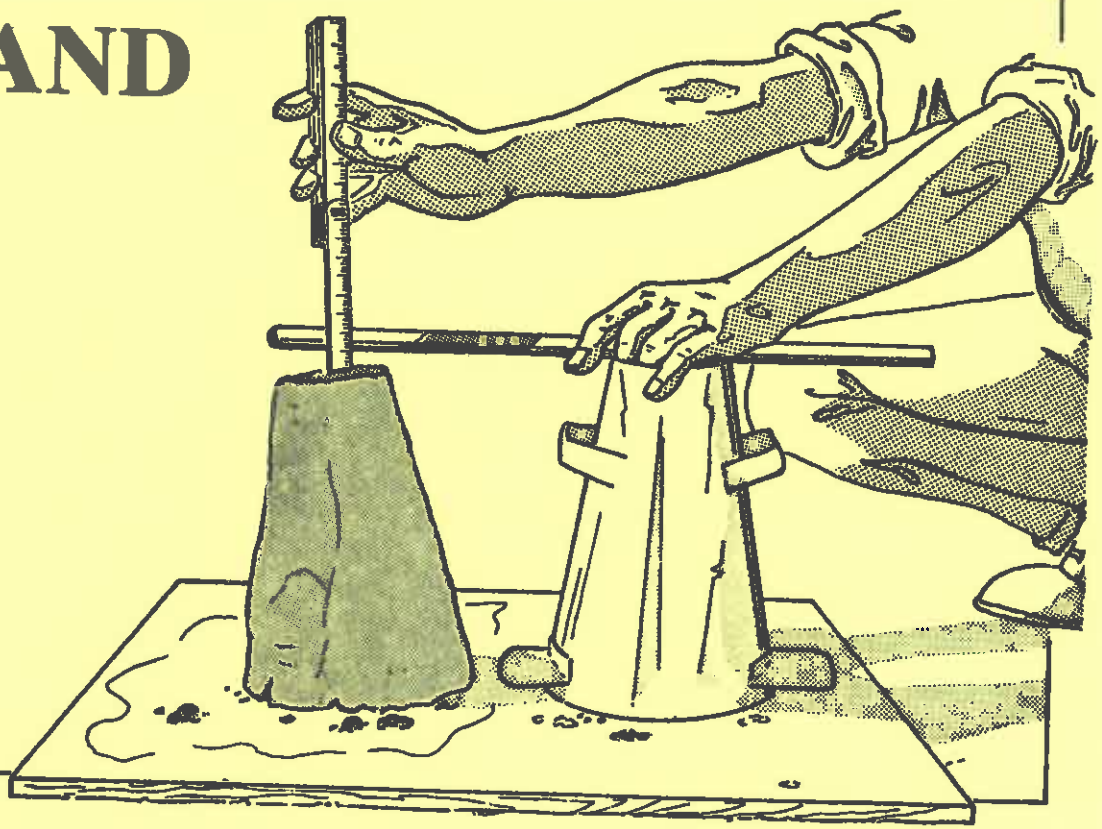
Florida Department of Transportation

PORTLAND CEMENT CONCRETE TESTING, PLACEMENT AND CONTROL



PORTLAND CEMENT CONCRETE TESTING, PLACEMENT AND CONTROL

a training course developed

for the

FLORIDA DEPARTMENT OF TRANSPORTATION

This 1999 revision was carried out under the direction of

Ken Blanchard, P. E., Area Construction Engineer

The Office of Construction
Florida Department of Transportation

Douglas Townes, State Construction Training Engineer
Yvonne Collins, State Construction Training Coordinator

DIRECTIONS TO COURSE USERS

TRAINING TECHNIQUE

This course has been designed for self-instructional training:

- You can work alone.
- You can make as many mistakes as are necessary for learning -- and correct your own mistakes.
- You can finish the training at your own speed.

You will keep this book as your reference, so work neatly.

PREREQUISITES

The Department of Construction Training Policy requires that you take two courses within the first year of your employment: Construction Math and Contract Plan Reading. Before taking Portland Cement Concrete Testing, Placement and Control, you should have completed at least Construction Math.

HOW TO USE THIS BOOK

This book gives you some information and then asks a series of questions about that information. The questions are asked in such a way that you will have to think carefully and draw some conclusions for yourself. If you have difficulty answering the questions, review the sections that give you trouble before going on.

The answers to the questions are in the back of each chapter.

For more complete information on the work discussed in this book, go to the standard and supplemental Specifications and Special Provisions for your project and the Florida Sampling and Testing Methods.

EXAMINATION

An Examination has been developed for Portland Cement Concrete Testing, Placement and Control.

To help you prepare for the Examination, a Review Quiz is included at the end of this book. If you do all right on the Review Quiz, the Examination should present no problems.

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CHAPTER ONE

Concrete and Concrete Acceptance

CONTENTS

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CONCRETE AND CONCRETE ACCEPTANCE

This chapter will train you to properly field sample portland cement concrete for quality control tests. The chapters following Chapter One cover the tests and the equipment and procedures needed to perform the tests. In this chapter, however, we will discuss what portland cement concrete is and how samples are collected for testing.

PORTLAND CEMENT CONCRETE

Portland cement concrete is a mixture of portland cement, aggregate, water and possibly admixtures. The portland cement and water form a paste which binds the aggregate (coarse and fine) together. As the paste ages, it hardens.

Concrete design mixes must be approved by the Department. All materials in a design mix must also be approved by the Department.

In case you did not know, "portland" is not a brand name, nor is the cement named for a city. Portland cement was named by an English stonemason, Joseph Aspdin, who patented it in 1824. He named his product portland cement because the concrete made with it looked like fine building stone quarried on the Isle of Portland in England.

QUIZ

Concrete is a mixture of_____ , _____ , _____ and possibly _____.

Concrete materials and design mixes must be approved by _____.

Your job will include _____ and _____ fresh concrete.

O.K.? Now, go on to CONCRETE DELIVERY

CONCRETE DELIVERY

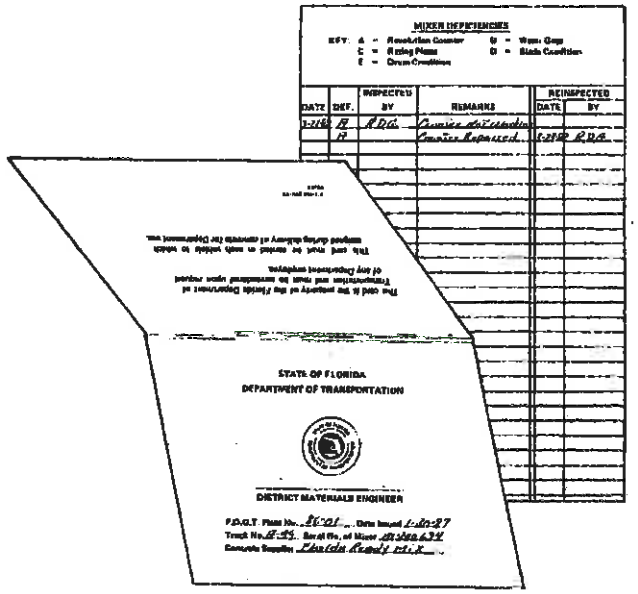
When concrete arrives at the job site, the Inspector is responsible for checking the concrete mixer truck drum revolution counter, water gauge and rating plate, collecting and checking the delivery ticket, and making initial tests (slump, air and temperature) on the plastic concrete. You will also be required to calculate the water cement ratio.

Check the information on the delivery ticket. Verify that the materials and quantities in the batch represented by the delivery ticket match the materials and quantities of the approved design mix for the placement at hand.

If the concrete is accepted for placement, the Inspector takes concrete samples and runs tests.
First though, we will look at what the Inspector does before samples are taken.

INSPECTING THE TRUCK

The Inspector is responsible for inspecting a mixer truck when it arrives on the job site. The first step in the inspection is to ensure that the truck has a valid Identification Card issued by the District Materials Office.



The concrete producer is responsible for securing a Card for each of its trucks. If the truck has no Card, the concrete is rejected.

The front of the card includes information for identification of the supplier, the truck and the truck mixer. Make sure the identification information matches the truck being inspected.

The inside of the card is a record of truck inspections, deficiencies and repairs to the deficiencies. The Inspector completes this part of the Card after the inspection.

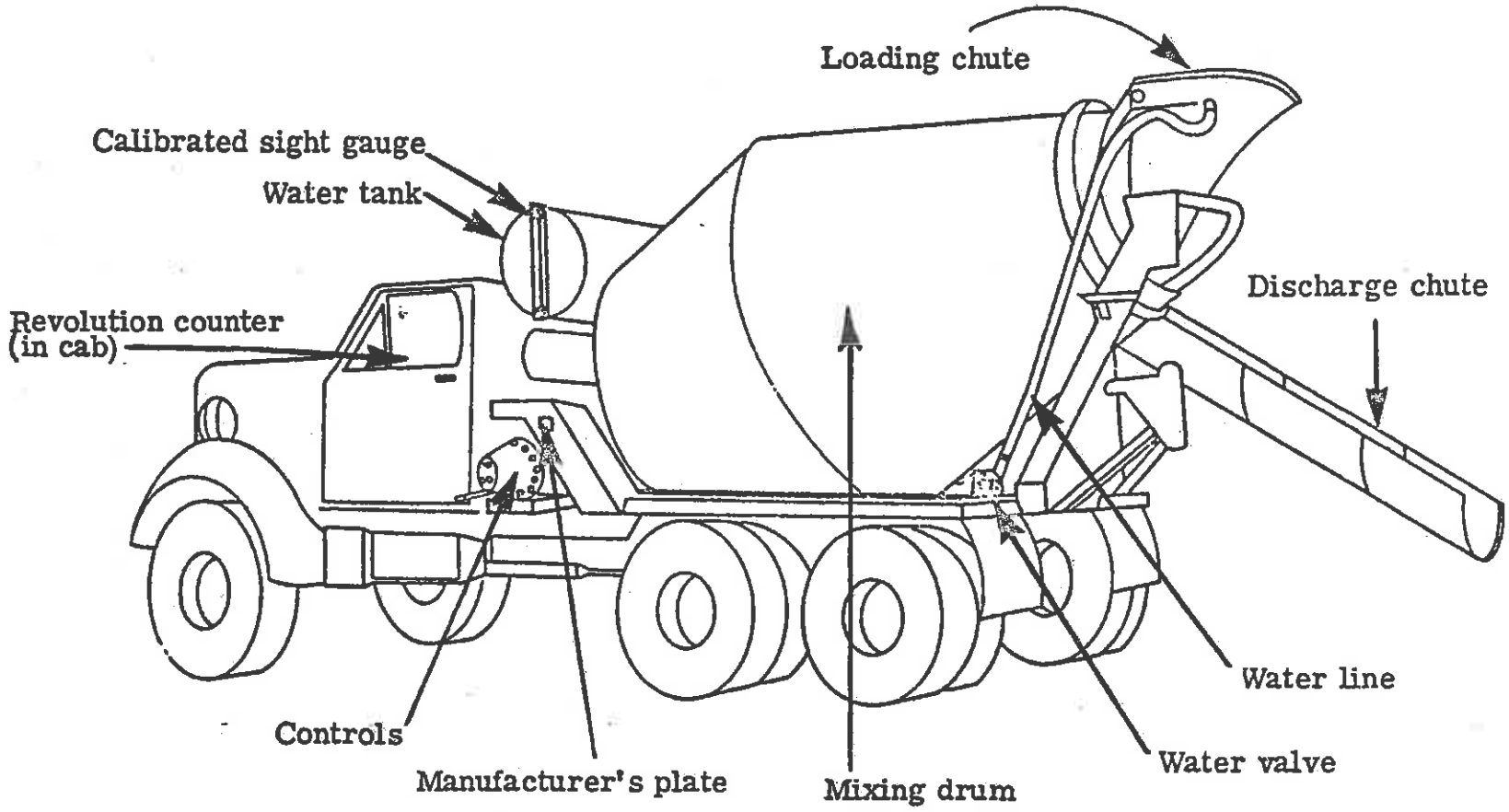
There are five inspection items listed on the Card. The Inspector is responsible for inspecting three of these items -- the ones that do not require going into the interior of the mixer drum. The items to be inspected are:

- the revolution counter,
- the water gage, and
- the rating plate.

Make sure that all three items are on the mixer truck, verify the revolution counter calibration document, and ensure the water gage indicates full to the top of the gage, and that water missing is documented on the truck ticket.

If any of the items are deficient (in non-compliance with Department specifications), note the deficiencies on the Card and notify the Project Engineer. If the Project Engineer agrees with your findings, the Card will be pulled and the concrete will be rejected. The Card will not be returned to the supplier until the truck is reinspected and no deficiencies are found.

There is an exception to this procedure. When the only deficiency is a non-working revolution counter, note the deficiency but do not pull the Card. The truck can discharge it's load if the delivery ticket shows the mixing time. On the next delivery by that truck, it must be reinspected for the revolution counter when it arrives at the site, and the repair to the counter must be noted on the Card. Documenting the repair is important. If the repair has not been made and is not documented on the Card, the truck is rejected.


Loading chute
Calibrated sight gauge
Water tank
Revolution counter
(in cab)
Discharge chute
Water line
Controls
Manufacturer's plate
Mixing drum
Water valve

COLLECTING THE DELIVERY TICKET

When a batch of concrete reaches the job site, the driver will have in his possession a delivery ticket such as the one shown here. This ticket is shown as an example and variations are acceptable provided that required information, as shown here, is also provided by the modified ticket.

On this ticket, all of the ingredient amounts are the amounts needed to make one cubic yard of concrete. For example, 564 pounds of cement would be used to produce 1 cubic yard of concrete. An actual ticket shows the total number of cubic yards in the batch and the total quantities of ingredient amounts used to produce the total number of cubic yards in the batch.

Keep this ticket—you will need it later.

Rev. 11-22-94

NAME OF CONCRETE COMPANY

Del. Ticket
Serial No. 10210
Date 11-22 1994

Plant No. 86-010
Delivered To SAN MARCO CONSTRUCTION
F.D.O.T. Project No. ROAD 860 AT 50th STREET

Truck No.	Time Loaded	Arrive	Discharge	Cubic yards This load
26	1:55 pm	*	*	1.0
DOT Class II	DOT Mix No. 2001			Cubic yards Total Today 1.0
Allowable Jobsite Water Addition _____ Lbs/yd³ 1.5 gal/yd³				Mixing Revolutions: At Plant 75 At Jobsite 30* (or Central Mixing Time :_____) Total Revs. at Completion of discharge *

FILL OUT ON FIST DELIVERY AND ON EACH CHANGE OF AGG. WEIGHT	DOT Job No. 86925-3503
Air DUREX (Brand) _____ (Amount) 5.5 oz.	Retarder WRDA79 (Brand) _____ (Amount) 45 oz
Cement I (Type) FlaP&d (Brand) 564 lbs (Amount)	Batch Water Amount _____ lbs/yd³ 22 gal/yd³
Coarse Agg. Amount 1773 lbs 2.0 % Moisture	Fine Agg. Amount 1217 lbs 40 % Moisture
Fly Ash _____ (Source) _____ (Amount) Lbs.	

