UNIT IV - CONCRETE

Lesson 6: Curing Concrete

Competency/Objective: Identify factors affecting the quality of cured concrete.

Study Questions

1. **What is the process of concrete curing?**
2. **Why is curing important?**
3. **What are the methods of curing concrete?**
4. **What are the different types of concrete defects?**
5. **When and how should forms be removed?**

References

1. *Agricultural Structures (Student Reference)*. University of Missouri-Columbia: Instructional Materials Laboratory, 1999, Unit IV.
2. Activity Sheet
   a) AS 6.1: Curing Concrete

UNIT IV - CONCRETE

Lesson 6: Curing Concrete

TEACHING PROCEDURES

A. ***Review***

Lesson 5 discussed the processes of pouring and finishing concrete. Perhaps the most important stage in working with concrete is the actual curing of the concrete. This lesson will explore the process of curing and the causes of common defects in concrete.

B. ***Motivation***

Ask students to explain how concrete hardens. One common answer will be that the concrete dries out as water evaporates. If they give this answer, have students explain why the concrete remains in a particular shape after drying and does not crumble away into the dry ingredients.

C. ***Assignment***

D. ***Supervised Study***

E. ***Discussion***

1. After the concrete is poured into the molds and finished, the concrete needs to harden. Ask the students why the concrete hardens.

   What is the process of concrete curing?

   a) Curing is the hardening of concrete.
   b) Curing is the result of hydration, which is the mixing of a compound with water.
   c) The curing process involves a chemical reaction between water and the elements in Portland cement.
   d) As the cement starts to react with the water, a substance called a gel is formed from the chemicals in the cement and water.
   e) Eventually the gel becomes a solid mass, thickening and hardening the concrete.
   f) The rate of curing for pure concrete without additives is affected by temperature.
      1) Between 65 and 75 degrees Fahrenheit - ideal temperatures for curing
      2) Higher than 75 degrees - will cause the concrete to cure too quickly
      3) Between 32 and 65 degrees Fahrenheit - concrete will cure, but more slowly
      4) Below 32 degrees - will not cure
   g) The length of time that pure concrete is allowed to cure depends on the outside temperature.
      1) Above 70 degrees Fahrenheit - at least five days
      2) 50 to 70 degrees Fahrenheit - at least seven days
      3) Less than 50 degrees Fahrenheit - at least seven to ten days and preferably longer
      4) Ideal curing time - 28 days

2. Ask students what would happen if the concrete did not cure completely. What effect would it have on the concrete?

   Why is curing important?

   a) Causes the concrete to harden and determines its strength

1) To a point, the more water the concrete can retain, the greater its strength will be.

2) For maximum strength, the concrete must have adequate water to continue the chemical reaction until it has completely hardened.

b) Gives concrete the ability to hold water in or out

3. Have the students list conditions that might affect curing concrete. What changes may be made to the curing process to counteract these conditions? Hand out AS 6.1.

What are the methods of curing concrete?

a) Cold weather curing
    1) Do not pour concrete onto frozen soil, because the ground will cause the water in the concrete to freeze; heat the ground using propane torches.
    2) When pouring concrete in temperatures below 50 degrees Fahrenheit, heat the concrete so that it is between 60 and 80 degrees Fahrenheit by heating the water added to the mixture.
    3) Provide protection for the forms in order to retain the heat.
        (a) Consists of straw, plastic, or paper spread directly on the surface of the concrete
        (b) Should remain over the concrete for at least 48 hours, and preferably for four to five days
    4) Another option for heating the concrete is to build an enclosure around the forms and heat the entire area with fuel-burning heaters.
        (a) Should be used with caution because of the carbon dioxide they give off, which sometimes reacts with the concrete to form a thin layer of calcium carbonate over its surface
        (b) Requires adequate ventilation for the exhaust fumes
    5) Leave the forms around the concrete for as long as possible to act as insulation.
    6) One way to test whether the concrete froze during curing is to pour hot water on it.

