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# INTRODUCTION TO CONCRETE

## Carpentry Series

## MODULE FOCUS

**Introduction**
Concrete is one of the most widely used building materials in the world. It is used to build roads, houses, bridges, skyscrapers, decorative elements, curbs, dams, and just about any other structure used in construction. Concrete is cost effective, flexible, and strong. The terms concrete and cement are often interchanged, but cement is actually an ingredient used in concrete.

**On the Internet**
You can learn more about concrete at these web sites:
- American Concrete Institute
- Portland Cement Association
- World of Concrete
  [http://www.worldofconcrete.com](http://www.worldofconcrete.com)

After completing this module, you will show the following competencies by mastering the activities on the Assignment and Job Sheets and by scoring at least 85% on the Module Quizzes.

1. Select the principal properties of concrete.
2. Select factors that affect properties of concrete.
3. Choose characteristics of workable fresh concrete, economical concrete mixes, and quality hardened concrete.
4. Select precautions that reduce the development of skin irritation in the use of cement products.
5. Select benefits of using admixtures in concrete.
6. Match types of admixtures used in concrete to their correct functions.
7. Choose the purposes of various types of concrete tests.
8. Obtain representative fresh-concrete test samples. (Job Sheet 1)
9. Perform a slump test. (Job Sheet 2)
10. Cast a concrete cylinder for a compression test. (Job Sheet 3, Commercial ONLY)
11. Identify types of reinforcing used in concrete.
12. Match common reinforcing bar numbers to their correct diameter sizes.
13. Interpret reinforcing bar size markings. (Assignment Sheet 1)
15. Identify reinforcing bar supports.
16. Identify hardware and accessories used to install reinforcing bars.
17. Interpret the sizes of welded wire fabric. (Assignment Sheet 2)
18. Lay and tie welded wire fabric. (Job Sheet 4)
INTRODUCTION TO CONCRETE
Carpentry Series

Student Name ________________________________
Start Date: ________  Completion Date: ________

1. Study Information Sheet 1, objective 1.
2. Discuss the principal properties of concrete.
3. Study Information Sheet 1, objective 2.
4. Discuss factors that affect properties of concrete and why concrete has become widely used in construction.
5. Study Information Sheet 1, objective 3.
6. Discuss characteristics of workable fresh concrete, economical concrete mixes, and quality hardened concrete.
7. Study Information Sheet 1, objective 4.
8. Discuss precautions that reduce the development of skin irritation in the use of cement products.
9. View samples of personal protection equipment such as rubber gloves/boots and safety goggles.
10. Take Quiz 1.
Select the principal properties of concrete.

<table>
<thead>
<tr>
<th>WORDS YOU SHOULD KNOW</th>
</tr>
</thead>
<tbody>
<tr>
<td>curing</td>
</tr>
<tr>
<td>maintenance of proper moisture and temperature in concrete during the initial stages</td>
</tr>
</tbody>
</table>

Concrete has the following properties when it is properly mixed and placed:

- Can be formed into practically any shape
- Can withstand extreme heat and fire
- Does not decay and resists corrosion
- Has a high level of resistance to wear or abrasive action
  Example: Wear caused by wheeled vehicles or flowing water
- Resists termites and rodents
- Use and strength can be expanded through the use of reinforcing

Select factors that affect properties of concrete.

Quality concrete should be workable, strong, durable, and watertight. These variables are most influenced by the following factors.

- **Classes of concrete** — Normally the plan will specify the class of concrete required for each major component of a structure. Study the following concrete classes.
  - Class AA — Slabs and girders without wearing surface, concrete piles, handrails and all bridge floors
  - Class A — Slabs and girders with wearing surface, pavements, piers, abutments, retaining walls, culverts and all reinforced concrete not requiring Class AA concrete
  - Class C — Concrete may be used for soil erosion control structures

- **Cement types** — The plan will specify the cement types which include:
Type I, IA, and IP are the general purpose cement used in concrete for most construction.

Type II and IIA are used in concrete exposed to moderate sulphate action

Type III and IIA are used when high early strength concrete is required

**Water/cement ratio**

The water/cement ratio is critical to the strength of the hardened concrete. Too much water can weaken the concrete and too little water reduces the workability of concrete.

✓ **NOTE:** Do not add water to ready-mix concrete without consulting the engineer or your supervisor.

**Slump**

Slump is the measure of the uniformity and consistency of freshly mixed concrete. The concrete slump must provide satisfactory workability. Usually several slump tests are performed during the construction process.

