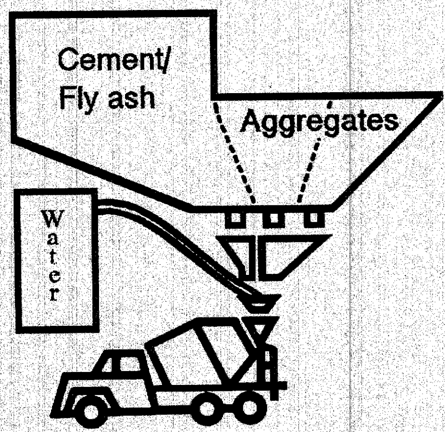
PORTLAND CEMENT CONCRETE PLANT INSPECTION MANUAL



TRUCK MIX PLANTS

U.S. Department
of Transportation
Federal Highway Administration

**Office of Engineering
Construction and
Maintenance Division
Materials Branch**

PORTLAND CEMENT CONCRETE PLANT INSPECTION

" Truck Mix Plants "

INTRODUCTION

This booklet and the accompanying video were prepared to provide engineers information on those operations of portland cement concrete plants that are critical to producing quality concrete. The booklet is meant to be used as a guide when performing in-depth inspections of plant operations. It begins with a discussion of the materials used in portland cement concrete and proceeds through the batching and mixing of the materials.

The test procedures and test result values referenced in this booklet are from the American Association of State Highway and Transportation Officials (AASHTO) Materials Manual and may not directly coincide with the tests performed by any particular highway agency. However, the types of test that are recommended, if not the actual procedures or test result values, should be performed if a quality product is to be achieved.

As this booklet is to be used in conjunction with an in-depth inspection of a portland cement concrete plant, a check list of critical inspection items is included at the end of the booklet.

MATERIALS

AGGREGATES

Portland cement concrete is basically made up of two sizes of aggregate. A coarse aggregate or stone and a fine aggregate or sand. By volume, typical concrete mixes will contain around 36-40% coarse aggregate and 24-28% fine aggregate. These aggregates will generally come from pre-approved sources and the only tests that will be performed at the plant are moisture content testing to determine the amount of free water in the aggregates and gradation testing for quality control.

Specifications

AASHTO M 6 - Fine Aggregate for Portland Cement Concrete

This specification provides values for gradation, uniformity of grading (fineness modulus), deleterious substances, and soundness. The fineness modulus of the fine aggregate should not vary by more than 0.20 from the base fineness modulus.

AASHTO M 80 - Coarse Aggregate for Portland Cement Concrete

This specification provides values for deleterious substances and other physical properties including abrasion and sulfate soundness.

AASHTO M 43 - Sizes of Aggregate for Road and Bridge Construction

This specification provides a number of aggregate size designations and gives gradation ranges for each. Typical size designations for coarse aggregate used in portland cement concrete are size numbers **57**, **67** and **357.**

Tests

Moisture Content

It is recommended that the moisture content of the coarse and fine aggregates be determined at the start of each day's production. Additional testing should also be performed whenever there has been a possible change in the moisture content of the materials. Typical mositure contents are between 1.5% to 2% for coarse aggregates and 2.5% to 4% for fine aggregates.

AASHTO T 255 - Total Moisture Content of Aggregates by Drying

The basic AASHTO T 255 test procedure is to first weigh a represenative sample of the material as it comes out of the stockpile. Material should be sampled at a location that provides a representative moisture content for the entire pile. The material is then dried over a hot plate or burner or in a drying oven and re-weighed. The total moisture content can be determined by the following formula:

$$P = 100(W-D)/D$$

where:

P = the moisture content of the sample in percent;
W = the mass of the original sample and;
D = the mass of the dry sample.

