OBJECTIVE SHEET

CONCRETE INGREDIENTS

8

INTRODUCTION

Concrete results from a careful mixture of portland cement paste and aggregates such as sand, gravel, crushed stone, and other materials. A chemical reaction called hydration causes the mixture to harden into the rock-like mass we know as concrete. When it is first mixed, concrete is soft and malleable, but when it hardens it is strong and incredibly durable. A concrete mixture is usually about two-thirds aggregate and cement and the rest is water and air. The characteristics of the concrete are determined by the quality of the cement paste. Creating good quality concrete means lowering the water-cement ratio as much as possible and still having a manageable mixture.

FOCUS ASSIGNMENTS

1. Learn more about concrete. Visit the Portland Cement Association online at <www.portcement.org> and click on "Concrete Basics." You can also visit the National Ready Mixed Concrete Association online at <www.nrmca.org>.

2. Why is it important to mix the ingredients in concrete using exact proportions?

Reading Writing Technology

UNIT OBJECTIVE

After completing this unit, you will show the following competencies by mastering the activities on the Assignment Sheet and by scoring at least 85% on the Written Test.

SPECIFIC OBJECTIVES

1. State the components of concrete and their proportions.
2. Identify types of portland cement and their uses.
3. Explain the importance of proportioning and mixing.
4. Explain how concrete sets.

5. Identify the characteristics of ingredients suitable for concrete.

6. Describe the categories of aggregate.

7. Test aggregates for quality using a silt test and a colorimetric test. (Assignment Sheet)

OBJECTIVE 1

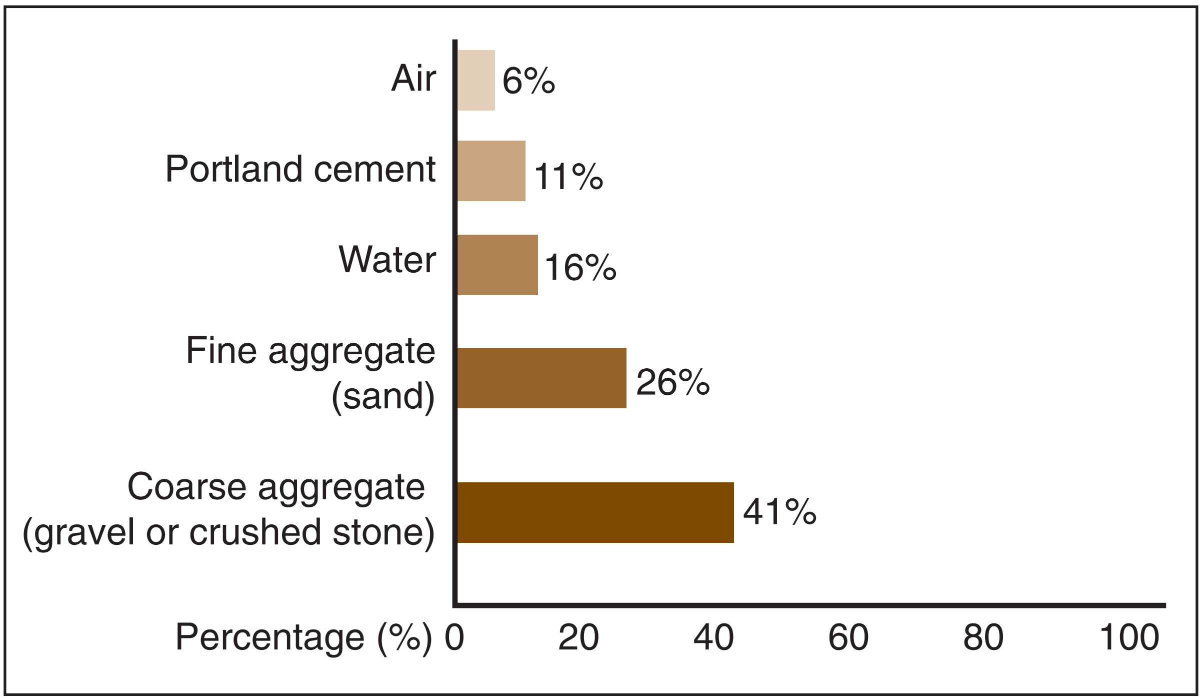
Optional Activities/ Resources in Instructor's Guide

State the components of concrete and their proportions.