Issuance of this ticket constitutes certification to the accuracy of the above recorded information.

Tom Burgers
Signature of Plant Operator or Company Rep.

Water Added by Receiver of Concrete: _____ lbs * _____ Gals *

Delivery tickets arrive partially completed. Your job is to (1) verify that the signature of the plant operator is an original and (2) complete the information in the spaces marked by asterisks on the example ticket.

The first starred blank is for the arrival time. This is the time that the concrete truck arrives at the job site.

The next starred blank is for the time that the batch was completely discharged. The concrete must be discharged within 60 minutes after water is added to the mix at the plant. If a special retarder is added to the mix, 90 minutes is the limit. If nonagitator trucks are used, 45 minutes is the limit without a retarder, and 75 minutes is the limit with a retarder.

The third and fourth starred blanks are for the number of mixing revolutions when water is added at the jobsite, and the total revolutions (mixing and agitating) at completion of discharge. Total (mixing and agitating) revolutions cannot exceed 300.

Mixing speed for the drums of transit mixer trucks is between 6 and 18 revolutions per minute; agitating speed is between 2 and 6 RPM.

"Mixing Revolutions at the Jobsite" is an important blank to complete. The drums of transit mixer trucks must turn at least 70 but not more than 100 revolutions at mixing speed before concrete placement. If water is added at the job site, however, at least 30 additional mixing revolutions must be made -- but the total mixing revolutions can not be more than 160. If the concrete comes from a central mix plant, revolution counters are not required -- but the space titled "Central Mix Time" must show at least 1 minute of mixing time.

The starred blanks for "Water Added by Receiver of Concrete" are the blanks for the number of gallons, or pounds, of water that are added at the job site. "Allowable Jobsite Water Addition" is the difference between the maximum water allowed by the design mix and the total mixing water in the load as shown on the delivery ticket when the load arrives at the jobsite. The Inspector should not permit "Water Added by Receiver of Concrete" to exceed "Allowable Jobsite Water Addition" or the maximum water-cement ratio. The "Receiver of Concrete" responsible for jobsite addition of water is the Contractor's representative on site.

CALCULATING THE WATER/CEMENT RATIO

The water/cement ratio is the pounds of water in the concrete divided by the pounds of Portland cement (including other cementitious material such as fly ash or slag). The quantities needed for the ratio calculation are on the delivery ticket -- stated as the quantities per cubic yard.

The pounds of cement (including other cementitious material such as fly ash or slag) per cubic yard are given on the delivery ticket. Our example ticket shows 564 pounds of cement per cubic yard of concrete. No fly ash or slag is used.

The water in the concrete has four possible sources:

- free water on the coarse aggregate,
- free water on the fine aggregate,
- batch water, and
- water added at the site.

The free water on the coarse or fine aggregate can be calculated from the pounds of aggregate per cubic yard and the percent of moisture -- both given in either the "Coarse Agg" or "Fine Agg" blanks of the ticket. The calculation depends on knowing the saturated surface dry (SSD) weight of the aggregate. The SSD weight is the weight of the aggregate without any free water. The percent moisture on the ticket is free water expressed as a percentage of the SSD weight, and the weight on the ticket is the total weight (SSD plus free water) of the aggregate. We can write these relationships as arithmetic expressions and then put them in a form that will be useful to us:

- Total weight = SSD weight + Free water
- Total weight = SSD weight + (Percent moisture) (SSD weight)
- Total weight = (1 + Percent moisture) (SSD weight)
- $\text{SSD weight} = \dfrac{\text{Total weight}}{1 + \text{Percent moisture}}$

Now we have a formula to calculate the SSD weight. Then we can subtract the SSD weight from the total weight to find the pounds of free water. Using the figures for coarse aggregate on the example ticket, the calculation is:

- SSD weight = $\frac{1773 \text{ lbs./cu. yd.}}{1 + 0.02}$
  SSD weight = 1738.2353 lbs./cu. yd
  Free water = 1773 - 1738.2353 = 34.7647 lbs./cu. yd.

Follow the same pattern to calculate the free water on the fine aggregate. You should get 46.8077 lbs./yd^3.

Now that we know the free water on the aggregate, we need to find the pounds of batch water and the pounds of water added at the job site. Both of these quantities are given on the ticket -- but both usually are given in gallons and the gallons added at the site are total gallons for the load. To convert gallons of water to pounds, multiply by 8.33 pounds of water per gallon. To convert total gallons to gallons per cubic yard, divide by the number of cubic yards in the load. For our example ticket, the calculations are:

- Batch water = 22 gallons/cu. yd. x 8.33 pounds/gallon
  = 183.26 pounds/cu. yd.
- Added water = 10 gallons ÷ 8 cu. yd.
  = 1.25 gallons/cu. yd. x 8.33 pounds/gallon
  = 10.4125 pounds/cu. yd.

Now we add the water from the four sources to find the total pounds (kilograms) of water per cubic yard (cubic meter) of concrete.

Coarse aggregate	34.747 lbs./cu. yd.
Fine aggregate	46.808
Batch water	183.260
Added water	10.412
Total water	275.227 lbs./cu. yd.

The water/cement ratio is:

$$\text{Water/cement ratio} = \frac{\text{Pounds of water}}{\text{Pounds of cement}}$$

$$= \frac{275.227 \text{ lbs./cu. yd.}}{564 \text{ lbs./cu. yd.}}$$

$$= 0.49$$

FM 5-501 in the "Florida Methods of Test" Manual shows the Water/ Cementitious Ratio Calculation.

QUIZ

What must each transit mixer truck have when it arrives at the job site?_____

What three items must you inspect? _____, _____ and _____

Can a truck be accepted if the revolution counter is not working? _____

For a transit mix truck, how many mixing revolutions are required if no water is added at the job site? _____ but not more than _____

When a batch of concrete reaches the jobsite, what must the truck driver have in his possession?_____

How many mixing revolutions must be made after water is added at the job site? _____

Is the Inspector the "Receiver of Concrete" on the delivery ticket? _____

Calculate the water/cement ratio, given the following information:

- Coarse aggregate total weight is 1722 pounds per cubic yard (1022 kg/m^3) with 1% moisture;
- Fine aggregate total weight is 1172 pounds per cubic yard (695 kg/m^3) with 6% moisture;
- Batch water is 21 gallons per cubic yard (104 L/m^3);
- No water is added at the job site; and
- Cement weight is 658 pounds per cubic yard (390.5 kg/m^3).

Water/cement ratio: _____.

Mixing speed for the drums of transit mixer trucks is between _____ and _____ rpm.; agitating speed is between _____ and _____ rpm.

Total mixing and agitating revolutions cannot exceed _____ .

CONCRETE SAMPLING AND TESTING

SAMPLING CONCRETE

To get the correct results from your concrete tests, it is necessary to get a sample that is representative of the whole batch. And, it's important to make sure that the concrete won't change very much between the time that you take your sample and the time that you run your tests. For these reasons, sampling procedures have been set by the Department in the "Florida Methods of Test" Manual (FM 1-T 141 or FM 5-501 for initial verification testing).

To take samples of concrete, you need only three pieces of equipment: a wheelbarrow, a cover and a shovel.

The first step is to dampen the wheelbarrow and shovel. There shouldn't be any pools of water left in the wheelbarrow because this would add water to the concrete. Just wet your tools, then drain off any extra water.

Unless you're using the "early sampling procedure" explained below, you should take your sample from the middle of the batch. Wait until about half of the concrete has been discharged from the truck, then divert the entire flow from the chute into your wheelbarrow. Be sure to get enough concrete to run the slump test, air content test, and to cast 2 cylinders. Be sure to take your sample after all water has been added to the concrete -- remember, your sample must be representative of the whole batch.

After you have obtained your sample, re-mix the concrete sample with your shovel -- just enough to give it a uniform appearance. Protect the sample from the sun and wind with a cover to avoid water evaporation.

Now, time becomes important. If you wait too long before testing the concrete, it will begin to set and your test results will be ruined. So you must start the slump and air tests within 5 minutes after obtaining the sample and you must start casting cylinders within 15 minutes.

The "Early Sampling Procedure" (FM 5-501) is required on the first load to provide a preliminary evaluation. The "Early Sampling Procedure" is the same as the normal sampling procedure, except that (1) the sample is taken when between 2 ft^3 and 6 ft^3 of concrete have been discharged; (2) the sample size is about ½-cubic foot; and (3) no concrete can be placed in the forms until all tests have been run and you have found that the concrete is O.K.

The normal sampling procedure (FM-1-T 141) is used for acceptance sampling. When conveyor belts, pumps or chutes are used, all samples are taken at the discharge of the conveyance at the point of final placement of the concrete.

TESTING CONCRETE

As an Inspector in the field, you will be expected to perform the following tests:

- check concrete temperature;
- perform slump tests;
- perform air content tests; and
- cast compressive strength cylinders.

You should check the Sampling, Testing and Reporting Guide for frequency of tests, sample size, material name, and other information necessary for reporting.

Procedures for completing these tests are in this chapter and following chapters of this course. Be sure you are familiar with all of these tests.

QUIZ

To sample concrete, you need a _____, _____ and a _____ shovel.

Unless you're using the "early sampling procedure", always sample from the _____portion of the batch, after all _____ has been added.

The slump test must be started within _____ minutes after you have your sample.

Before sampling concrete, be sure that the wheelbarrow and shovel are _____ .

Casting of cylinders must begin within _____ minutes after getting a sample of concrete.

The air test must be started with in_____ minutes after getting a sample of concrete.

AIR AND CONCRETE TEMPERATURES

The temperatures of the air and the concrete are critical to the quality of the final product. No concrete shall be mixed when the air temperature is below 45°F (7°C) and falling. Concrete may be mixed and placed when the air temperature in the shade, away from artificial heat, is above 40°F (4°C) and rising. Heating aggregates or the use of salts is not allowed.

The Contractor needs to protect fresh concrete from freezing until the concrete reaches a minimum compressive strength of 1500 psi (10MPa).

The procedure for taking the concrete temperature is as follows:

1. Put the thermometer in the sample;
2. Cover the sample to shade it;
3. Wait at least 2 minutes for the temperature to stabilize.

The concrete temperature at placing must not exceed 85°F (29°C), except concrete designed as a "hot weather mix" can be placed at a concrete temperature up to 100°F (38°C).

QUIZ

No concrete shall be placed when the air temperature is below_____ and falling.

Concrete may be mixed and placed when the air temperature in the shade is above _____ and rising.

Fresh concrete needs to be protected from freezing until it reaches a minimum compressive strength of ____ .

When taking concrete temperature, wait at least _____ for the temperature to stabilize.

Concrete temperature at placing must not exceed _____, unless the concrete is designed as a "hot weather mix", in which case the concrete can be placed at a concrete temperature up to _____.

ANSWERS TO QUESTIONS

Page 1-3

- Portland cement
  aggregate
  water
  admixtures
- the department
- sampling
  testing

Page 1-12

- Identification Card
- revolution counter
  water gauge
  rating plate
- yes, if previous deficiencies have been corrected
- 70
  100
- a delivery ticket
- 30
- no, the Contractor is
- 0.39
- 6, 18 ; 2, 6
- 300

Page 1-16

- wheelbarrow
  cover
  shovel
- middle
  water
- 5
- damp
- 15
- 5

Page 1-18

- 45°F (7°C)
- 40°F (4°C)
- 1500 psi (10MPa)
- 2 minutes
- 85°F (29°C)
- 100°F (38°C)

CHAPTER TWO

Concrete Slump Tests

CONTENTS

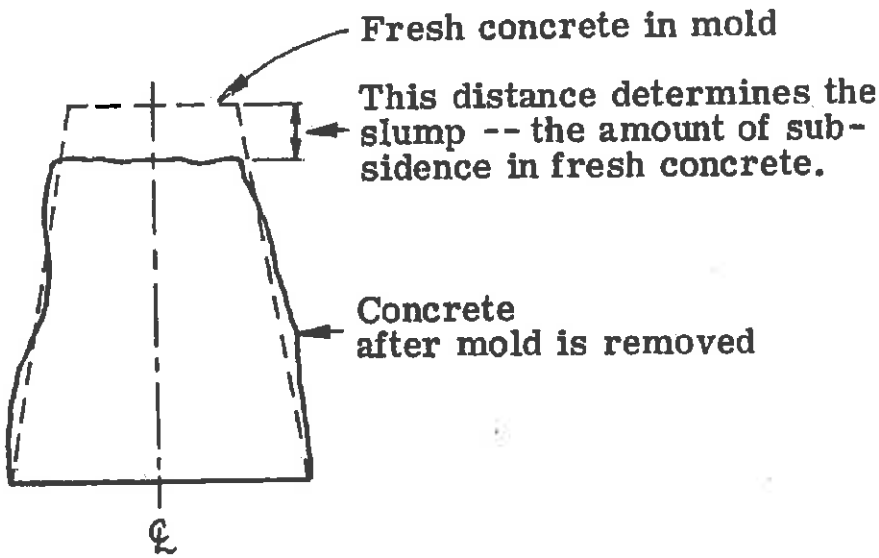
2

CONCRETE SLUMP TESTS

PURPOSE OF SLUMP TESTS

One important characteristic of plastic concrete is its consistency. Slump tests are performed to measure the slump (amount of subsidence) of the concrete.

The diagram at right shows the basics of a slump test. Concrete is placed and supported in a mold, then the mold is removed, allowing the concrete to slump. The difference between the heights of the supported concrete and the slumping concrete is its slump. The slump is measured in inches (millimeters) to the nearest 1/4-inch (5-mm).



Slump tests are measures of the consistency of plastic concrete. They measure how wet or dry the concrete is and what changes have taken place in the aggregate proportions and water contents of different batches. The slump is an indication of the water-cement ratio which in turn directly affects the strength of the concrete.

PERFORMING A SLUMP TEST

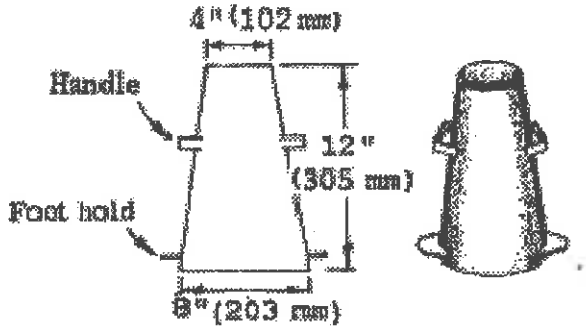
Remember that this is an introductory course designed to familiarize you with basic procedures. Consult the appropriate testing standard (FM I-T 119) before performing slump tests on a job.

