the structure. Bars are classified as to \_\_\_\_\_ , \_\_\_\_\_ , and whether they are \_\_\_\_\_ or \_\_\_\_\_ .  
Reference \_\_\_\_\_
52. Although accuracy is important, it is necessary to allow for slight inaccuracies in the \_\_\_\_\_ . These allowances are called \_\_\_\_\_ . The typical tolerance for a straight bar is plus or minus \_\_\_\_\_ inch.  
Reference \_\_\_\_\_
53. Reinforcing steel must be secured in place. Distances from subgrade and forms should be maintained by the use of \_\_\_\_\_ , \_\_\_\_\_ , \_\_\_\_\_ or other approved \_\_\_\_\_ .  
Reference \_\_\_\_\_
54. Heating in order to bend reinforcing can only be done when approved by the \_\_\_\_\_ with the concurrence of the \_\_\_\_\_ . If heating is approved, bars should be heated \_\_\_\_\_ and air cooled \_\_\_\_\_ .  
Reference \_\_\_\_\_
55. Reinforcement is used to control cracks in slabs caused by \_\_\_\_\_ and \_\_\_\_\_ of the concrete resulting from temperature \_\_\_\_\_ . The reinforcement does not prevent \_\_\_\_\_ .  
Reference \_\_\_\_\_
56. Grades of reinforcing steel are specified by the \_\_\_\_\_ and must be indicated on the \_\_\_\_\_ and \_\_\_\_\_ .  
Reference \_\_\_\_\_



## CHAPTER 19

### HOT AND COLD WEATHER CONCRETING

**Objectives:** To obtain an understanding of the requirements for placing concrete in hot and cold weather, as well as how to minimize the effects of—and how to control and protect concrete in—weather extremes.

**Lesson Notes:** It is best to delay placing concrete when weather extremes occur; however, if placement must proceed, a little extra effort can obtain good, durable concrete.

- What is considered hot weather for placing concrete?
- List the possible undesirable effects of hot weather on concrete.
- Does hot weather concreting affect strength?
- How much additional mixing water might be required for a temperature increase of 10°F?
- Explain how shrinkage and cracking is aggravated during hot weather.
- Will hot weather affect concrete after it has hardened?
- Where does control of the temperature of fresh concrete begin?
- Describe the ways in which controlling the aggregate temperature can be a benefit.
- How is mixing water kept cool?
- May ice ever be used to cool fresh concrete?
- Which type of admixtures are used to best advantage during hot weather concreting?
- List the items that must be planned prior to placing and finishing concrete in hot weather.
- How do fog nozzles help protect fresh concrete from the effects of hot weather?
- What is the best curing during hot weather concreting?
- Review the summary of hot weather precautions given in Table 19.1 of the *Concrete Manual*.
- At what temperature does cold weather become a concern for placing concrete?
- How does cold weather affect the hydration process?
- How is strength affected by cold weather concreting?
- During what period of time should fresh concrete be protected from cold weather?
- List the indirect effects of cold weather on the durability of concrete.
- What is the best means of heating concrete when freezing temperatures are expected?
- How are aggregates heated?
- When should preparation for cold weather concreting begin?
- What should be the minimum temperatures for concrete placed in thick and thin members?
- When should calcium chloride not be used to accelerate setting time?
- Is air-entrainment desirable for cold weather concreting?
- What admixture is used to lower the freezing temperature of concrete?
- How would a frozen subgrade affect concrete?
- List the best means of providing heat in a protective enclosure.
- How long should minimum temperatures be maintained?
- Should forms be left in place during cold weather?

- Review the summary of cold weather precautions listed in Table 19.3 of the *Concrete Manual*.

## CHAPTER 19—QUIZZES

### I Multiple Choice

1. Which one of the following is not an effect of hot weather concreting?
- a. accelerated setting
  - b. increased plastic shrinkage
  - c. lower volume of mixing water
  - d. rapid slump loss
  - e. reduced strength

Response \_\_\_\_\_ Reference \_\_\_\_\_

2. Considerations for cold weather concreting should begin when the temperature drops below \_\_\_\_\_°F.
- a. 25
  - b. 32
  - c. 40
  - d. 45
  - e. 50

Response \_\_\_\_\_ Reference \_\_\_\_\_

3. Concrete should never be placed \_\_\_\_\_.
- a. on unreinforced slabs
  - b. on a frozen subgrade
  - c. during hot weather over 95°F
  - d. during cold weather below 25°F
  - e. all of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

4. Which one of the following should not be used to accelerate the curing for prestressed concrete in cold weather?
- a. air-entrainment
  - b. calcium chloride
  - c. water-reducing admixture
  - d. steam
  - e. curing compounds

Response \_\_\_\_\_ Reference \_\_\_\_\_

5. An economical and effective way to minimize the effects of hot weather is to cool the \_\_\_\_\_.
- a. mixing water
  - b. sand
  - c. coarse aggregate
  - d. cement
  - e. subgrade

Response \_\_\_\_\_ Reference \_\_\_\_\_

6. If the temperature of a 10 cu yd batch of fresh concrete (in transit from the batch plant to the job site) increases from 50°F to 75°F, an additional \_\_\_\_\_ gallons of water will be required to maintain the same slump. Water weighs 8.33 lb per gallon.
- a. 10
  - b. 20
  - c. 30
  - d. 40
  - e. none of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

7. In the absence of special precautions, undesirable cold weather effects may include \_\_\_\_\_.
- a. slower setting
  - b. slower strength gain
  - c. permanent damage that is due to early freezing
  - d. reduced durability
  - e. all of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

8. Which one of the following is an acceptable procedure to cool the concrete ingredients during hot weather concreting?
- a. sprinkle coarse aggregate stock piles
  - b. substitute ice as part of the mix water
  - c. inject liquid nitrogen into the truck mixer
  - d. provide cold air jets in the aggregate batcher bins
  - e. all of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

**II True/False**

9. Concrete needs about 7 pounds more water for each 10°F rise in temperature.  
T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_
10. When heating mixing water, the temperature of the water should exceed 175°F.  
T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_



11. During hot weather concreting, plans must be made so that concrete can be received and placed as rapidly as possible. All equipment should be of adequate capacity, and a sufficient number of workers of all necessary trades should be on hand.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
12. High temperature can adversely affect the strength, durability and cracking of concrete, and its ultimate strength may not be as high as that of concrete placed at moderate temperatures.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
13. When curing concrete during hot weather, allowing the surface to dry between applications of water is not detrimental to the concrete except when Type III cement is used.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
14. If concrete mix proportions for a specified strength and slump were determined at a laboratory temperature of 50°F, and the actual temperature at time of batching is 75°F, additional water and cement will be required to maintain the specified strength and slump.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
15. To control the temperature of fresh concrete during hot weather concreting, use of a calcium chloride accelerator is an economical admixture to cool the ingredients.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_

### III Completion

16. Because uniform heating of aggregates is difficult, heating of the aggregates \_\_\_\_\_ be done when heating of the \_\_\_\_\_ alone would ensure delivery of the concrete at the required temperature.  
Reference \_\_\_\_\_
17. Results of observations have shown that concrete made and cured at temperatures between \_\_\_\_\_ °F has a later higher strength than that of \_\_\_\_\_ cured concrete.  
Reference \_\_\_\_\_
18. Especially during hot weather, the amount of mixing of concrete should be the minimum that can achieve the necessary \_\_\_\_\_ and \_\_\_\_\_, and \_\_\_\_\_ must be avoided.  
Reference \_\_\_\_\_

19. Inadequate precautions during hot weather can have an appreciably \_\_\_\_\_ effect on durability, the resistance to freezing and thawing cycles, and a \_\_\_\_\_ resistance to attack by \_\_\_\_\_ solutions.

Reference \_\_\_\_\_

20. The indirect effects of low temperatures include cracking of dehydrated areas caused by a lack of \_\_\_\_\_ of the surface from heaters and freezing of corners and edges of green concrete that has \_\_\_\_\_ but is still saturated with water and has \_\_\_\_\_.

Reference \_\_\_\_\_

## CHAPTER 20

### PRECAST AND PRESTRESSED CONCRETE

**Objectives:** To obtain an understanding of the pretensioning and post-tensioning methods of prestressing concrete, including the manufacture and production of precast and prestressed concrete products. Also discussed will be the handling and erection of pretensioned prestressed concrete units. Field procedures for post-tensioned slab construction, using the unbonded single-strand tendons, is also addressed.

**Lesson Notes:** For more details on the installation of unbonded post-tensioned tendons the reader is referred to the *Field Procedure Manual for Unbonded Single Strand Tendons*. Also, the *Manual for Quality Control for Plants and Production of Precast and Prestressed Concrete Products* is suggested for an in-depth treatise on the manufacture and production of precast and prestressed concrete products. Refer to the resource references section at the back of the *Concrete Manual* for the relevant addresses.

#### **Key Points:**

- Define *precast concrete*.
- List the advantages of prestressed concrete when compared with conventional concrete.
- What is the difference between load-bearing and nonload-bearing members?
- Explain the reason for using shop drawings.
- Who should review shop drawings?
- Describe all the items that shop drawings should contain.
- What concerns are associated with form oils for precast concrete?
- How do extruding machines work?
- List the items to be checked by the inspector prior to placing concrete for precast members.
- What is the most frequently used method of curing precast elements?
- What is prestressed concrete?
- Compare and contrast the pretensioning and post-tensioning methods of prestressing.
- Which prestressing steel is the most widely used?
- What is the most commonly used grade of prestressing steel?
- Define *elastic modulus*.
- What is the average elastic modulus of prestressing steel?
- Describe the use of bulkheads in casting beds.
- How is prestressing steel elongated?
- How is the amount of elongation determined?
- What may be a source of error in measuring jacking forces?
- What is detensioning?
- What is the difference between multiple- and single-strand detensioning?
- To minimize cracking, what is important in developing a detensioning pattern?
- What is the acceptable amount of broken wires or strands in prestressing steel?
- What is the first concern after a precast unit is placed in a structure?
- What is the most common size of unbonded single-strand tendons?