**Water quality** — Generally, water that is fit to drink is suitable for making concrete. The water should be:

- Tasteless and odorless
- Clean and free of impurities (Examples: salts, minerals, industrial wastes, algae)

✓ **NOTE:** Water departments will usually provide an analysis of local water. However, when water that has not been analyzed and may contain unknown impurities is considered for use, particularly on large jobs, it is a good practice to make a concrete strength test.

**Aggregate** — granular material which makes up about 60 to 80 percent of the volume of concrete

- Aggregate gradation

  - The size or gradation of aggregate is determined by using a sifting device called a sieve. Sieves are graded by the size of the opening through which aggregates fall. Large variations in aggregate grades can have serious effects on the uniformity of concrete from one batch to another.
Aggregate types

- Fine aggregate — consists of both natural or manufactured sand
- Coarse aggregate — can be gravel or crushed stone. Coarse aggregate are classified by their durability to withstand the freeze/thaw cycle and their ability to withstand wear. Classes A, AA, C, and P5/P6 are available in most areas.

Weather conditions

- Cold weather
  - The weather conditions have a significant effect in the setting times of concrete. Concrete sets very slowly when the surrounding air temperature is cold. When concrete is poured in cold weather, it sets best when the surrounding air temperature is kept at or above 40 degrees F.
  - Plans to protect fresh concrete from freezing include providing heating and/or enclosures during the first 2 to 3 days of setting time. Insulated blankets can also be used to protect the concrete from the effects of cold weather. Discuss these plans with the engineer or your supervisor well in advance of the planned concrete pour.

- Hot weather
  - At higher air temperatures, greater concrete strength can be achieved by slowing the concrete setting process using curing methods.

- Changing weather conditions
  - Consult with the engineer and your supervisor to ensure the planned concrete placement considers the effects of local weather conditions. Ensure that all necessary equipment and materials are on-site in preparing for changing weather conditions.

Curing methods/times — Curing methods are used to slow the setting process and achieve greater concrete strength. As a general rule, concrete should attain its design strength in 28 days. Form removal and loading may be allowed much sooner under certain conditions. Always consult with the engineer or your supervisor. Common curing methods include:

- Covering the partially hardened concrete with burlap material.
- Water can be sprayed over partially hardened concrete.
Liquid curing compounds can be sprayed over partially hardened concrete.

Sheet materials can be used to cover the concrete.

Linseed oil emulsion can be sprayed over the hardening concrete.

**NOTE:** It is critical that proper curing methods be used where area weather conditions are hot and dry. Remember that to achieve the maximum strength in concrete, it must be allowed to harden slowly over time.

- **Admixture** — material added to a batch of concrete which improve the quality and/or change the characteristics of concrete. Admixtures add color, control strength, shorten or lengthen setting time, or modify temperature range of the mix. Admixtures types include:
  - Accelerating
  - Air-entraining
  - Pigments
  - Plasticizers (Water-reducing)
  - Pozzolan
  - Retarding
  - Waterproofing

**OBJECTIVE 3**

Choose characteristics of workable fresh concrete, economical concrete mixes, and quality hardened concrete.

Study the following characteristics of concrete:

A. Characteristics of workable fresh concrete
   - Easily placed
   - Easily consolidated
   - Easily finished

B. Characteristics of an economical concrete mix
   - Utilizes the largest aggregate possible
   - Produces the stiffest mix practical
   - Utilizes optimum ratio of fine to coarse aggregate
C. Characteristics of quality hardened concrete

- Freeze/thaw-resistant
- Watertight
- Strong
- Wear-resistant
- Durable

Select precautions that can reduce the development of skin irritation in the use of cement products.

Cement is a major cause of skin irritation for people who frequently work with concrete. When wet, the lime contained in cement causes it to heat and burn the skin. Prolonged exposure and inhalation could result in sores appearing on the skin and/or in the lining of the mouth and nose. This condition is called cement poisoning or cement dermatitis and these factors contribute to its formation:

- Failure to observe precautions
- A pre-existing dermatitis or allergy

Study the following precautions that can reduce your risk to cement dermatitis.

- Use of goggles
- Use of face mask
- Use of knee pads
- Frequent washing of body areas exposed to cement
- Bathing after each shift
- Use of rubber gloves/boots
- Use of a lanolin-based soap or lotion

✔ NOTE: Medical care should be sought for those who develop dermatitis.
Information Sheet 2, objective 5.

- Study

Information Sheet 2, objective 6.

- Study

Information Sheet 2, objective 7.

- Study

Optional

Listen to a representative from an admixture manufacturer to discuss the use of admixtures.

- Study

Quiz 2.

- Take

the introduction to Job Sheet 1, objective 8.

- Read
10. Ask your instructor to demonstrate guidelines and procedures in the Job Sheet. Use the Job Sheet to follow along. Pay careful attention to any guidelines, cautions, and warnings.

