Chapter 7

Concrete Plant Supervisor and Operations

Topics

1.0.0 Concrete Batch Plant Supervisor Responsibilities

2.0.0 Portland Cement

3.0.0 Materials Handling and Management

4.0.0 Computing Concrete Volume

5.0.0 Types of Concrete Plants, Operations, and Safety

6.0.0 Quality Control

To hear audio, click on the box.

Overview

Most concrete production operations are conducted by an experienced Builder (BU). However, EOs must understand the basic principles of concrete production, mixing procedures, and maintenance processes to produce quality concrete. This chapter addresses the responsibilities of the Concrete Plant Supervisor, along with the materials and equipment associated with concrete plants.

Concrete is a mixture of aggregate held together by a hardened paste made from cement and water. Although there are other kinds of cement, the word “cement” in common usage refers to Portland cement. A chemical reaction between the Portland cement and water--not the evaporation of water--causes concrete to harden. This reaction is called hydration. Concrete will actually harden underwater due to hydration.

The Naval Construction Force (NCF) has equipment that is used to provide concrete for construction purposes. This equipment ranges from a barrel mixer and a transit mixer to a mobile concrete mixer plant (Crete mobile) and a concrete batch plant.

Objectives

When you have completed this chapter, you will be able to do the following:

1. Understand the responsibilities of the Concrete Plant Supervisor.
2. Identify types and storage of cement.
3. Understand the use, handling, and management of cement materials.
4. Understand how to compute concrete volume.
5. Understand types of concrete plants, operations and safety.
6. Understand cement quality control.

Prerequisites

None

This course map shows all of the chapters in Equipment Operator (EO) Advanced. The suggested training order begins at the bottom and proceeds up. Skill levels increase as you advance on the course map.

Well Drilling Supervisor and Operations	↑	E O
Asphalt Plant Supervisor and Operations		
Concrete Batch Plant Supervisor and Operations		A D V A N C E D
Crusher Supervisor and Operations		
Quarry Supervisor and Operations		
Project Supervisor		
Crane Crew Supervisor		
Air Detachment Equipment Supervisor		
Transportation Supervisor		

Features of this Manual

This manual has several features which make it easy to use online.

- Figure and table numbers in the text are italicized. The figure or table is either next to or below the text that refers to it.
- The first time a glossary term appears in the text, it is bold and italicized. When your cursor crosses over that word or phrase, a popup box displays with the appropriate definition.
- Audio and video clips are included in the text, with italicized instructions telling you where to click to activate it.
- Review questions that apply to a section are listed under the Test Your Knowledge banner at the end of the section. Select the answer you choose. If the answer is correct, you will be taken to the next section heading. If the answer is incorrect, you will be taken to the area in the chapter where the information is for review. When you have completed your review, select anywhere in that area to return to the review question. Try to answer the question again.
- Review questions are included at the end of this chapter. Select the answer you choose. If the answer is correct, you will be taken to the next question. If the answer is incorrect, you will be taken to the area in the chapter where the information is for review. When you have completed your review, select anywhere in that area to return to the review question. Try to answer the question again.

1.0.0 CONCRETE BATCH PLANT SUPERVISOR RESPONSIBILITIES

When assigned as the supervisor of a concrete batch plant in the NCF, you will supervise the production and transport of concrete products used to construct sidewalks, roads, footers, foundations, walls, roofs, runways, rapid runway repairs, and so forth. You should be aware of the processes involved in the entire concrete making process from aggregate production to equipment maintenance, including all necessary safety precautions.

1.1.0 Resources/Instructions

NCF Equipment Management Instruction, COMFIRSTNCDINST 11200.2 establishes policy, assign action and provide guidance for the Naval Construction Force Equipment Management Program.

MOBILCRETE Model H-10DT, Operation, Maintenance and Parts Manual provides step-by-step operation and maintenance procedures for the H-10DT mobile batch plant.

National Concrete Pavement Technology Center, Concrete Paving Training and Field Reference gives an insight into concrete mixtures and operations.

Field Manual No.5-428, Concrete and Masonry, Headquarters, Department of the Army contains an in-depth discussion of every aspect of concrete processes.

Unified Facilities Criteria 3-320-06A, Concrete Floor Slabs on Grade Subjected to Heavy Loads, Department of Defense discusses admixtures and applications for concrete.

Portland Cement Association, Cement and Concrete Basics has a comprehensive website that provides training and specific details for the production of multiple types of concrete.

American Society for Testing and Materials, ASTM C150 Standard Specification for Portland cement is the industry-accepted standard for Portland cement.

American Concrete Institute, Aggregates for Concrete, ACI Education Bulletin E1-07 provides introductory training for concrete quality control personnel.

2.0.0 PORTLAND CEMENT

Portland cement is a type of hydraulic cement. Hydraulic cement is any cement that hardens after being combined with water. Portland cement is usually made of materials such as limestone or marl and shale or clay. The raw materials are crushed, pulverized, and mixed in proper proportions for the correct chemical composition. Then the raw material is fed into a rotary kiln and is calcined (burned) at a temperature of approximately 2700°F. This process transforms the material into clinker. The clinker is cooled and pulverized so fine that nearly all of the powder can pass through a No. 200 mesh sieve (*Figure 7-1*).

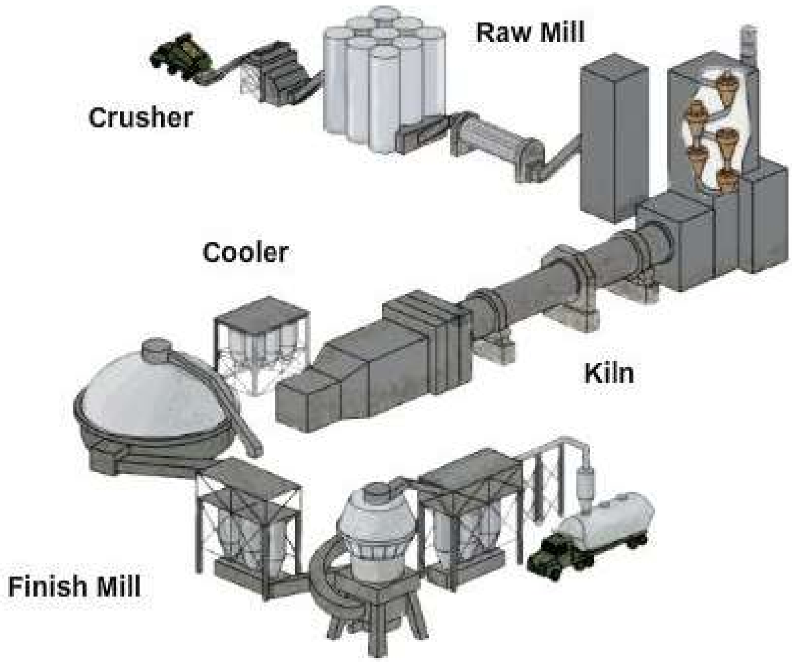

Figure 7-1—Cement making process.