EQUIPMENT

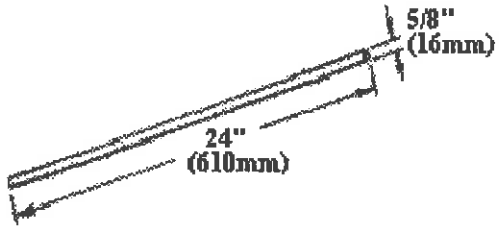
The most important equipment for a slump test is a slump cone and a tamping rod. You will also need other equipment including:

- a square-pointed shovel, wheelbarrow and cover for collecting a sample;
- a metal scoop or trowel for handling the concrete;
- a non-absorbent base, such as a clean, smooth, wet piece of plywood;
- a rule for measuring the slump; and
- a torpedo level

A slump cone is a galvanized metal mold, with both the top and bottom open.



A steel tamping rod has one hemispherical-shaped end. A steel reinforcing bar is NOT a substitute for open. a tamping rod.



SAMPLING

Sample the fresh concrete according to the instructions in Chapter One. Remix the concrete with a shovel before you perform your tests. Remix it just enough to give it a uniform appearance.

Time is a factor in performing concrete tests, particularly slump tests. The slump test must begin within five minutes after the sample is obtained. This means that the sample must be thoroughly mixed within those five minutes. Also, once the slump test begins, you have only 2.5 minutes to complete it.

TEST PREPARATIONS

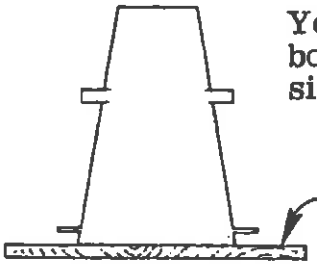
Before the test is begun, you must select the test site and prepare the equipment:

- Perform the slump test well away from heavy equipment and vibrators. Ground vibrations can cause the concrete to settle or slump more than it would otherwise.
- Make sure the slump board is leveled in both directions and large enough to hold both the specimen and the empty slump cone side-by side.
- Make sure all equipment is clean.
- Wet the cone and its base. Both should be moist, but there should be no free-standing water.

PROCEDURES

There are seven steps to a slump test:

1. A clean, wet cone is placed on its base -- a flat, moist, level nonabsorbent surface.

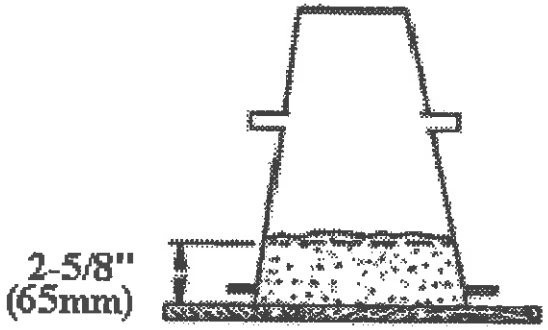


You should use a base large enough to hold both the specimen and the empty slump cone side-by-side.

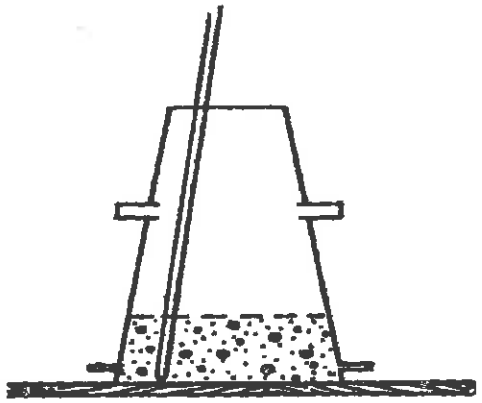
Plywood base

Note: Slump cones need to be held in place by standing on the foot holds.

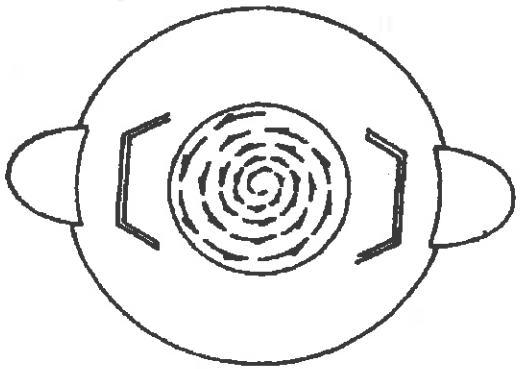
2. Fill the slump cone slightly more than 33 % full -- by volume -- with evenly distributed concrete. Thirty-three percent of the volume is obtained when the concrete height is 2-5/8 inches (65mm) above the base. You can mark this on the outside of the cone to help you fill it to the proper level.



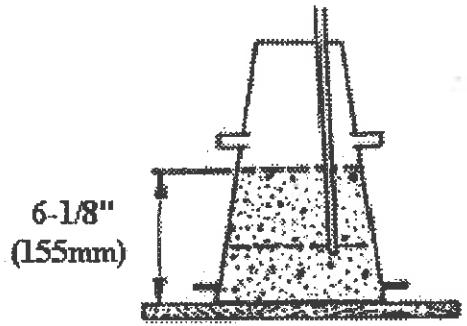
3. Rod the layer with the hemispherical-shaped end of the tamping rod 25 times. Distribute the strokes uniformly over the layer. Rod the concrete to full depth, but don't strike the base forcefully.



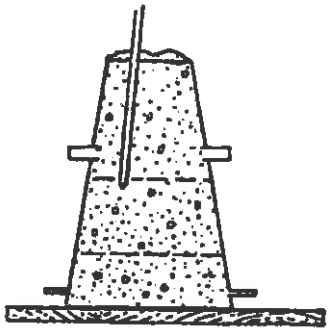
When rodding each layer, about half of the strokes should be made near the edge. The remaining strokes should be made in a spiral pattern toward the center.



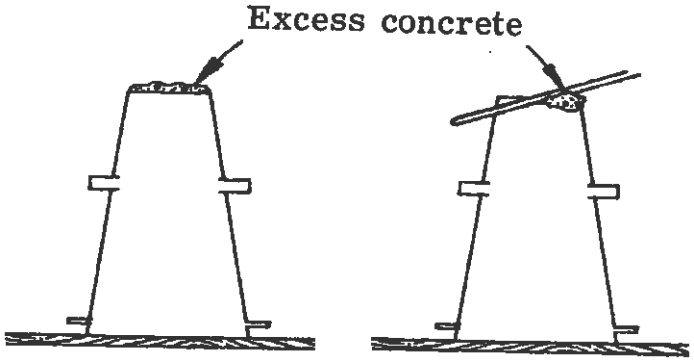
4. Fill the slump cone slightly more than 65 % full -- by volume – and rod the layer 25 times as before. Rod the second layer deep enough to just penetrate the first layer. The 65% volume height is 6-1/8 inches (155mm) above the base, which you can mark on the cone.



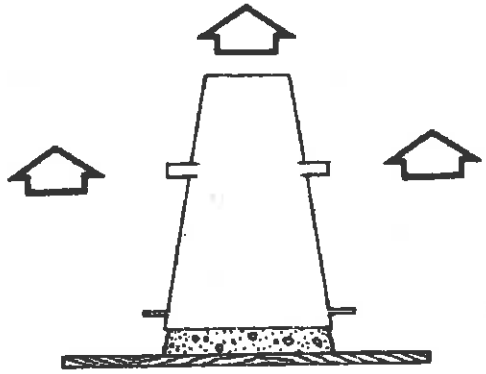
5. Fill the cone to overflowing and rod 25 times, as before. The excess concrete should be above the top of the mold.



6. Strike off the excess concrete with the tamping rod, using a screeding and rolling motion. Clean excess concrete from around the bottom of the mold.

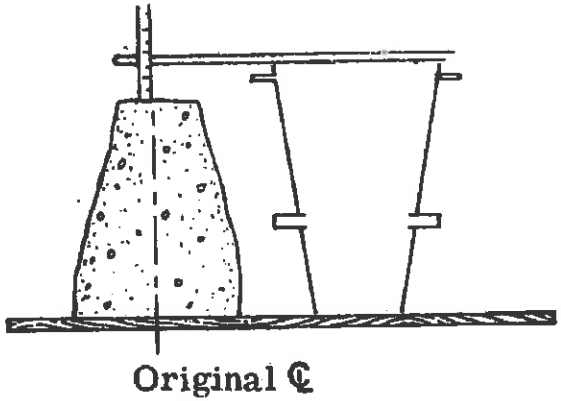


7. Grasp the cone tightly by holding the handles, step off the footholds, then remove the slump cone by gently raising it vertically immediately after step 6. Do not twist while raising.



You have approximately 3 to 7 seconds in which to raise the mold, so be sure to pull straight up on the cone in one motion. Remember, the cone must be removed within 2.5 minutes after the test begins.

8. Place the tamping rod on the inverted slump cone (extending across the center of the specimen), then measure the difference between the top of the slump cone and the displaced original center of the top surface of the slumped concrete. Measure to the nearest ¼ inch (5 mm).



SLUMP TEST RESULTS

For information about slump ranges, check the most recent FDOT Standard Specifications and Supplemental Specifications for your project -- and for each project, check the special provisions.

If you doubt the results of the test, or if the slump is outside the range, run the test again immediately. If the second test shows that the slump is outside the slump range, contact the Contractor so that adjustments can be made to successive loads. Unless otherwise instructed by your Project Engineer, you will reject for use all concrete that has a slump in excess of the permissible range.

Finally, report your results. All results must be reported -- whether the concrete passes or fails your tests.

Slump Test results should be marked on the bottom of the truck ticket, and the type of test noted: Initial (I), Intermediate verification (IV), Acceptance (A), etc.

Clean the equipment thoroughly immediately after the test has been completed.

QUIZ

The galvanized metal mold is called a _____.

Slump tests measure the _____ of concrete.

A 2-1/4-inch(57mm) slump refers to a 2-1/4-inch(57mm) difference between the top of the _____ and the _____.

What time limit must be observed for performing a slump test from the time of taking the sample?_____

QUIZ, continued

How is the slump cone held in place while you are filling it? _____

How deep should you rod the top layer in the slump cone? _____

When rodding a layer, how many strokes should be near the edge of the cone?_____

How should the mold be removed? _____

Should the mold be twisted as it is removed? _____

What is done to the slump cone before it is stored? _____

Before a slump test begins, what four preparations must be completed?

_____
_____
_____
_____

QUIZ, continued

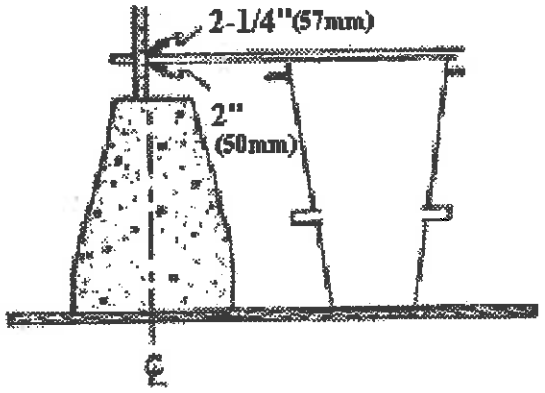
The concrete layers in the slump cone should be rodded in a _____ pattern toward the center.

After the final layer of concrete is rodded, what should be the level of the concrete in the slump cone?

____ A. Higher than the top of the mold

____ B. Level with the top of the mold

____ C. Slightly below the top of the mold



What is the slump of the concrete tested at the right?

_____

ABOUT LEARNING

Most persons learn best, and retain learned information best, by taking the time necessary to answer quiz-type questions in writing. No one will know if you skip this part of the training -- but tests consistently indicate that persons who skip the quizzes gain little time and learn less.

Learn at your own pace. If you miss answers, reread the material and answer the questions correctly before going on. This course becomes more advanced later on, so it is best to clear up difficulties as you go.

ANSWERS TO QUESTIONS

Page 2-10

- slump cone
- consistency
- slump cone
  displaced original center of the top surface of the slumped concrete.
- begin testing within 5 minutes of taking the sample

Page 2-11

- by standing on its footholds
- just deep enough to penetrate its middle layer
- about half of total
- pull straight up with one motion
- no
- it is washed clean
- select site away from heavy equipment and vibration;
  be sure board is level;
  be sure equipment is available and clean;
  moisten the slump cone and base

Page 2-12

- spiral
- A (so there is concrete to strike off)
- 2 inches (50 mm)

CHAPTER THREE

Air Content Tests

CONTENTS

3

AIR CONTENT TESTS

PURPOSE OF AIR CONTENT TESTS

The air content of fresh concrete is tested to determine if it is sufficient to give the concrete the necessary design requirement. Entrained air is used to make the concrete more durable -- to withstand freezing and thawing. Air entrainment is accomplished by adding an air-entraining admixture -- usually in liquid form -- to the mixing water during batching.

Different tools and methods may be used to test for air content. This course will present the volumetric method for performing air content tests using the Roll-A- Meter. The air content of the concrete is determined as a percentage of the total concrete volume. This information is used to control the amount of air-entraining admixture being added at the plant.

In this chapter we will discuss the method of testing air content of concrete using the Roll-A-Meter. This method can be used to test freshly mixed concrete containing any type of aggregate, whether it may be dense, cellular, or lightweight.

PERFORMING AIR CONTENT TESTS USING THE VOLUMETRIC METHOD

(ROLL-A-METER)

Consult FM I-T 196 before performing Air Content Tests on the Job.