11. Practice the procedure demonstrated by your instructor. Use the Job Sheet as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

12. Stop and have your instructor evaluate your work from the Job Sheet. After your work has been evaluated, follow your instructor’s recommendations.

13. Discuss with your instructor the safety issues involved in obtaining representative fresh-concrete test samples.


15. Ask your instructor to demonstrate guidelines and procedures in the Job Sheet. Use the Job Sheet to follow along. Pay careful attention to any guidelines, cautions, and warnings.

16. Practice the procedure demonstrated by your instructor. Use the Job Sheet as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.
17. Stop and have your instructor evaluate your work from the Job Sheet. After your work has been evaluated, follow your instructor’s recommendations.

18. Discuss with your instructor the safety issues involved in performing a slump test.

**NOTE:** Job Sheet 3 is required only for Commercial Carpentry.

19. Read the introduction to Job Sheet 3, objective 10.

20. Ask your instructor to demonstrate guidelines and procedures in the Job Sheet. Use the Job Sheet to follow along. Pay careful attention to any guidelines, cautions, and warnings.

21. Practice the procedure demonstrated by your instructor. Use the Job Sheet as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

22. Stop and have your instructor evaluate your work from the Job Sheet. After your work has been evaluated, follow your instructor’s recommendations.

23. Discuss with your instructor the safety issues involved in casting a concrete cylinder for a compression test.
Select the benefits of using admixtures in concrete.

The number and extent of benefits will vary with the admixtures. The list below gives the major benefits possible through the planned use of admixtures.

- Increases durability
- Controlled setting time
- Increased early strength
- Improved resistance to effects from freezing and thawing
- Enhanced appearance
- Improved workability
- Less heat generation
- Lower cost

Match types of admixtures used in concrete with the purpose of each admixture.

| WORDS YOU SHOULD KNOW | bleeding | process of water rising to the surface of concrete prior to setting |

Study the following admixtures and their purposes.

- **Accelerator** — speeds setting of concrete
- **Air-entraining** — incorporates microscopic air bubbles into concrete to improve workability and durability
- **Pigment** — agent used to achieve a desired color; pigment can be a natural or a man-made substance.
- **Plasticizer** (water reducer) — reduces the quantity of mix water needed without decreasing concrete strength
**Pozzolan** — improve workability and quality of concrete by reducing the chemical reaction between the aggregates and the cement used in concrete

✓ **NOTE:** The chemical reactions often produce heat, which leads to expansion of the concrete. The expansion weakens the concrete, changes its volume, causes increased bleeding, and makes the concrete more permeable.

**Retarder** — delays setting of concrete

**Waterproofer** — helps to seal concrete against water penetration

Choose the purposes of various types of concrete tests.

<table>
<thead>
<tr>
<th>WORDS YOU SHOULD KNOW</th>
</tr>
</thead>
<tbody>
<tr>
<td>flexural-strength</td>
</tr>
</tbody>
</table>

Study the following types of concrete tests and their purposes.

- **Air test** — determines the amount of entrained air in fresh concrete

- **Beam molding or flexural-strength** — Procedure completed at job site to obtain a concrete sample to be used later in laboratory flexural-strength tests.

  ✓ **NOTE:** Flexural-strength tests determine the bending strength of concrete.

- **Cylinder molding for compression tests** — procedure completed at job site to obtain concrete sample to be cured and used later in laboratory compression tests to measure concrete strength gain

  ✓ **NOTE:** Compression tests measure concrete strength gain.

- **Impact test** — determines approximate strength of the concrete

- **Slump test** — procedure completed at job site to obtain a molded sample used as a rough measure of the consistency of fresh concrete

  ✓ **NOTE:** The slump test measures how wet or dry the fresh concrete is; it is NOT a measure of workability or proper water content.

- **Temperature test** — checks the temperature of fresh concrete
INTRODUCTION TO CONCRETE
Carpentry Series

Student name ______________________________ Score _________

Obtain representative fresh concrete test samples.

The following job sheet outlines the procedures for obtaining representative fresh concrete test samples. The following procedures apply to obtaining a samples from stationary mixers (except paving mixers), from revolving-drum truck mixers or agitators, and from open-top truck mixers, non-agitating equipment, or other types of open-top containers.

- Concrete
- Hand scoops
- Personal protection equipment

⚠️ CAUTION: Always wear rubber gloves, safety goggles, and protective clothing when working with fresh concrete.

- Plastering towels
- Sampling and mixing containers

✔️ NOTE: Use suitable containers, wheelbarrows, or flat, clean, nonabsorbent mixing boards.