2.1.0 Types

When powdered Portland cement (*Figure 7-2*) and water are combined, hydration occurs. The amount of water per unit weight of cement is called the water-cement ratio, normally given in terms of pounds of water per pounds of cement. Concrete with a low water-cement ratio gains more ***strength*** than cement with a higher water-cement ratio.

Figure 7-2—Powdered Portland cement.

2.1.1 Type I (Normal Portland Cement)

Type I (normal Portland cement) is the most widely used cement for pavements, sidewalks, buildings, bridges, masonry units, and soil-cement mixtures. In general, it is used when the concrete will not be subjected to special sulfate hazards or where the heat generated by the hydration of the cement does not cause an objectionable rise in temperature. It is very ***durable*** cement.

2.1.2 Type II (Modified Portland Cement)

Type II (modified Portland cement) has a lower heat of hydration than Type I. This lower heat gives this cement an improved resistance to sulfate attack. Type II cement is used in large structures where cement of moderate heat of hydration tends to minimize a rise in temperature. Examples are as follows: large piers, heavy abutments, and heavy retaining walls. Type II is also used when the concrete is placed in warm weather and in drainage structures where the sulfate concentrations are higher than normal.

2.1.3 Type III (High-Early Strength Portland Cement)

Type III (high-early-strength Portland cement) is used when superior strength is required in a short time. It is used in cold-weather construction to reduce the period of protection against low temperatures. Type III is also used when forms have to be removed immediately to allow the concrete to be put in service as quickly as possible. Type III cement requires less protection time from freezing and attains normal 3-day strength in 1 day. The volume of heat during hydration is also accelerated. Normally, this cement is not used in large-scale construction operations because it is very expensive.

2.1.4 Type IV (Special Cement)

Type IV – Type IV cement is a special cement. It has a low heat of hydration and is intended for applications requiring a minimal rate and amount of heat of hydration. Its strength also develops at a slower rate than the other types. Type IV is used primarily in very large concrete structures, such as gravity dams, where the temperature rise from the heat of hydration might damage the structure. Type IV cement reaches its design strength in about 90 days.

2.1.5 Type V (Sulfate Resistant)

Type V – Type V cement is essential in the construction of canal linings, culverts, and siphons because of their contact with ground waters containing sulfates. This is required because sulfates cause serious deterioration and swelling to the other types of Portland cement. The serious deterioration will eventually cause the concrete to fail. Type V Portland cement is rarely used in everyday construction, but is routinely used in harsh marine environments. Type V cement reaches its design strength in about 60 days.

2.2.0 Storage

Portland cement is a moisture-sensitive material that must be protected from damp air or moisture. Cement that was not protected in storage sets more slowly because hydration has already begun; therefore, it has less strength than Portland cement that is kept dry.

Most types of Portland cement are shipped in bulk by rail, truck, or barge. Pneumatic loading and unloading of the transport vehicles is the usual method of handling bulk cement. Bulk cement is measured in tons (2,000 lbs.), and smaller quantities are bagged in cloth or paper sacks, each containing 94 pounds of cement. A 94-pound sack of cement is equal to 1 cubic foot by loose volume.

Cement bags should not be stored on damp floors, but should rest on pallets. The bags should be stacked against each other to prevent circulation of air between them, but not stacked against outside walls. If the stacks of cement are to be stored undisturbed for long periods, they should be covered with tarpaulins (*Figure 7-3*).

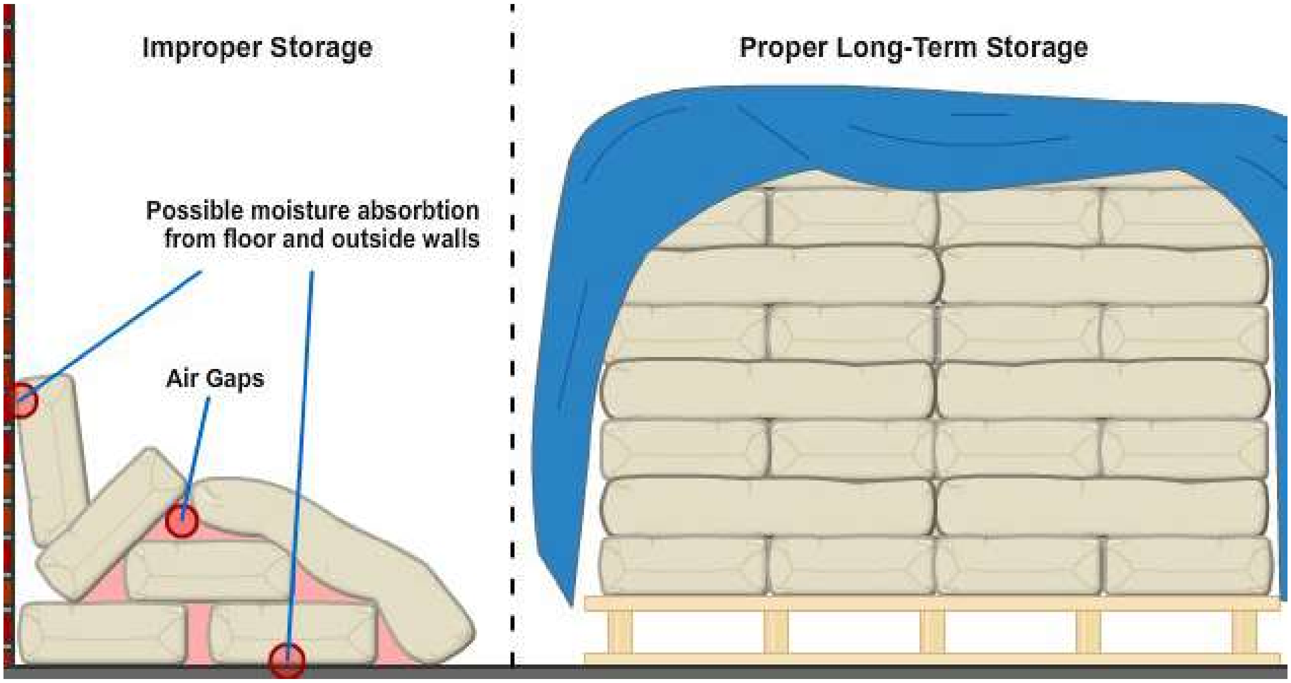

Figure 7-3 — Storage of cement.

Cement bags that have been stacked in storage for long periods sometimes acquire a hardness called "warehouse pack." This can usually be loosened by rolling the sack around. Cement that has lumps or is not free-flowing should not be used.

Test your Knowledge (Select the Correct Response)

1. What chemical reaction occurs when water and cement are combined?

   A. Emulsification
   B. Hydration
   C. Solidification
   D. Hydraulic fusion

3.0.0 MATERIALS HANDLING and MANAGEMENT

Aggregates containing particles of different sizes have a natural tendency to segregate whenever loaded, transported, or otherwise disturbed. Aggregates strongly influence concrete's freshly mixed and hardened properties, mixture proportions, and economy. Aggregates should always be handled and stored by a method that minimizes segregation.