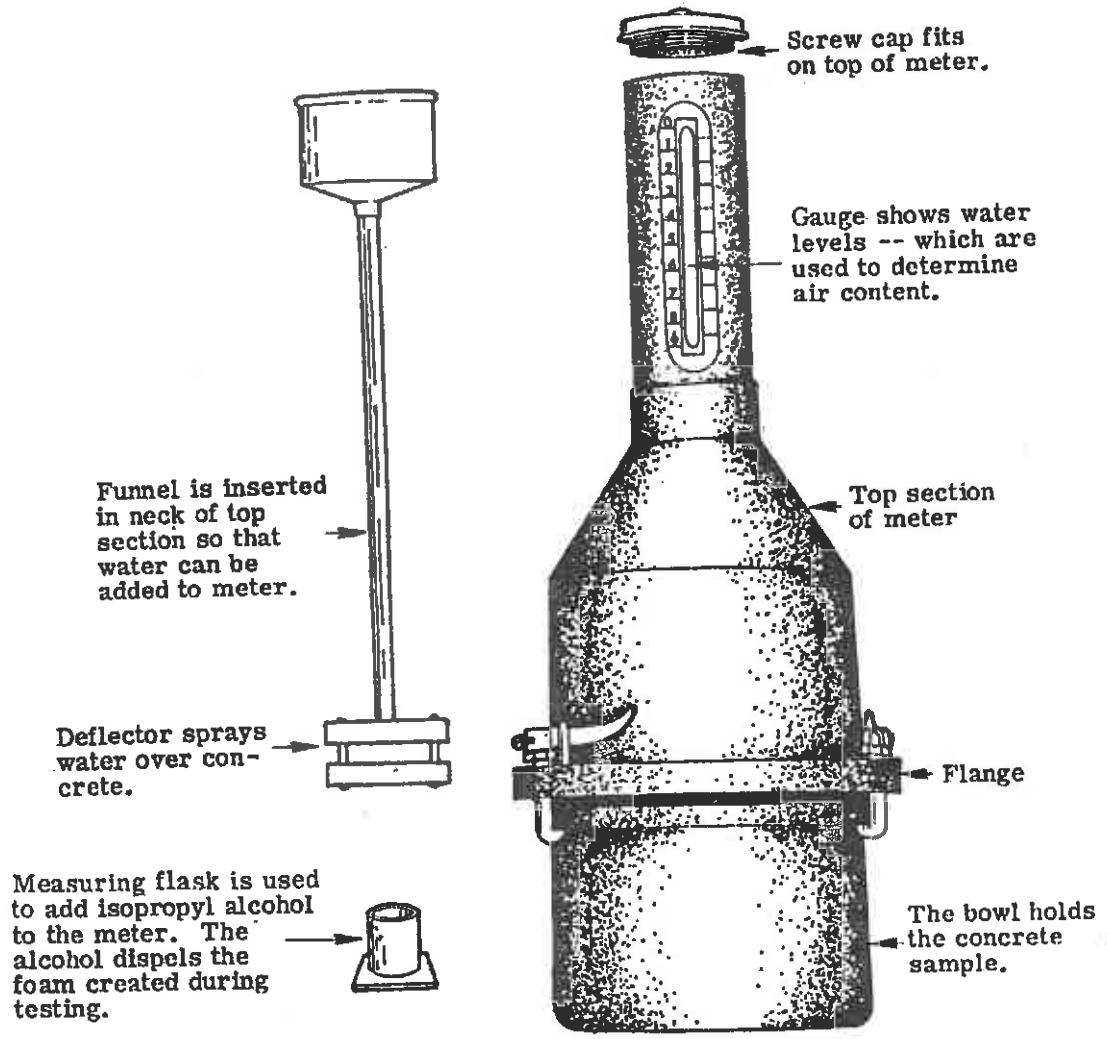
EQUIPMENT

You will need the equipment listed below to perform an air content test using the Roll-A-Meter:

- a Roll-A-Meter, including a funnel and a small measuring cup;
- a tamping rod;
- a scoop;
- isopropyl alcohol;
- a syringe;
- a rubber or rawhide mallet; and
- a strike-off bar.

The major parts of the Roll-A-Meter are described below.

ROLL-A-METER



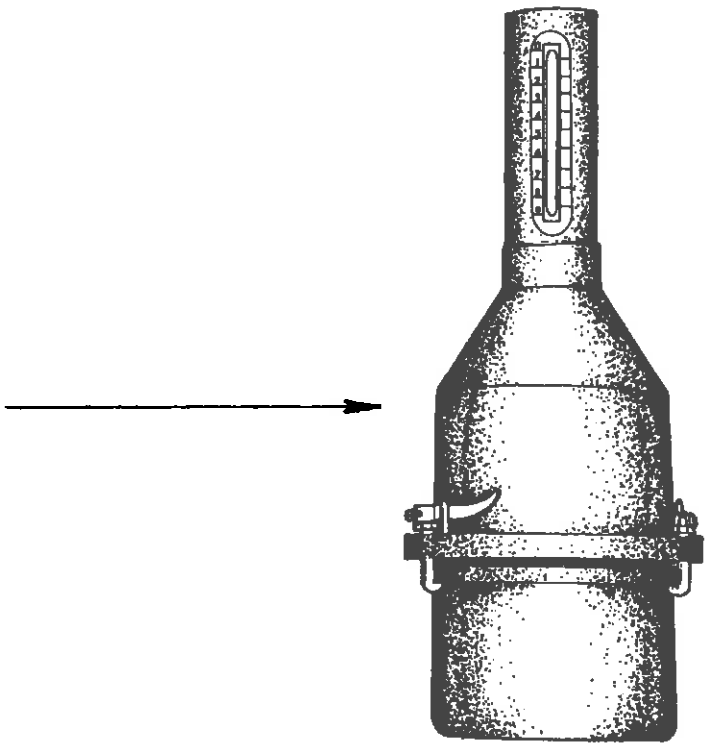
PROCEDURES

1. Fill the bowl with concrete in 3 equal layers. The concrete must be evenly distributed. Rod each layer 25 times and tap the side of the bowl with the mallet 10 to 15 times after each layer is rodded, or until no large air bubbles appear on the surface. Each rodding should just penetrate the previous layer.

2. Strike off the excess concrete with the strike-off bar, using a sawing motion.

3. Clean the top of the bowl and the flange.

4. Remove the screw cap from the top section, wet the rubber gasket in the flange, and clamp the top section over the bowl.

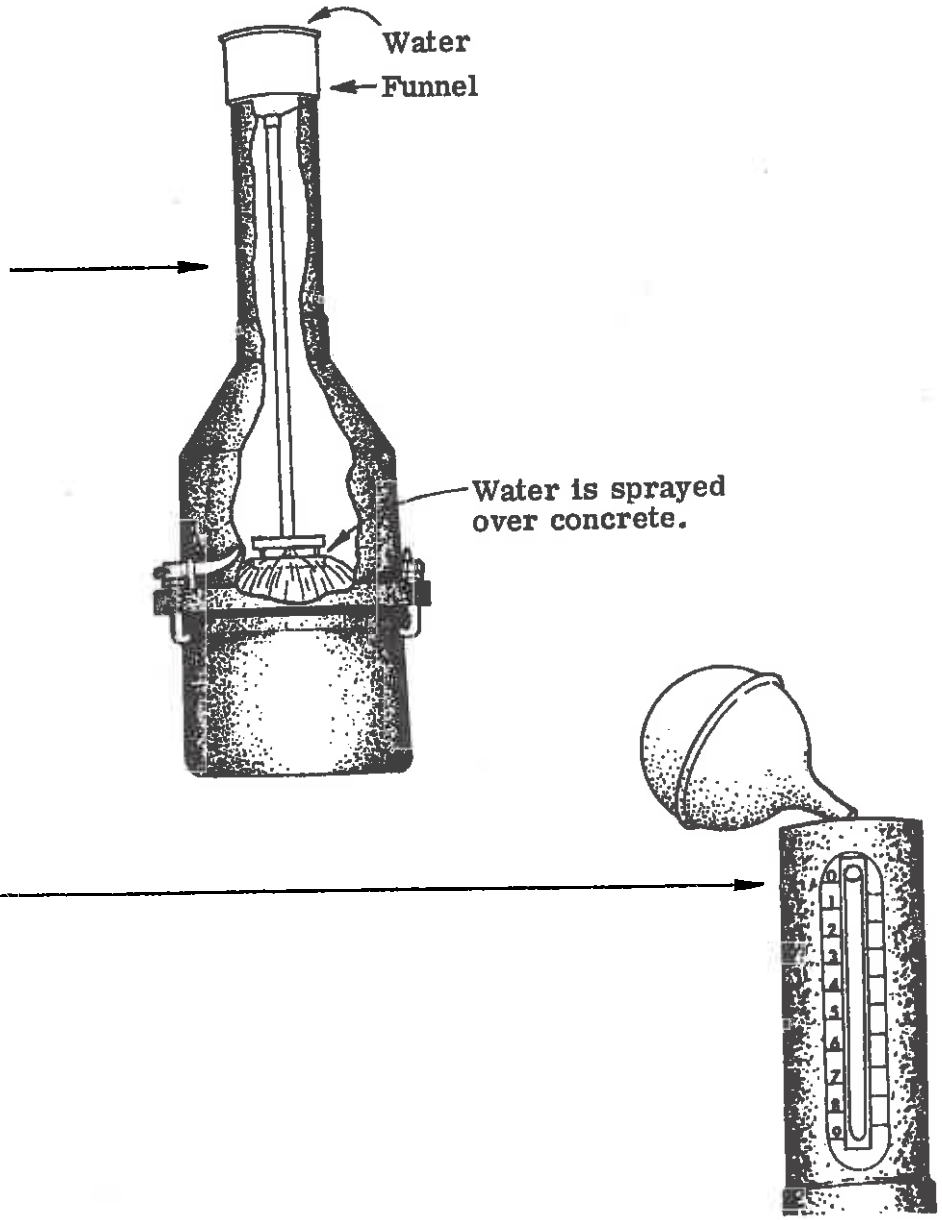


5. Insert the funnel all the way down into the top opening.

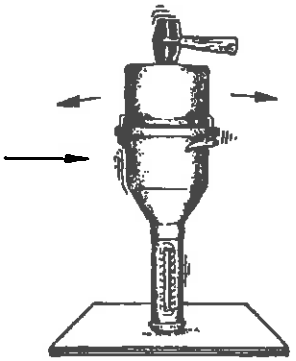
6. Add water through the funnel until the water level appears in the sight glass on the gauge, then remove the funnel.

7. Adjust the water level by adding water with the syringe until the bottom of the water meniscus is level with the zero mark.

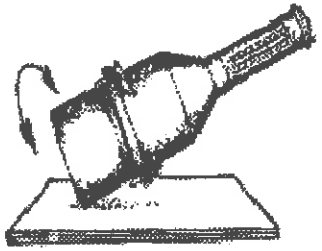
8. Wet the gasket on the screw cap, and screw it onto the meter.



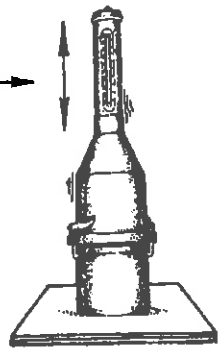
9. Turn the meter upside down and rest the top on the plywood, then tap the Roll-A-Meter with a mallet (holding the flange) until all the concrete settles free from the base. The construction of some meters may not be sufficiently sturdy to allow this procedure without damaging the meter. Invert and agitate repeatedly for a minimum of 45 seconds until the concrete settle free from the base. Each time the meter is inverted, it will not be for more than five seconds at a time (This is incompliance with ASTM C 173M which is the procedure required for the ACI Level I Concrete Field Test).



10. With the neck elevated, roll and rock the unit until the air appears to have been removed from the concrete.



11. Set the meter upright and jar it lightly and allow it to stand until the air rises to the top.



12. When the air rises to the top, the water level should be below the zero mark.

13. Repeat the operation of inverting, rocking and rolling until you observe no further drop in the water level.

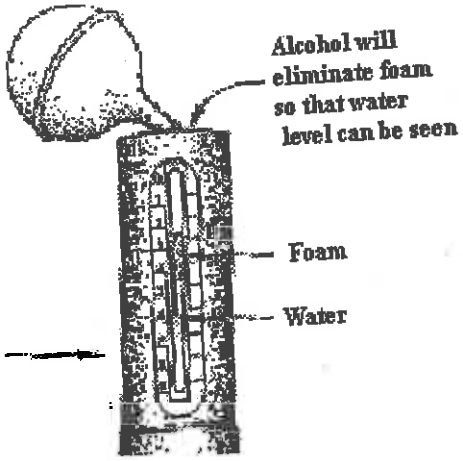
14. Remove the screw cap.

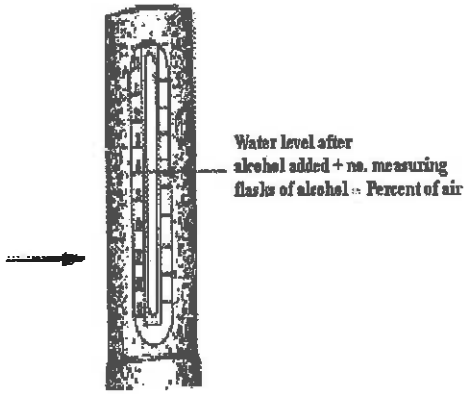
15. Wait until no more air bubbles appear. While you are waiting, you can go ahead and cast your cylinders. We'll discuss cylinders later.

16. Add isopropyl alcohol in one measuring flask 8 fl. oz (235 ml) increments until the foam on the surface of the water disappears. Keep track of the number of measuring flasks of alcohol that are added. Use the syringe to suck the alcohol out of the measuring flask and to spray it across the top of the foam.

17. Read the meter to the nearest 0.1%. The correct amount of entrained air is obtained by adding the number of measuring flasks of alcohol used to the gauge reading.

Before taking the quiz, review the procedures once more.





AIR CONTENT TEST RESULTS

For information about air content ranges, check the most recent FDOT Standard Specifications and Supplemental Specifications for your project -- and for each project, check the special provisions.

If you doubt the results of the test, or if the air content is outside the range, immediately run the test again. If the second test shows that the air content is outside of the range, contact the Contractor so that adjustments can be made to successive loads. Unless otherwise instructed by the Project Engineer, reject for use all concrete that has an air content outside of the permissible range.