- Shovels

Yes ☐ No ☐

1. At regularly spaced intervals during discharge of the middle portion of batch, take two more sample portions, using one of the following methods.

☐ ☐ A. Repeatedly pass sampling container through entire discharge stream, or

☐ ☐ B. Completely divert discharge stream into sampling container.
2. Collect suitable portions to produce composite sample.

3. Transport composite sample to test location.

4. Using a shovel, combine and remix composite sample just enough to ensure mix uniformity.

5. Begin testing.

---

**SKILL TEST RECORD**

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

- Proper use of safety equipment
  - 4
  - 3
  - 2
  - 1

- Samples taken from middle of mix
  - 4
  - 3
  - 2
  - 1

- Uniform remix of samples
  - 4
  - 3
  - 2
  - 1

Evaluator note: To obtain an average rating for the Profile of Training Mastery, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

**KEY**

- 4 **Skilled** — Can perform job with no additional training
- 3 **Moderately Skilled** — Has performed job during training program; limited additional training may be required
- 2 **Limited Skill** — Has performed job during training program; additional training is required to develop skill
- 1 **Unskilled** — Is familiar with process, but is unable to perform job
Perform a slump test.

- Chart for recording test results
- Clean, firm, level, nonabsorbent test surface (EXAMPLES: Smooth plank, concrete slab)
- Container of water
- Pencil
- Personal protection equipment

⚠️ CAUTION: Always wear rubber gloves, safety goggles, and protective clothing when working with fresh concrete.

- Scoop or trowel
- Standard slump cone (See Figure 1)

✔️ NOTE: Made of galvanized metal, the standard slump cone is 8" in diameter at the base, 4" in diameter at the top, and 12" high. The base and top are open, and the cone has foot pieces and handles.

FIGURE 1

- Steel tape
- Tamping rod

✔️ NOTE: The tamping rod for this test is a smooth, 5/8" by-24", bullet-nosed [hemispherical-tipped] steel rod.
1. Put on personal protection equipment.

2. Obtain representative concrete test sample. See Job Sheet 1.

3. Dampen slump cone and test surface with water.

4. Place slump cone base down on test surface and stand on cone’s foot pieces to hold cone firmly in place. See Figure 2.

5. Fill slump cone with concrete to 1/3 cone’s capacity (about 2 5/8”), distributing concrete spirally around inside perimeter of cone.

6. Insert tamping rod in cone, and rod concrete twenty-five times, using the following procedures:

   A. Use an up-and-down motion of the rod, rodding layer throughout its depth.

   B. Distribute rod strokes evenly by starting at perimeter of cone and moving in a spiral toward center of cone. See Figure 3.
7. Fill next 1/3 of slump cone (to about 6 1/8") with concrete, distributing concrete spirally around perimeter cone.

8. Rod concrete twenty-five times, using the following procedures. See Figure 4.

   A. Use an up-and-down motion, making rod just penetrate into underlying layer of concrete.

   B. Distribute rod strokes evenly by starting at perimeter of cone and moving in a spiral toward center of cone.


10. Rod concrete twenty-five times, following the procedures in Step 8 and also adding additional concrete as necessary to keep concrete above top of cone. See Figure 5.
11. Using a screening and rolling motion of tamping rod, strike off (level) excess concrete from top of slump cone. See Figure 6.

12. Clean excess concrete away from base of slump cone.

13. Raise slump cone from test sample with a steady, vertical (upward) lift.  

**CAUTION:** Do not move the cone laterally (sideways) or turn the cone in any way that would disturb the test sample.

14. Turn slump cone upside down and gently place it next to test sample.  

**CAUTION:** Do not disturb the test sample.

15. Place tamping rod across slump cone’s base so that rod extends over test sample. See Figure 7.
16. Using rule, measure (to nearest 1/4") the distance from bottom of tamping rod to displaced center of test sample. See Figure 8.

✓ NOTE: This measurement is called the slump of the concrete.

17. Record the slump measurement in inches.

18. Clean area and put away equipment and supplies.

SKILL TEST RECORD

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of “3” or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.
Criteria:

Proper use of safety equipment

Cone filled to proper level (2 5/8")

Proper rodding of concrete

Striking off concrete from cone top

Proper measuring of rod displacement (± 1/4")

Evaluator note: To obtain an average rating for the Profile of Training Mastery, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

**KEY**

4 Skilled — Can perform job with no additional training

3 Moderately Skilled — Has performed job during training program; limited additional training may be required

2 Limited Skill — Has performed job during training program; additional training is required to develop skill

1 Unskilled — Is familiar with process, but is unable to perform job

Evaluator’s Comments
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Carpentry Series

Cast a concrete cylinder for a compression test. (Commercial Only)

A cylinder cast is made to determine the compressive strength of concrete. After a predetermined curing time, the cylinder is subjected to compressive force until it fractures. This is done to ensure the rate of strength gain and the effectiveness of job-site curing.