3.1.0 Aggregates

The aggregates used in concrete must be strong, durable, and chemically inert and generally occupy 60 to 75 percent of the concrete mix in volume (70 to 85 percent by weight). Natural aggregate deposits are excavated from pits, rivers, lakes, or sea beds. These natural deposits consist of gravel and sand that can be readily used in concrete after minimal processing. Recycled concrete is a viable source of aggregate and has been satisfactorily used in granular subbases, soil-cement, and new concrete. Crushed aggregates are produced by crushing quarry rock, boulders, cobbles, or large-sized gravel. Crushed aggregates are usually washed and graded before being used in concrete. The most commonly used aggregates are sand and gravel which, when combined with cement, produce a strong, durable mass that is practically without voids (*Figure 7-4*).

The coarse aggregates used in a mix usually consist of gravel or crushed stone up to 1 1/2 inches in size. Coarse aggregates are primarily used as filler. These aggregates can pass through a 3-inch sieve and are retained on a No. 4 sieve. In massive structures like dams, the coarse aggregates may include natural stones or rocks ranging up to 6 inches or more in size.

Figure 7-4—Aggregate separation.

Fine aggregates are those materials that can pass through a No. 4 sieve but are retained on a No. 100 sieve. The fine aggregates and sand in concrete are used to fill the voids between the large aggregates. Care should be taken to prevent dirt and other debris from getting mixed into the sand. The foreign material affects the bonding quality of the sand.

The gradation of the aggregate is a major factor in the workability, water requirements, and strength of concrete. Fine and coarse aggregates are usually sieved separately--the fine aggregates on sieves with openings 1/4 inch or smaller and the coarse aggregate on sieves with square openings from about 1/4 inch and larger. The fine sieves are numbered—the larger the number, the smaller the sieve opening; for instance, the No. 100 sieve has 100 openings per inch, and the No. 4 sieve has 4 openings per inch.

The grading of both coarse and fine aggregate and the relative proportions of each in the mix can greatly affect the properties of the fresh concrete (*Figure 7-5*). Concrete made with coarse sand or not enough sand is hard to pump and will be harsh and difficult to trowel. Also, aggregates can segregate or separate from the cement paste during placement, producing non-uniform concrete. Air-entraining will help in overcoming grading problems of this kind. Coarse aggregates should be round or subround in shape. This shape allows the cement paste to coat the particles more easily during mixing.

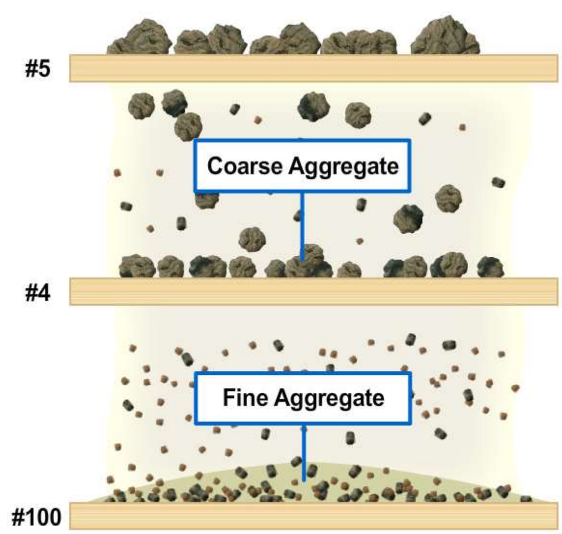

Figure 7-5—Grading aggregates.

Harmful substances that may be present in aggregates include organic impurities, silt, clay, lignite, and certain lightweight and soft particles. These may occur naturally in the aggregate, or may be introduced when the aggregates are transported in gondola cars, barges, or trucks previously used to haul those contaminating substances. Aggregates can be contaminated by oil during handling.

Organic impurities such as peat, humus, organic loam, and sugar delay setting and hardening of concrete, and sometimes lead to deterioration.

Silt, clay, or other materials passing the No. 200 sieve may be present as dust or may form a coating on aggregate particles. Excessive amounts of this material may unduly increase the water required to produce a given slump for the concrete, or, if the amount of fine material varies from batch to batch, may cause undesirable fluctuations in the slump, air content, and strength. Thin coatings of dust on the coarse particles may weaken the bond between cement paste and coarse aggregate.

Coal, lignite, lightweight cherts, and other lightweight or soft materials such as wood may affect the durability of concrete if present in excessive amounts. If these impurities occur at or near the concrete surface, they may result in popouts or staining.

3.2.0 Water

The primary function of water used in a concrete mix is to start the hardening process of the concrete through hydration of the cement. A secondary function is to make the mix workable enough to satisfy the requirements of the job. However, too much water will cause a loss of strength by upsetting the water-cement ratio. It will also cause “water gain” on the surface, a condition which leaves a surface layer of weak material called ***laitance***. Also, an excessive amount of water will impair the water tightness of the concrete.

Water used in mixing concrete must be clean and free from oils, alkalis, acids, and organic materials. Most specifications recommend that the mixing water be fit for drinking. Excessive impurities in mixing water not only may affect setting time and concrete strength, but also may cause ***efflorescence***, staining, corrosion of reinforcement, volume instability, and reduced durability. Specifications usually set limits on chlorides, sulfates, alkalis, and solids in mixing water unless tests can be performed to determine the effect the impurity has on various properties. Seawater may be used for unreinforced concrete.

3.3.0 Additives Used in Concrete

Admixtures (*Figure 7-6*) are classed by what they do. There are five separate classes of chemical admixtures: air-entraining, water-reducing, retarding, accelerating, and plasticizers (superplasticizers). All other varieties of admixtures fall into the specialty category whose functions include corrosion inhibition, shrinkage reduction, alkali-silica reactivity reduction, workability enhancement, bonding, damp proofing, and coloring. Additives are not recommended if the end result can be reached more economically by altering the mix proportions.

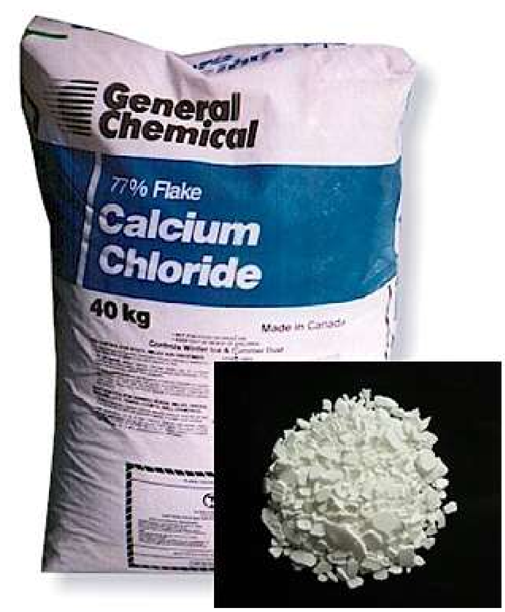

Figure 7-6—Additives.