AASHTO T 217 - Determination of Moisture in Soil by Means of Calcium Carbide Gas Pressure Moisture Tester

AASHTO T 217, commonly called the Speedy Moisture test, can also be used to determine the moisture content for fine aggregates. The basic test procedure is accomplished using a pressure meter. Calcium carbide is first placed in the body of the meter. A predetermined weight of fine material is then placed in the cap of the meter, the meter is sealed and then agitated to mix the calcium carbide thoroughly with the aggregate. Pressure is produced through the reaction of the moisture with the calcium carbide and a pressure reading is taken. A chart is then used to convert the pressure reading to percent moisture.

Once the moisture content of the aggregates has been determined, this value should be used to adjust the amount of water that is added to the mix when batching.

Gradation

Gradation testing should be done at the plant site on a regular basis. Typical specifications call for one test per day or one for every 500 cyds of concrete produced.

AASHTO T 11 - Materials Finer than the 75 um (No. 200)sieve by Washing

This test determines the amount of material finer than the 75 um sieve by washing. The basic test procedure is to first weigh a sample of material that has been dried to a constant weight. Wash the material with water over a 75 um sieve, dry the material and reweigh the material. The amount of material that passes the 75 um sieve is then calculated as follows;

$$A = [(B-C)/B] \times 100$$

where:

A = the percentage of material finer than the 75 um sieve,
B = the original dry mass of the sample and,
C = the dry mass of the sample after washing.

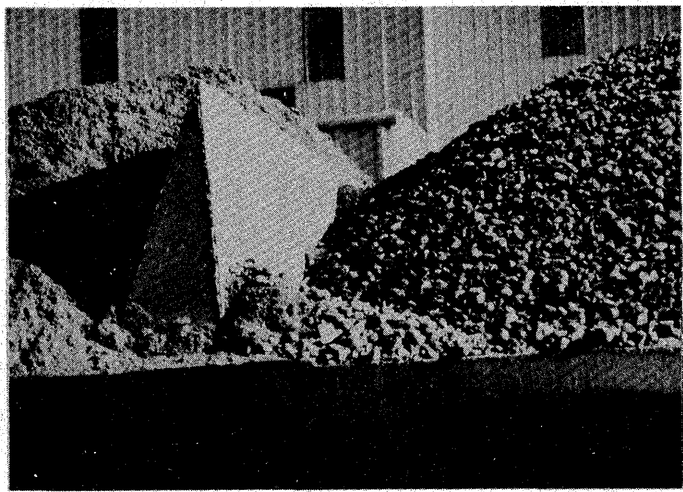
AASHTO M 80 recommends that for the coarse aggregate the amount of material passing the 75 um sieve be limited to not more than 1.0%. This value can be increased to 1.5% if the fine material is primarily produced from crushing.

AASHTO T 27 - Sieve Analysis of Fine and Course Aggregate

This test determines the partial size distribution for fine and coarse aggregates. At the plant site periodic verification of the gradation of the stockpiles should be done. The basic test procedure is to dry the material, sieve the material, and weigh the amount of material retained on each screen.

Storing and Transporting

It is important that the aggregates are stored and transported in such a manner to limit the possibility of contamination, degradation or segregation. Each size aggregate must be stored in an individual stockpile and the separation of these stockpiles must be complete. If space permits, this can be accomplished by two separate stockpiles. Where space is limited, bulkheads or dividers can be used to separate the piles.



Ideally, stockpiles should be built in layers of uniform thickness to prevent segregation. Conical shaped stockpiles will segregate along the face with coarser material dropping to the bottom.

Stockpiles should also be well drained and constructed on hard level surfaces to prevent contamination by the underlying soils.

Aggregates can be transported from the stockpiles to the feed hoppers by various means including underground belt feeds or front-end loaders. In some cases the transport vehicles will deposit the aggregates directly into the feed hoppers.

If front end loaders are used, aggregates should be removed from the bottom of the stockpile lifting through the face of the pile. This results in some mixing of the aggregate. Care should be taken not to cut too deeply to avoid taking material from the underlying soil. Segregation will occur if aggregates are pushed over from the top of the pile.

Generally, separate feed hoppers are used when transporting the aggregates to the storage hoppers. The feed hoppers should be separated to assure that the material does not overlap.