At the job-site there should be four cylinders made that are representative of the entire batch being poured. These cylinders will be allowed to cure and then tested after one, three, seven, and twenty-eight days.

- Bullet-nosed steel rod (smooth), 5/8" by 24"
- Concrete
- Molds and tags furnished by instructor
- Personal protection equipment

⚠️ CAUTION: Always wear rubber gloves, safety goggles, and protective clothing when working with fresh concrete.

- Scoop or trowel
- Shovel
- Wheelbarrow

Yes No

1. Put on personal protection equipment.

2. Take concrete sample from three parts of load in wheelbarrow.

3. Remix concrete sample in wheelbarrow with shovel.
4. Place cylinder mold on firm, level surface. See Figure 9.

**FIGURE 9**

5. Fill one-third of cylinder mold with concrete. See Figure 10.

**FIGURE 10**

6. Rod with up and down motion twenty-five times using the steel rod.

**NOTE:** Always distribute rodding strokes evenly by starting at outer edge and moving in a spiral toward center.

7. Fill 2/3 of cylinder mold with concrete. See Figure 11.

**FIGURE 11**
8. Rod twenty-five times, barely penetrating into first layer.

9. Fill cylinder mold to overflowing with concrete. See Figure 12

**FIGURE 12**

10. Rod twenty-five times using the same precautions about depth and distribution of strokes.

11. Level top of mold with steel rod so that it is level full. See Figure 13

12. Tag cylinder.

A. Fill out information on tag.

B. Insert ends of wire into concrete along edge of mold.

13. Clean excess concrete from around cylinder mold. See Figure 13

**FIGURE 13**

14. Cover top of mold to prevent loss of moisture.
15. Clean up area and put away equipment and supplies.

16. Do not move mold for at least twenty-four hours.

**CAUTION:** Be careful during handling since it is necessary that molds do not suffer any damage.

**NOTE:** Cylinders should be cast in a protected area where temperatures will not exceed 80°F (27°C) or fall below 60°F (16°C). After twenty-four hours, cylinders should be stored under conditions that maintain 60-80°F (16-27°C) and tops should be covered to prevent loss of moisture. Specimens can also be sent to a laboratory for similar standard curing.

### SKILL TEST RECORD

**Evaluator note:** Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of “3” or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

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<thead>
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<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
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<tbody>
<tr>
<td>Proper use of safety equipment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Used samples from three parts</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Filled cylinder mold to proper level (½)</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Rodded proper number of times</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Covered top of mold to set</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

**Evaluator note:** To obtain an average rating for the Profile of Training Mastery, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.
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INTRODUCTION TO CONCRETE
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Student Name ________________________________

Start Date: _______  Completion Date: ________

1. Study  Information Sheet 3, objective 11.

2. Discuss  the different types of reinforcing used in concrete.

3. Study  Information Sheet 3, objective 12.

4. Discuss  the various sizes of reinforcing bar.

5. Study  Information Sheet 3, objective 13.

6. Discuss  reinforcing bar markings and the line and number systems.

7. Complete  Assignment Sheet 1.

8. Study  Information Sheet 3, objective 14.

9. Discuss  reinforcing bar shapes and their purposes.

10. Discuss  how the use of the supports is determined by the placement of the reinforcing bars and how the supports determine the amount of concrete coverage on the rebar.
11. Take Quiz 3.

12. Study Information Sheet 3, objective 15.

13. Discuss reinforcing bar supports.

14. Study Information Sheet 3, objective 16.

15. Discuss hardware and accessories used to install reinforcing bars.

16. Discuss reasons for making splices.

Optional Use vendor catalogs to show the various types and uses of rebar hardware and accessories.

17. Take Quiz 4.

18. Study Information Sheet 3, objective 17.

19. Discuss interpreting sizes of welded wire fabric.


21. Read the introduction to Job Sheet 4, objective 18.
22. Ask your instructor to demonstrate guidelines and procedures in the Job Sheet. Use the Job Sheet to follow along. Pay careful attention to any guidelines, cautions, and warnings.

23. Practice the procedure demonstrated by your instructor. Use the Job Sheet as a guide. Notify your instructor when you are ready to perform the procedures for evaluation.

24. Stop and have your instructor evaluate your work from the Job Sheet. After your work has been evaluated, follow your instructor’s recommendations.

25. Discuss with your instructor the safety issues involved in laying and tying welded wire fabric.
Identify types of reinforcing material used in concrete.