WORDS YOU SHOULD KNOW

aggregate	filler material in concrete that adds volume at low cost EXAMPLES: sand, gravel, crushed stone
cement	ingredient in concrete; a powder made from alumina, silica, lime, iron oxide, and magnesia burned in a kiln and finely pulverized
concrete	building material that is a mixture of air, water, cement, and aggregates in specific proportions

FIGURE 1



✔ **NOTE:** Proportions may vary, based on the intended use of the concrete. A typical mixture has 5-8% air, 10-15% cement, 15-20% water, and 60-75% aggregate.

OBJECTIVE 2

Optional Activities/ Resources in Instructor's Guide

Identify types of portland cement and their uses.

✔ **NOTE:** All cement manufacturers make portland cement; it is a type of cement, not a brand name.

- **Type I** — normal
  - ❏ General-purpose
  - ❏ Used when the project doesn't require the special properties of the other cement types
  - ❏ Used when the construction isn't subject to sulfate attack from soil or water
  - ❏ The hydration causes a temperature rise (Type I is a good choice if this temperature rise isn't a problem.)

    EXAMPLES: pavement, sidewalk construction, reinforced concrete buildings, bridges, railway structures, tanks, reservoirs, culverts, water pipe, masonry units

  ✔ **NOTE: Type IA** is normal, air-entraining cement.

- **Type II** — modified
  - ❏ Hydrates at lower heat than Type I
  - ❏ Generates heat at a slower rate
  - ❏ Resists moderate sulfate attacks
  - ❏ May be used to minimize the temperature rise in big structures

    Examples: large piers, abutments, retaining walls, drainage structures

  ✔ **NOTE: Type IIA** is a moderate sulfate-resistant air-entraining cement.

- **Type III** — high, early-strength
  - ❏ Used when craftworkers want to use the concrete quickly or need to remove the forms as soon as possible

    Examples: prestressed concrete plants, cold-weather construction

  ✔ **NOTE: Type IIIA** is a high, early-strength, air-entraining cement.

- **Type IV** — low-heat
  - ❏ Used where the amount and rate of heat generated must be kept low
  - ❏ Used where concrete craftworkers need large masses of concrete

    EXAMPLE: large gravity dams
- **Type V** — sulfate-resistant
  - ❏ Used only in construction exposed to severe sulfate action
  - ❏ Often used in Western states where the soil or water has a high alkali content
  - ❏ Gains strength more slowly than "normal" portland cement

✔ **NOTE:** Type IV and V cement are typically only available by special order.

OBJECTIVE 3

Optional Activities/ Resources in Instructor's Guide

Explain the importance of proportioning and mixing.

- Concrete is a mixture of paste and aggregates. (The portland cement, water, and air form the paste.) The quality of the paste determines the character of the concrete:

  If the mixture has *too little* paste, it will not fill all of the voids (gaps) between the aggregates. The mixture will result in porous concrete that is difficult to place. It will have a rough, honeycombed surface.

  If the mixture has *too much* paste, the concrete may be easy to place and will yield a smooth surface. However, it will be more likely to shrink more.
- The water-cement ratio determines the strength of the paste. In general, using less water (lowering the water-cement ratio) produces a higher-quality concrete (if the concrete is properly placed, consolidated, and cured).
- Selecting the aggregates is important. Aggregates influence the properties of the concrete mixture and the hardened concrete. They also affect the proportions (and cost) of ingredients in the mixture.
- The right concrete mixture combines the desired workability (of the fresh concrete) with the required strength and durability (of the hardened concrete).