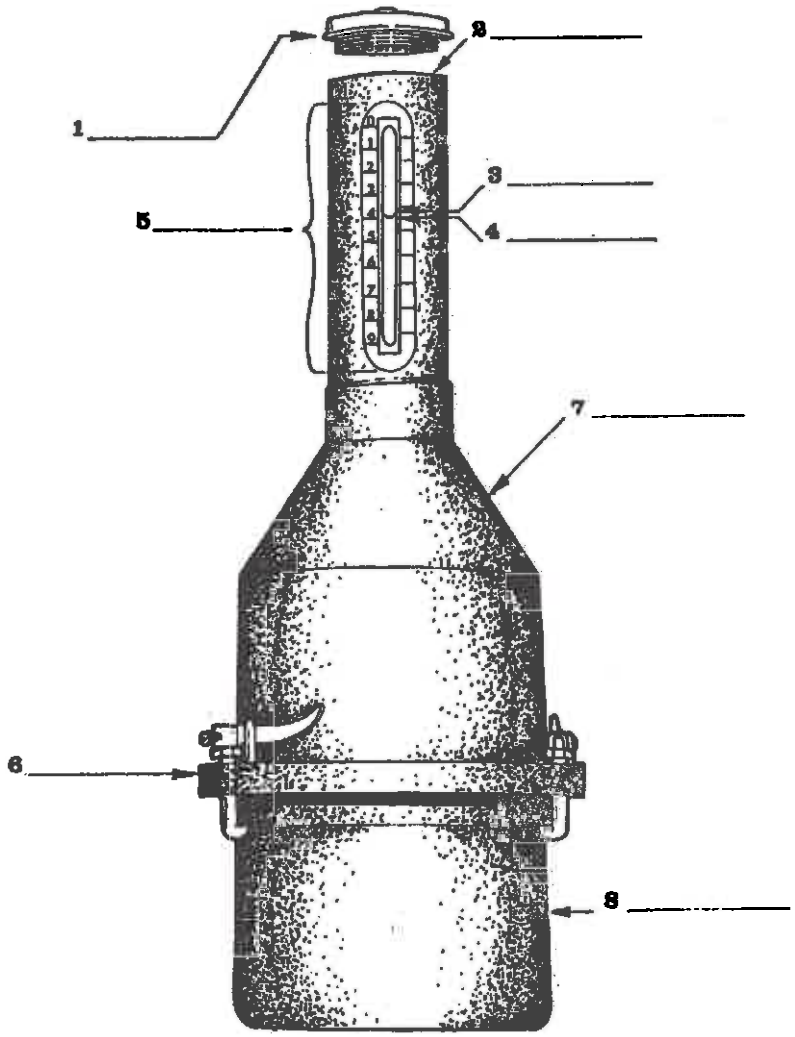
Finally, report your results. All results must be reported -- whether the concrete passes or fails your tests.

Air Content test results should be marked at the bottom of the truck ticket, and the type of test noted: Initial (I), Intermediate Verification (IV), Acceptance (A), etc.

Clean equipment thoroughly immediately after the test has been completed.

QUIZ

Identify the numbered spaces at right.



QUIZ, continued

The Roll-A-Meter can be divided into two sections, which are called the _____ and _____.

Each layer of concrete must be rodded _____ times.

Each layer of concrete should be tapped _____ to _____ times or until no large _____ appear on the surface.

You should strike off the excess concrete with the _____ using a sawing motion.

Water should be added until the water level approaches the _____ mark.

After the screw cap is tightened, you should check for _____ where the top section and the bowl meet. The next step is to _____.

What is used to dispel foam in the meter? _____

Alcohol can be added so long as the water level does not go over the _____ mark.

If the final water level reading on the meter is 3.5 (3-1/2) after you have added 2 measuring flasks of alcohol, what is the corrected air content reading? _____

ANSWERS TO QUESTIONS

Page 3-10

1. screw cap
2. top opening
3. top of meniscus
4. bottom of meniscus
5. gauge
6. flange
7. top section
8. bottom section (bowl)

Page 3-11

- bowl
  top section
- 25
- 10
  15
  air bubbles
- strike-off bar
- zero
- leaks; turn the meter upside down
- isopropyl alcohol
- zero
- 5.5 %

CHAPTER FOUR

Concrete Strength Tests

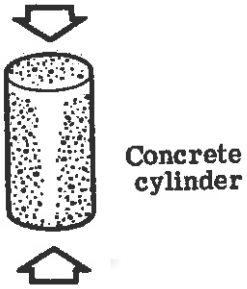
CONTENTS

4

CONCRETE STRENGTH TESTS

PURPOSE OF CONCRETE STRENGTH TESTS

Concrete strength test specimens are made to check whether the concrete incorporated into the work has the required strength.



Compressive strength tests indicate the ability of the concrete to resist compression.

We will discuss the procedures for making cylinders on the following pages.

COMPRESSIVE STRENGTH SPECIMENS

Concrete cylinder test specimens are made, cured, protected and transported in accordance with the requirements of FM 1-T 023.

You must begin casting cylinders for compressive strength tests within 15 minutes after the sample is obtained. Remember -- try to keep the sample protected from wind and sunlight. In this section we will discuss first how to cast concrete cylinders, then how to store and cure them.

CASTING CYLINDERS

Equipment

You will need the following equipment:

- 6- inch diameter and 12- inch deep cardboard or plastic molds;
- a scoop;
- a blunted trowel;
- a tamping rod; and
- plastic sheeting or plastic bags.

The first step is to select a location that is removed from construction equipment -- so that ground vibrations will not affect the cylinders.

Note: Cylinder molds must not be used more than once.

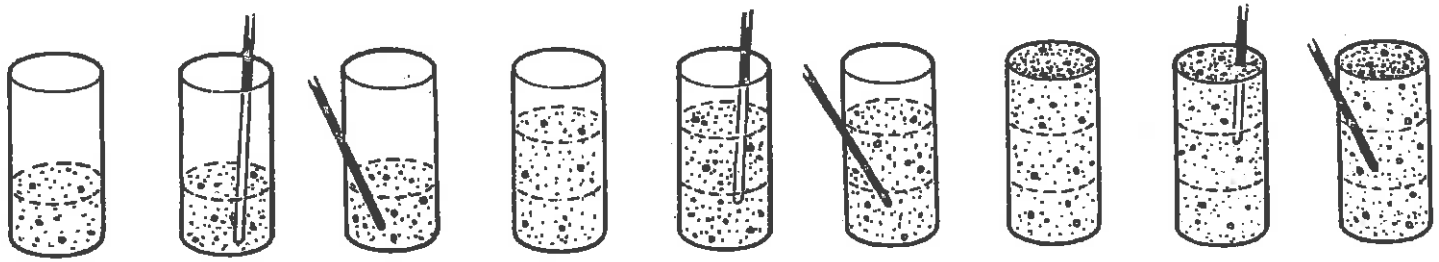
Procedures

Cylinder molds must be placed on rigid, level surfaces.

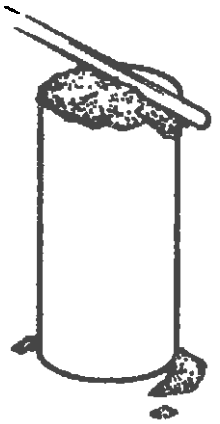
A cylinder mold is filled much like a slump cone:

Fill the mold in three equal layers, by volume. Rod each layer with the tamping rod 25 times in a circular pattern, just penetrating into the previous layer. If additional concrete is needed to fill the mold, add while rodding. Be sure that each layer is distributed evenly, so that no air pockets are created. If cardboard molds are used, take care not to penetrate the sides or bottoms of the molds. Care should be taken also to prevent cardboard molds from bulging or elongating.

After each layer is placed and rodded, lightly tap the outside of the mold with an open hand to close any holes left by rodding to release any large air bubbles that may have been trapped.



For each cylinder, strike off the excess concrete with the tamping rod using a screeding and rolling motion and level the top of the concrete. Smooth with a trowel.



Cover the molds with the plastic sheeting or tight plastic bags. This will help to keep the moisture in the concrete. If you're using plastic molds, use the plastic caps that come with the molds -- they serve the same purpose.

STORING AND TRANSPORTING CYLINDERS

Cylinders can be moved immediately after being struck off, provided extreme care is taken to prevent any damage to the molds or the struck off surface of the concrete. Otherwise, do not move the cylinders for 24 ± 8 hrs after casting. During this initial curing period, the cylinders will be maintained in a temperature environment between 60 and 80°F. ASTM C 31 and Florida Test Methods require specimens to be demolded in 24 ± 8 hrs. and standard cure started if specimens are not to be transported prior to 48 hours after casting.

Specimens to be transported prior to 48 hrs. after casting will not be demolded, but will continue initial curing at 60 to 80°F (16 to 27°C) until time for transporting. Specimens to be transported after 48 hrs. after casting will be demolded in 24 ± 8 hrs., and standard cure started.

During the standard curing period, the cylinders are removed from the molds and immersed in saturated lime-water, to be maintained at 73.4 + or - 3 degrees F (23 + or -1.7 degrees C) for the remainder of the 28 day cure period. Make sure that the demolded cylinders are completely under water until they are shipped to the lab. Don't remove the cylinders from the molds if they are to be shipped to the lab prior to 48 hours after molding.

During shipment, the cylinders should be carried in stable racks or wet sawdust -- any jarring or bouncing could harm the cylinders and affect the test results. Also, the cylinders should be kept damp during shipment. Wet burlap or wet sawdust does a good job.

QUIZ

Why are the sides of cylinder molds tapped? _____

You must begin casting cylinders within _____ minutes after the sample is obtained.

Cylinders should be covered with _____ or _____or _____.

Cylinders shouldn't be moved from the casting location for _____ hrs.

During standard cure the cylinders must A) be demoulded
or
B) remain in the mold _____.

During standard cure the cylinders should be totally immersed in _____.

The standard cure temperature for demolded cylinders is _____.

ANSWERS TO QUESTIONS

Page 4-7

- to eliminate voids in the fresh concrete
- 15
- plastic sheeting
  plastic bags
  plastic caps
- 24 ± 8hrs.
- A
- saturated lime water
- 73.4 + or -3 degrees F (23 + or -1.7 degrees C)

CHAPTER FIVE

Concrete Placement Operations

CONTENTS

CONTENTS, continued

5

CONCRETE PLACEMENT OPERATIONS

If needed, falsework, forms and reinforcement are erected and set in place.* Then the contractor will be ready to begin placing concrete. This phase is the most critical operation in building a concrete structure. Previous operations can be corrected without too much trouble, but replacing concrete is probably the most costly and time-consuming rework. For this reason, all possible efforts should be made to make the concrete placement properly.

In this chapter, we will discuss concrete equipment, concrete placement and consolidation, and concrete finishing and curing.

Let's begin our discussion with a review of the equipment which may be used.

---

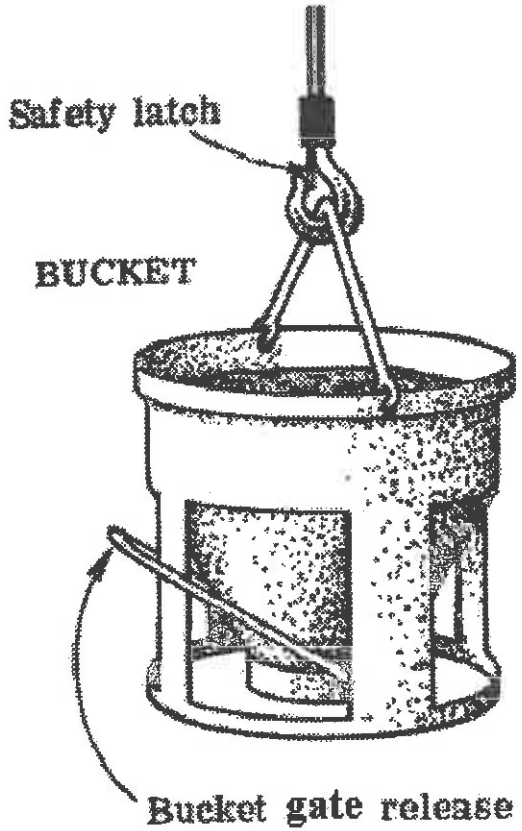
* Falsework, forms, reinforcement and other aspects of structure construction are covered in Structures I, Structures II and Structures III.

EQUIPMENT

There are several types of equipment which may be used to place concrete. Most Contractors use a crane and bucket. Other acceptable methods are conveyor belts, pumps, and chutes.

BUCKETS

A bucket, like the one shown on the right, is suspended from the crane. The crane swings the bucket to a waiting concrete truck which discharges its load into the bucket. The crane then swings the bucket directly over the location of the desired concrete placement. One of the workers releases the concrete by opening the bucket gate.



As an Inspector, you must watch the following:

- The bucket must be supported, while being loaded, to keep the bucket out of mud and dirt. A support, such as a piece of 4' by 4' plywood may be used.
- The bucket gate must be mortar tight, and must be closed before the bucket is loaded.
- The hook-up must have a safety latch.

- Ample manpower must be provided.

  - If the crane operator cannot see the bucket discharge point, then a signal person must be used.

  - Two or more people should handle the bucket -- at discharge.

  - At least two vibrators should be at the work site -- one vibrator should be in operation, and one vibrator as a stand-by.

CONVEYOR BELTS

Conveyor belts are used when concrete must be moved over long distances. Concrete is placed directly onto conveyor belts which carry the concrete to the desired placement location. In order to prevent contamination of the concrete, you must be sure that belts are kept clean and are dampened before use. A good way to do so is to be sure a scraper is installed at the discharge point. Also, the belts should be washed with water after use. Long conveyor belt systems may need to be covered in hot weather to prevent evaporation of water from the mix.

When conveyor belts are authorized by the Department to transport concrete to its final destination, you should be sure of the proper working condition of the equipment by checking for the following:

- All parts of the conveyor must be intact, in good repair and properly supported (not resting on reinforcing steel). Struts may be required to prevent knocking holes in the forms.

- Belts must be tight and running level to prevent concrete spill.

- The conveying device must be free of dried concrete. Baffles must be correctly spaced and the strike-off must be at the correct level.

- A baffle or "elephant's trunk" should be used at the end of the belt, to avoid segregation of the coarse aggregate and mortar.

- Samples must be taken at the discharge end of the conveyor belt.

- Conveyor belt systems shall not exceed a total length of 550 linear feet (168m).

PUMPS

The Department may authorize the use of equipment which will pump the concrete into position. Your responsibilities will be similar, but most importantly, the specified slump and air of the concrete must be maintained.

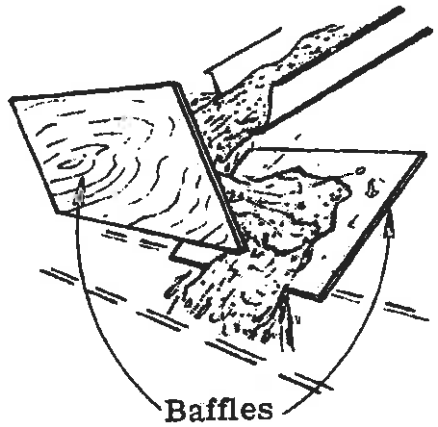
When a concrete pump is used, you must be sure that the hoses are lubricated. Hoses usually are lubricated by pumping cement grout through them. This grout is then wasted. During pumping operations, the hoses must be kept as cool as possible, since rises in the temperatures in the hoses will change the plastic properties of the concrete. The hoses can be kept cool by placing wet burlap over them and continuously wetting them with water.

Since concrete plastic properties may change in the hoses, you must take your concrete samples from the discharge end of the hoses. A dry run should be made to be sure all equipment is in proper working condition before placement begins.

Pump lines must be a minimum of 4 inches (100mm) in diameter.