Reinforcing materials are used with concrete to increase the tensile strength of the finished concrete product.

- **Reinforcing bar or rebar** — steel bars that have a raised or rough surface that interlocks with the concrete; comes in many different sizes

  ✔ **NOTE:** The most commonly available strengths are grade 40 and grade 60.

- **Welded wire fabric or wire mesh** — heavy gage wires that have been welded in a grid; comes in many different sizes; usually used on flat concrete work such as floor slabs, pavements, and sidewalks
Fiber mesh — fiberglass or steel strands that are added to the concrete mix to reduce cracking

**Match common reinforcing bar numbers to their correct diameter sizes.**

Rebar comes in standard lengths. If it is necessary, the bars may be lapped and wired together. A lap should be a minimum length of thirty times the diameter of the rebar. Laps should be determined by the designer. Rebars are sized in increments of 1/8". The rebar # refers to the number of eights in diameter.

### TABLE 1

<table>
<thead>
<tr>
<th>Rebar Number</th>
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<tbody>
<tr>
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</tr>
<tr>
<td>4</td>
<td>1/2&quot;</td>
</tr>
<tr>
<td>5</td>
<td>5/8&quot;</td>
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<td>1 3/8&quot;</td>
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<tr>
<td>14</td>
<td>1 3/4&quot;</td>
</tr>
<tr>
<td>18</td>
<td>2 1/4&quot;</td>
</tr>
</tbody>
</table>
Interpret reinforcing bar size markings.

There are two methods used to mark the specifications of rebar: the line system and the number system.

**FIGURE 17**

**LINE SYSTEM**

- **Line system**

**FIGURE 18**

**NUMBER SYSTEM**

- **Number system**
1. The first mark down from the top is the letter or symbol of the producing mill.

2. The second mark down from the top is bar size number (diameter).

3. The third mark down from the top is the letters designating the type of steel.
   - N — billet
   - A — axle
   - I — rail

   **NOTE:** There is also an S for billet steel meeting supplementary requirements, an R for rail meeting bend test requirements, and a W for Low-Alloy steel.

4. The fourth mark down from the top:
   - Line system - Lengthwise lines designate grades of steel; no line - Grade 40 & 50; one line - Grade 60; two lines - Grade 75.
   - Number system - numbers show Grades 60 & 75; no numbers for 40 & 50.

   **NOTE:** Grades 60 & 75 bars must show grade marks, either by lines or by numbers; one line for 60,000 psi, two lines for 75,000 psi; the grade line marks are small and are between the two main ribs which are on opposite sides of all U.S. made bars.

   **NOTE:** Industry standard may label 60,000 psi as 60 ksi. 60 ksi = 60,000 psi.
Interpret reinforcing bar size markings.

The rebar installer must be able to verify identification markings on rebars to be sure the correct grades and sizes are being placed in the proper locations. There are some variations in bar identification markings. Some of the more common variations are:

- Some markings may be read horizontally
- Grade mark numbers may be placed within separate consecutive deformation spaces and may read vertically or horizontally

Grade mark lines must be continued at least five deformation spaces. If you cannot read the markings for some reason, you should check with your supervisor.

Interpret the rebar markings on the following illustrations using Objective 13 from the Information Sheet and the following list of companies. Use the line system for questions 1 and 3 and the number system for questions 3 and 4.

C  Continental Steel Company
I  Inland Steel Company
F  Florida Steel Company
◆ Diamond Steel Mill
B  Bethlehem Steel
P  Pittsburgh Steel Corporation
H  Holland Steel Company
L  Lynchburg Mills
A. **Line System**

**FIGURE 19**

![Diagram of a line system with labeled parts A to L.]

1. Write the answers in the blanks below that correspond with the letters in the illustration above.

   A. _____________________
   B. _____________________
   C. _____________________
   D. _____________________
   E. _____________________
   F. _____________________
   G. _____________________
   H. _____________________
   I. _____________________
   J. _____________________
   K. _____________________
   L. _____________________

**FIGURE 20**

![Diagram of another line system with labeled parts A to L.]

2. Write the answers in the blanks below that correspond with the letters in the illustration above.

   A. _____________________
   B. _____________________
   C. _____________________
   D. _____________________
   E. _____________________
   F. _____________________
A. **Number System**

**FIGURE 21**

3. Write the answers in the blanks below that correspond with the letters in the illustration above.

A. _____________________
B. _____________________
C. _____________________
D. _____________________
E. _____________________
F. _____________________
G. _____________________
H. _____________________
I. _____________________
J. _____________________
K. _____________________
L. _____________________
4. Write the answers in the blanks below that correspond with the letters in the illustration above.