OBJECTIVE 4

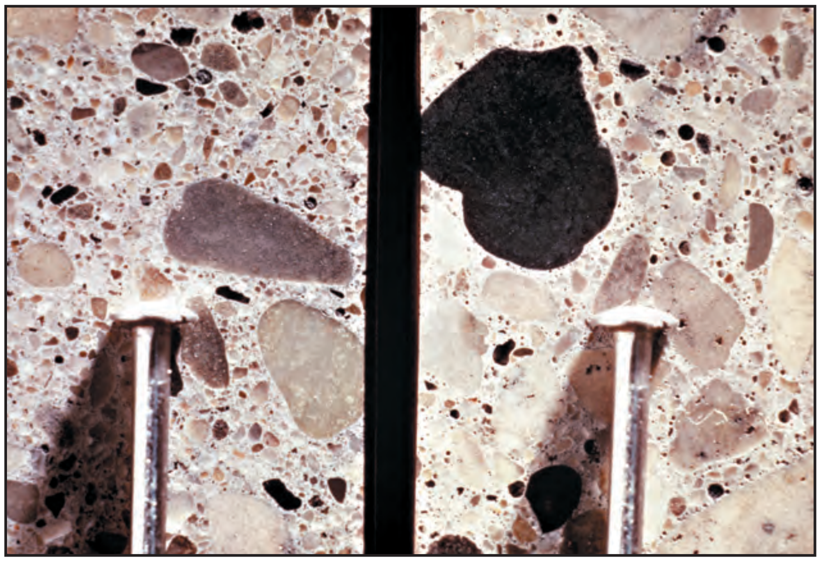
Optional Activities/
Resources in Instructor's
Guide

Explain how concrete sets.

Learn more about how hydration works to form concrete. Visit the Portland Cement Association online at <www.portcement.org> and click on "Concrete Basics." You can also visit the National Ready Mixed Concrete Association online at <www.nrmca.org>.

- The concrete ingredients are combined and mixed in the right proportions. The mixture (paste) surrounds every particle of aggregate (sand, gravel or stone) and fills the spaces (voids) between the aggregate pieces. (Figure 2)

FIGURE 2



- A chemical reaction between the cement and the water *(hydration)* hardens the mixture. Hydration binds the aggregate into a strong, durable, solid mass.

- The concrete is *consolidated* during placement. Consolidation compacts the concrete within the forms. It also removes possible flaws (air pockets, honeycombs).

- Curing begins once the exposed surfaces of the concrete are hard enough to resist marring. *Curing* allows the hydration process to continue. Methods include sprinkling the concrete with water fog, covering the concrete with fabrics that keep moisture in (such as burlap or cotton), or sealing the surface to prevent evaporation. Sealing may involve using plastic or special sprays (curing compounds). The concrete becomes stronger and more durable the longer it is kept moist.

OBJECTIVE 5

Optional Activities/ Resources in Instructor's Guide

Identify the characteristics of ingredients suitable for concrete.

WORDS YOU SHOULD KNOW	
workability	the ease of placing, consolidating, and finishing concrete

- **Cement**
  - ❑ Dry and free-flowing

    ✔ **NOTE:** Cement will keep its cementing quality indefinitely as long as it does not come into contact with moisture.

  - ❑ Free of lumps
- **Water**
  - ❑ Tasteless and odorless
  - ❑ Clean and free of excessive impurities

    ✔ **NOTE:** Impurities include salts, minerals, algae, industrial wastes, etc. Impure water may reduce the cement's bonding ability, may affect the setting time (slowing or accelerating it), may stain the concrete, or may corrode steel used as reinforcing material. Water departments will usually provide an analysis of local water. When water may contain unknown impurities, it is good practice to make a concrete strength test and a setting time test.
- **Aggregates**
  - ❑ Clean and free of impurities (dust, silt, clay, plant matter, absorbed chemicals, etc.)

    ✔ **NOTE:** Impurities can prevent the cement paste from properly binding the aggregate.

  - ❑ Grading

    ✔ **NOTE:** Well-graded aggregate is a mixture of coarse and fine aggregate in which the smaller pieces fit among the larger ones. (Figure 3) Well-graded aggregate is more economical because it requires less paste to create a bond. Some jobs specify that certain sizes of aggregate particles be omitted (gap-graded aggregate). This is often done to achieve a uniform texture in the exposed concrete surfaces.

FIGURE 3

- ❏ Durability

  - ➤ abrasion and skid resistance

    ✔ **NOTE:** Minerals in the aggregate wear and polish at different rates. Softer aggregate can wear rapidly when exposed to weather. Harder aggregate can offer better abrasion and skid resistance (such as in heavy-duty floors, pavements, etc.).