- Describe what a tendon consists of.
- What is the purpose of the rubber or plastic block used in post-tensioning work?
- How is the steel in an unbonded tendon system protected?
- What information do the installation drawings for unbonded tendons contain?
- Describe in detail how unbonded tendons are shipped, labeled and placed.
- What are the concerns when welding near unbonded tendons?
- What admixture(s) should not be used in concrete placed in an unbonded slab system?
- When is shoring removed after placing concrete?
- Give a brief description of the stressing operation.
- What are the distinct construction phases in a post-tensioning system?

## CHAPTER 20—QUIZZES

### I Multiple Choice

1. Which of the following must not be used in post-tensioned prestressed concrete?
- a. air-entrainment
  - b. calcium chloride
  - c. Type III cement
  - d. graded aggregates
  - e. all of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

2. Sheathing of unbonded prestressing tendons must prevent \_\_\_\_\_ during concrete placement.
- a. spalling
  - b. intrusion of cement paste
  - c. fracturing of anchorages
  - d. displacement of tendons
  - e. stressing of tendons

Response \_\_\_\_\_ Reference \_\_\_\_\_

3. Preassembled post-tensioning tendons are usually shipped to the job site in \_\_\_\_\_ foot diameter coils.
- a. 3
  - b. 4
  - c. 5
  - d. 6
  - e. 7

Response \_\_\_\_\_ Reference \_\_\_\_\_

4. For the pretensioning method of prestressing, there must not be a difference of more than \_\_\_\_\_ percent between stress computed from jacking pressure and stress computed from measurement of elongation.
- a. five
  - b. six
  - c. seven
  - d. eight
  - e. nine

Response \_\_\_\_\_ Reference \_\_\_\_\_

5. The concrete cover between a tendon and an opening in a post-tensioned slab should not be less than \_\_\_\_\_ inches.
- a. 4
  - b. 5
  - c. 6
  - d. 7
  - e. 8

Response \_\_\_\_\_ Reference \_\_\_\_\_

6. Prestressing force must be determined by \_\_\_\_\_.
- a. visual observation of tendon stress
  - b. measurement of tendon elongation
  - c. observation of jacking force
  - d. both a and b
  - e. both b and c

Response \_\_\_\_\_ Reference \_\_\_\_\_

7. Sheathing of unbonded tendons in prestressed concrete must \_\_\_\_\_.
- a. be within 2 inches of each end
  - b. be within 12 inches of each end
  - c. not be allowed
  - d. be with duct tape if within 12 inches of an end
  - e. be over the entire length

Response \_\_\_\_\_ Reference \_\_\_\_\_

8. Any difference between tendon elongation and jacking force on a calibrated gage must not exceed \_\_\_\_\_ percent for post-tensioned construction.
- a. two
  - b. four
  - c. five
  - d. seven
  - e. ten

Response \_\_\_\_\_ Reference \_\_\_\_\_

9. Unbonded prestressing tendons must be coated with \_\_\_\_\_.
- a. light oxide
  - b. cement paste
  - c. material to ensure corrosion protection
  - d. paint
  - e. galvanizing

Response \_\_\_\_\_ Reference \_\_\_\_\_

10. Which one of the following is not considered to be a precast structural unit?

- a. mullion
- b. box unit
- c. stemmed unit
- d. girder
- e. joist

Response \_\_\_\_\_ Reference \_\_\_\_\_

11. The most common method of curing in precasting plants is \_\_\_\_\_.

- a. mechanical
- b. high-temperature
- c. chemical
- d. moist
- e. all of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

12. Immediately after placement of precast units in a structure, \_\_\_\_\_ must be accomplished.

- a. grouting
- b. temporary bracing
- c. final welding
- d. permanent bracing
- e. none of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

13. Type \_\_\_\_\_ cement is most commonly used for precast prestressed concrete work.

- a. II
- b. III
- c. IV
- d. V
- e. none of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

14. Construction details for post-tensioning work prepared by the post-tensioning fabricator are referred to as \_\_\_\_\_ .

- a. installation drawings
- b. placing drawings
- c. shop drawings
- d. structural drawings
- e. none of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

15. For the installation drawing shown on page 449 of the *Concrete Manual*, indicated strand stressing number (43) consists of \_\_\_\_\_ strands.
- a. one
  - b. two
  - c. three
  - d. four
  - e. five

Response \_\_\_\_\_ Reference \_\_\_\_\_

16. For high-temperature curing of precast-prestressed units, the maximum curing temperature is limited to \_\_\_\_\_ °F.
- a. 100
  - b. 125
  - c. 150
  - d. 175
  - e. 200

Response \_\_\_\_\_ Reference \_\_\_\_\_

## II True/False

17. Differences in the modulus of elasticity of different production lots of steel is a source of error in measuring jacking forces.  
T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_
18. Prestressed concrete requires less reinforcing steel and concrete to produce units with strength equal to conventionally reinforced concrete.  
T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_
19. At least two certified test reports should be furnished for each 20-ton production of each size of prestressing steel.  
T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_
20. In general, most prestressing strands are tensioned to about 70 percent of ultimate strength.  
T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_
21. Conduits and other utilities cannot be accommodated in precast concrete.  
T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_
22. Positioning of prestressing strands is not critical in precast units.  
T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_
23. Unbonded single-strand tendons used in post-tensioned slabs usually consist of 1/2-inch, or 0.6-diameter seven-wire strand.  
T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_



24. Batching of concrete mix ingredients at precasting plants is by weight, although water and liquid admixtures can be batched by volume.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
25. Casting bed bulkheads are usually set with a space of 6 inches between them to facilitate subsequent operations.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
26. Precast prestressed units can be stored on the ground and stacked after curing, provided the surface is level.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
27. In long precast prestressing beds it is sometimes the practice to oil the tendons before they are placed in the forms.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
28. At strand detensioning, the tension in the prestressing strands is transferred to the concrete, placing the concrete under compression.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
29. Long casting beds are not practical for producing multiple units of identical cross section and strand pattern.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
30. It is essential that the shoring for post-tensioned slabs be left in place until the stressing is completed.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
31. The greatest majority of forms for precast concrete are made of steel.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
32. The most widely used prestressing steel in building construction is the  $1\frac{1}{2}$ -inch 270K stress-relieved-seven-wire strand.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
33. A small amount of rust on the surface of prestressing steel is beneficial to bond.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
34. For the installation drawing shown on page 449 of the *Concrete Manual*, strand stressing number (19) consists of one strand with an indicated elongation of  $7\frac{1}{4}$  inches.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_

35. For the installation drawing shown on page 449 of the *Concrete Manual*, strand stressing number (34) is 36 feet in length.

T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_

36. The precast industry almost exclusively uses the 4-inch by 8-inch cylinder for evaluation and acceptance of concrete.

T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_

### III Completion

37. When installing unbonded tendons, an inspector should check that the tendons are placed at the correct \_\_\_\_\_ and \_\_\_\_\_ elevations and that the profiles are \_\_\_\_\_ and correctly \_\_\_\_\_.

Reference \_\_\_\_\_

38. In post-tensioned concrete, the tendons are placed \_\_\_\_\_ the reinforcing steel, electric conduit, and mechanical work.

Reference \_\_\_\_\_

39. The shop drawings for precast concrete units are usually prepared by the \_\_\_\_\_ or the \_\_\_\_\_.

Reference \_\_\_\_\_

40. Where space permits, on site precasting can be adopted for buildings where there are many \_\_\_\_\_ units.

Reference \_\_\_\_\_

41. In any prestressing operation there is a small amount of slippage that develops as the \_\_\_\_\_ grip the \_\_\_\_\_ at the \_\_\_\_\_.

Reference \_\_\_\_\_

42. Pretensioning is the method of prestressing in which the tendons are elongated \_\_\_\_\_ to the placement of \_\_\_\_\_, and post-tensioning is the method of prestressing in which the tendons are elongated \_\_\_\_\_ the placement of \_\_\_\_\_.

Reference \_\_\_\_\_

43. Prestressing strand is available in low-relaxation and \_\_\_\_\_. Low-relaxation strand has a lower steel-relaxation \_\_\_\_\_ and a higher \_\_\_\_\_ strength.

Reference \_\_\_\_\_

44. Most precast concrete units have lifting hardware \_\_\_\_\_ in the concrete when the unit is \_\_\_\_\_. This hardware usually consist of an \_\_\_\_\_ and an \_\_\_\_\_ element.

Reference \_\_\_\_\_

45. Post-tensioned tendons have a grease applied to the strand, which acts as a \_\_\_\_\_ coating and a \_\_\_\_\_ between the strand and the \_\_\_\_\_.

Reference \_\_\_\_\_

46. The modulus of elasticity of prestressing steel averages about \_\_\_\_\_ psi. This can vary as much as \_\_\_\_\_ percent between lots.

Reference \_\_\_\_\_



## CHAPTER 21

### LIGHTWEIGHT AND HEAVYWEIGHT CONCRETE

**Objectives:** To give an introduction to the batching, mixing, handling, placing and finishing of lightweight and heavyweight concrete.

