

**INTRODUCTION**

Admixtures are ingredients in concrete—other than cement, water, and aggregate—that are added immediately before or during mixing. They may be natural or manufactured chemicals. There are also different types for different purposes. However, all admixtures are used to change the characteristics of the fresh or hardened concrete.

**FOCUS ASSIGNMENTS**

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1. Read the section on Concrete Basics at the National Ready Mixed Concrete Association. Go to <[www.nrmca.org](http://www.nrmca.org)>. Click on “Concrete Engineering/Technical” then “Concrete Basics.” Click on “Ingredients.”
2. The key to achieving a strong, durable concrete rests on what?



**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. Discuss the objectives of concrete-mix design.
2. List the characteristics of quality hardened concrete, workable fresh concrete, and an economical concrete mix.
3. State steps in determining optimum concrete-mix design.
4. Select from a list job requirements that must be determined before a concrete mix is designed.
5. Name concrete-mix design factors determined to meet job requirements.
6. State the rule used to determine maximum coarse-aggregate size.



7. Name the methods used to determine optimum mix proportions.
8. Describe air-entrained concrete and its uses.
9. State types of mix designs and their definitions.
10. Match types of concretes to their correct definitions.
11. State factors used in selecting aggregate for heavyweight concrete.
12. Match types of concretes to their correct uses.
13. State standard mixing requirements for the stationary mixers with up to 1-cubic-yard capacities and for truck mixers with Truck Mixer Manufacturers' Bureau-rated capacity for the size of the mixer being used.
14. State standard delivery and discharge times for stationary and truck mixers.
15. Give reasons why admixtures are useful ingredients in concrete.
16. Identify the classes of admixtures.
17. Demonstrate the effects of admixtures. (Assignment Sheet)



**OBJECTIVE 1**

Optional Activities/  
Resources in Instructor's  
Guide

**Discuss the objectives of concrete-mix design.**

**WORDS YOU SHOULD KNOW**

<b>workable</b>	ease of placing, consolidating, and finishing concrete
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✓ **NOTE:** The ingredients used in a concrete mix (cement, water, aggregates, and admixtures) must be combined to obtain the following objectives.

- To produce quality hardened concrete
- To produce a workable concrete
- To produce an economical concrete

**OBJECTIVE 2**

Optional Activities/  
Resources in Instructor's  
Guide

**List the characteristics of quality hardened concrete, workable fresh concrete, and an economical concrete mix.**

- Quality hardened concrete
  - ❑ Low permeability
  - ❑ Strong
  - ❑ Wear-resistant
  - ❑ Durable
  - ❑ Freeze/thaw-resistant (where needed)
- Workable fresh concrete
  - ❑ Easily placed
  - ❑ Easily consolidated
  - ❑ Easily finished



- Economical concrete mix
  - ❑ Utilizes the largest aggregate possible, which reduces cracking and shrinkage
  - ❑ Produces the stiffest mix practical
  - ❑ Utilizes optimum ratio of fine to coarse aggregate

### OBJECTIVE 3

Required Activities/  
Resources  
— Handouts 1 and 2

Optional Activities/  
Resources in Instructor's  
Guide

#### State steps in determining optimum concrete-mix design.



Your instructor will show you a worksheet that is used to design concrete mixes.

- Job requirements are determined.
- Concrete-mix design factors are determined to meet job requirements.
- Trial batches are mixed to determine optimum mix design.

### OBJECTIVE 4

Optional Activities/  
Resources in Instructor's  
Guide

#### Select from a list job requirements that must be determined before a concrete mix is designed.

- Size and shape of the member to be constructed
- Amount and distribution of reinforcing material required to construct the member
- Concrete strength required to construct the member
- Conditions the constructed member will be exposed to

### OBJECTIVE 5

Optional Activities/  
Resources in Instructor's  
Guide

#### Name concrete-mix design factors determined to meet job requirements.

#### WORDS YOU SHOULD KNOW

**range of slump**      maximum to minimum range of concrete fluidity allowed for various types of construction

✓ **NOTE:** After the job requirements have been determined, a concrete mix is designed to meet those requirements. In designing the mix, the maximum permissible water/cement ratio, total air content, and range of slump are determined through the use of tables based on American Concrete Institute (ACI) standards.