b) Hot weather curing
    1) If outside temperatures are above 80 degrees Fahrenheit, more water will be needed in the concrete mixture to maintain the optimal slump of 1 to 3 inches.
    2) High temperatures will also shorten the time that the concrete can be worked or finished; reduce the time needed for pouring by having plenty of labor available.
    3) Hot weather can cause incomplete curing due to the rapid curing of the outside layer of the concrete.
    4) Several methods can be used to keep the concrete cool.
        (a) Adding cold water
        (b) Dampening the subgrade
        (c) Placing wet burlap over the concrete
        (d) Lightly spraying cold water on the concrete

c) Moist curing
    1) Retaining the moisture on the surface of the concrete is called moist curing.
    2) Moist curing can be accomplished using a variety of methods.
        (a) Placing moist burlap sacks over the surface of the concrete
        (b) Spraying the surface with water
        (c) Covering it with waterproof paper
        (d) Covering the surface with plastic sheets
        (e) Spraying the concrete with a curing compound, which places a chemical membrane over the concrete to seal in the moisture

4. After curing, different types of defects may become apparent. Ask students to describe concrete defects that they have seen. Discuss the sources of various types of faults.

What are the different types of concrete defects?

a) Honeycomb surface
   1) Results from the use of a concrete mixture that was too dry and needed more water to mix completely
   2) Causes air pockets around the unmixed dry materials, resulting in a honeycomb structure
   3) Prevention
      (a) Moist enough mix
      (b) Spading the edges of the forms to avoid dry spots
b) Air pocket
   1) A hole left in the concrete after curing due to the presence of a confined body of air
   2) Prevention
      (a) Spading the edge of the forms
      (b) Wiping oil on the surface of the forms
c) Rock pocket or gravel streak - caused by cracks or knotholes in the forms that allow the mortar to flow out, leaving pockets and veins of coarse aggregate
d) Sand streaking
   1) Involves small ribbons of sand running across the surface of the concrete
   2) Caused by a mixture that was too wet, which allows the coarse aggregates to sink and separate out from the rest of the mixture, leaving the fine aggregate to work to the top
e) Red to pink stain
   1) The result of the resin in the plywood forms reacting with the concrete
   2) Will generally happen with forms used for the first time and will diminish with continued use
   3) Can be reduced by using older forms
   4) Difficult to remove but will fade and disappear in time
f) Rust stain
   1) Caused by steel reinforcement that has worked to the edge or surface of the concrete
   2) Can be cleaned from the concrete using a chemical solution of diluted oxalic acid but will reappear as long as the exposed metal is present
g) Dusting
   1) The appearance of a powdery material on the surface of newly hardened concrete
   2) Causes
      (a) Excess clay or silt in the concrete
      (b) Premature floating and troweling
      (c) Addition of carbon dioxide from heating systems
      (d) Condensation of water on the surface before floating and troweling have been completed
      (e) Dry-heat heaters that lower the humidity too quickly and cause incomplete curing
      (f) Inadequate or no curing due to insufficient water in the mixture
h) Scaling
   1) Occurs when the surface of hardened concrete slabs breaks away to a depth of 1/16 to 3/16 of an inch
   2) Causes
      (a) Freezing and thawing of newly placed concrete
      (b) Freezing and thawing of concrete that is not air-entrained
      (c) Application of deicing salts on concrete that is not air-entrained
      (d) Faulty workmanship caused by finishing the concrete while it was still “bleeding” or giving off water
i) Crazing

1) The presence of numerous fine hairline cracks in the surface of a newly hardened slab due to shrinkage
2) Causes
    (a) Rapid surface drying by the sun or wind
    (b) Premature floating and troweling on a moist surface along with the rapid loss of moisture
    (c) Overuse of tools such as a power screed or bull float, which works too much mortar to the surface of the concrete

5. After the concrete has cured, it is time to remove the forms. Ask students to describe how and when the forms should be removed.

When and how should forms be removed?

a) Remove the forms when the concrete has cured sufficiently to support its own weight.
    1) In summer or warm weather conditions - two days after pouring
    2) In winter or cold weather conditions - at least four to seven days
    3) Can be removed in less time if accelerating additives are used; can cut the curing time in half
b) Any reinforcement around the forms should be loosened prior to their removal, including all the duplex nails holding the forms together.
c) If the forms were properly coated with oil, they should come away easily, without the use of force.
d) The forms should then be cleaned to remove any concrete residue before storing them away for future use.
e) The slab can be cleaned with water once the forms have been removed.

F. ***Other Activities***

Observe the concrete around the school. Have students look for defects. Discuss what could have been done to avoid these problems.

G. ***Conclusion***

Concrete curing is caused by the reaction of water and cement; it allows the concrete to harden and gain strength. The process of curing concrete may vary depending on weather and temperature conditions. When the concrete is cured to the point that it can support its own weight, the forms may be removed. Various types of defects may become apparent after curing if the concrete was not mixed or worked properly.