3.3.1 Air-Entraining

Air-entraining agents entrain small air bubbles in the concrete. The major benefit of air-entraining is enhanced durability in freeze-thaw cycles, especially relevant in cold climates. While some strength loss typically accompanies increased air in concrete, it generally can be overcome by reducing the water-cement ratio via improved workability (due to the air-entraining agent itself) or through the use of other appropriate admixtures. Air-entrained concrete has been used in pavements in the northern United States for about 25 years with excellent results. Air-entrained concrete also reduces both the amount of water loss and the capillary/water channel structure.

An air-entrained admixture may also be added to Types I, II, and III Portland cement. The manufacturer specifies the percentage of air entrainment that can be expected in the concrete. An advantage of using air-entrained cement is that it can be used and batched like normal cement. The air-entrained admixture comes in a liquid form or mixed in the cement. To obtain the proper mix, add the admixture at the batch plant. More information on admixtures is included later in this chapter.

3.3.2 Water-Reducing

Water-reducing admixtures usually reduce the required water content for a concrete mixture by about 5 to 10 percent. Consequently, concrete containing a water-reducing admixture needs less water to reach a required slump than untreated concrete. The treated concrete can have a lower water-cement ratio. This usually indicates that a higher strength concrete can be produced without increasing the amount of cement. Recent advancements in admixture technology have led to the development of mid-range water reducers. These admixtures reduce water content by at least 8 percent and tend to be more stable over a wider range of temperatures. Mid-range water reducers provide more consistent setting times than standard water reducers.

3.3.3 Retarders

Retarders are used to slow down the rate of setting of a concrete. High temperatures of fresh concrete (85°F - 90°F and higher) are often the cause of an increased rate of hardening that makes placing and finishing difficult. One practical way to reduce the temperature of the concrete is by cooling the mixing water or the aggregates. Retarders do not decrease the initial temperature of the concrete. Retarders are sometimes used to offset the accelerating effect of hot weather on the setting of concrete, delay the initial set of concrete when difficult or unusual conditions of placement occur, such as placing concrete in large piers and foundations, or delay the set for a special finishing process, such as an exposed aggregate surface.

Some of the materials used to retard the set of a concrete mixture are lignin, borax, sugar, tartaric acid, and salt. These materials should be added to the mixing water.

⚠ CAUTION ⚠

If 20 percent by volume of retarding agent is added to the mix, the effect is reversed and it then acts as an accelerator.

3.3.4 Accelerators

Accelerators are used to accelerate the strength development of concrete at an early age. Calcium chloride is the material most commonly used in accelerating admixtures; however, in addition to accelerating strength gain, calcium chloride causes an increase in drying shrinkage, potential reinforcement corrosion, discoloration, and scaling potential. Calcium chloride should be added to the concrete mix in solution form as part of the mixing water. If added to the concrete in dry form, all of the dry particles may not be completely dissolved during mixing. Undissolved calcium chloride in the mix can cause pop-outs of dark spots in the hardened concrete (*Figure 7-7*). The amount of accelerator used should not exceed 2 percent by weight of cement.

3.3.5 Superplasticizers

Superplasticizers, also known as plasticizers or high-range water reducers (HRWR), reduce water content by 12 to 30 percent and can be added to concrete with a low-to-normal slump and water-cement ratio to make high-slump flowing concrete. Flowing concrete is a highly fluid but workable concrete that can be placed with little or no vibration or compaction. The effect of superplasticizers lasts only 30 to 60 minutes, depending on the brand and dosage rate, and is followed by a rapid loss in workability. As a result of the slump loss, superplasticizers are usually added to concrete at the jobsite.

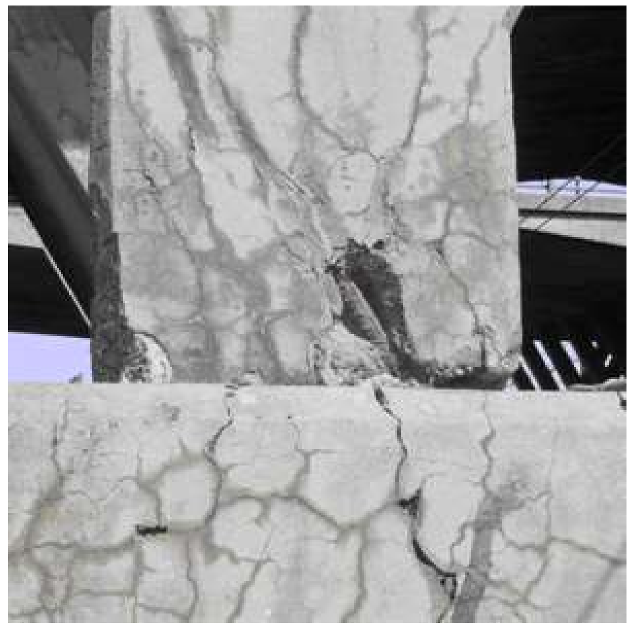

Figure 7-7— Result of too much accelerator.

3.3.6 Corrosion-Inhibitors

Corrosion-inhibiting admixtures fall into the specialty admixture category and are used to slow corrosion of reinforcing steel in concrete. Corrosion inhibitors can be used as a defensive strategy for concrete structures such as marine facilities, highway bridges, and parking garages that will be exposed to high concentrations of chloride. Other specialty admixtures include shrinkage-reducing admixtures and alkali-silica reactivity inhibitors. The shrinkage reducers are used to control drying shrinkage and minimize cracking, while ASR inhibitors control durability problems associated with alkali-silica reactivity.

3.3.7 Handling and Storage

Aggregates containing particles of different sizes have a natural tendency to segregate whenever loaded, transported, or otherwise disturbed. Aggregates should always be handled and stored by a method that minimizes segregation.

Stockpiles should not be built up in cone shapes or formed by dropping successive loads at the same spot (*Figure 7-8*). This process causes larger aggregate particles to segregate and roll down the sides, leaving the pile with a large amount of fine aggregate at the top and a large amount of coarse aggregate at the bottom. A stockpile should be built up in layers, each made by dumping successive loads alongside each other.

Figure 7-8 — Aggregate segregation.

If aggregate is dropped in a free fall from a clamshell, loader, or a conveyor, some of the fine material may be blown aside, causing segregation of fines on the lee side of the pile. Clamshells, loaders, and conveyors should be discharged in contact with the pile.

The bottom of an overhead charging bin should always slope at least 50 degrees towards the center outlet. If the slope is less than 50 degrees, segregation will occur as the material is discharged. When a bin is being charged, the material should be dropped from a point directly over the outlet. Material dropped in at an angle or discharged against the sides of the bin will segregate. Since a long drop causes both segregation and the breakage of aggregate particles, the length of a drop into a bin should be kept to a minimum by keeping the bin as full as possible at all times.

Test your Knowledge (Select the Correct Response)

2. What process must be minimized when stockpiling aggregates?

   A. Segregation
   B. Separation
   C. Solidification
   D. Disintegration

4.0.0 COMPUTING CONCRETE VOLUME

To compute the volume of concrete required for a concrete pad, multiply the length of the pad by its width times its depth to get cubic feet (L x W x D). For example, a concrete pad is 20 feet in length by 30 feet in width and has a depth of 3 inches. First, convert the 3 inches into feet by dividing 3 by 12 to get 0.25 foot. Next, multiply the 20-foot length by the 30-foot width to get 600. Finally, multiply the 600 by 0.25 to determine the volume of concrete required for the pad which, in this case, is 150 cubic feet (*Figure 7-9*).