CHUTES & TREMIES

Concrete may not be dropped freely more than 5 feet. Chutes or tremies called elephant trunks are used when concrete must drop more than 5 feet into the forms. Usually, chutes are connected to transit-mix trucks -- so that the concrete is mixed and then carried directly into the forms. When chutes or troughs are used under steep slope conditions, they should be equipped with baffles or be used in short lengths to alter the direction of movement. This will minimize segregation.



Again, it is important to keep chutes and tremies free from dried concrete and dirt. They should be flushed with water before and after use. If dried concrete or dirt get mixed in with the fresh concrete, that portion of the concrete should be rejected.

QUIZ

What type of equipment usually is used to move concrete over long distances? _____

Concrete is released from the bucket by opening the bucket _____.

Conveyor belts should be cleaned after use by _____.

Why is it important to avoid contamination of fresh concrete? _____

Concrete must be moved 30 feet down a hill to the forms. If chutes are used, which method would be better?

____ A. Six 5-foot sections, zigzagging down the hill
____ B. Two 15-foot sections, as straight and direct as possible

In the text we discussed the working condition requirements for each part of a conveyor belt system. We said that all parts must be intact, in good repair and properly supported. What are the things you should check on the following parts?

Belt:_____ Baffles:_____
Conveying Device:_____ Strike-Off:_____

What minimum pump line diameter is required ?_____

Concrete may not be dropped freely more than _____ feet.

QUIZ, continued

Why must buckets be supported on something like plywood at loading points? _____

There are two important safety points that must be considered before a bucket is filled. What are they?
_____ and _____

If a crane operator is not able to see the bucket discharge point, what must the Contractor do? _____
_____

May the contractor use concrete pumps or conveyor belts at his own choice? _____

What is the most common type of equipment used for placing concrete? _____

When concrete is pumped or handled by conveyor belts, the samples are taken at the _____ end of the hoses or belts.

Chutes used for placing concrete on a steep slope use _____ to minimize segregation.

What is the reason for having at least two vibrators at a work site? _____

What maximum total length of conveyor belt system is allowed _____.

CONCRETE PLACEMENT

PREPARATIONS FOR CONCRETING

The Contractor must give sufficient advance notice as to when he intends to start placing concrete. This will allow you, the Inspector, enough time to check the forms for alignment and the reinforcement for proper spacing and cover. Also, the forms and reinforcing bars must be given a final check for cleanliness. All sawdust, chips and any other debris from the interior of the forms must be removed.

Before concrete is placed, there are other things to be checked:

- Before any concrete is placed in the form, all water should be drained from the forms.

- Approved equipment must be on hand for placing concrete in every part of the structure. The equipment must be the proper types, in the numbers needed, and in good working condition.

- Shovels, rakes and other miscellaneous hand tools for spreading the concrete must have handles long enough to reach all parts of the forms, and the vibrators must be checked to see that they are in good condition. An extra vibrator and an extra power source must be on hand in case of breakdowns.

- You must be sure that all embedded fixtures are in their correct positions and are solidly fastened. After all reinforcement has been placed, a special check should be made to be sure that tubes or inserts for any required weep holes -- drain holes -- have been installed and have not been displaced.

- When rain is expected, the Contractor should be discouraged from placing concrete; however, if the Contractor insists on proceeding, some kind of material (polyethylene, etc.) should be available to cover the concrete which has been placed. The cover will not be needed if the weather is good -- but when rain begins or is imminent, the Contractor should cover the concrete quickly.

- Concrete should not be placed in the rain. You don't want rain water getting into the concrete. If it starts to rain during a placement, discontinue placing concrete and concentrate on protecting (covering) the concrete already placed. Forming a bulkhead or construction joint may be necessary.

PLACING CONCRETE

The forms should be wetted before the concrete is placed. But, water should not be allowed to form puddles within the forms. The methods used to place concrete will, to a great extent, determine what the finished product will be like. Improper handling during placement can turn a good concrete mix into a poor finished product. For this reason, you need to pay particular attention to the methods used by the Contractor. Two things you should remember: (1) never permit extra water above that allowed in the design mix to be added to increase workability and (2) do not permit the vibrators to be used to move the concrete mix from one place to another.

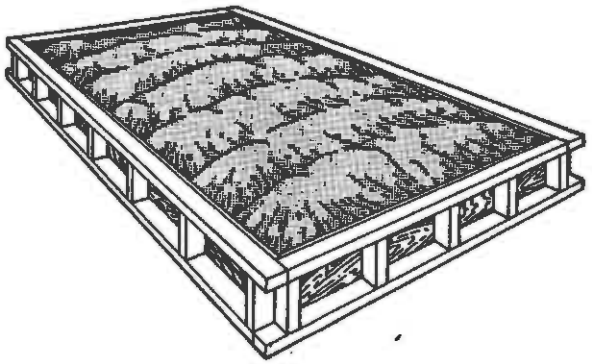
To obtain a uniform mass of concrete, the rate of placement must be timed so that each layer does not reach initial set before the next layer is placed. The maximum time interval between the placing of successive layers should not be more than 20 minutes, unless the Project Engineer determines that the initial set has not occurred. If it does set, the bond between the layers will be poor. This will result in a plane of weakness which can cause a failure in this part of the structure. The Contractor should regulate his operations so that the interval between deliveries of concrete does not interrupt the placement operations. The Standard Specifications and Supplement Specifications for your project require minimum placement rates for certain types of placements. You should be sure that the Contractor is prepared to meet the time intervals before the concrete is placed. The method and sequence of placing concrete should be approved by the Project Engineer. In addition, concreting should be done during daylight hours. If permission is obtained for night placement, suitable artificial lighting must be provided by the Contractor for both the placing and testing operations.

The Contractor should provide sample and satisfactory equipment for conveying concrete from the mixer to the final position in the forms. Closed chutes or pipes -- also called tremies and elephant trunks -- must be used when the concrete is to be dumped or dropped more than 5 feet. Where short, steep slopes are required, open chutes can be used if they are equipped with baffles, or are in short lengths which will enable the direction of movement to be reversed.

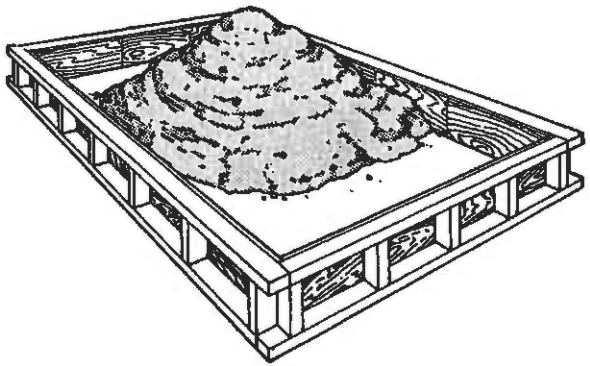
Care should be taken to fill each part of the form by depositing the concrete as near final position as possible. Only square ended shovels should be used to move concrete. When moved, the concrete tends to segregate. Usually, the rock tends to stay where it was dumped and all that moves is the mortar and fine material. Watch this work closely. Once the concrete is placed it should be moved as little as possible.

The placing should start in the corners and at one end and progress in uniformly placed layers within the forms, as shown below:

THIS

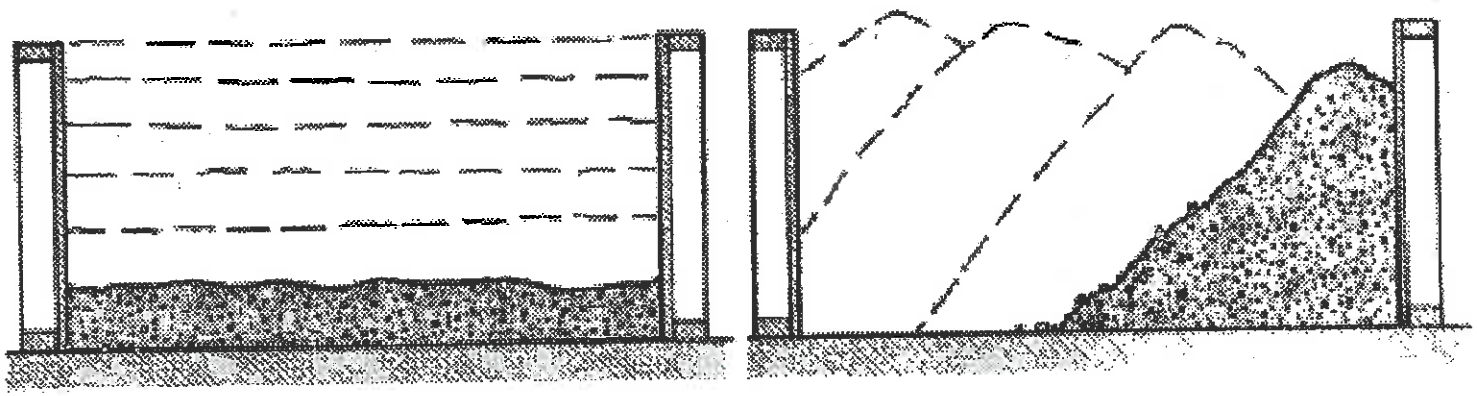


NOT THIS



When concrete is being placed in walls or other long, narrow sections, you must be sure that a uniform depth is maintained. Also watch that the layers are not more than12 inches (300 mm) deep to ensure adequate consolidation. Layers 6 to 12 inches (150 to 300 mm) in depth are about right for easy handling. When concrete is placed on a slope, placement should start at the bottom of the slope.

Concrete layers that are allowed to slope can become segregated. Here again, you will end up with areas of weak concrete.



Even layers keep the mix uniform.
This is the correct method.

Piling the mix segregates the larger aggregates from the rest of the mix.
This method is incorrect.

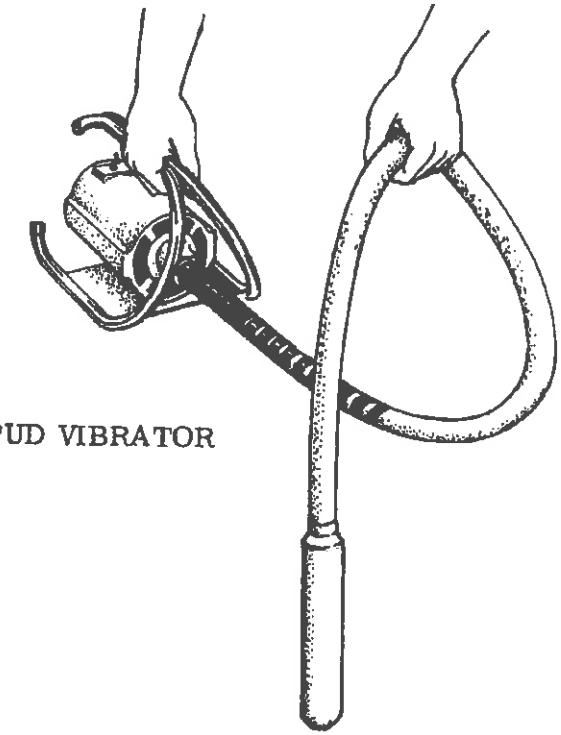
As an inspector, you must know the temperature limitations to concreting. Concrete in cold or hot weather are spelled out in the Standard and Supplemental Specifications. Standard requirements for concrete temperatures are shown in Chapter One of this book.

CONSOLIDATION OF CONCRETE

As concrete is placed, it will contain areas with undesirable voids. If it were left this way, the concrete would have a rough surface and questionable strength. To eliminate the undesirable voids, the concrete must be consolidated to a uniform density while it is being placed.

EQUIPMENT

Vibrators are used to consolidate the concrete. The portable spud-type vibrator shown here is the most common type.



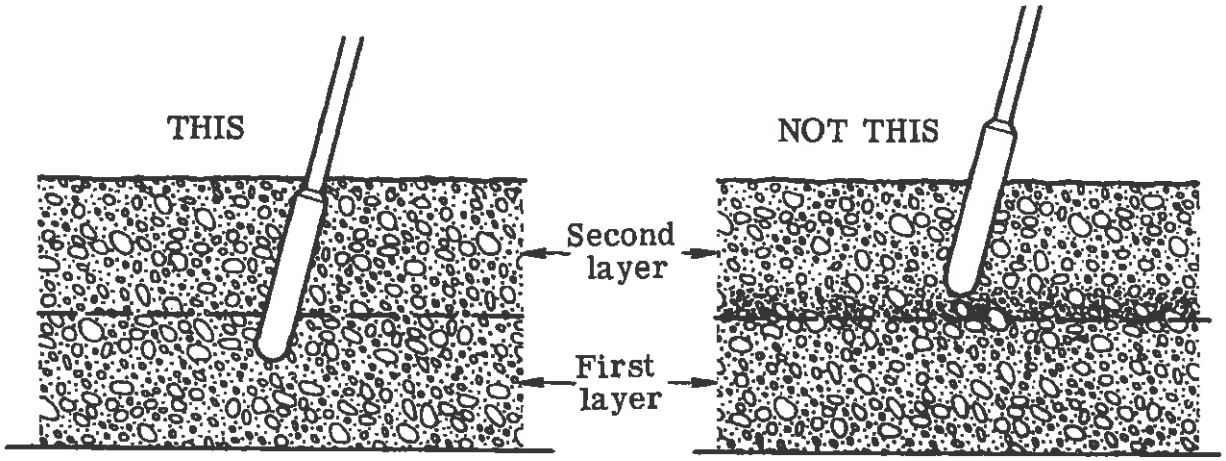
SPUD VIBRATOR

Inspection

As an Inspector, you must be sure that the Contractor's workers use vibrators effectively. Improper vibration will result in segregated concrete and ultimately a weak structure. Below are some important points which you must verify to obtain dense and well consolidated concrete.

- Vibrators should enter and leave the surface vertically. This prevents possible segregation at the surface.
- A glistening surface generally indicates sufficient vibration and 5 seconds at a particular location is usually adequate.
- Care should be taken to be sure that vibrators are not used to move the concrete in the forms. This will cause segregation.
- There should be enough workers and equipment to consolidate the concrete at the same rate as it is being placed.

- In multilayered placements, concrete must be placed in layers less than 300 mm (12 inches) and each layer of concrete must be vibrated after it is placed. However, allow the vibrators to penetrate the previous layer approximately 2 inches (50 mm) to permit good mixing of the layers.



- The vibrators should not rest against reinforcing steel bars which extend from concrete that may have taken an initial set. The vibrations will break the bond between the concrete and the bars.

- Vibrators should not touch the inside surfaces of the form walls. This will cause a double vibration that can loosen the forms and weaken the supports. This also causes segregation against the form walls.

- The Contractor will have a stand-by vibrator, and all vibrators must have a sufficient length of line to reach all areas within the forms.