**Lesson Notes:** Lightweight and heavyweight concrete have many similarities to normal-weight concrete; however, each of these two classes of concrete has special requirements that must be followed if their intended purpose is to be met. Compare the aggregate grading requirements for lightweight concrete in Table 21.2 with those for normal weight concrete in Table 8.5.

#### **Key Points:**

- Name the two general types of lightweight concrete.
- What is the primary reason to use lightweight structural concrete?
- Name some of the advantages of structural lightweight concrete.
- List the natural and manufactured materials that are used as aggregates in lightweight concrete.
- Describe the properties of lightweight aggregates for structural concrete.
- Describe in detail the two processes for manufacturing lightweight structural aggregates.
- What is the maximum absorption rate variation in the rotary kiln process?
- Which ASTM Standard covers lightweight aggregates?
- Can the principles of normal-weight concrete proportioning be applied to lightweight concrete?
- Give a brief description of the process of vacuum treatment of lightweight aggregate.
- How might the variations in specific gravity of particles be affected by water?
- Which affects the quality of lightweight concrete: active or free moisture?
- How is volumetric batching of lightweight concrete accomplished?
- Describe the appearance of fresh lightweight concrete.
- What slump is best for lightweight concrete slabs and structural elements?
- How should lightweight concrete be mixed in a truck mixer?
- What does a change in the unit weight indicate?
- How is air content determined for lightweight concrete?
- What are the concerns regarding vibration of lightweight concrete?
- How is finishing of lightweight concrete different from that for normal-weight concrete?
- What is the density of lightweight insulating concrete?
- Which types of aggregates are used for lightweight insulating concrete?
- What is perlite?
- Give the water requirements for perlite and vermiculite.
- Describe the ways to mix insulating concrete at the site or in transit.
- What actions may cause insulating concrete to become denser?
- What is the most common use of lightweight insulating concrete?
- Briefly describe the methods of placing lightweight insulating concrete.
- Define *cellular concrete*.

- Describe the two methods for making mechanically foamed cellular concrete.
- Where is heavyweight concrete most frequently used?
- Name the principal aggregates used for heavyweight concrete.
- List the requirements for heavyweight concrete with regard to mixing, placing and vibration.
- What is the intrusion method of placing concrete?
- How is heavyweight concrete affected by temperature?

## CHAPTER 21—QUIZZES

### I Multiple Choice

1. Which of the following is not one of the principle aggregates used in heavyweight concrete?
- a. barite
  - b. granite
  - c. limonite
  - d. magnetite
  - e. iron

Response \_\_\_\_\_ Reference \_\_\_\_\_

2. Screeding and bullfloating operations for lightweight concrete slabs must be kept to a minimum because of the tendency of the aggregate to \_\_\_\_\_.
- a. segregate
  - b. float to the surface
  - c. absorb additional water
  - d. sink to the bottom
  - e. none of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

3. In the kiln process of manufacturing lightweight aggregate, the material reaches a temperature of \_\_\_\_\_ °F.
- a. 800 to 1000
  - b. 1000 to 1200
  - c. 1200 to 1600
  - d. 1600 to 1800
  - e. 1800

Response \_\_\_\_\_ Reference \_\_\_\_\_

4. Lightweight structural concrete is usually defined as having a compressive strength in excess of \_\_\_\_\_ psi at 28 days.
- a. 1800
  - b. 2000
  - c. 2500
  - d. 3000
  - e. 325

Response \_\_\_\_\_ Reference \_\_\_\_\_

5. Aggregate for lightweight insulating concrete includes \_\_\_\_\_.
- a. limonite
  - b. barite
  - c. magnetite
  - d. perlite
  - e. all of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

### II True/False

6. Manufactured aggregates for lightweight structural concrete do not include clay and slate.

T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_

7. Except for absorption factors, the principles of normal-weight concrete proportioning apply to lightweight concrete.

T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_

8. In heavyweight concrete, segregation concerns are the same as for normal-weight concrete because the specific gravity is about the same.

T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_

9. Natural aggregates used in lightweight structural concrete are normally smooth and round in shape, except for coated manufactured aggregates.

T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_

10. The appearance of fresh lightweight concrete is similar to that of normal-weight concrete.

T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_

### III Completion

11. In the sintering process of manufacturing aggregates for lightweight structural concrete, the raw material is \_\_\_\_\_, then mixed with a \_\_\_\_\_ amount of pulverized \_\_\_\_\_ or \_\_\_\_\_.

Reference \_\_\_\_\_

12. Cellular concrete contains bubbles of \_\_\_\_\_ or \_\_\_\_\_ that are formed in the plastic mortar with the porous structure \_\_\_\_\_ after the material hardens.

Reference \_\_\_\_\_



13. Lightweight structural concrete in walls and columns should be consolidated by using \_\_\_\_\_. Special care must be used to prevent \_\_\_\_\_.

Reference \_\_\_\_\_

14. In lightweight concrete, differences in the amount of \_\_\_\_\_ water result from slight variations in the \_\_\_\_\_ of the particles, time of exposure to \_\_\_\_\_ and different mixes.

Reference \_\_\_\_\_

15. One method of making mechanically foamed cellular concrete is to mix the cement, aggregate, \_\_\_\_\_ and \_\_\_\_\_ together in a \_\_\_\_\_ or \_\_\_\_\_ mixer.

Reference \_\_\_\_\_



## CHAPTER 22

### SPECIAL CONCRETING TECHNIQUES

**Objectives:** To obtain a general awareness of the special concreting techniques of tilt-up construction, slipforms, lift slabs, placing concrete under water, preplaced aggregate concrete, vacuum concrete and shotcrete. To give an introduction to polymer, fiber-reinforced, refractory, sulfur, cellular and self-consolidating concrete, and controlled low-strength backfill material. Also, to provide a review of the architectural applications of concrete.

#### **Key Points:**

- Define *tilt-up construction*.
- What is used as the casting platform for tilt-up construction?
- What is the best type of bond breaker for tilt-up construction?
- Give two methods for setting tilt-up panels.
- When can a tilt-up panel be raised?
- How can panels that need to be broken loose from the casting floor be moved without injury to the concrete?
- How are temporary braces attached?
- What is a slipform?
- What structures are well suited to slipform construction?
- In vertically moving slipforms, what is the purpose of having a slight draft?
- How close to being plumb should a vertical slipform be?
- How is true vertical movement provided for a slipform?
- How is a level condition maintained on a vertical slipform?
- What is the recommended slump of concrete used in vertical slipforms?
- Give the important considerations for vertical slipforms in the following areas: consolidation, placing delays and time constraints, finish, curing and rate of slip.
- For what are horizontal slipforms used?
- Describe the operation of a horizontal slipform.
- Briefly describe the lift slab technique.
- What is the usual jacking rate of a lift slab?
- What two items are of special importance to lift slabs?
- Can concrete be placed in running water?
- What admixtures are advantageous when placing concrete in water?
- What is the recommended slump for concrete placed under water?
- What methods of placement are used for concrete placed underwater?
- What is a tremie? How should a tremie be supported?
- How is the best end-control achieved?
- What criteria are followed for placing concrete with a tremie?
- What are the advantages and disadvantages of using a tremie?
- How is concrete placement with a pump accomplished?
- Why is it important to keep the discharge end of the pump submerged in the fresh concrete?
- Briefly describe the preplaced aggregate method.

- Which admixtures are used in preplaced aggregate concrete?
- Define *vacuum concrete*.
- How is the vacuum process accomplished?
- Name the benefits of the vacuum process.
- Define *shotcrete*.
- By what other name is shotcrete known?
- Describe the dry-mix and wet-mix methods of preparing shotcrete.
- Can shotcrete be used to repair concrete?
- What is rebound and can rebound be reused?
- How is shotcrete finished and cured?
- Describe how shotcrete is tested.
- How are the anchor bolts for a base plate set?
- What is the correct way to set an anchor bolt template?
- What is dry pack and how is it installed?
- Why add powdered aluminum to grout?
- Where might prebagged dry concrete be used?
- Define *polymer concrete*.
- What are the two types of polymer concrete?
- Describe the polymer-impregnated process.
- Compare and contrast the polymer-impregnated and the polymer-Portland cement processes.
- What is fiber-reinforced concrete?
- Name the types of fiber used in fiber-reinforced concrete.
- What are the common uses for each of these types of fiber?
- Where is refractory concrete used? Can refractory concrete be used for structural components?
- List the types of aggregates used in refractory concrete.
- When is concrete classified as architectural?
- Describe the four categories of architectural concrete.
- Why make a sample panel prior to placing architectural concrete?
- How is pigmented concrete mixed and placed?
- What special precautions must be taken when using pigmented concrete?
- How long should concrete age before paint is applied?
- How is Portland cement paint applied and cured?
- List the other types of paints that can be used on concrete.
- Describe the sand-bedding and aggregate transfer methods for preparing exposed aggregate.
- What does the term *rubbing* mean?
- Why and when is rubbing used?
- What is grout cleaning?
- How old should concrete be before attempting grout cleaning treatment?
- What effects do various aggregates have on white concrete?
- How do admixtures and pigments respond to white concrete?
- How are materials for white concrete batched?
- How might mixing time affect white concrete?
- How is finishing and curing of white concrete done?

- On what does roughness depend when sandblasting concrete?
- Will sandblasting remove surface lines?
- What type of aggregate is used in sandblasting?
- What is a bushhammer?
- How and for what is a bushhammer used?
- What is acid etching?
- How is etching done at a precast plant?
- How is the acid applied?
- What precautions must be taken when acid etching?
- How old should concrete be before grinding is done?
- How is sulphur concrete produced?
- Define autoclaved cellular concrete (ACC).
- What are the principal ingredients in ACC?
- How is ACC manufactured?
- Define *self-consolidating concrete* (SCC).
- Describe the primary use of SCC.
- Describe the J-ring test method for SCC.
- What is controlled low-strength material (CLSM)?
- What is the primary use of CLSM?