- Maximum permissible water/cement ratio
- Maximum coarse-aggregate size
- Total air content
- Range of slump

## OBJECTIVE 6

Optional Activities/  
Resources in Instructor's  
Guide

**State the rule used to determine maximum coarse-aggregate size.**

Maximum coarse-aggregate size should *not* exceed:

- One-fifth the minimum dimension of the member to be constructed
- Three-fourths the clear space between reinforcing bars or between reinforcement and forms
- One-third the thickness of unreinforced slabs

## OBJECTIVE 7

Required Activities/  
Resources  
— Handouts 3 and 4

Optional Activities/  
Resources in Instructor's  
Guide

**Name the methods used to determine optimum mix proportions.**



Your instructor will give you handouts that show the results of laboratory tests on trial batches.

✓ **NOTE:** After the concrete-mix design factors have been determined, trial batches are mixed. In mixing these trial batches, the percentage of fine aggregate (of total aggregates) is varied in order to determine the optimum mix proportions. The size of the trial batch is dependent upon the equipment available and on the number and size of the test specimens to be made; however, large batches produce more accurate data.

- Small, carefully proportioned trial mixes
- Job-size trial batches made during normal concrete production

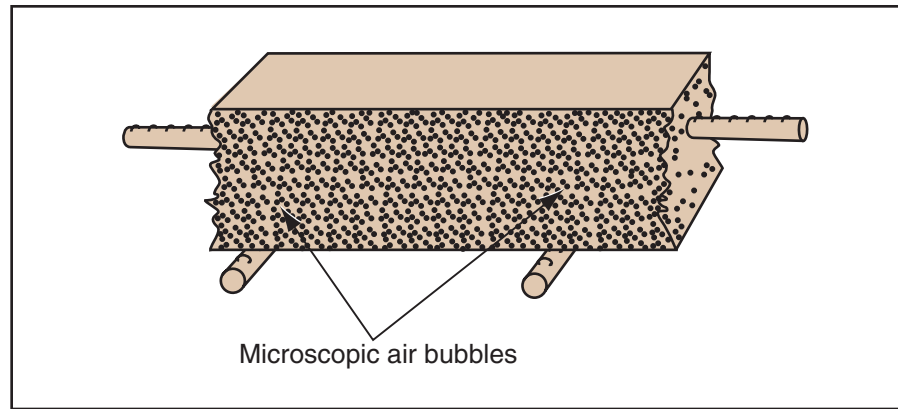
## OBJECTIVE 8

**Describe air-entrained concrete and its uses.**

- Air-entrainment is the process of intentionally introducing air into the cement mix. This is done by using air-entraining admixture during mixing or, rarely, by using cement with entraining admixture in it. Air-entrained concrete contains millions of microscopic air bubbles dispersed throughout the paste. (Figure 1) These air bubbles make up from 4 to 8 percent of the volume of the concrete mix.



FIGURE 1



- The entrained air bubbles improve the durability of hardened concrete that is exposed to freezing water. Water expands when it freezes and this expansion can cause concrete to rupture. The air bubbles give the water room to expand without causing damage. The environment determines the amount of air that is entrained. The more extreme the freeze/thaw cycle is, the more air that will be introduced. Conversely, air is not necessary in areas such as the tropics where temperatures remain more constant and above freezing.
- Air-entrainment also increases the workability of the concrete, acting like tiny ball bearings, enabling the finisher to pour at a lower slump. This helps offset the weakening of the mix which occurs when air replaces solid mass.
- Air entrainment also helps to prevent scaling in concrete that comes into contact with de-icing chemicals. Air entrained concrete should be used in all work exposed to freeze/thaw cycles.
- Air also helps decrease segregation in the mix, which increases strength and is also useful in applications such as exposed aggregate. Bleed water is dramatically decreased by the blocking of capillaries that lead to the surface. Bleed water can weaken the surface by raising the water/cement ratio at that point.
- Because air entrained concrete is sticky, magnesium floats, instead of wood, should be used to prevent the tearing of the surface.
- Air entrained concrete will also pick up on kneeboards and sliders. Over sealing air entrained concrete will magnify the problem by trapping air and water just below the surface causing delamination.
- As with all mixes, the cement mason should know the mix design they are working with so they can make the necessary adjustments to have a successful job.