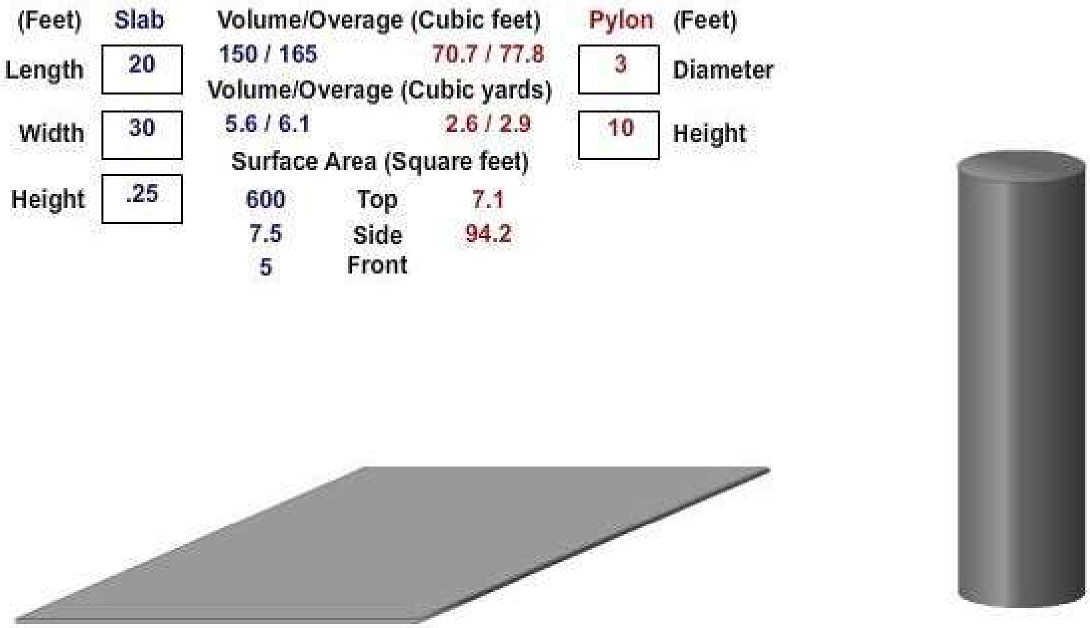

Figure 7-9 — Computing concrete volume.

Concrete is ordered and produced in quantities of cubic yards. To calculate the number of cubic yards required for the pad, divide the cubic feet of the pad by 27. This is required because there are 27 cubic feet in 1 cubic yard. Therefore, the concrete pad described in the previous paragraph, which has a volume of 150 cubic feet, requires 5.56 cubic yards of concrete: 150 cubic feet divided by 27 = 5.56 cubic yards.

Concrete projects often present varying degrees of difficulty; therefore, extra concrete is required to compensate for these difficulties. Once the total number of cubic yards of concrete is computed, add a little extra, normally 10 percent, to compensate for waste. To calculate the excess needed, multiply the cubic yards by .10 (10 percent). In the above case, multiply 5.56 cubic yards by .10 to get 0.556 cubic yards. Add the 0.556 cubic yards to the 5.56 cubic yards for a total of 6.116 or 6.12 cubic yards required for the concrete pad.

5.0.0 TYPES OF CONCRETE PLANTS, OPERATIONS AND SAFETY

5.1.0 Concrete Batch Plant

On large jobs, the aggregate is weighed out in an aggregate batching plant, usually shortened to batch plant. Batching is the process of weighing or volumetrically measuring and introducing into a mixer the ingredients for a batch of concrete. To produce a uniform quality concrete mix, measure the ingredients accurately for each batch. Most concrete specifications require that the batching be performed by weight, rather than by volume, because of inaccuracies in measuring aggregate, especially damp aggregate.

Whenever possible, a batch plant is located near and used in conjunction with a crushing and screening plant. A crushing and screening plant crushes stone into various particle sizes, and then screens it into separate piles (*Figure 7-10*). In a screening plant, the aggregate in its natural state is screened by size into separate piles.

Figure 7-10—Crusher plant.

The batch plant, which is usually portable and can be taken apart and moved from site to site, is generally set up adjacent to the pile of screened aggregate. The plant may include separate hoppers for several sizes of fine and coarse aggregates, or only one hopper for fine aggregate and another for coarse aggregate. It may have one or more divided hoppers, each containing two or more separate compartments for different sizes of aggregates.

Each storage hopper or storage hopper compartment can be discharged into a weigh box, which can, in turn, be discharged into a mixer or a batch truck. When a specific weight of aggregate is called for, the operator sets the weight on a beam scale. The operator then opens the discharge chute on the storage hopper. When the desired weight is reached in the weigh box, the scale beam rises and the operator closes the storage hopper discharge chute then opens the weigh box discharge chute, and the aggregate discharges into the mixer or batch truck. Batch plant aggregate storage hoppers are usually loaded by clamshell-equipped cranes.

5.2.0 Mobile Concrete Mixer Plant

The trailer-mounted mobile concrete mixer plant carries cement, sand, and coarse aggregates in divided bins mounted on the unit. The cement is carried in a separate bin located across the rear of the unit, and the sand and aggregate are carried on each side of the unit. Water is carried in a single tank mounted in front of the aggregate bins and is pumped to the mix auger. Sand and aggregates are accurately proportioned by weight or volume and simultaneously dropped with a mixture of cement from the material feed system into the charging end of the mix auger/conveyor at the rear of the unit (*Figure 7-11*). At this point, a predetermined amount of water enters the mix auger. The action of this combined auger and paddle homogenizer mixes the ingredients and water rapidly, thoroughly, and continuously to produce a continuous flow of uniform quality concrete. The material mixing action is a continuous process that can proceed until the aggregate bins are empty. On the other hand, mixing and delivery may be stopped at any time and then started again at the will of the operator. This permits production to be balanced to the demands of the placing and finishing crews and other job requirements.

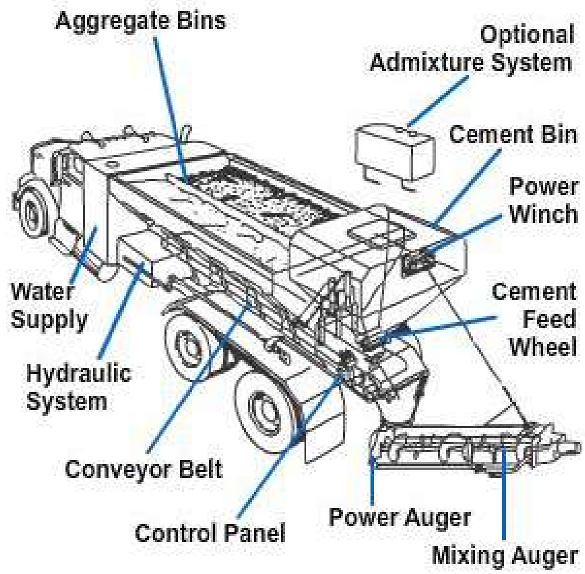

Figure 7-11—Mobile concrete mixer plant.