## CHAPTER 22—QUIZZES

### I Multiple Choice

1. A type of construction in which wall panels are cast in a horizontal position at the jobsite is called \_\_\_\_\_.
- a. slipform
  - b. lift slab
  - c. shotcrete
  - d. tilt-up
  - e. none of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

2. Finishers on horizontal slipforms make repairs and contraction joints from \_\_\_\_\_.
- a. an outrigger
  - b. grade
  - c. openings in the center of the form
  - d. an apron
  - e. none of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

3. When shotcreting, the nozzle should be held uniformly about \_\_\_\_\_ feet away from the surface.
- a. 6
  - b. 5
  - c. 4
  - d. 3
  - e. 2

Response \_\_\_\_\_ Reference \_\_\_\_\_

4. Concrete surfaces are classified as \_\_\_\_\_.
- a. 1, 2, 3 and 4
  - b. A, B, C and D
  - c. integral, smooth, rough and treated
  - d. unfinished, smooth, semirough and rough
  - e. none of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

5. When appearance is important, the recommended amount of white cement to produce white concrete is about \_\_\_\_\_ pounds per cubic yard.
- a. 500
  - b. 560
  - c. 620
  - d. 640
  - e. none of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

6. When the pumping method is used to place concrete underwater, the end of the discharge line must be kept continuously \_\_\_\_\_.
- a. submerged in the fresh concrete
  - b. charged with water
  - c. ahead of the concrete
  - d. at the bottom of the element
  - e. none of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

7. When sulphur concrete is being placed, the temperature of the concrete must be between \_\_\_\_\_ °F.
- a. 150 and 200
  - b. 175 and 225
  - c. 275 and 300
  - d. 350 and 425
  - e. none of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

8. To make an expansive grout, powdered aluminum can be added in the amount of \_\_\_\_\_ per sack of cement.
- a.  $\frac{1}{2}$  pound
  - b. 1 pound
  - c. 1 cup
  - d. 1 quart
  - e. 1 teaspoon

Response \_\_\_\_\_ Reference \_\_\_\_\_

9. Columns between tilt-up panels may be bonded to the panel concrete with \_\_\_\_\_ cast in the panel and extending into the column.
- a. tie bars
  - b. jacks
  - c. stirrups
  - d. rigging
  - e. none of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_



10. For preplaced aggregate concrete, if plaster sand is used in the cement-sand grout, the coarse aggregate can be as small as \_\_\_\_\_ inch.

- a. 1
- b.  $\frac{7}{8}$
- c.  $\frac{3}{4}$
- d.  $\frac{1}{2}$
- e.  $\frac{3}{8}$

Response \_\_\_\_\_ Reference \_\_\_\_\_

11. Concrete should be at least \_\_\_\_\_ days old before grinding the surface.

- a. 7
- b. 14
- c. 21
- d. 28
- e. 35

Response \_\_\_\_\_ Reference \_\_\_\_\_

12. Concrete mixes for vertical slipforms should have a slump between \_\_\_\_\_ inches.

- a. 4 and 6
- b. 3 and 6
- c. 4 and 8
- d. 2 and 6
- e. 2 and 4

Response \_\_\_\_\_ Reference \_\_\_\_\_

13. Accurately setting anchor bolts for a base plate can be done by means of \_\_\_\_\_.

- a. reinforcing dowels
- b. set screws
- c. a template
- d. embedded nuts
- e. hooks or stirrups

Response \_\_\_\_\_ Reference \_\_\_\_\_

14. The time and method of rubbing a concrete surface is stated in the \_\_\_\_\_.

- a. job specifications
- b. building code
- c. placing drawings
- d. rubbing manual
- e. curing schedule

Response \_\_\_\_\_ Reference \_\_\_\_\_

15. Concrete conveyed through a hose in a stream of air and shot onto a surface at high velocity is known as \_\_\_\_\_.

- a. gunite
- b. vacuum concrete
- c. refractory concrete
- d. shotcrete
- e. polymer concrete

Response \_\_\_\_\_ Reference \_\_\_\_\_

16. Sandblasting may cut a concrete surface as deep as \_\_\_\_\_ inch(es).

- a.  $\frac{1}{4}$
- b.  $\frac{1}{2}$
- c.  $\frac{3}{4}$
- d. 1
- e.  $1\frac{1}{2}$

Response \_\_\_\_\_ Reference \_\_\_\_\_

17. Polymer-impregnated concrete can achieve compressive strengths of \_\_\_\_\_ psi.

- a. 3000 to 5000
- b. 3000 to 8000
- c. 5000 to 18,000
- d. 5000 to 25,000
- e. none of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

18. If a pure white concrete is specified, white sand and coarse aggregate can be made by crushing white \_\_\_\_\_.

- a. quartzite
- b. limestone or quartz
- c. granite or mica
- d. marble or feldspar
- e. none of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

19. In tilt-up construction, a \_\_\_\_\_ must first be placed on the casting floor.

- a. pickup point
- b. sack coat
- c. polymer
- d. epoxy resin
- e. bond breaker

Response \_\_\_\_\_ Reference \_\_\_\_\_

20. Portland cement paint should have a creamy, thick consistency and should be applied with \_\_\_\_\_.
- a. a spray gun
  - b. scrub brushes
  - c. horse hair brushes
  - d. sponges
  - e. a wood float

Response \_\_\_\_\_ Reference \_\_\_\_\_

21. Autoclaved cellular concrete is a porous material with a compressive strength between \_\_\_\_\_.
- a. 150 and 300 psi
  - b. 300 and 1000 psi
  - c. 300 and 1500 psi
  - d. 1000 and 3000 psi
  - e. 1500 and 2500 psi

Response \_\_\_\_\_ Reference \_\_\_\_\_

22. A self-compacting concrete that can flow into tight and inaccessible spaces is termed \_\_\_\_\_.
- a. autoclaved aerated concrete
  - b. controlled low-strength concrete
  - c. polymer concrete
  - d. self-consolidating concrete
  - e. shotcrete

Response \_\_\_\_\_ Reference \_\_\_\_\_

23. The slump diameter of a well-proportioned SCC mix is approximately \_\_\_\_\_ inches.
- a. 18
  - b. 24
  - c. 30
  - d. 36
  - e. none of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

24. Controlled low-strength material is \_\_\_\_\_.
- a. a flowable fill material
  - b. a porous building material
  - c. self-leveling concrete
  - d. very flowable concrete
  - e. all of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

25. The J-ring is a modified slump test used to measure unblocked flow of \_\_\_\_\_.

- a. autoclaved aerated concrete
- b. controlled low-strength concrete
- c. fiber-reinforced concrete
- d. self-consolidating concrete
- e. none of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

26. A freshly mixed batch of pervious concrete has a \_\_\_\_\_.

- a. high cement-past content
- b. low void content
- c. high fine aggregate content
- d. very low slump
- e. all of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

27. Ultra-high performance concrete provides compressive strengths up to about \_\_\_\_\_ psi.

- a. 5,000
- b. 10,000
- c. 15,000
- d. 20,000
- e. 29,000

Response \_\_\_\_\_ Reference \_\_\_\_\_

28. Ultra-high performance concrete provides a material that is very \_\_\_\_\_.

- a. durable
- b. ductile
- c. high strength
- d. impermeable
- e. all of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

## II True/False

29. Raising of a lift slab is accomplished by means of jacks mounted on top of the building columns.

T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_

30. There are four basic shotcreting processes: dry-mix, wet-mix, pneumatic and injected.

T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_

31. Grout for cleaning concrete walls should consist of one part cement with one and one-half to two parts fine sand that passes a 16 mesh screen.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
32. For steel-fiber-reinforced concrete, a five percent fiber content by volume of concrete is considered an upper limit.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
33. Strength test samples of shotcrete are made by filling a 6-inch by 12-inch cylinder directly from the nozzle.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
34. After proper curing, refractory concrete can be heated up immediately at a rapid rate.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
35. A bushhammer consists of a flat-faced tool that fits into a chipping gun.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
36. The vacuum process to produce vacuum concrete is accomplished by applying a vacuum to a fresh concrete surface to extract water and entrapped air.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
37. The sand-bedding technique to produce an exposed aggregate surface results in a depth of exposed aggregate up to 4 inches.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
38. Among the causes of color variation in white concrete are different brands of cement, different forming materials, different slumps and variations in curing.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
39. Vertical slipforms consist of an inside and outside form made of sheet steel. The outside form extends above the inside form about 6 inches.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
40. Sack rubbing is done to fill in or cover rock pockets or honeycombing defects.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
41. The slipform method of placing concrete requires a steady supply of available fresh concrete and placement made so that there is not more than an hour's delay between lifts.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_

42. The principal advantage of using a tremie to place concrete underwater is that dewatering of the foundation area is unnecessary.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
43. The size and location for pickup points on a tilt-up panel are determined by its size, weight, compressive strength and unit weight.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
44. Autoclaved cellular concrete is a nonstructural lightweight precast concrete building material.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
45. Autoclaved cellular concrete (ACC) can be used for structural applications if properly reinforced.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
46. Self-consolidating concrete is proportioned with about the same amount of mixing water as conventional concrete.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
47. Autoclaved cellular concrete is a special type of lightweight precast prestressed concrete building material.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
48. Controlled low-strength material requires some vibration for adequate consolidation.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
49. Individual ACC building elements are joined together by embedded dowels or ties.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
50. Self-consolidating concrete is proportioned to flow between and around reinforcement without vibration.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
51. Pervious concrete is a very high impermeable concrete that drains quickly.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
52. Pervious concrete resembles popcorn.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
53. The void structure of pervious concrete allows water to pass through and percolate into the ground.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_