## OBJECTIVE 9

Required Activities/  
Resources  
— Transparencies 1-4

Optional Activities/  
Resources in Instructor's  
Guide

### State types of mix designs and their definitions.



Your instructor will show you transparencies that illustrate the ratios of ingredients in rich and lean concrete mixtures.

- Rich — Mix containing a high proportion of cement (Figure 2)
- Lean — Mix containing a low proportion of cement (Figure 3)

FIGURE 2

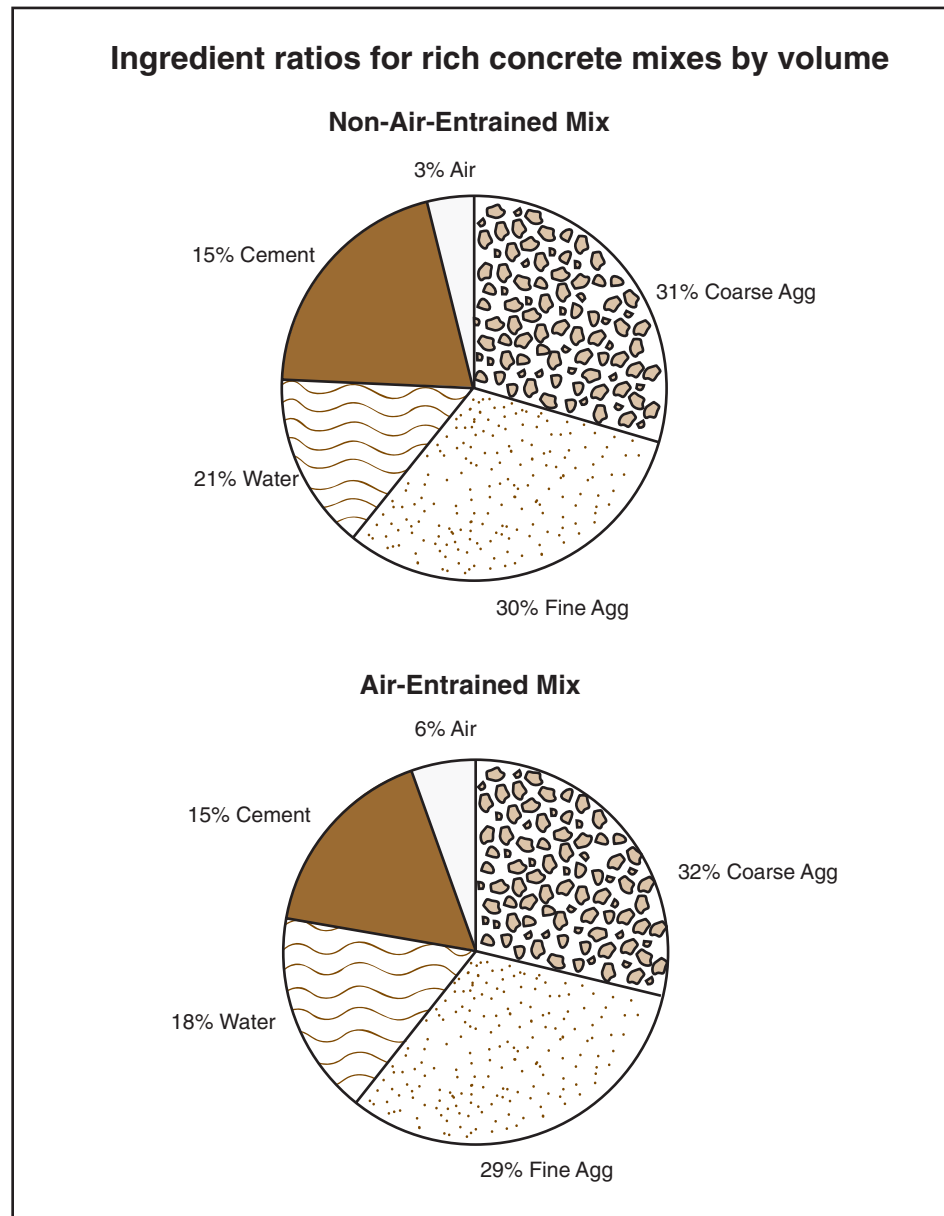
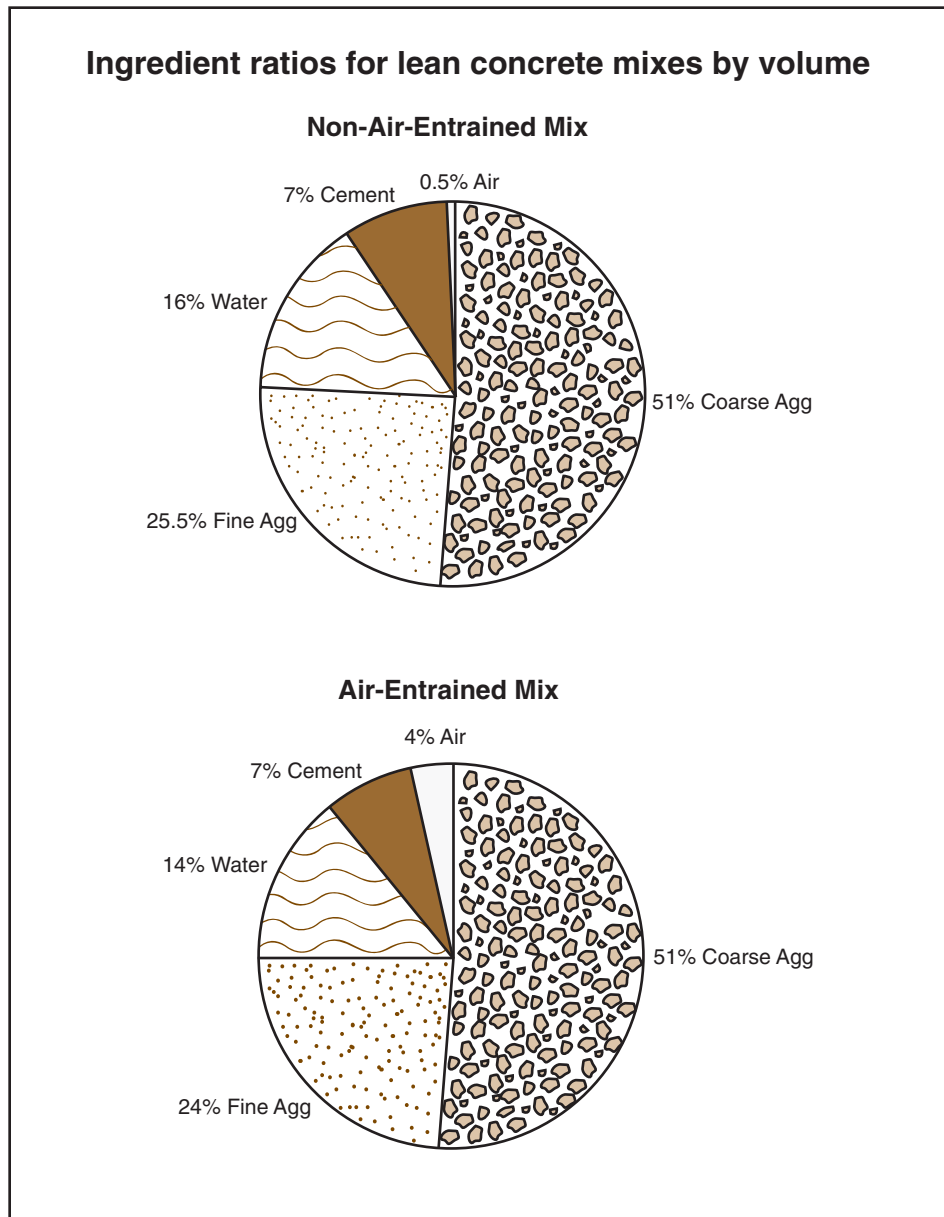