Operators assigned to the "crete mobile" must thoroughly read and understand the technical manual before operating the plant.

5.3.0 Transit Mixer

"Transit mixing" refers to concrete that is mixed, either wet or dry, en route to a job site. A transit mix truck carries a mixer and a water tank from which the driver can, at the proper time, introduce the required amount of water into the mix. The truck picks up the dry ingredients at the batch plant together with a slip which tells how much water to introduce to the mix upon arrival at the site. The mixer drum is kept revolving en route and at the job site so that the dry ingredients do not segregate. Transit mix trucks are part of the battalion's equipment inventory and are widely used on all but the smallest concrete jobs assigned to a battalion (*Figure 7-12*).

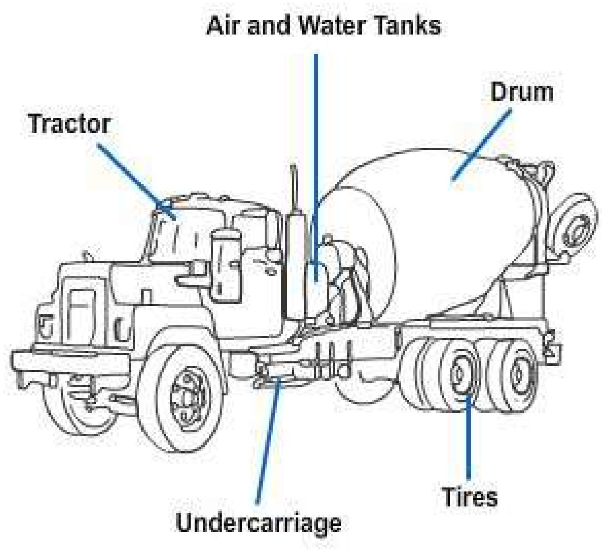

Figure 7-12—Transit mixer.

The use of transit mixers on construction projects impose traffic problems that must be considered. Caution must be used during the backing of the transit mixer. Backing should be controlled by a signalman, positioned so the operator can clearly observe the directions given. Extreme caution must be used when traveling on a construction site. The stability of the mixer is greatly reduced with the extra weight of the concrete. Also, the weight of the mixer can crush newly placed underground utilities, sink in the mud, crack sidewalks, and so forth. In such cases, a slow speed is recommended.

5.4.0 Small Portable Concrete Mixer

Portable concrete mixers are used when small amounts of concrete are needed. They are capable of mixing up to nine cubic feet of concrete. Portable concrete mixers usually come with two or four wheels and a towing tongue so you can tow them from site to site. They are light enough to move around a jobsite by hand (*Figure 7-13*).

The rotation drum is either electric or combustion-motor powered. A lever or wheel on the cement mixer will let you tip the unit and pour the concrete or mortar right into a wheelbarrow for transport. Concrete mixers mix at an angle, meaning the drum is not entirely used at once, leaving only 2/3 of the cement mixer for actual mixing.

Figure 7-13—Portable mixer.

Test your Knowledge (Select the Correct Response)

3. When a specific weight of aggregate is called for, what type of scale is used?

   A. Dial
   B. Beam
   C. Pressure
   D. Balance

6.0.0 QUALITY CONTROL

6.1.0 Mixing Concrete

Concrete should be mixed until it is uniform in appearance and all the ingredients are evenly distributed. Mixers should not be loaded above their rated capacities and should be operated at approximately the speeds for which they were designed. If the blades of the mixer become worn or coated with hardened concrete, the mixing action will be less efficient. Worn blades should be replaced and the hardened concrete removed periodically, preferably after each production of concrete.

When a transit mixer (TM) is used for mixing concrete, 70 to 100 revolutions of the drum at the rate of rotation designated by the manufacturer as mixing speed are usually required to produce the specified uniformity. No more than 100 revolutions at mixing speed should be used. All revolutions after 100 should be at a rate of rotation designated by the manufacturer as agitating speed. Agitating speed is usually about 2 to 6 revolutions per minute, and mixing speed is generally about 6 to 18 revolutions per minute. Mixing for long periods of time at high speeds, more than 1 hour, can result in concrete strength loss, temperature rise, excessive loss of entrained air, and accelerated slump loss.

Concrete mixed in a transit mixer should be delivered and discharged within 1 1/2 hours or before the drum has revolved 300 times after the introduction of water to cement and aggregates, or the cement to the aggregates. Mixers and agitators should always be operated within the limits of the volume and speed of rotation designated by the equipment manufacturer.

6.2.0 Over Mixing Concrete

Over mixing concrete damages the quality of the concrete, tends to grind the aggregate into smaller pieces, increases the temperature of the mix, lowers the slump, decreases air entrainment, and decreases the strength of the concrete. Also, over mixing puts needless wear on the drum and blades of the transit mixer.

To select the best mixing speed for a load of concrete, estimate the travel time to the project (in minutes) and divide this into the minimum desired number of revolutions at mixing speed--70. The results will be the best drum speed; for instance, if the haul is 10 minutes, 70 divided by 10 equals 7. With this drum speed, the load will arrive on the jobsite with exactly 70 turns at mixing speed, with no over mixing of the concrete mix and no unnecessary wear on the equipment. If the concrete cannot be discharged immediately, the operator should turn the drum at the minimum agitating speed of 2 revolutions per minute. When the transit mixer arrives at the project having used the minimum amount of mixing turns, the operator is able, if necessary, to delay discharging the concrete. Delay is limited by the maximum of 300 rotations allowed.

6.3.0 Remixing Concrete

Concrete begins to stiffen as soon as the cement and water are mixed. However, the degree of stiffening that occurs in the first 30 minutes is not usually a problem; concrete that is kept agitated generally can be placed within 1 1/2 hours after mixing.

Fresh concrete left to agitate in the mixer drum may be used if upon remixing it becomes sufficiently plastic to be consolidated in the forms. Under careful supervision a small amount of water may be added to remix the concrete provided the following conditions are met: (1) maximum allowable water-cement ratio is not exceeded, (2) maximum allowable slump is not exceeded, (3) maximum allowable mixing and agitating time (or drum revolutions) are not exceeded, and (4) concrete is remixed for at least half the minimum required mixing time or number of revolutions.

Adding too much water to make concrete more fluid should not be allowed because this lowers the quality of the concrete. Remixed concrete can be expected to harden quickly. Subsequently, a cold joint may develop when concrete is placed next to or above the remixed concrete.

6.4.0 Slump Test

The slump test is used to measure the consistency of a concrete mix. The test is normally performed by an Engineering Aid (EA) and is made by using a slump cone. The cone is 12 inches high with an 8-inch-diameter base and a 4-inch-diameter top (*Figure 7-14*).