54. The addition of plastic fibers in a concrete mixture will require more water to maintain a specified slump.

T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_

55. Self-consolidating concrete (SCC) tends to have higher plastic shrinkage cracking than conventional concrete.

T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_

56. SCC is used in precasting plants because it produces a good surface finish.

T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_

### III Completion

57. Part of the wet-mix shotcrete process is that all ingredients, including \_\_\_\_\_, are thoroughly mixed together, placed in the delivery equipment \_\_\_\_\_ and conveyed by \_\_\_\_\_ to a nozzle.  
Reference \_\_\_\_\_

58. Glass-fiber-reinforced concrete is manufactured by a spray-up process that feeds a continuous strand of glass fiber into a compressed-air-powered \_\_\_\_\_, where it is cut into \_\_\_\_\_ and combined with a \_\_\_\_\_ and \_\_\_\_\_ slurry.  
Reference \_\_\_\_\_

59. Acid etching of a concrete surface can be done as soon as \_\_\_\_\_ days(s) after placing concrete, and all comparable areas should be etched at about the same \_\_\_\_\_ .  
Reference \_\_\_\_\_

60. Methods for placing concrete underwater include the use of \_\_\_\_\_, \_\_\_\_\_ and \_\_\_\_\_ .  
Reference \_\_\_\_\_

61. After a base plate has been adjusted to the correct position, the space underneath is filled with \_\_\_\_\_ or \_\_\_\_\_ .  
Reference \_\_\_\_\_

62. When using pigments to color concrete, only pure metallic \_\_\_\_\_ should be used, in an amount determined by \_\_\_\_\_ .  
Reference \_\_\_\_\_

63. When repairing old concrete with shotcrete, all old unsound material must be \_\_\_\_\_, corroded steel must be \_\_\_\_\_, and reinforcing securely \_\_\_\_\_ or \_\_\_\_\_ in place.  
Reference \_\_\_\_\_

64. When acid is applied to a concrete surface, the acid reacts with the \_\_\_\_\_ and will also attack \_\_\_\_\_ and \_\_\_\_\_ aggregate.

Reference \_\_\_\_\_

65. Compared to untreated concrete, polymer-impregnated concrete has strength values \_\_\_\_\_ times greater, improved resistance to \_\_\_\_\_ and \_\_\_\_\_, increased resistance to \_\_\_\_\_ attack, improved \_\_\_\_\_ resistance and \_\_\_\_\_ water absorption.

Reference \_\_\_\_\_

66. When using a bucket to place concrete underwater, the bucket should be lowered \_\_\_\_\_ while underwater and should not be opened until the bucket contacts \_\_\_\_\_ concrete.

Reference \_\_\_\_\_



## CHAPTER 23

### WATERPROOFING AND DAMPPROOFING

**Objectives:** To introduce dampproofing and waterproofing of concrete and to introduce some of the available materials and methods used to achieve this.

**Lesson Notes:** There are many materials and methods available for dampproofing and waterproofing of concrete. Care must be taken to follow all the manufacturer's directions explicitly to obtain an acceptable and lasting seal. There are also many new products not mentioned in the text that are effective in the repair of leaks in existing structures.

#### **Key Points:**

- Describe the two ways that water passes through concrete.
- What can contribute to the problem of maintaining a water-tight structure?
- Review permeability in Chapter 5 and waterproofing in Chapter 9.
- Of what materials do surface treatments consist?
- Give one effective method of providing protection of porous concrete under low water pressure.
- Describe some ways to provide drainage away from concrete walls.
- What are the three primary requirements for waterproofing or dampproofing concrete?
- List the types of materials used to waterproof concrete.
- Where is waterproofing required?
- List the concerns associated with the installation of a waterproofing membrane.
- Of what does an elastomeric membrane consist?
- How is elastic membrane applied and what care must be taken during installation?
- How does preformed sheet elastomeric membrane differ?
- How are single-component liquids applied?
- What is the minimum number of plies when using a bituminous membrane for waterproofing?
- Describe the conditions for application of a bituminous membrane system.
- When using plaster to waterproof concrete, how is it applied?
- How is sheet lead used to waterproof concrete?
- When is dampproofing appropriate?
- What is the difference between dampproofing and waterproofing?
- Can treatments for dampproofing be substituted for waterproofing? Is the reverse also true?
- Give a detailed description of how to seal a leaking structure subject to a hydrostatic head.
- Is Type III cement a good material for this purpose?



## CHAPTER 23—QUIZZES

### I Multiple Choice

1. When a waterproofing system fails, the problem can usually be traced to \_\_\_\_\_.

- a. improper construction
- b. material breakdown
- c. faulty materials
- d. temperature fluctuations
- e. all of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

2. Quick-setting cement can be made by mixing Type III cement with \_\_\_\_\_.

- a. perlite
- b. aluminous cement
- c. calcium chloride
- d. magnesium sulfate
- e. none of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

3. Walls in basements should have surface water drain by sloping the ground away from the structure about  $\frac{1}{2}$  inch in \_\_\_\_\_ feet.

- a. 5
- b. 10
- c. 15
- d. 20
- e. 25

Response \_\_\_\_\_ Reference \_\_\_\_\_

4. To ensure watertightness of concrete, it should be wet cured for at least \_\_\_\_\_ days.

- a. 3
- b. 6
- c. 7
- d. 14
- e. 28

Response \_\_\_\_\_ Reference \_\_\_\_\_

5. Modified polyurethanes that are applied directly to the concrete from a can and spread with a notched squeegee are known as \_\_\_\_\_ .
- a. sheet membrane
  - b. bituminous membrane
  - c. elastomeric membrane
  - d. single-component liquid
  - e. none of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

### II True/False

6. Waterproofing materials cannot be used to dampproof a structure.  
T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_
7. Plaster used to waterproof a structure is applied either by hand or machine in three coats, each about  $\frac{3}{8}$  inch thick.  
T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_
8. A waterproof membrane should be protected as soon as it has been installed, and if the membrane is punctured it can be repaired by applying a patch of the membrane material.  
T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_
9. Outdoor pools are sealed with a membrane of sheet lead that is placed prior to placing concrete.  
T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_
10. There are usually two plies of bituminous membrane applied to an exterior vertical surface.  
T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_

### III Completion

11. Manufacturers of bituminous membranes usually specify that, prior to application, the concrete is \_\_\_\_\_ , \_\_\_\_\_ and \_\_\_\_\_ . Also, all surface voids must be \_\_\_\_\_ with \_\_\_\_\_ and all fins and irregularities \_\_\_\_\_ .  
Reference \_\_\_\_\_
12. Leaks can be repaired by removing \_\_\_\_\_ concrete and \_\_\_\_\_ , and cracks should be \_\_\_\_\_ . A good proprietary material is then applied, starting from the \_\_\_\_\_ and working to the \_\_\_\_\_ point.  
Reference \_\_\_\_\_

13. Bituminous coatings consist of \_\_\_\_\_ or \_\_\_\_\_ layers of bitumen, mopped on either \_\_\_\_\_ or \_\_\_\_\_. Cold-applied bituminous coatings can be reinforced with \_\_\_\_\_, \_\_\_\_\_ or other inert fibers.

Reference \_\_\_\_\_

14. Waterproofing is required below \_\_\_\_\_ where groundwater is present against \_\_\_\_\_ and \_\_\_\_\_, and above grade wherever protection is required against the \_\_\_\_\_.

Reference \_\_\_\_\_

15. To ensure watertight impermeable concrete, aggregates should be \_\_\_\_\_ and of \_\_\_\_\_, and sand particles should be \_\_\_\_\_.

Reference \_\_\_\_\_



## CHAPTER 24

### INTRODUCTION TO INSPECTION

**Objectives:** To give an overview of the responsibilities and authority of building inspectors, special inspectors and quality control inspectors.

**Lesson Notes:** The job of the inspector is probably the most difficult of all of the members of the construction team. He or she must understand and apply all of the various tests, procedures, code requirements and specifications related to each individual project. He or she must know not only the exact wording of each of these but the intent as well, insofar as each project presents its own unique problems and conditions.

#### Key Points:

- Why is the team concept important in concrete construction?
- List each of the team players and their roles in providing quality concrete construction.
- Define *inspection*.
- Who might the inspector represent?
- Why is it not recommended to award a contract for inspection services to the lowest bidder?
- What can be the advantages to contractors who provide their own inspection staff?
- Who should employ the testing or inspection staff?
- List the qualities of a good inspector.
- To whom should the inspector give suggestions and instructions?
- How should the supervisor support the inspector?
- When a permit is required, who is the primary inspector?
- Describe the responsibilities of a special inspector.
- Is the building code the only document with which the inspector must be familiar?
- List the primary documents that should guide the inspector.
- What is the first duty of an inspector when assigned a project?
- List the duties of the inspector.
- What equipment does a testing agency usually provide on the jobsite?
- Which materials are usually tested at the manufacturer?
- What should accompany approved materials?
- When can rejected materials be used on a site?
- When are retests of rejected materials appropriate?
- How should the inspector be involved in job safety?
- What are the inspection tasks for batch plant inspection?
- Describe some methods for testing the moisture content of aggregates.
- What does the inspector check when inspecting reinforcing steel?
- When can alternate materials be used on a project?