FIGURE 3



## OBJECTIVE 10

Optional Activities/  
Resources in Instructor's  
Guide

### Match types of concretes to their correct definitions.

TABLE 1: Definitions of concrete types

Type	Definition
<b>Normal-weight</b>	Concrete made with aggregates such as sand, gravel, and crushed stone; and having a unit weight of approximately 150 pounds per cubic foot
<b>Lightweight</b>	
Group I	Lightweight insulating concrete made with aggregates of expanded materials such as perlite or vermiculite; and having a unit weight of no more than 50 pounds per cubic foot
Group II	Lightweight fill concrete made with aggregates manufactured by expanding, calcining, or sintering materials such as blast-furnace slag, clay, diatomite, fly ash, shale, or slate, or by processing natural materials such as pumice, scoria, or tuff; and having a unit weight ranging from 50 to 90 pounds per cubic foot
Group III	Lightweight structural concrete made with lightweight aggregate; and having a unit weight of 90 to 115 pounds per cubic foot
<b>Heavyweight</b>	Concrete made with aggregates such as barite, ferrophosphorus, goethite, hematite, ilmenite, limonite, magnetite, steel punchings, and steel shot and having weight in excess of 150 pounds per cubic foot
<b>Colored</b>	Concrete made by using colored aggregate and/or by adding color pigment to the mix
<b>White</b>	Concrete made with white cement and with aggregates and water that contain no materials to discolor the concrete



## OBJECTIVE 11

Required Activities/  
Resources  
— Handout 5

Optional Activities/  
Resources in Instructor's  
Guide

**State factors used in selecting aggregate for heavyweight concrete.**



Your instructor will show you a list of aggregates used in special-weight concrete.

- Physical properties
- Availability
- Cost

## OBJECTIVE 12

Optional Activities/  
Resources in Instructor's  
Guide

**Match types of concretes to their correct uses.**

TABLE 2: Uses of concrete types

Type	Definition
<b>Normal-weight</b>	Used in standard concrete construction
<b>Lightweight</b>	
Group I	Used for insulating members such as roofs, fire walls, and conduit linings
Group II	Used in making lightweight masonry units
Group III	Used in making light but strong structural members such as those needed in high-rise buildings
<b>Heavyweight</b>	Used in making high-density shielding against nuclear radiation
<b>Colored and white</b>	Used in architectural effect

## OBJECTIVE 13

Optional Activities/  
Resources in Instructor's  
Guide

**State standard mixing requirements for the stationary mixers with up to 1-cubic-yard capacities and for truck mixers with Truck Mixer Manufacturers' Bureau-rated capacity for the size of the mixer being used.**

✓ **NOTE:** Mixing requirements can be found in the specifications.

- Stationary mixer — One minute

✓ **NOTE:** Increase the mixing time fifteen seconds for each additional yard or fraction of a yard to be mixed.



## OBJECTIVE 14

Required Activities/  
Resources  
— Handout 6

Optional Activities/  
Resources in Instructor's  
Guide

- Truck mixer — Seventy to one hundred revolutions at mixing speed designated by mixer manufacturer

### State standard delivery and discharge times for stationary and truck mixers.



Your instructor will show you a table that illustrates standard discharge times.

✓ **NOTE:** Delivery and discharge times are regulated by the American Society for Testing and Materials (ASTM).

- Stationary mixer — Discharge within one and one-half hours after the introduction of water into the mix
- Truck mixer — Deliver before the drum has revolved three hundred times

## OBJECTIVE 15

Optional Activities/  
Resources in Instructor's  
Guide

### Give reasons why admixtures are useful ingredients in concrete.



How can admixtures affect concrete construction? Ask your instructor for examples of the following uses.

#### WORDS YOU SHOULD KNOW

<b>workability</b>	the ease of placing, consolidating, and finishing concrete
<b>admixture</b>	an agent that is added to the concrete mix—immediately before or during mixing—to change one or more of the characteristics of the concrete

- They modify the properties of the hardened concrete.

#### EXAMPLES:

faster or shorter setting time  
faster strength development  
better workability, durability, and strength  
better resistance to weather extremes (heat, cold, freeze/thaw)  
better resistance to corrosion (by reinforcing steel)  
less shrinkage and surface cracking

- They can reduce the cost of concrete construction.

**EXAMPLE:** Using a *water-reducing admixture* can achieve a high-strength workable concrete by reducing water-cement ratio.



- They can overcome emergencies or difficult construction situations.

EXAMPLES: Placing the concrete during hot or cold weather; special requirements for the early strength of the concrete; very low specifications for the water-cement ratio; etc.

- They help maintain the appearance of the concrete over time.