A bucket is filled with a sample of the concrete from the discharge chute of the mixer. From this sample, the cone is filled in three layers. Each layer should contain approximately one third of the volume of the cone. Each layer is rodded in the cone with 25 strokes from a 5/8-inch-diameter tamping rod 24 inches long. The strokes should be distributed uniformly over the cross section of the cone and should penetrate into the underlying layer. The bottom layer should be rodded throughout the depth. The strokes will eliminate any voids when the concrete is placed in the cone.

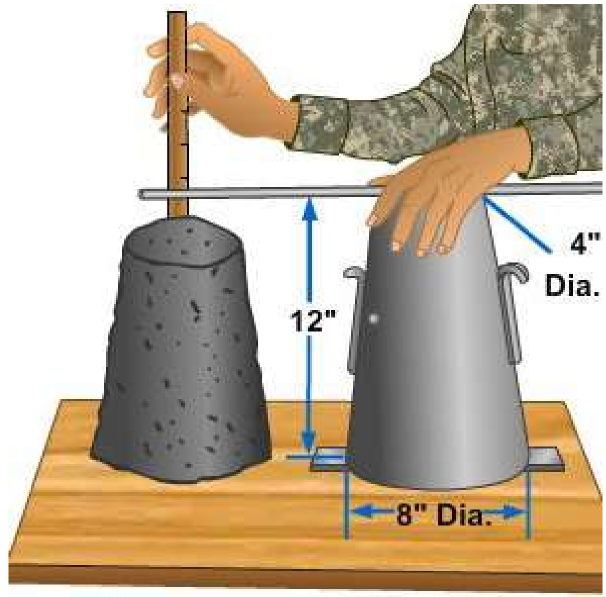

Figure 7-14—Slump test.

If the cone is overfilled, the excess concrete is made flush with the top of the cone with a straightedge. The cone is raised from the concrete by raising the cone carefully in a vertical direction. The slump is determined by measuring the difference between the height of the cone and the height of the concrete specimen. The slump is recorded in inches on the quality control report.

After the slump measurement is completed, the side of the mix is tapped gently with the tamping rod. The behavior of the concrete under this test is a valuable indication of the cohesiveness, workability, and placability of the concrete mix. If the mix is well proportioned, tapping will only cause it to slump lower and retain its original identity, but a poor mix will crumble, segregate, and fall apart. Normally, the EAs perform three slump tests per truck load of concrete. Another test performed by the EAs on a concrete mix is a concrete strength test. This test is performed to control the quality of concrete manufactured in the field, to evaluate the performance of available materials used in a concrete mix, and to establish mix proportions that give concrete the required strength.

6.5.0 Maintenance

As an EO you will be responsible for first echelon maintenance. If any problem arises beyond the scope of first echelon maintenance, write up the discrepancy for the CMs.

6.5.1 Batch Plant

The way to keep your batch plant in good working condition is to set up and follow a regular maintenance schedule. Because batch plants come in many different styles with various layouts and types of equipment, there is no one maintenance plan that can be used at every plant. There are, however, some general steps that any plant can follow in developing an effective maintenance schedule.

Carefully examine the operation and maintenance manuals supplied by the batch plant manufacturer. Also, take advantage of any training on maintenance offered by that manufacturer. Some manufacturers will send a representative out to your plant to make sure that equipment is properly used and maintained.

Depending on the specific batch plant you have, manufacturers may recommend different schedules for lubrication and inspection of components. When it comes to the batching control panel and its related electrical equipment, having a qualified specialist perform the maintenance may be a good idea.

After you have determined the recommended maintenance procedures for your batch plant, you then must consider what other items at your plant may not have been mentioned in the operation manual. Such components may include gear boxes, bearings, bushings, and an air system. Because such items and other devices are common at ready-mix operations, manufacturers may not provide specific maintenance instructions for them. It is necessary for you, therefore, to determine the best schedule for these components based on your experience and other recommendations.

Keep in mind that safety is crucial when maintenance is being performed. Crew members should be instructed to lock out equipment that is being worked on, tag it, and notify other employees in the work area that maintenance is under way. Many accidents can be prevented if all crew members at the plant are made aware of maintenance procedures being done.

6.5.2 Concrete Mixer

The handling and delivery of concrete material is demanding on equipment. Unless a frequent, comprehensive, periodic maintenance program is established, rapid wearout and/or damage to the equipment can occur. Proper cleaning, lubrication, and maintenance will provide a longer life, more satisfactory service, and more economical use of the equipment.

Use of proper oil in the hydraulic system is of the utmost importance in ensuring proper operation. Cleanliness in handling cannot be stressed enough. Keep hydraulic oil in original closed containers before opening for use, and handle with clean measures and funnels. Refer to the Lubricant and Hydraulic oil specifications section of the equipments manual for selection of proper hydraulic oil.

The oil in a new unit should be drained at the end of the first two weeks (not more than 100 hours) of operation and the case thoroughly flushed with light oil. Refill with 1 pint of recommended lubricant. After the initial change, oil should be changed every 2000 hours or annually, whichever occurs first. Check the level of the gear case monthly.

Grease in bearings acts to prevent excessive wear and corrosion, and aids in preventing heat build-up. It is important that grease maintain proper consistency during operation; it must not be fluid or channel. Points to be lubricated are identified on the lubrication specification chart. All points have standard grease fittings and are lubricated by pumping grease in slowly until a light bead forms around the seals. Make sure that all fittings are clean before grease is injected.

Nose down the machine; remove any material build-up on the sprockets or beneath the chain. If material is allowed to build up, the chain may ride up and damage the body.

If material builds up under the chain, the chain will ride on the material instead of the bottom panel. The more material that builds up, the closer the chain becomes to the chain shield; if the chain should catch on a shield, it could permanently distort the chain, the shield, or the body.

In the same manner, if material builds up on the sprockets, the chain will have a larger diameter to follow and the chain will move closer to the chain shields until damage has occurred.

WARNING

Do not remove material while the conveyor is running.

The conveyor chain is lubricated by the chain oiler. The reservoir should be filled daily with a mixture of 75% fuel oil and 25% SAE 10 oil. Open the petcock and run the conveyor until the full length of the chain has been oiled.

Proper tension is a factor of both chain and sprocket life. The proper chain tension is illustrated below. Ensure that both sides are tensioned equally. This adjustment is made on each side of the unit at the idler bearing. Conveyor chains that are too tight will tend to stretch, causing excessive sprocket wear and eventually breakage. Conversely, excess slack may cause the chain to catch on the sub-frame parts and damage the body. Straighten or replace bent or distorted chain bars immediately.

A high degree of vibration occurs when the mixer is in operation, which over a period of time can cause fasteners to loosen up. Periodically check all bolts and screws and tighten as required. Check body mounting bolts weekly.

Test your Knowledge (Select the Correct Response)

4. Concrete mixed in a transit mixer should be delivered and discharged within 1 1/2 hours or before the drum has revolved what maximum number of times?