  - ➤ freeze/thaw resistance

    ✔ **NOTE:** Aggregate particles that are not freeze/thaw resistant will decrease the durability of the concrete.

- ❏ Shape

  ✔ **NOTE:** Cuboid shapes work best. Aggregate particles with flat, elongated shapes require more paste to produce workable concrete and are therefore more expensive to use. Longer particles may also lead to poor *workability* and consolidation.

OBJECTIVE 6

Required Activities/
Resources
— Transparency

Optional Activities/
Resources in Instructor's
Guide

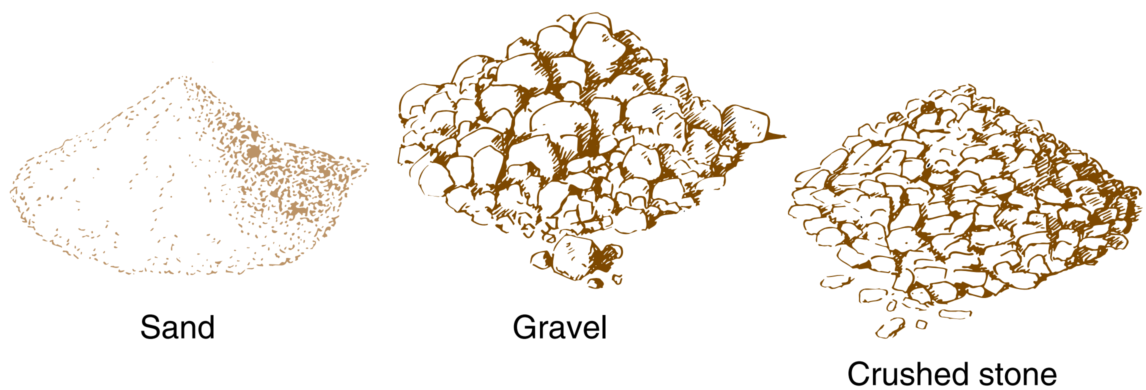
Describe the categories of aggregate.

Your instructor will show you a transparency that illustrates the categories of aggregates.

- Fine aggregates
  - ❏ Generally consist of natural sand or crushed stone
  - ❏ Range in size from very fine up to ¼ inch
- Coarse aggregates
  - ❏ Consist of gravels or crushed stone
  - ❏ Generally range between ⅜ and 1 ½ inches in diameter

✔ **NOTE:** In addition to natural aggregates, artificial aggregates are also used. They include vermiculite, ceramic spheres, fly ash, iron slag, plastics, and other materials. Using artificial aggregates helps to offset the supplies of natural aggregates. They also accommodate the weight requirements of certain concrete applications.

FIGURE 4



OBJECTIVE 7

Complete the Assignment Sheet.

ASSIGNMENT SHEET 8

CONCRETE INGREDIENTS

Name ______________________________________ Score________

OBJECTIVE 7

Test aggregates for quality using a silt test and a colorimetric test.

BASIC SKILLS

Reading Science Critical Thinking Employability

INTRODUCTION

Aggregates suitable for use as an ingredient in concrete must be well-graded, clean, and free from impurities such as fine dust, silt, loam, clay, or vegetable matter. If not well-graded and clean, the cement paste will not properly bind the aggregate particles together, thus reducing the strength of the concrete. Two simple tests can be given to determine aggregate quality in two areas: (1) the silt test, used to detect the presence of extremely fine materials in an aggregate and (2) the colorimetric test, used to detect the presence of harmful amounts of vegetable matter in an aggregate.

EQUIPMENT AND SUPPLIES

Part 1: Silt Test

- 1-quart fruit jar and lid for each aggregate sample
- Dry aggregate (sand)
- Water
- Ruler or tape
- Chart for recording test results
- Pencil or pen
- Personal protective equipment

✔ **NOTE:** Refer to C.F.R. 1926.28 Sub Part C in regard to personal protective equipment.