## CHAPTER 24—QUIZZES

### I Multiple Choice

1. When special inspection is required, the special inspector should be in the employ of the \_\_\_\_\_ .
- a. contractor
  - b. subcontractor
  - c. owner
  - d. building official
  - e. none of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

2. When a permit is required, the inspector employed by the building official is the \_\_\_\_\_ inspector.
- a. primary
  - b. secondary
  - c. special
  - d. additional
  - e. none of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

3. Safety and accident prevention on the job site are the responsibility of the \_\_\_\_\_ .
- a. owner
  - b. inspector
  - c. architect
  - d. engineer
  - e. contractor

Response \_\_\_\_\_ Reference \_\_\_\_\_

4. There are \_\_\_\_\_ primary sources of authority that guide the inspector.
- a. one
  - b. two
  - c. three
  - d. four
  - e. five

Response \_\_\_\_\_ Reference \_\_\_\_\_

5. Job specifications usually permit the use of alternative materials, provided necessary test reports and other pertinent information is submitted for approval by the \_\_\_\_\_.
- a. building official
  - b. engineer
  - c. architect
  - d. owner
  - e. engineer and owner

Response \_\_\_\_\_ Reference \_\_\_\_\_

6. At the time of use, cement should contain no lumps that cannot be broken by \_\_\_\_\_.
- a. a hammer
  - b. crushing
  - c. light pressure between the fingers
  - d. the aggregate
  - e. none of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

7. When required, test specimens of reinforcing steel should be chosen at random from the lot. Samples should be at least \_\_\_\_\_ inches long.
- a. 12
  - b. 18
  - c. 20
  - d. 24
  - e. 30

Response \_\_\_\_\_ Reference \_\_\_\_\_

8. Which of the following is not provided by the testing and/or inspection agency?
- a. slump cone
  - b. on-site storage
  - c. scoop or shovel
  - d. cylinder molds
  - e. air content meter

Response \_\_\_\_\_ Reference \_\_\_\_\_

## II True/False

9. Inspection is the review of a contractor's work to make sure that specifications, drawings and codes are being followed.

T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_

10. Cement is rarely furnished to a job site because practically all concrete comes from a commercial ready-mix manufacturer.

T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_

11. A special inspector is required to be on site only while concrete is being placed.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
12. One of the first duties of an inspector is to become familiar with the job requirements that pertain to inspection.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
13. Admixtures, curing compounds, joint fillers and similar materials are usually accepted on the manufacturer's certification.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
14. Rejected materials should be disposed of, modified or regenerated.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
15. Each load of approved materials should be accompanied by a tag or card of identification issued by the testing laboratory.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
16. When the specifications require a particular material, substitution of a different material, even if of equal quality, is never allowed.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
17. The approval of materials is usually the responsibility of the on-site inspector.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
18. 4-inch by 8-inch cylinder molds are never permitted for final evaluation and acceptance of structural concrete.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_

### III Completion

19. Of the several methods for obtaining the moisture content of an aggregate, the most common method is to \_\_\_\_\_ the aggregate in and \_\_\_\_\_ or over a \_\_\_\_\_.  
Reference \_\_\_\_\_
20. Although cement is manufactured under close \_\_\_\_\_ and rarely fails to meet \_\_\_\_\_, wide fluctuations in the cement's \_\_\_\_\_ may still exist.  
Reference \_\_\_\_\_
21. To obtain approval of a material, supporting data should be supplied that contain the history and \_\_\_\_\_ record as well as typical \_\_\_\_\_, \_\_\_\_\_ or shop \_\_\_\_\_, including those by an \_\_\_\_\_ testing laboratory.  
Reference \_\_\_\_\_

22. When an inspector is assigned a project, one of his or her first tasks is to become familiar with the \_\_\_\_\_ requirements and the \_\_\_\_\_.

Reference \_\_\_\_\_

23. The inspector should give \_\_\_\_\_ and \_\_\_\_\_ relative to the acceptance or rejection of construction or materials to the contractor or producer, not the \_\_\_\_\_.

Reference \_\_\_\_\_

24. An inspector at a batch plant should check the aggregate and have all \_\_\_\_\_, \_\_\_\_\_ or other \_\_\_\_\_ removed.

Reference \_\_\_\_\_

## CHAPTER 25

### INSPECTION OF CONCRETE CONSTRUCTION

**Objectives:** To build on the information provided in Chapter 24 by deepening the understanding of the duties and responsibilities of the inspector, from preliminary arrangements to the final product.

**Lesson Notes:** One of the most important aspects of an inspector's job is to keep accurate records and reports. When good records and reports are kept, problems and questions that arise afterward can be addressed with facts instead of speculation.

#### **Key Points:**

- List the factors that determine the amount and extent of inspection.
- After the preliminary inspections, what are the three stages of inspection?
- What does each of the stages of inspection include?
- What is the most common method of batching and mixing concrete?
- What items need to be inspected at the time of proportioning and mixing?
- List the duties of the plant inspector at the beginning of each day.
- At what point does an inspector take samples and perform field tests of the fresh concrete?
- What items are to be inspected at the batch plant during the concreting phase?
- List the types of inspection that should occur during mixing, delivery, handling and placing of concrete.
- What should be inspected during jointing and finishing?
- Why is the keeping of accurate records and reports necessary?
- When is a narrative report done?
- When an inspector is assigned numerous jobs, what items should his or her diary include?
- Define *special inspection*.
- Why are special inspectors needed?
- Describe the role of the special inspector with relation to the enforcement agency.
- List the types of work related to concrete that are required to have special inspection.
- Give the general areas of responsibility and the qualifications of the special inspector.
- Review the job task analysis given in Table 25.1. Describe how each of the tasks might impact a project.



## CHAPTER 25—QUIZZES

### I Multiple Choice

1. Which one of the following is not part of the first stage of inspection?

- a. steel grade and size
- b. soil compaction
- c. strength tests
- d. form stability
- e. adequate lighting

Response \_\_\_\_\_ Reference \_\_\_\_\_

2. The general building code typically requires that the special inspector be employed by the \_\_\_\_\_ .

- a. building official
- b. owner
- c. contractor
- d. subcontractor
- e. none of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

3. A key element in the approval of a fabricating plant is \_\_\_\_\_ by an approved quality control agency.

- a. independent inspection
- b. testing
- c. supervision
- d. sampling
- e. sampling and testing

Response \_\_\_\_\_ Reference \_\_\_\_\_

4. A concrete inspection log should contain \_\_\_\_\_ .

- a. strength specimen results
- b. unusual placing delays
- c. the number of workers
- d. ready-mix drum rotations
- e. all of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

5. Ready-mix trucks should be checked by the inspector to verify that

\_\_\_\_\_.

- a. engines are operational
- b. mixing water pump is adequate
- c. drums and chutes are clean of concrete
- d. mixing blades are worn
- e. all of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

6. A special inspector supplements inspections provided by the building official with \_\_\_\_\_ inspections to help ensure that construction complies with the code.

- a. partial
- b. periodic
- c. overtime
- d. continuous
- e. any of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

7. Which one of the following is not part of the preliminary arrangements prior to actual inspections?

- a. approving aggregates
- b. checking forms for line and grade
- c. calibrating scales and batchers
- d. preparing mix designs
- e. rejecting unsuitable materials

Response \_\_\_\_\_ Reference \_\_\_\_\_

8. Which one of the following is not part of inspection during the final stage of concreting?

- a. applying curing compound
- b. repairing rock pockets
- c. timely removal of forms
- d. installing construction joints
- e. filling tie rod holes

Response \_\_\_\_\_ Reference \_\_\_\_\_

**II True/False**

9. The second stage of inspection includes verifying the size, location and grade of the reinforcing steel.

T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_



10. Areas of inspection of prestressed concrete include size and grade of tendons, placing of tendons, concrete placement and strand stressing.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
11. In building construction, the inspector is not called on to review nonstructural elements of a building, except at the request of the building official.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
12. A special inspector should notify the building official and engineer when discrepancies are not corrected.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
13. It is important for the inspector to maintain accurate and complete reports, but it is not necessary to include weather conditions and visitors to the job site.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
14. The general building code typically states that the fabricator's facility and personnel must be verified by an approved inspection or quality control agency.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
15. Repairs of rock pockets should be made as early as possible because it is easier to work on green concrete.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
16. It is normal practice to sample concrete and perform tests at the point of placement after all water has been added and while concrete is being discharged.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
17. Special considerations for tilt-up construction include applying parting compound, watching for rebound and avoiding sudden jerks when lifting.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
18. The International Code Council offers a certification for reinforced concrete and prestressed concrete special inspector.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
19. Special inspection is always required for precast prestressed concrete manufactured in a precasting plant.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
20. Special inspection is always required for post-tensioned prestressed concrete construction.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_

### III Completion

21. The second stage of inspection of concrete occurs during the actual \_\_\_\_\_, \_\_\_\_\_ and \_\_\_\_\_ of the concrete and extends through the \_\_\_\_\_ period.

Reference \_\_\_\_\_

22. Although inspection may not be required, a \_\_\_\_\_ is usually necessary for concrete jobs, regardless of \_\_\_\_\_.

Reference \_\_\_\_\_

23. The special inspector is responsible for furnishing \_\_\_\_\_ to the building official and observing the work for compliance with approved \_\_\_\_\_ and \_\_\_\_\_.

Reference \_\_\_\_\_

24. In addition to verifying that applicants are technically competent, the building official should verify that applicants have related work experience and are aware of local code \_\_\_\_\_, \_\_\_\_\_ and \_\_\_\_\_.

Reference \_\_\_\_\_

25. When inspecting prestressed concrete, the inspector should check the \_\_\_\_\_ of the stressing ram and the stressing \_\_\_\_\_.

Reference \_\_\_\_\_

26. Inspection of heavy-duty floors should include screeding, \_\_\_\_\_ and \_\_\_\_\_, troweling, wearing curse and special \_\_\_\_\_.