A. _____________________
B. _____________________
C. _____________________
D. _____________________
E. _____________________
F. _____________________
G. _____________________
H. _____________________
I. _____________________
J. _____________________
K. _____________________
L. _____________________
Identify reinforcing bar shapes and their purposes.

Study the following reinforcing bar shapes and their purposes.

FIGURE 23

- **Shear or truss bars** — primarily used in rebar mats to reinforce concrete

**FIGURE 24**

- **Stirrups** — shaped to support other reinforcement such as rebar, beams, plates, or welded fabric

**FIGURE 25**

- **Column reinforcement** — shaped to support columns and can be bent/-shaped at the job site or preshaped/assembled and transported to the job site; most common shapes are square, round, and spiral
Identify reinforcing bar supports.

Study the following reinforcing bar supports.

FIGURE 26

- **Slab bolster (SB)** — used to support the top layer of rebar

FIGURE 27

- **Slab bolster upper (SBU)**

FIGURE 28

- **Slab bolster with plates (SBP)**

FIGURE 29

- **Slab spacer (SS)**

FIGURE 30

- **Beam bolster (BB)**
• Beam bolster upper (BBU)

FIGURE 32

• Individual bar chair (BC)

FIGURE 33

• Joist chair (JC)

FIGURE 34

• Individual high chair (HC)

FIGURE 35

• High chairs for metal deck (HCM)

FIGURE 36

• Continuous high chair (CHC)
- **Continuous high chair upper (CHCU)**

- **Continuous high chair for metal deck (CHCM)**

- **Upper joist chair (UJC)**

- **Supports with plastic caps** — Many types and sizes of supports are equipped with plastic caps to prevent rusting when exposed to the elements.

  ✔ NOTE: The special supports below are just a few of the methods used to support the upper mast of a thick concrete slab with two layers of rebars; in some cases such as the dowel block, the special support will support both mats.

- **High chair with plates (HCP)**
Identify hardware and accessories used to install reinforcing bars.

Study the following hardware and accessories used to install reinforcing bars.

A. Wire ties

NOTE: 16 gauge, black annealed wire or wire pigtail are used to make the ties below. Each tie end should be twisted 3 to 4 twists.

- Single tie (snaptie)
- Wall tie (wrap and snaptie)
• Saddle tie

• Saddle tie with twist (wrap and saddle tie)

• Double strong single tie

• Cross tie (figure eight tie)
FIGURE 49

- **Tie wire**

FIGURE 50

- **Wire tie (pigtail)**

B. **Plastic rebar fasteners/clips**

FIGURE 51

- **Plastic rebar fasteners/clips**

C. **Rebar Splicing**

FIGURE 52

- **Wire tie lap splice**
• **G-loc butt splice**

**FIGURE 53**

• **Steel coupler type splice**

**FIGURE 54**

• **Dowel bar splicer**

**FIGURE 55**

• **Speed sleeve butt splice**

**FIGURE 56**
D. Miscellaneous

FIGURE 57

- Rebar caps

✔ NOTE: Rebar caps must be placed over any protruding rebar ends to protect personnel (OSHA requirement) from injuries.

FIGURE 58

- Welding

Interpret the sizes of welded wire fabric.

Welded wire fabric comes in rolls and sheets and is usually used in flat concrete work such as floor slabs, pavements, and sidewalks. Welded wire fabric comes in a variety of sizes such as the following example.

EXAMPLE: 6 x 6 — W1.4 x W1.4

The first two numbers indicate the spacing of the steel. 6 x 6 means the steel is spaced 6” apart both ways. The second two numbers indicate the gauge of the steel fabric.
W 1.4 = 10 gauge
W 2.0 = 8 gauge
W 2.9 = 6 gauge
W 4.0 = 4 gauge
W 5.5 = 2 gauge.

Study the following common sizes of welded wire fabric.

**A. Rolls** — Rolls of welded wire fabric are manufactured 5' wide by 150' long which is 750 square feet.

**FIGURE 59**

1. 6 x 6 – W 1.4 x W 1.4
2. 6 x 6 – W 2.0 x W 2.0
3. 6 x 6 – W 2.9 x W 2.9
4. 6 x 6 – W 4.0 x W 4.0
5. 4 x 4 – W 1.4 x W 1.4
6. 4 x 4 – W 2.0 x W 2.0
7. 4 x 4 – W 2.9 x W 2.9
8. 4 x 4 – W 4.0 x W 4.0

**B. Sheets (mats)** — Sheets of welded wire fabric are manufactured 8' wide by 20' long which is 160 square feet.

1. 6 x 6 – W 2.9 x W 2.9
2. 6 x 6 – W 4.0 x W 4.0
3. 6 x 6 – W 5.5 x W 5.5
4. 4 x 4 – W 4.0 x W 4.0
5. 4 x 4 – W 5.5 x W 5.5
Interpret the sizes of welded wire fabric.