Each size of aggregate should be stored in separate storage bins, and the separation must be complete. Aggregate storage bins are generally located at the top of the plant above the weigh hoppers.

Belts and splitters should be positioned so that the aggregate drops freely into the storage bin and the drop height is not too great. Improper positioning of the belts or splitters could cause degradation or segregation of the aggregates. Baffles are generally installed to control the fall of the aggregates.

CEMENT AND MINERAL ADMIXTURES

Cement and mineral admixtures make up approximately 12% to 15% of the mix by volume and are generally accepted by certification from the supplier. Cement certifications will include the type of cement, the specification reference, and may include time of set test results.

Each agency should have a verification process for manufacturer's compliance with specifications. Some typical specifications for cement and mineral admixtures include:

Specifications

AASHTO M 85 - Portland Cement

This specification provides information on the basic chemical and physical requirements for eight types of portland cement. It also specifies the testing requirements to assure compliance with the specification.

The eight types of cement included are:

- Type I & IA - Non-specialized cement without (I) or with (IA) air entrainment. This cement will be used if no type of cement is specified.

- Type II & IIA - For general use and when moderate sulfate resistance and moderate heat of hydration is desired.

- Type III & IIIA - For use when high early strength is desired.

- Type IV - For use when low heat of hydration is desired.

- Type V - For use when high sulfate resistance is desired.

AASHTO M 295 - Fly Ash and Calcined Natural Pozzolan For Use as a Mineral Admixture in Portland Cement Concrete

The specification provides information on the chemical and physical requirements for Class F and Class C fly ash and for natural pozzolans.

AASHTO M 307 - Micro silica for Use in Concrete and Mortar

This specification provides information on the chemical and physical requirements for micro silica when used as an admixture for portland cement concrete.

Tests

AASHTO T 127 - Sampling and Amount of Testing of Hydraulic Cement

There are a number of verification tests that can be performed on portland cement. This test describes the sampling and amount of testing that is used for hydraulic cement after it has been manufactured and is ready to be offered for sale. It describes the sampling technique to be used to obtain a representative sample of the material and recommends the number of tests that should be performed to verify cement certification.

Sampling of cement can be from the distribution line or from bulk samples. In some cases, a slotted tube sampler can be used. When the tube sampler is used it is inserted into the cement container at various places and depths to obtain a representative sample. Mineral admixtures are sampled in a similar fashion.

Storing and Transporting

The cement/mineral admixture storage bins or silos are generally the tallest structures at the plant and are one of the distinctive features of a concrete proportioning plant.

Cement is generally transported to the plant by a sealed storage truck. The cement and mineral admixtures are stored in separate storage bins and the trucks are unloaded into the bins through a pneumatic hose or mechanical auger system.

It is important that the storage silos are water tight to prevent contamination. Ventilation systems should also be provided to ensure that condensation will not form inside the silo. The silos should be periodically emptied to check for caking of the cement.

WATER

In general, for concrete construction, any potable water is suitable for use. Concrete plants will use local city water if possible. However, some plants may have the water transported to the plant by truck or they may have drilled an on-site well to supply the water. Some plants will also reuse the wash water from mixer washout. The water content of the mix will vary based on the maximum water cement ratio. Maximum water cement-ratios typically range from 0.40 to 0.45.

Specifications

AASHTO M 157 - Ready Mix Concrete

This specification sets forth the general quality requirements of the water, including the wash water. The basic requirement is for the water to be clear and free from injurious amounts of oil, acid, alkali, organic matter or other deleterious material. If wash water is used, chemical limitations for the amount of chloride ion, sulfate, alkalis, and total solids are provided. However, if there is any question as to the quality of the water, the 7 day compressive strength and the time of set should be compared with a control sample. The 7 day compressive strength limit is 90% of the control and the time of set limit is from 1 hour earlier to 1½ hours later.