Reference \_\_\_\_\_

27. During concrete placement, the inspector should confirm that the \_\_\_\_\_ indicates the correct mixture, the concrete is \_\_\_\_\_ and the mix is used within the specified \_\_\_\_\_.

Reference \_\_\_\_\_

## CHAPTER 26

### QUALITY CONTROL

**Objectives:** To define quality control and its application to concrete construction.

**Key Points:**

- Define *quality control*.
- What are some of the primary areas in which quality control can be applied to construction?
- Who is responsible for quality control of concrete?
- What benefit does an owner obtain from quality control?
- What is needed for quality control to succeed?
- What is the difference between quality control and acceptance sampling?
- How have recent advances in technology aided statistical quality control (SQC)?
- What information is provided by statistical quality control?
- On what is statistical quality control based?
- What is a standard deviation?
- In what two ways is a standard deviation expressed?
- Define *coefficient of variation*.
- What leads to the greatest uniformity in the quality of concrete?
- In the area of concrete quality control, why are rigid numerical limits unrealistic for contractors and inspectors?
- What is the best index of concrete quality?
- What test is used to determine concrete strength?
- What accounts for the differences in strength of test cylinders?
- Do low strength results in some cylinders mean that construction quality is jeopardized?
- Is there an absolute minimum specified strength for concrete in building construction?
- What is a good index of the quality of concrete?
- Is the inspector expected to be able to make quality control computations?
- How can 28-day results be determined based on seven-day strength curves?
- What action might be required to correct deficiencies in concrete quality?
- In the production of concrete, what standard deviation value indicates good control? Fair control? Poor control?
- Why is it important for an inspector to understand the significance of statistical quality control?
- Does quality control result in added cost for the contractor?
- What section of the ACI 318 Standard states the requirements for concrete quality?



## CHAPTER 26—QUIZZES

### I Multiple Choice

1. If quality control is to succeed, there must be a rational system for analyzing the results of \_\_\_\_\_ .
- a. research
  - b. tests
  - c. samples
  - d. SQC
  - e. all of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

2. An evaluation is possible to determine probable 28-day strengths from seven-day strength tests by using \_\_\_\_\_ .
- a. strength averaging
  - b. known mix designs
  - c. statistical analysis
  - d. a control chart
  - e. all of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

3. In general, strength is a good index of concrete \_\_\_\_\_ .
- a. quality
  - b. durability
  - c. workability
  - d. tensile strain
  - e. uniformity

Response \_\_\_\_\_ Reference \_\_\_\_\_

4. \_\_\_\_\_ is a measure of variation derived mathematically from test results.
- a. Standard deviation
  - b. Range
  - c. Average
  - d. Coefficient of variation
  - e. none of the above

Response \_\_\_\_\_ Reference \_\_\_\_\_

5. The total number of test values under consideration is called the \_\_\_\_\_.

- a. range
- b. mean
- c. population
- d. deviation
- e. numeric average

Response \_\_\_\_\_ Reference \_\_\_\_\_

6. The calculated standard deviation ( $s = 353$  psi) illustrated in Tables 26.3 and 26.4, for the column concrete with a specified strength of 4000 psi, represents \_\_\_\_\_.

- a. excellent quality control
- b. good quality control
- c. fair quality control
- d. poor quality control
- e. unacceptable quality

Response \_\_\_\_\_ Reference \_\_\_\_\_

7. If a local ready-mix producer is proposing to use strength data with a standard deviation of 390 psi to bid on a project that requires concrete with a specified strength of 3500 psi, the required average strength used as the basis for selecting concrete mix proportions for the specified 3500 psi concrete should be \_\_\_\_\_.

- a. 3500 psi
- b. 3900 psi
- c. 4000 psi
- d. 4100 psi
- e. 4700 psi

Response \_\_\_\_\_ Reference \_\_\_\_\_

## II True/False

8. Quality control is a system by which construction is controlled by scientific methods rather than chance.

T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_

9. The inspector is not usually called upon to make computations on the job site; however, he or she should know and understand the significance of the statistical values used, and thus how well the job is being controlled.

T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_

10. A slump test does not lend itself to the precision of measurement that a strength test does, and the results of the analysis ordinarily are not as meaningful.

T \_\_\_\_\_ F \_\_\_\_\_ Reference \_\_\_\_\_

11. Quality control is a relatively new concept with regard to products manufactured at a permanently located factory or mill.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_
12. To obtain accurate information, the results of a small number of tests should be presumed to be representative of the concrete produced.  
T\_\_\_\_\_ F\_\_\_\_\_ Reference \_\_\_\_\_

### III Completion

13. Computer programs allow a continuing analysis that provides up-to-the-minute information on \_\_\_\_\_, aggregate sieve \_\_\_\_\_, \_\_\_\_\_ equivalents and any other test done on a \_\_\_\_\_ basis.  
Reference \_\_\_\_\_
14. Statistical methods provide the best basis for analyzing test results, determining potential \_\_\_\_\_ and \_\_\_\_\_, and expressing \_\_\_\_\_ in the most useful form.  
Reference \_\_\_\_\_
15. When writing specifications, it is more realistic to base probabilities on statistical methods and permitting a certain \_\_\_\_\_ of strength tests \_\_\_\_\_ than specified \_\_\_\_\_ strength.  
Reference \_\_\_\_\_
16. Quality control \_\_\_\_\_ cost money, and the potential \_\_\_\_\_ are substantial.  
Reference \_\_\_\_\_
17. The primary function of compression tests is to serve as a measure of the \_\_\_\_\_ and \_\_\_\_\_ of concrete. The magnitude of variations in strength of concrete test specimens depends on how well the \_\_\_\_\_, concrete \_\_\_\_\_ and tests are \_\_\_\_\_.  
Reference \_\_\_\_\_





## ANSWER KEYS

### Chapter 1—Fundamentals of Concrete

1. Sec. 1.1 b
2. Sec. 1.8 c
3. Sec. 1.3 b
4. Sec. 1.2 a
5. Sec. 1.1 e
6. Sec. 1.5 T
7. Sec. 1.8 F
8. Sec. 1.7 F
9. Sec. 1.1 T
10. Sec. 1.2 T
11. Sec. 1.3 green
12. Sec. 1.6 durability
13. Sec. 1.7 expansion, contraction, destructive solutions
14. Sec. 1.1 gypsum
15. Sec. 1.1 rotary kiln

### Chapter 2—The Fresh Concrete

1. Sec. 2.8 a
2. Sec. 2.2 a
3. Sec. 2.5 d
4. Sec. 2.4 d
5. Sec. 2.2 c
6. Sec. 2.1 T
7. Sec. 2.1 F
8. Sec. 2.4 F
9. Sec. 2.5 F
10. Sec. 2.6 T
11. Sec. 2.8 unit weight, bleeding
12. Sec. 2.7 unit weight
13. Sec. 2.1 consolidation, compaction, segregate
14. Sec. 2.2 pavements, mass concrete, precast concrete
15. Sec. 2.6 Bleeding

### Chapter 3—The Strength of Concrete

1.	Sec.	3.3	d
2.	Sec.	3.11	b
3.	Sec.	3.13	e
4.	Sec.	3.11	b
5.	Sec.	3.15	d
6.	Sec.	3.11	b
7.	Sec.	3.7	b
8.	Sec.	3.11	a
9.	Table	3.1	d
10.	Sec.	3.2	a
11.	Fig.	3-2	d
12.	Sec.	3.4	c
13.	Sec.	3.5	c
14.	Sec.	3.7	b
15.	Sec.	3.11	b
16.	Fig.	3-8	a
17.	Sec.	3.13	d
18.	Sec.	3.14	b
19.	Table	3.5	c
20.	Sec.	3.16	b
21.	Sec.	3.2	c
22.	Sec.	3.15	b
23.	Sec.	3.5	T
24.	Sec.	3.9	F
25.	Sec.	3.13	T
26.	Sec.	3.17	T
27.	Sec.	3.2	T
28.	Sec.	3.15	T
29.	Sec.	3.17	F
30.	Sec.	3.11	T
31.	Sec.	3.15	F
32.	Sec.	3.14	slowed
33.	Sec.	3.4	Modulus, rupture, third, 6, 6
34.	Sec.	3.13	high-early-strength, accelerating, retention of, high-temperature, cements
35.	Sec.	3.11	2.25, one and one-half
36.	Sec.	3.9	swiss hammer, windsor probe

**Chapter 4—The Durability of Concrete**

- |     |      |      |  |
|-----|------|------|--|
| 1.  | Sec. | 4.10 | e  |
| 2.  | Sec. | 4.3  | c  |
| 3.  | Sec. | 4.1  | d  |
| 4.  | Sec. | 4.5  | b  |
| 5.  | Sec. | 4.2  | b  |
| 6.  | Sec. | 4.4  | c  |
| 7.  | Sec. | 4.3  | d  |
| 8.  | Sec. | 4.11 | F  |
| 9.  | Sec. | 4.3  | T  |
| 10. | Sec. | 4.11 | T  |
| 11. | Sec. | 4.1  | T  |
| 12. | Sec. | 4.3  | F  |
| 13. | Sec. | 4.12 | F  |
| 14. | Sec. | 4.2  | T  |
| 15. | Sec. | 4.8  | Chamfers, fillets                                  |
| 16. | Sec. | 4.6  | nonbreaking, breaking, broken                      |
| 17. | Sec. | 4.9  | hydraulic, lowering                                |
| 18. | Sec. | 4.3  | resistant, barrier                                 |
| 19. | Sec. | 4.1  | material, concrete, exposure, loads, construction, |
| 20. | Sec. | 4.3  | Ammonium, ammonia, hydrogen, acid                  |