H. ***Answers to Activity Sheet***

1. The concrete cured at room temperature should be the strongest for each test. The other environments are too wet, too cold, too hot, or too dry.
2. The concrete should get stronger as the length of time increases.
3. Concrete should be cured at room temperature and for longer periods of time, up to 28 days.

I. ***Answers to Evaluation***

1. d
2. d
3. a
4. c
5. c
6. d

7. Answers may include any three of the following: excess clay or silt in the concrete, premature floating and troweling, addition of carbon dioxide from heating systems, condensation of water on the surface before floating and troweling have been completed, dry-heat heaters that lower the humidity too quickly and cause incomplete curing, and inadequate or no curing due to insufficient water in the mixture.

8. Adding cold water to the concrete mix
9. Curing is important because it causes the concrete to harden and strengthen and because it gives concrete the ability to hold water in or out.

10. Answers may include any two of the following: placing moist burlap sacks over the surface of the concrete, spraying the surface with water, covering it with waterproof paper, covering the surface with plastic sheets, and spraying the concrete with a curing compound, which places a chemical membrane over the concrete to seal in the moisture.

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EVALUATION

Circle the letter that corresponds to the best answer.

1. The curing process is the result of:

   a. Evaporation.
   b. Drying.
   c. Stiffening.
   d. Hydration.

2. Which defect is caused by a knothole in the form that allows the mortar to flow out?

   a. Sand streaking
   b. Crazing
   c. Honeycomb surfaces
   d. Rock pockets

3. In summer, forms can be removed ____________ days after pouring pure concrete.

   a. Two
   b. Three
   c. Four
   d. Five

4. When temperatures are below 50 degrees Fahrenheit, heat the concrete mix to:

   a. 40° to 60° F
   b. 50° to 70° F
   c. 60° to 80° F
   d. 70° to 90° F

5. What is the name of the defect that results in small cracks on the surface of newly hardened concrete?

   a. Dusting
   b. Honeycomb
   c. Crazing
   d. Scaling

6. The ideal temperature for curing pure concrete is:

   a. 50° to 60° F
   b. 55° to 65° F
   c. 60° to 70° F
   d. 65° to 75° F

Complete the following short answer questions.

7. What are three possible causes of dusting on concrete?

   a.

   b.

   c.

8. How can concrete be cooled?

9. What are two reasons that curing is important?

   a.

   b.

10. What are two ways to keep concrete moist for moist curing?

    a.

    b.

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Curing Concrete

Objective: Compare the strength of concrete that is cured in different environmental conditions.

Materials and Equipment:

Mixed concrete
15 3" pieces of PVC pipe, 6" long
Hydraulic press
Oil (new motor oil)
¼" steel rod, 8" long
4' × 4' piece of plywood or sheet metal
Buckets
Oven
Freezer
Sand

Procedure:

1. Cover the inside of the PVC pipes with a light coating of oil to prevent the concrete from sticking to the pipes.

2. Prior to filling the pipes with concrete, label and number them to identify the type of curing: freezer, room, water, oven, and sand. Three pieces of pipe should be used for each type of curing. For instance, the pipes to be placed in the freezer may be labeled “Freezer 1”, “Freezer 2”, “Freezer 3”, etc.
3. Fill each of the pipes with concrete. Stand the pipes on a piece of plywood or sheet metal.

4. After filling each pipe, work the steel rod through the concrete to remove any air pockets.

5. Place the pipes in the appropriate environments: in a freezer, at room temperature in the laboratory, submerged in water, in an oven at 150 degrees Fahrenheit, and submerged in a bucket of dry sand.

6. After three days, remove the pipes labeled with the number 1 from each location.

7. Remove the cement from each pipe using a hydraulic press.

8. Once the column of cement has been removed, test its strength by placing it horizontally on the hydraulic press and forcing the press downward until it breaks. If possible, use a hydraulic press that measures the force exerted, and record the measurements.

9. Compare the six columns to determine which has the most strength.

10. After seven days, repeat the tests with concrete from the pipes labeled with a 2, and determine which has the most strength.

11. After 14 days, repeat with the process with the concrete from the last set of pipes. Determine which column of concrete has the most strength.

Key Questions:

1. Which cylinder from each test had the most strength, and why?

2. What difference did time have on the strength of concrete?

3. Considering the information from this test, how should concrete ideally be cured?