Undesirable Consolidation Practices

Tools used in concrete consolidation tend to tire a worker faster than most other tools do. For this reason you should be watching for tendencies toward shortcuts and sloppy work. A poorly consolidated job will decrease the strength of the concrete. Properly consolidated concrete will be more uniform, stronger, more durable and will require less patching of honeycomb. Some undesirable shortcuts to look for might include:

- Treating the vibrator like a fishing rod. When an operator throws the vibrator out on the surface of the concrete and drags it back toward him, it has a tendency to segregate the concrete.

- Overvibration. When overvibration occurs, the surface of the concrete appears wet and consists of a layer of mortar containing little coarse aggregate. This top layer will be weak and will deteriorate quickly.

- Using the vibrator to move the concrete around within the forms. This practice causes segregation. Concrete should be placed as close to its final position as possible. Concrete can be placed with chutes, tremies and, when necessary to move it, use square-ended shovels.

- Using a dirty vibrator. This practice will introduce material into the concrete which will weaken the structure and increase the possibility of future failures.

In each case described above, you should contact the Contractor's foreman to have the situation corrected.

QUIZ

Forms must be checked for proper _____ and _____ .

Reinforcement must be checked for proper _____, _____, and _____.

Provisions must be made for draining the forms, so that_____.

In order to reach all parts of the structure, hand tools must have _____.

QUIZ, continued

Spreading concrete with vibrators will cause the concrete to _____.

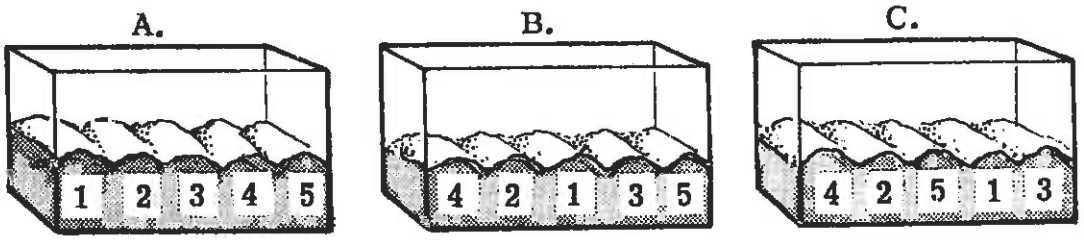
If concrete is placed on a slope, from where should the placement start? _____

What should workers use to spread concrete? _____

If concrete pumps are being used to place the concrete, may the Contractor add water to the mix to create a high slump concrete? _____

During placement, concrete should not be dropped more than _____ feet (meters) unless closed chutes or tremies are used.

The diagrams below represent a culvert wall. Which diagram shows the best order of concrete placement?
_____



QUIZ, continued

For ease of handling, layers of concrete in walls should be between _____ and _____ inches (mm) deep.

What causes concrete to segregate when it is dropped more than 5 feet (1.5m)?_____

Is the rate of placement of concrete important in producing a uniform mass of concrete?_____

Are vibrators an acceptable means for moving concrete? _____

Voids in concrete are eliminated by _____ with vibrators.

Vibrators should enter and leave the surface _____.

If vibrators are used to move concrete, what will happen to the concrete?_____

Why must vibrators not rest against reinforcing steel?_____

QUIZ,continued

Overvibration will most likely leave an excess of _____ on the surface of the concrete.

Although there is no set amount of time a vibrator must be left in the concrete, _____ seconds usually is adequate.

In multilayered placements, must each layer be vibrated? _____

If the concrete is being overvibrated, what step should you take to correct the situation? _____

The maximum time between the placing of successive layers should not be more than _____ minutes.

Is it Ok to allow rain to fall on either freshly placed concrete or concrete being transported and placed ?____

FINISHING PLASTIC CONCRETE

Once the concrete has been placed and consolidated, it needs to be finished to the proper elevation. The method the Contractor uses to finish the concrete depends on what element is being constructed. Small areas, like tops of walls, are finished with wood floats. Larger areas, like the floors and tops of box culverts, may be finished using screeds that move back and forth over the tops of the forms, then the surface is float finished . Still other placements require more specific finishes. The Standard Specifications and Supplemental Specifications for your project will specify finishes. The Standard Specifications and Supplement al Specifications for your project will specify the class of finish required for any specific element. Then requirements for that Class of finish will also be described in the specifications.

The Contractor must finish the concrete to the required elevations -- as shown in the plans. That is why the forms are graded before the concrete is placed. The concrete must be placed and finished to the exact grades specified in the plans.

FINISHING HARDENED CONCRETE

Finishing surfaces should begin immediately after the forms are removed. Here are the different types of finishes:

- General Surface Finish -- given to all concrete surfaces
- Class I Surface Finish
- Class II Surface Finish
- Class III Surface Finish
- Class IV Floor Finish
- Class V Applied Finish Coating

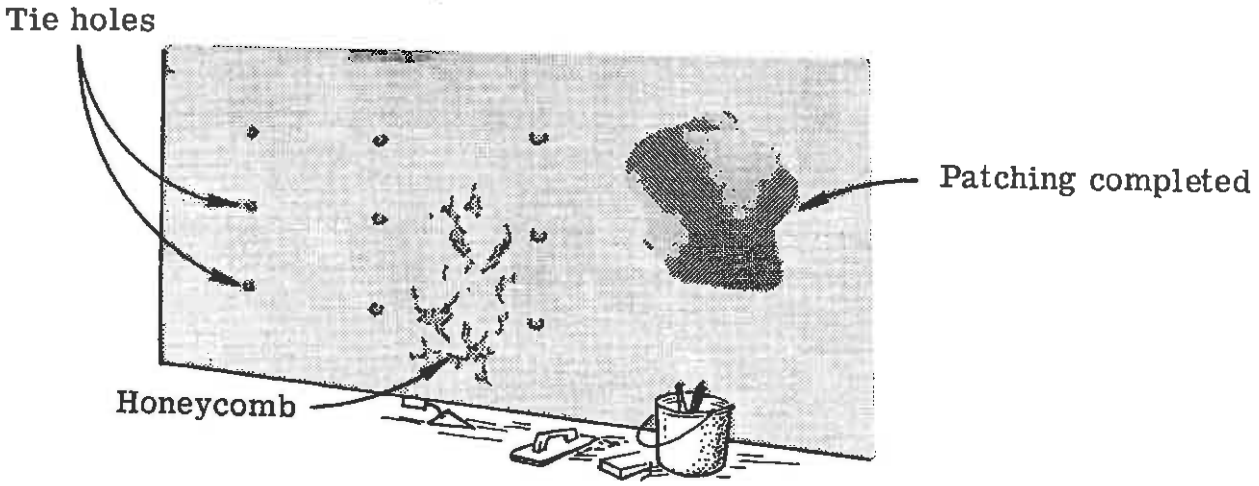
A General Surface Finish is required on all exposed concrete surfaces. In addition to the General Surface Finish, one of the special finishes shown above may be required. Let's start by looking at the requirements of the General Surface Finish.

GENERAL SURFACE FINISH

Immediately following removal of the forms, all fins and irregular projections should be removed from all surfaces which are to be exposed.

Concrete placed in forms will generally have a fairly smooth surface when the forms are removed. When these surfaces are not seen, the only finishing needed is to fill holes left by ties or honeycomb. Honeycomb may form in areas where the concrete was not vibrated thoroughly. If the structure is to receive an Applied Finish Coat, the General Surface Finish must be performed with greater care.

Repairing small holes like the tie holes and minor honeycomb by using a trowel is called "pointing." Large areas are repaired by patching.



Small areas of honeycomb are repaired by chipping out loose and weak concrete until sound, solid concrete is exposed. Large areas or many small areas of honeycomb indicate that vibration was insufficient during placement. If there is excess honeycomb, the entire section may need to be removed and replaced. You should discuss this with the Project Engineer before repairs are started.

Before tie holes or honeycombed areas are repaired by pointing (using a small trowel for repair):

- all loose materials must be removed;
- the holes must be cleaned; and
- the exposed concrete must be saturated with water.

Pointing should be performed as soon as possible after removal of forms. Mortar used for pointing should be mixed in the same proportion -- cement and sand -- used in the class of concrete being finished. It should be thoroughly worked into the holes and then blended in with the other concrete. Also, this mortar must be allowed to take an initial set, then it must be reworked. Do not allow the workers to just plaster a patch over the hole.

In addition to the above requirements, be sure all construction and expansion joints in the completed work are free of mortar and concrete. The joint filler must be left exposed for its full length with clean and true edges.

CLASS I SURFACE FINISH

The purpose of a rubbed finish is to improve the appearance of those areas of concrete that are exposed to view. By using a rubbed finish, air bubbles, blemishes and marks in the concrete (caused by either the forms or the strike-off and finishing operations) can be removed. The concrete should have as smooth and even a surface texture as possible.

After completion of the general surface finish, all surfaces which will receive a rubbed finish should be thoroughly saturated with water. Also, holes repaired by pointing should have thoroughly set. The surfaces are then rubbed, using a medium-coarse carborundum stone in a circular motion to produce a paste on the surface. Be careful to observe that the carborundum stone is not used until the concrete has hardened enough so the sand will grind, not ravel or roll. A grout should be worked up by the stone itself -- make sure that the workers don't put mortar on the stone. Rubbing should continue as long as needed to remove any form marks and imperfections or until a smooth dense surface without pits or irregularities is obtained. However, rubbing should stop before it causes exposure of the coarse aggregate. The paste produced by this rubbing should be left in place.

The final surface finish is then obtained by thoroughly rubbing the concrete with a fine carborundum stone and water. This final rubbing should be done after the curing period has expired. Rubbing should continue until the entire surface has a smooth texture and is uniform in color and appearance. Care should be taken to avoid contamination by dust, mud or other foreign matter.

CLASS V APPLIED FINISH COAT

At the Contractor's option, he may give the concrete A Class V Applied Finish Coat rather than a Class I Surface Finish .

Preparations for the Applied Finish Coat include a General Surface Finish to fill any air pockets or honeycombs. If it is necessary, the General Finish Coat is supplemented by using an approved grout to smooth the surface. The grout is applied by using burlap pads or float sponges.

As soon as the grout has taken an initial set, the surface is brushed to remove all loose grout. The surface must be smooth and free of air holes, dirt, oil, flaking and dust.

When the Contractor begins spraying on the applied finish coat, be sure that he applies the texture coat at the rate indicated by the manufacturer's instructions. You should also be sure that he sprays with the correct color texture coat. The required color can be found on the plans or in the Special Provisions.

If, for any reason, application of the Applied Finish Coat is delayed, a second inspection of the surface is necessary.

CLASS II SURFACE FINISH

As soon as the mortar that was used for pointing up has set, the exposed surfaces are saturated with water and rubbed with a medium-coarse carborundum stone. The rubbing continues until the surface has been ground to a paste and all form marks, irregularities, and projections have been removed.

After the surface has a smooth finish, the material that has been ground to a paste is brushed to a uniform texture, and it is allowed to reset.

CLASS III SURFACE FINISH

Where a Class III finish is required, the forms used must be either metal or wood with a form liner.

After the concrete has been placed and consolidated, all exposed surfaces that aren't held by the forms are finished to produce a texture that will look as much as possible like the surface produced by the forms. Usually, this is done by finishing with a steel trowel. Pointed areas can be rubbed with a dry carborundum stone, or can be worked by another method to make all surfaces look alike.

CLASS IV FLOOR FINISH

Before any finishing is done, a 10-foot (3.048-meter) straightedge is used on the fresh concrete to detect any unevenness. Any irregularities of more than 1/8-inch (3 mm) must be corrected immediately. After the water sheen disappears from the surface and before the concrete attains its initial set, the concrete surface is finished to a uniform texture using a burlap drag, fine bristle broom, belt or float.

If a belted finish is used, the belt must be at least (2 feet) 0.6 m longer than the surface to be finished. The belt is laid down parallel to the centerline and is dragged back and forth along the length of the concrete to form a herringbone pattern.

Broomed finishes are applied across the surface -- perpendicular to the centerline. The broom is drawn across the concrete in long, even strokes.

Whichever method is used -- belting or brooming -- the surface must be given a uniform texture, forming regular corrugations not more than 1/16-inch (1.5 mm) deep.

QUIZ

Small areas such as tops of walls are struck off with _____.

Why is it necessary to grade the forms before placing concrete? _____

Honeycomb indicates that the concrete was not sufficiently _____.

Mortar to be used in pointing and patching must be allowed to take an _____, then it must be reworked before being used.

What three things must be done to tie holes and honeycombed areas before they are repaired?

_____
_____
_____

Surfaces which will receive an Applied Finish Coat should first receive a _____ finish.

QUIZ

Initial rubbing should be done in a _____ motion to produce a paste on the surface.

The rubbing is done with a medium-coarse _____ stone and water.

In the General Surface Finish, all _____, _____, _____ and _____ must be corrected.

Before a Class IV Floor Finish is applied, a _____ (foot) meter straightedge is used to detect any irregularities larger than _____ inch (mm).

If a belt is used for a Class IV Finish, the belt must be at least _____ (feet) meter longer than the surface to be finished.

If a Class IV Finish is to be broomed, the broom is drawn _____ to the centerline.

Belted and broomed Class IV Finishes must not leave corrugations more than _____ (inch) mm deep.

CURING CONCRETE

Concrete gains strength as the chemical action -- called hydration -- between the cement and water takes place, binding the aggregate together. This means that the water must be kept inside the concrete to allow hydration to take place. If the concrete dries out, hydration will stop and hairline cracks could develop. To prevent this from happening, the concrete curing (preventing water from evaporating from the concrete) must begin as soon as possible after placement in a manner which will produce sound, strong, durable concrete. Concrete will cure best at temperatures of about 70°F (21°C) and should be kept moist for at least 72 hours. Bridge decks require 7 days curing.

If forms are kept in place for the time specified in the specifications, without loosening, no further curing is needed for surfaces covered by the forms. If forms are removed prior to three days, then curing must begin by another approved means. The two most common methods of curing concrete are:

- water curing and
- membrane-forming curing compounds.

Either method may be used unless specified in project specifications. The time to start the curing period is after the finishing operation is completed and just about the time the water sheen leaves the surface of the concrete. When the forms are left tightly in place, they act as protection for curing the concrete.

For curing concrete in environments of temperature extremes, check project specifications for concreting in cold and hot weather.

WATER CURING

Water and polyethylene-coated burlap or white polyethylene sheeting are the materials needed for water curing. Moisture is applied completely and continuously to the concrete surface, then the coated burlap or sheeting is placed over the moist concrete. You should know, however, that this method of curing is permitted only where burlap or sheeting can maintain contact with the entire concrete surface. Burlap or sheeting should be placed when concrete has hardened enough to prevent marring the surface texture of the concrete.