**Chapter 5—Volume Changes and Other Properties**

- |     |      |      |   |
|-----|------|------|---|
| 1.  | Sec. | 5.11 | c   |
| 2.  | Sec. | 5.1  | c   |
| 3.  | Sec. | 5.1  | d   |
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| 6.  | Sec. | 5.7  | b   |
| 7.  | Sec. | 5.1  | a   |
| 8.  | Sec. | 5.14 | F   |
| 9.  | Sec. | 5.1  | T   |
| 10. | Sec. | 5.3  | F   |
| 11. | Sec. | 5.1  | F   |
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| 13. | Sec. | 5.1  | F   |
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| 19. | Sec. | 5.8  | measure of elasticity, E                    |
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| 2.  | Sec. | 7.4  | c   |
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| 5.  | Sec. | 7.8  | d   |
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| 8.  | Sec. | 7.2  | T   |
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| 10. | Sec. | 7.9  | F   |
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| 12. | Sec. | 7.10 | T   |
| 13. | Sec. | 7.2  | F   |
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| 15. | Sec. | 7.11 | T   |
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| 17. | Sec. | 7.4  | sulfate-resistant, soil, ground, sulfate        |
| 18. | Sec. | 7.8  | hydrates, accelerates                           |
| 19. | Sec. | 7.5  | IS, IS-A, S, IP, P                              |
| 20. | Sec. | 7.2  | gypsum, setting time                            |
| 21. | Sec. | 7.6  | iron, I, tinted, colored                        |
| 22. | Sec. | 7.0  | skin irritation, chemical burns                 |
| 23. | Sec. | 7.11 | volcanic tuff, volcanic ash, pumicite, obsidian |
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11.	Sec.	8.5	F
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18.	Sec.	8.7	three, two, fines, dust
19.	Sec.	8.9	blast furnace
20.	Sec.	8.1	three, igneous, sedimentary, metamorphic
21.	Sec.	8.3	two tenths, two or three, one and one-half
22.	Sec.	8.3	three, one-half, one
23.	Sec.	8.4	heavy media, jigging, impact crusher, elastic fraction-
24.	Sec.	8.4	clay, silt, revolving, log washer, screw washer
25.	Sec.	8.6	few, high, cone, layers, closely, vertical
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12.	Sec.	9.2	intermixed, manufacturers
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| 9.  | Sec. | 10.2 | embed, compressing                        |
| 10. | Sec. | 10.1 | polyethylene, butyl, neoprene             |
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| 9.  | Sec. | 11.6  | c   |
| 10. | Sec. | 11.4  | T   |
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| 12. | Sec. | 11.1  | T   |
| 13. | Sec. | 11.1  | F   |
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| 16. | Sec. | 11.1  | sagging, settlement, $\frac{1}{4}$ inch, span |
| 17. | Sec. | 11.1  | joint, anchorages, 4 inches, lift             |
| 18. | Sec. | 11.11 | dirt, mortar, hardware, other material        |
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28.	Sec.	17.1	edging, chipping, damage
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- 47. Sec. 18.2 one, 60, two, 75
- 48. Sec. 18.5 beams, midspan, cover
- 49. Sec. 18.6 freezing, thawing, de-icing salts
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- 51. Sec. 18.3 reinforcing, size, length, straight, bent
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- 54. Sec. 18.4 building official, engineer, slowly, slowly
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| 35. | Sec. | 22.13 | T   |
| 36. | Sec. | 22.6  | T   |
| 37. | Sec. | 22.13 | F   |
| 38. | Sec. | 22.13 | T   |
| 39. | Sec. | 22.2  | T   |
| 40. | Sec. | 22.13 | F   |
| 41. | Sec. | 22.2  | T   |
| 42. | Sec. | 22.4  | T   |
| 43. | Sec. | 22.1  | F   |
| 44. | Sec. | 22.15 | F   |
| 45. | Sec. | 22.15 | F   |
| 46. | Sec. | 22.16 | T   |
| 47. | Sec. | 22.15 | F   |
| 48. | Sec. | 22.17 | F   |
| 49. | Sec. | 22.15 | F   |
| 50. | Sec. | 22.16 | T   |
| 51. | Sec. | 22.18 | F   |
| 52. | Sec. | 22.18 | T   |
| 53. | Sec. | 22.18 | T   |
| 54. | Sec. | 22.11 | T   |
| 55. | Sec. | 22.16 | T   |
| 56. | Sec. | 22.16 | T   |
| 57. | Sec. | 22.7  | mixing water, chamber, compressed air                             |
| 58. | Sec. | 22.11 | gun, predetermined lengths, sand, cement                          |
| 59. | Sec. | 22.13 | one, age  |
| 60. | Sec. | 22.3  | tremies, buckets, pumping   |
| 61. | Sec. | 22.8  | dry-pack mortar, grout  |
| 62. | Sec. | 22.13 | oxide, test panels  |
| 63. | Sec. | 22.7  | removed, sandblasted, doweled, bolted                             |
| 64. | Sec. | 22.13 | hydrated cement, limestone, marble                                |
| 65. | Sec. | 22.10 | three to four, freezing, thawing, sulfate, abrasion,<br>decreased |
| 66. | Sec. | 22.4  | slowly, previously placed   |

**Chapter 23—Waterproofing and Dampproofing**

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| 1.  | Sec. | 23.2 | b   |
| 2.  | Sec. | 23.3 | a   |
| 3.  | Sec. | 23.5 | c   |
| 4.  | Sec. | 23.1 | c   |
| 5.  | Sec. | 23.4 | d   |
| 6.  | Sec. | 23.4 | F   |
| 7.  | Sec. | 23.3 | F   |
| 8.  | Sec. | 23.2 | T   |
| 9.  | Sec. | 23.3 | T   |
| 10. | Sec. | 23.3 | T   |
| 11. | Sec. | 23.3 | clean, dry, smooth, filled, mortar, removed   |
| 12. | Sec. | 23.5 | unsound, encrustation, V-grooved, top, lowest |
| 13. | Sec. | 23.2 | one, more, hot, cold, glass, plastic          |
| 14. | Sec. | 23.3 | grade, walls, floors, passage of liquid       |
| 15. | Sec. | 23.1 | well-graded, low porosity, rounded            |

**Chapter 24—Introduction to Inspection**

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| 1.  | Sec. | 24.1  | c   |
| 2.  | Sec. | 24.1  | a   |
| 3.  | Sec. | 24.8  | e   |
| 4.  | Sec. | 24.4  | d   |
| 5.  | Sec. | 24.12 | a   |
| 6.  | Sec. | 24.10 | c   |
| 7.  | Sec. | 24.11 | e   |
| 8.  | Sec. | 24.6  | b   |
| 9.  | Sec. | 24.1  | T   |
| 10. | Sec. | 24.9  | T   |
| 11. | Sec. | 24.1  | F   |
| 12. | Sec. | 24.5  | T   |
| 13. | Sec. | 24.12 | T   |
| 14. | Sec. | 24.7  | F   |
| 15. | Sec. | 24.7  | T   |
| 16. | Sec. | 24.12 | F   |
| 17. | Sec. | 24.7  | F   |
| 18. | Sec. | 24.6  | F   |
| 19. | Sec. | 24.10 | dry, oven, hot plate                        |
| 20. | Sec. | 24.9  | quality control, specifications, properties |
| 21. | Sec. | 24.7  | service, mill, factory, tests, independent  |
| 22. | Sec. | 24.5  | job, construction documents                 |
| 23. | Sec. | 24.1  | suggestions, instructions, workers          |
| 24. | Sec. | 24.10 | trash, mud, contaminates                    |

**Chapter 25—Inspection of Concrete Construction**

1.	Sec.	25.3	c
2.	Sec.	25.9	b
3.	Sec.	25.10	a
4.	Sec.	25.8	b
5.	Sec.	25.2	c
6.	Sec.	25.9	d
7.	Sec.	25.1	b
8.	Sec.	25.5	d
9.	Sec.	25.4	F
10.	Sec.	25.6	T
11.	Sec.	25.0	F
12.	Sec.	25.1	T
13.	Sec.	25.8	F
14.	Sec.	25.10	T
15.	Sec.	25.5	T
16.	Sec.	25.2	T
17.	Sec.	25.6	F
18.	Sec.	25.9	T
19.	Sec.	25.10	F
20.	Sec.	25.10	F
21.	Sec.	25.1	batching, mixing, placing, finishing
22.	Sec.	25.7	permit, size
23.	Sec.	25.9	inspection reports, design drawings, specifications
24.	Sec.	25.9	amendments, procedures, requirements
25.	Table	25.1	calibration, sequence
26.	Sec.	25.4	tamping, rolling, aggregate
27.	Sec.	25.2	load ticket, thoroughly mixed, time limits

**Chapter 26—Quality Control**

1.	Sec.	26.1	b
2.	Sec.	26.2	d
3.	Sec.	26.2	a
4.	Table	26.1	a
5.	Sec.	26.1	c
		26.1	
6.	Sec.	26.3	a
7.	Sec.	26.3	c
8.	Sec.	26.1	T
9.	Sec.	26.1	T
10.	Sec.	26.1	T
11.	Sec.	26.1	F
12.	Sec.	26.2	F
13.	Sec.	26.1	concrete strength, analysis, sand, continuing
14.	Sec.	26.2	quality, strength, results
15.	Sec.	26.2	percentage, lower, design
16.	Sec.	26.1	does not, savings
17.	Sec.	26.2	uniformity, quality, materials, manufacture, controlled