Given the spacing and gauge of the steel, write the size of welded wire fabric in the correct format.

1. Spacing = 4"
   Gauge = 6
   ____________________

2. Spacing = 6"
   Gauge = 2
   ____________________

3. Spacing = 6"
   Gauge = 6
   ____________________

4. Spacing = 6"
   Gauge = 10
   ____________________

5. Spacing = 4"
   Gauge = 2
   ____________________

6. Spacing = 4"
   Gauge = 10
   ____________________

7. Spacing = 4"
   Gauge = 4
   ____________________

8. Spacing = 6"
   Gauge = 8
   ____________________

9. Spacing = 6"
   Gauge = 4
   ____________________

10. Spacing = 4"
    Gauge = 8
     ____________________
INTRODUCTION TO CONCRETE
Carpentry Series

Student name _________________________ Score _________

1 roll – 6 x 6 - W1.4 x W1.4 welded wire fabric
• Bolt cutters
• Personal protection equipment
• Side cutters
• Steel tape
• Wire reel and tie wire

Yes  No
1. Put on personal protection equipment.

2. Roll out wire fabric to length desired and cut

✓ NOTE: To help the fabric lay flatter, turn it upside down.

CAUTION: To avoid injury be sure to stand on both edges of fabric as you cut the fabric.

3. Be sure the wire fabric is 3” from form.

4. Turn roll and set next to the first strip of wire fabric.

5. Roll out second strip of wire fabric, lapping at least 6”; cut off and turn upside down.

6. Tie edges of wire that are lapped, using simple tie. See Figure 60.

✓ NOTE: Place ties every 30” to 36”.
7. Put away equipment and supplies.

**SKILL TEST RECORD**

**Evaluator note:** Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of “3” or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.
Criteria:

<table>
<thead>
<tr>
<th>Description</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wire fabric turned upside down</td>
<td>4 3 2 1</td>
</tr>
<tr>
<td>Second strip overlapped 6&quot; (± 6&quot;)</td>
<td>4 3 2 1</td>
</tr>
<tr>
<td>Ties at 30&quot; to 36&quot; intervals (± 1&quot;)</td>
<td>4 3 2 1</td>
</tr>
<tr>
<td>Wire fabric 3&quot; from form (± ¼&quot;)</td>
<td>4 3 2 1</td>
</tr>
</tbody>
</table>

**Evaluator note:** To obtain an average rating for the Profile of Training Mastery, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

4 **Skilled** — Can perform job with no additional training  
3 **Moderately Skilled** — Has performed job during training program; limited additional training may be required  
2 **Limited Skill** — Has performed job during training program; additional training is required to develop skill  
1 **Unskilled** — Is familiar with process, but is unable to perform job
Follow the link below to learn about the history of cement and to answer the following questions.

Instructions:

- Go to http://www.portcement.org
- Click on “Concrete Basics” in the menu on the left side of the page.
- Click on “Working Safely” at the top of the page.
- Read the “Working Safely with Concrete” section and answer the following questions.

1. What can be used to restrict public access to a job site?

2. When working with fresh concrete, care should be taken to avoid what two things?

3. What is the meaning of hygroscopic? _________________________

4. Why should you not wear clothing that has become saturated with moisture from fresh concrete?

5. What four clothing items should be worn to protect your skin from concrete?
6. What two pieces of safety equipment should be worn to protect your head and face?

7. Concrete materials can be very heavy. What steps can be taken to protect your back when lifting heavy materials?

8. What should be used between fresh concrete surfaces and knees, elbows, hands, etc., to protect the body during finishing operations?

9. What should you do if concrete come in contact with your eyes?

10. What is the best way to avoid skin irritation?
Virtual Cement Plant Tour

Follow the link below to learn about a cement plant and to answer the following questions.

Instructions:

- Go to http://www.portcement.org
- Click on “Virtual Plant Tour: Tour a Cement Plant Online” in the menu in the middle of the page.
- Follow the links to take a virtual tour of a cement plant and to answer the following questions.

1. What are the four basic elements of concrete?

2. What three raw materials are taken from the quarry?

3. What happened during proportioning and blending?

4. What is the purpose of the preheater tower?

5. What is the kiln?

6. What temperature does the flame reach in the kiln?

7. What temperature does the flame reach in the kiln?
8. What new substance is created by the physical and chemical changes caused by the intense heat in the kiln?

9. What is the purpose of the ball mill?

10. What substance is added to the clinker during final grinding to control the set?