   A. 100
   B. 200
   C. 300
   D. 400

Summary

This chapter discussed some of the major types of Portland cement. Information was also provided on the various methods by which you, as Concrete Plant Supervisor, can select the proportions for quality concrete mixtures and adjust these mixtures to suit job requirements. Also covered were types and uses of admixtures and slump testing procedures. Finally, the chapter pointed out some of the types of equipment you are likely to encounter in concrete construction.

Review Questions (Select the Correct Response)

1. Portland cement is manufactured from finely ground limestone mixed with which materials?

   A. Clay
   B. Shale
   C. Marl
   D. All of the above

2. The chemical reaction between cement and water that produces concrete is known by what term?

   A. Concrete
   B. Hydraulics
   C. Hydration
   D. Evaporation

3. How is laitance produced in concrete?

   A. Water collects under the surface of the cement.
   B. Cement is hydrated with saltwater.
   C. Cement is hydrated with minimum water.
   D. Cement is hydrated with excess water.

4. **(True or False)** Aggregate is the material combined with cement and water to make concrete.

   A. True
   B. False

5. Aggregates used in concrete occupy what percentage of the mix by weight?

   A. Between 90% to 95%
   B. Between 70% to 85%
   C. Between 60% to 70%
   D. Between 50% to 60%

6. For highway construction, Type III Portland cement is sometimes preferred to Type I because Type III has which characteristic?

   A. Finer finish
   B. Less working time
   C. Stronger
   D. Less expensive

7. What type of cement was developed for use in areas subject to severe frost and ice conditions?

   A. Air-entrained
   B. Keene's
   C. Type V
   D. Type IV

8. **(True or False)** Admixtures are NOT recommended if the end result can be achieved more economically by altering the cement mix proportions

   A. True
   B. False

9. What percent do water reducing admixtures usually reduce the required water content for a concrete mixture?

   A. 1% to 2% only
   B. 1% to 3%
   C. 3% to 7%
   D. 8% to 10%

10. What is the most commonly used material in accelerating admixtures?

   A. Alkali-silica
   B. Chlorine bleach
   C. Calcium chloride
   D. Ammonium chloride

11. The primary reason for using an air-entraining agent in a concrete mix is to improve what property of the concrete?

   A. Hardness
   B. Tensile strength
   C. Resistance to freezing and thawing exposure
   D. Color

12. **(True or False)** The accepted use for retarders is to increase the rate of hydration.

   A. True
   B. False

13. Which material can be used to retard the set of a concrete mix?

   A. Borax
   B. Sugar
   C. Salt
   D. All of the above

14. What is the main reason to store cement in a dry place?

    A. To prevent it from becoming concrete while in storage
    B. To prevent it from setting too fast and producing weak concrete
    C. To prevent it from setting too slowly and producing weak concrete
    D. To avoid warehouse pack

15. When storing sacks of cement in a warehouse, what is the main reason to stack them close together?

    A. To allow them to draw moisture from each other
    B. To restrict the circulation of air between them
    C. To prevent warehouse pack
    D. To prevent them from getting mixed up

16. Before using warehouse-packed cement, what should you do to make it free of lumps?

    A. Restack the sacks to allow air to circulate around them.
    B. Raise the temperature where the sacks are stored.
    C. Roll the sacks around.
    D. Cover the sacks for 48 hours with tarpaulins.

17. **(True or False)** Fine aggregates are those materials that are retained on a No. 4 sieve.

    A. True
    B. False

18. **(True or False)** To prevent aggregate from segregating during stockpiling, you should build up piles in layers by dumping successive loads alongside each other.

    A. True
    B. False

19. You have a concrete pad that has a length of 60 feet, a width of 15 feet, and a thickness of 6 inches. What would be the volume of the concrete pad, in cubic feet?

    A. 350
    B. 450
    C. 500
    D. 900

20. To calculate the number of cubic yards required for a pad, divide the cubic feet of the pad by what number?

A. 27
B. 28
C. 30
D. 40

21. **(True or False)** Concrete specifications most often require that batching be performed by volume.

A. True
B. False

22. How many rotations of the drum on a transit mixer at mixing speed are required to produce concrete of the specified uniformity?

A. 10 to 30
B. 30 to 50
C. 70 to 100
D. 90 to 120

23. **(True or False)** Concrete has high ability to resist stretching, bending, and twisting.

A. True
B. False

24. What principle factor controls the strength of concrete?

A. Dryness
B. Water-cement ratio
C. Age
D. Reinforcement

25. **(True or False)** The major factor controlling the durability of concrete is its strength.

A. True
B. False

26. If more water is added to a concrete mix than is needed to hydrate the cement, the concrete becomes less_______.

A. porous
B. brittle
C. fluid
D. watertight

27. A_______ may develop when concrete is placed next to or above remixed concrete.

A. discoloration
B. cold joint
C. smooth area
D. depressed area

28. Concrete is denser and stronger when which condition is met?

A. All voids are filled.
B. Voids are large and unfilled.
C. Aggregate particles are not solidly bonded.
D. Aggregate particles are not coated with a cement-water paste.

29. You are conducting a slump test. Which result indicates a poor mix?

A. The concrete mix crumbles.
B. The concrete mix segregates.
C. The concrete mix falls apart.
D. All of the above

30. With how many strokes should you rod each layer of concrete placed in the compressive strength test mold?

A. 10
B. 15
C. 20
D. 25

Terms Introduced in this Chapter

Durable	The durability of concrete refers to the extent to which the material is capable of resisting deterioration caused by exposure to service conditions. The major factor that controls the durability of concrete is its strength. The stronger the concrete, the more durable it is.
Efflorescence	The process by which water leeches soluble salts out of concrete or mortar and deposits them on the surface.
Laitance	A layer of weak material containing cement and fines from aggregates brought to the top of over-wet concrete, the amount of which is generally increased by overworking and over-manipulating concrete at the surface by improper finishing.
Strength	The compressive strength of concrete. (meaning its ability to resist compression) is very high, but its tensile strength (ability to resist stretching, bending, or twisting) is relatively low.

Additional Resources and References

This chapter is intended to present thorough resources for task training. The following reference works are suggested for further study. This is optional material for continued education rather than for task training.

American Concrete Institute, Aggregates for Concrete, ACI Education Bulletin E1-07, Farmington Hills, MI. 2007

American Society for Testing and Materials, ASTM C150 Standard Specification for Portland Cement

Field Manual No.5-428, Concrete and Masonry, Headquarters, Department of the Army, Washington, DC. 1998

MOBILCRETE Model H-10DT, Operation, Maintenance and Parts Manual provide step by step operation and maintenance procedures for the H-10DT mobile batch plant, Tulsa, OK.

Naval Construction Force Equipment Management Instruction, COMFIRSTNCDINST 11200.2 Norfolk, VA. 2006

National Concrete Pavement Technology Center, Concrete Paving Training and Field Reference, Ames IA. 2006

Portland Cement Association, Cement and Concrete Basics, Skokie, IL. 2009

Unified Facilities Criteria 3-320-06A, Concrete Floor Slabs on Grade Subjected to Heavy Loads, Department of Defense, Washington, DC. 2005

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