EXAMPLE: architectural block

## OBJECTIVE 16

Optional Activities/  
Resources in Instructor's  
Guide

### Identify the classes of admixtures.



Look at samples of admixtures provided by your instructor.

#### WORDS YOU SHOULD KNOW

<b>bleeding</b>	the appearance of mixing water on the surface of newly placed concrete; caused by the settling of solid materials in the mixture
<b>slump</b>	a measure of consistency of freshly mixed concrete

- Accelerating admixtures — Used during cold weather to speed up the setting process and early strength development; this allows forms to be removed sooner and improves the concrete's resistance to freezing at an early age
- Air-entraining admixtures — Introduce tiny air cells into the concrete to improve weather resistance—against severe frost, cycles of wetting and drying, deicer attack, and cycles of freezing and thawing—improve workability and durability, and reduce *bleeding*

✓ **NOTE:** Concrete that is air-entrained contains billions of air cells. These air cells relieve the internal pressure on the concrete. They do this by providing tiny spaces for the expansion of water when it freezes. For example, parking lots and sidewalks are subjected to cycles of freezing and thawing.



- High range water reducers (plasticizers/superplasticizers) — Used to greatly reduce the amount of mix water needed and to increase slump; may also increase the air content and delay or accelerate the setting process; also called *high-range water reducers* (HRWR); increase the workability without decreasing strength.

✓ **NOTE:** These admixtures are added to concrete that has a low- to normal-slump and water-cement ratio. The result is flowing concrete that has a high slump. The effect of superplasticizers lasts only 30-60 minutes. The workability of the mixture decreases quickly after this time.

- Retarding admixtures — Used to offset the accelerating effects of hot weather on the setting process, and to delay the setting time when required for difficult or unusual placement conditions

✓ **NOTE:** High temperatures can increase the rate of hardening. This makes it more difficult to place and finish the concrete. Retarding admixtures may be called *water-reducing retarders* because most also act as water-reducing agents.

- Specialty admixtures — Used for specific functions, such as to reduce alkali-silica reactivity; inhibit corrosion; reduce shrinkage; enhance workability; bonding, dampproofing, and coloring

#### EXAMPLES:

*Pigment*—finely ground, pure mineral oxides—added to produce colored hardened concrete to create decorative effects, reduce glare, and highlight surfaces for safety purposes.

*Corrosion inhibiting admixtures* slow the corrosion of reinforcing steel (such as in parking garages and highway bridges).

*Shrinkage reducers* control shrinkage during drying and minimize cracking.

*Alkali-silica reactivity inhibitors* (ASR) control durability problems related to alkali-silica reactivity.

*Damp proofing* usually refers to materials that are painted onto the surface of hardened concrete; decrease permeability and help maintain appearance.

*Fiber reinforcement*—may rescue surface cracking due to plastic shrinkage; may increase toughness

*Pozzolan*—natural or processed materials; may improve workability and plasticity.



- Water-reducing admixtures — Used to reduce the amount of mix water needed for a given consistency. These admixtures increase workability without decreasing strength. They also increase slump.

✓ **NOTE:** Concrete with a water-reducing admixture needs less water to reach a required consistency. The water-cement ratio can be lower (than with untreated concrete). The result can be a higher strength concrete without adding cement.

## OBJECTIVE 17

**Complete the Assignment Sheet.**



Name \_\_\_\_\_ Score \_\_\_\_\_

OBJECTIVE 17

**Demonstrate the effects of admixtures.**

BASIC SKILLS



Writing



Mathematics



Critical Thinking

EQUIPMENT AND SUPPLIES

- Pen or pencil
- Concrete ingredients (to instructor's specifications)
- Admixture (type and quantity to instructor's specifications)

INSTRUCTIONS

- You instructor will assign you to a group. In your group, make a small amount of concrete mix. Use the ingredients and quantities that your instructor specifies. Describe the *workability* and the *slump* of your mixture.
- Mix a second amount of concrete. Use the ingredients and quantities your instructor specifies. This time, also add the admixture that your instructor provides. Describe the workability and the slump of your second mixture.
- Compare the workability and the slump of the mixtures.

**Mixture #1**

Workability:

Slump:



**Mixture #2**

Workability:

Slump:

How did the workability and the slump of the mixture compare?