Part 2: Colorimetric Test

- 12-ounce prescription bottle and rubber stopper for each aggregate sample
- Dry aggregate (sand)
- Caustic-soda solution (1 ounce sodium hydroxide and 1 quart distilled water)

✔ **NOTE:** Sodium hydroxide can be purchased at a drug store.

- Glass bottle with rubber stopper for storing caustic-soda solution

- Chart for recording test results
- Pencil or pen
- Rubber gloves
- Personal protective equipment

✔ **NOTE:** Refer to C.F.R. 1926.28 Sub Part C in regard to personal protective equipment.

INSTRUCTIONS

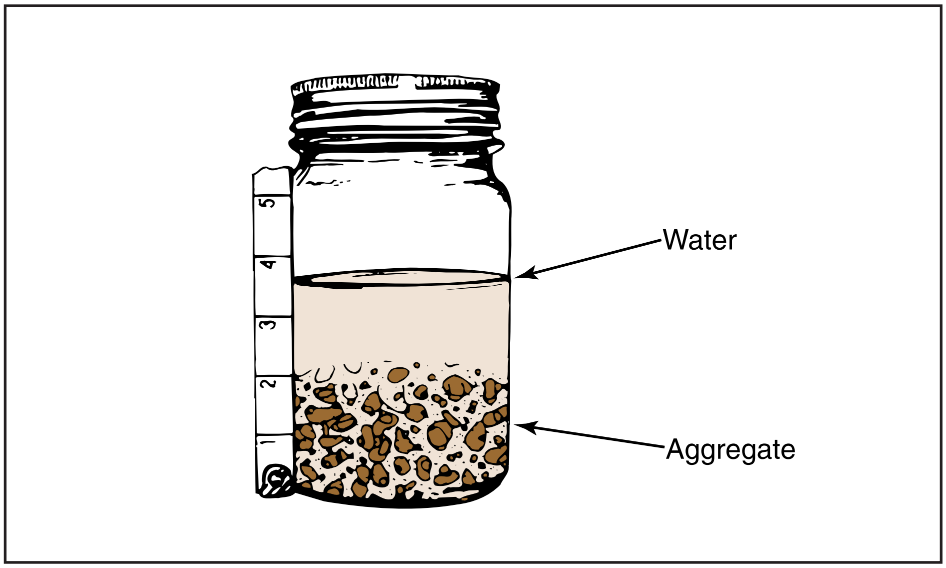
Using the following procedures for the silt test and the colorimetric test, determine the quality of aggregate samples.

Part 1: Silt Test

1. Pour aggregate into the fruit jar to a depth of 2 inches. (Figure 1)

2. Add water until the jar is about three-fourths full. (Figure 1)

FIGURE 1



3. Cover the jar opening with the lid and shake the jar vigorously for one minute, using an up-and-down motion.

4. Shake the jar, using a side-to-side motion, until the aggregate is level in the jar.

5. Allow the jar to stand undisturbed for one hour.

6. Measure the silt layer in the fruit jar and record the measurement on the chart.

7. Determine the quality of aggregate, using the following guidelines: If the silt layer is more than ⅛ inch deep, aggregate is not satisfactory for concrete work unless excess silt is removed.

Part 2: Colorimetric Test

1. Mix a caustic-soda solution and store it in a glass bottle tightly closed with a rubber stopper.

   CAUTION: Never handle sodium hydroxide with moist hands. Serious burns may result. Wear rubber gloves.

2. Pour the aggregate into the bottle to the 4½-ounce mark.

3. Pour the caustic-soda solution over the aggregate to the 7-ounce mark; put the stopper in the bottle and thoroughly shake the contents.

   CAUTION: Handle the caustic-soda solution carefully; it can seriously burn the skin and is highly injurious to clothing, leather, and many other materials.

4. Allow the bottle to stand undisturbed for 24 hours.

5. Record the test results and determine the quality of the aggregate, using the following guidelines: Colorless solution indicates aggregate is free of vegetable matter; straw-colored solution indicates some vegetable matter in aggregate, but not enough to make aggregate unsatisfactory for concrete work; bright yellow to medium brown solution indicates the aggregate contains unsatisfactory amounts of organic matter and should not be used for concrete work unless washed and tested again. (Figure 2)

FIGURE 2