Concrete surfaces must be kept completely and continuously moist. Curing must be continued for a period of at least 72 hours.

MEMBRANE-FORMING CURING COMPOUNDS

Membrane-forming curing compounds are liquids that form watertight seals when sprayed on concrete surfaces. They must be applied uniformly, much like fog sprays, at a minimum rate of 1 gal per 200 ft^2 (0.2 L/m^2) of concrete. These compounds contain pigments. The pigments tend to settle, so the liquids should be well agitated before application.

The coat is applied immediately following acceptance of the concrete finish, just about the time the water sheen leaves the concrete surface. The concrete should not be allowed to dry out. The compound can be applied just as the surface film of water disappears.

The compound should be protected against marring after it is applied. If the membrane is marred or broken within 72 hours, it should be repaired immediately.

No membrane curing compound is allowed if concrete will be placed on the layer being cured -- such as construction joints -- unless it is specifically allowed by the Engineer, in which case the curing compound residue will need to be removed by sand or water blasting before the surface of the curred concrete receives fresh concrete. However, these areas should be cured by other means. Possible other curing methods include wet burlap, wet sand and curing blankets. Remember that burlap and sand must be kept continuously wet for 72 hours.

Where burlap or sheeting is required for curing concrete, a membrane curing compound may be required for initial curing, until the concrete hardens enough to allow placing burlap or sheeting without marring the finished concrete surface. Check your project specifications.

QUIZ

The chemical action between water and cement is called _____.

Curing should start about the time when the _____ disappears from the surface.

The curing period for concrete is generally _____ hours, unless otherwise specified.

Curing compound is applied at a minimum rate of 1 gal./_____ sq. ft. (_____ L / m^2).

Before coated burlap is placed, the concrete surface should be sprayed with _____.

Concrete cures best at a temperature of about _____.

Before curing compounds are applied, they must be _____ in their containers.

ANSWERS TO QUESTIONS

Page 5-7

- conveyor belts
- gate
- flushing with water
- contamination can cause weak spots in finished concrete
- A
- tight, level
  free of concrete
  correct spacing
  correct level
- 4 inches (100mm)
- 5 (1.5m)

Page 5-8

- so buckets stay clean
- door must be closed; safety latch in place
- use a signal person
- no, only when approved by the Department
- crane and bucket
- discharge
- baffles
- the second one is a standby in case of breakdown
- 550 feet (168m)

ANSWERS TO QUESTIONS, continued

Page 5-17

- alignment
  cleanliness
- spacing
  cover
  cleanliness
- no water is trapped within the forms
- long enough handles

Page 5-18

- segregate
- the bottom
- square-ended shovel
- no
- 5 (1.5)
- A

ANSWERS TO QUESTIONS, continued

Page 5-19

- 6 (150)
  12 (300)
- mortar splashes around while the rock stays in place
- yes
- no
- consolidation
- vertically
- it will segregate
- they will break the bond between the concrete and the bars when initial set has occurred

Page 5-20

- mortar
- 5
- yes
- inform the foreman
- 20
- No

ANSWERS TO QUESTIONS, continued

Page 5-29

- wooden floats
- to set the correct elevation to which concrete should be placed and struck off
- vibrated (consolidated)
- initial set
- remove loose material;
  clean holes;
  saturate exposed concrete with water
- general surface

Page 5-30

- circular
- carborundum
- air pockets
  honeycomb
  form marks
  projections
- 10 (3.048)
  1/8 (3)
- 2 (0.6)
- perpendicular
- 1/16 (1.5)

ANSWERS TO QUESTIONS, continued

Page 5-33

- hydration
- water sheen
- 72
- 200 (0.2)
- water
- 70°F (21°C)
- agitated

That completes your study of Portland Cement Concrete, Testing, Placement and Control.

When you feel that you understand the subject matter, take the Review Quiz. If you do well on the Review Quiz, you should have no trouble with the Examination.

GOOD LUCK

CHAPTER SIX

Review Quiz

Things which you learned in this course are going to help you do a better job as an Inspector. This Review Quiz is designed to help you know how well you have learned. It will also help to prepare you for the Examination.

Listed below are instructions on how to take the quiz.

1. Do not take this quiz immediately after you finish the last chapter of the course. Wait one day or more.

2. Do not cram the night before you take the quiz. Remember that the objective is not to test your memory. The objective is to help you evaluate how well you have learned the material and how well you can think through your everyday work problems.

3. When you take this quiz, make sure that you will not be disturbed for about an hour.

4. Attempt all questions.

5. You may refer to the course material if you get stuck on a question. But first try to reason out the problem.

6. Finally, keep track of your incorrect answers. Instructions on how to grade yourself follow the Review Quiz. If you score less than 90% on the quiz, do not be disappointed. Go back and study the course materials once again and reattempt the quiz.

6

REVIEW QUIZ

Portland cement concrete consists of:

_____
_____
_____

Aggregate is bound together by a _____ formed by mixing portland cement and water.

The galvanized metal mold used for slump tests is called a _____.

A concrete mixer truck arrives at the job site without an Identification and Acceptance Card. What do you do? _____

A concrete mixer truck arrives at the job site without any rating plates. What do you do?
_____

A concrete mixer truck arrives at the job site with a non-working revolution counter. You look at the Identification and Acceptance Card and see that the counter was broken yesterday. What do you do?

_____

A concrete mixer truck arrives at the job site with a non-working revolution counter. You look at the Identification and Acceptance Card and see that the counter was in good order yesterday. What do you do? _____

Water is added to a load of concrete at a job site. What is the minimum number of mixing revolutions that the mixer must make after the addition? _____

An agitating truck arrives on the job. It was loaded at the plant at 2:00 P.M. Retardant has been added to the mix. By when must the load be completely discharged? _____

The delivery ticket for a 8 cubic yard (6 m^3) load gives the following information:

- Coarse aggregate total weight is 1722 pounds per cubic yard (1022 kg/m^3) with 2% moisture;
- Fine aggregate total weight is 1225 pounds per cubic yard (726 kg/m^3) with 5% moisture;
- Batch water is 21 gallons per cubic yard (104 L/m^3);
- 10 gallons (38 L) of water is added at the job site; and
- Cement weight is 658 pounds per cubic foot (390.5 kg/m^3).

What is the water/cement ratio? _____

Samples taken from stationary and truck mixers should be taken from which portion of the batches?_____

Slump tests measure the _____ of concrete.

A 2-inch (50 mm) slump refers to a 2-inch (50 mm) difference in height between the top of the slump cone and_____.

A slump cone can be firmly held in place by standing on the _____.

A slump test should begin within _____ minutes after the sample is obtained.

How deep should you rod the top layer of concrete in the slump cone? _____

When rodding a layer, how many strokes should be around the edge of the slump cone? _____

How should the slump cone be removed from the specimen? _____

Each layer of concrete in a slump cone should be rodded _____ times.

Excess concrete in a slump cone is struck off with a _____.

In measuring the slump, your answer should be rounded to the nearest _____ Inch (mm).

Where should the plywood base for concrete tests should be placed? _____

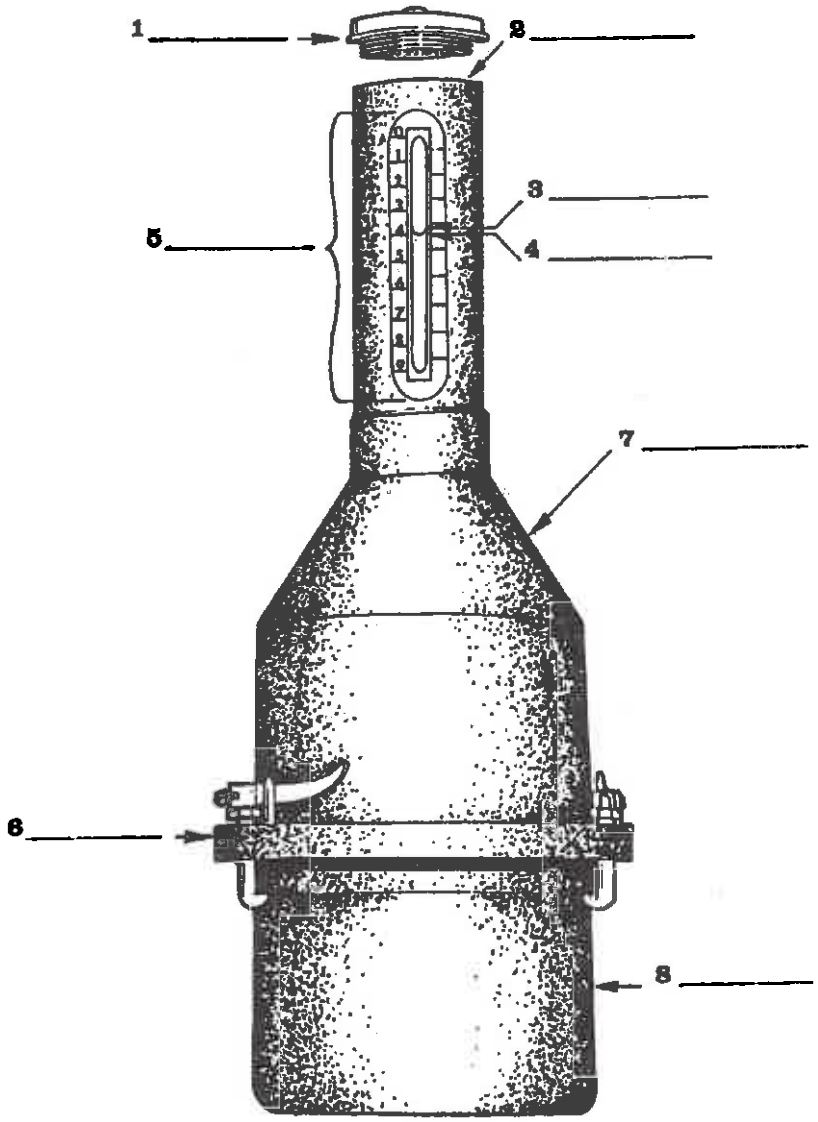
What is the time limit for beginning a slump test? _____

Casting cylinders must begin within _____ minutes after the sample is obtained.

Why are the sides of cylinder molds tapped with an open hand? _____

Where are cylinders marked? _____

Identify these numbered spaces:



The Roll-A-Meter can be divided into two sections, which are called the _____and the _____.

Each layer of concrete in the bowl of the Roll-A-Meter must be rodded _____ times.

Each layer of concrete should be tapped _____ to _____ times, to release large _____ from the surface.

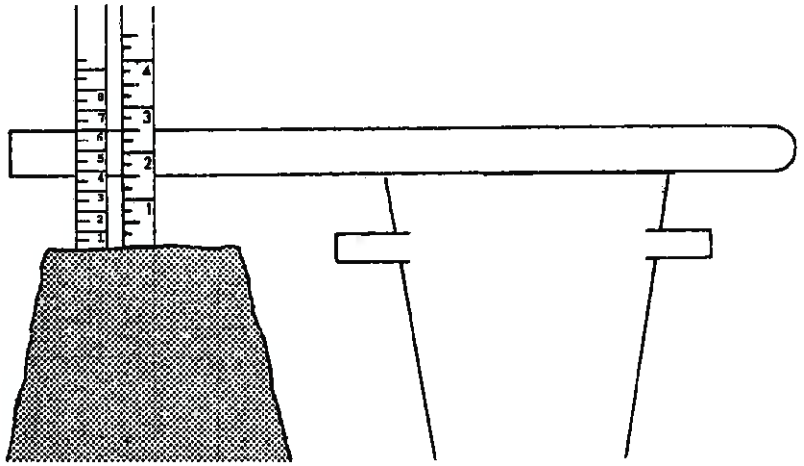
You should strike off the excess concrete with the _____ using a sawing motion.

Water should be added until the water level approaches the _____ mark on the gauge.

What is the most important thing to watch for when cylinders are being transported?

_____

What is the slump of the concrete in the diagram below? Slump _____



If conveyor belts are used in concrete placement, a _____ should be used at the end of the belt.

Chutes are used when concrete must be dropped more than _____ feet (meter).

Is the rate of placement important in producing a uniform mass of concrete? _____

Can extra water be added to concrete to make it more suitable for movement? _____

The maximum time allowed between placement of successive layers is _____ minutes.

Only _____ shovels should be used to move concrete.

Spreading concrete with vibrators is not permissible, since it will cause the concrete to _____.

Concrete layers _____ to _____ inches (millimeter) are best for handling.

Placement on a slope is started _____.

_____ are used to consolidate concrete.

What finish is required on all exposed concrete surfaces? _____

Repairing small holes like tie holes is called _____

The chemical action between water and cement is called _____

Concrete will cure best at temperatures around _____ °F (°C).

During curing, concrete should be kept moist for _____ hours.

Now to grade yourself on the Review Quiz, total your incorrect answers. There are about 70 answers in the quiz.

If you scored less than 90% -- that's more than seven incorrect answers -- go back and study the parts of the course that gave you trouble. Then, take the Review Quiz again. When you can answer the Review Quiz questions correctly, you will have no trouble with the Examination.

ANSWERS TO QUESTIONS

Page 6-2

- water
  aggregate
  Portland cement
- paste
- slump cone
- reject the concrete
- reject the concrete

Page 6-3

- reject the concrete
- accept the concrete, note the deficiency on the Card
- 30
- 3:30 P. M.
- 0.42

ANSWERS TO QUESTIONS, continued

Page 6-4

- middle third
- consistency
- the displaced center of the top of the slumped specimen
- footholds
- 5
- deep enough to just penetrate the middle layer
- half of the total
- pull straight up in one continuous motion

Page 6-5

- 25
- tamping rod
- 1/4 (5)
- on firm, level ground away from vibrations
- 5 minutes after taking the sample
- 15
- to eliminate voids in the concrete
- on one end

ANSWERS TO QUESTIONS, continued

Page 6-6

1. screw cap
2. top opening
3. top of meniscus
4. bottom of meniscus
5. gauge
6. flange
7. top section
8. bottom section (bowl)

Page 6-7

- bowl
  top section
- 25
- 10
  15
  air bubbles
- strike-off bar

ANSWERS TO QUESTIONS, continued

Page 6-8

- zero
- cylinders must not be jarred or bounced
- 1-1/2 inch (40 mm)

Page 6-9

- baffle or "elephant trunk"
- 5 (1.5)
- yes
- no
- 20
- square ended
- segregate
- 6 (150)
  12 (300)
- at the bottom

Page 6-10

- Vibrators
- general surface finish
- pointing
- hydration
- 70 (21)
- 72

SUBJECT INDEX

This document was promulgated at an annual cost of $14.84 per copy to provide training for the Construction of highway transportation facilities by the Department of Transportation, Consultants, Contractors and the Citizens of the State of Florida.