Tests

AASHTO T 26 - Quality of Water Used in Concrete

This test provides the procedures to follow when determining the acidity, alkalinity, and percent of total solids for water used in concrete. It also references those tests that should be performed when comparing a control sample of distilled water to the water that is proposed for use.

LIQUID ADMIXTURES

There are a wide variety of liquid admixtures that can be added to portland cement concrete. Three of the most widely used admixtures are air entraining agent, water reducing agent and set retarders. As with cement, liquid admixtures are generally accepted by certification from the supplier. Verification testing by the highway agency should include quality sampling and testing at the source and/or uniformity testing performed on samples obtained at the plant.

Specifications

AASHTO M 154 - Air-Entraining Admixture for Concrete

This specification gives tolerances for uniformity and equivalency testing when comparing a field sample to a quality control sample or to the manufacturer's specifications. This includes allowable ranges for PH, specific gravity, and the air content in mortar.

It also specifies tolerances for concrete that contains air-entraining agent. This includes bleeding, time of set, flexural and compressive strengths, resistance to freezing and length change.

AASHTO M 194 - Chemical Admixtures for Concrete

This specification provides tolerances for uniformity/equivalency testing of the admixtures and tolerances for both plastic and hardened concrete containing liquid admixtures. Seven types of liquid admixtures are listed. These types are:

- Type A - Water reducer.
- Type B - Retarder.
- Type C - Accelerator.
- Type D - Water reducer and retarder.
- Type E - Water reducer and accelerator.
- Type F - High range water reducer.
- Type G - High range water reducer and retarder.

For uniformity/equivalency testing, tolerances are specified for infrared analysis, residue by oven drying, and specific gravity.

For tests on freshly mixed concrete, tolerances are specified for slump, air content, time of set and water content.

For tests of hardened concrete, tolerances are specified for compressive and flexural strength, length change and relative durability.

Tests

Generally, no actual testing of the liquid admixtures will be performed in the field. However, uniformity/equivalency samples may be taken when required. Samples may be of the "grab" type, or the composite type. Grab samples are one grab from the storage tank. Composite samples are a combination of three or more grab samples. The inspector should be careful to completely mix the material stored in the tank before taking the sample. This can be accomplished through agitating or stirring.

Storage and transporting

The storage and handling of liquid admixtures can be critical and must be done properly. All admixtures should be stored in sealed containers.

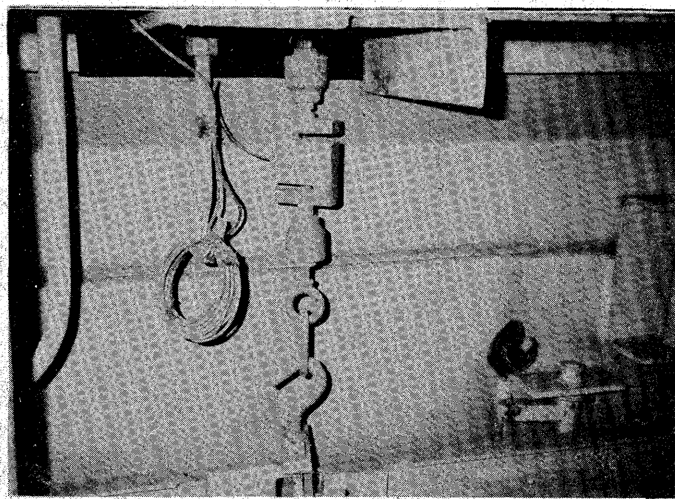
Each container should be located so as to limit adverse weather effects such as excessive cold or heat. For example, if an air entraining agent has been frozen it will lose some of its effectiveness and will not perform properly. Each admixture should be stored correctly to prevent contamination or damage. Some admixtures have a specific shelf life and this should be checked. Admixtures will also have a tendancy to settle and should be agitated or stirred on a regular basis prior to use.

BATCHING

Concrete batching is the accurate measurement of the ingredients that will be combined to form concrete. The dry ingredients including the aggregate, cement, and mineral admixture will be measured by weight. The liquid ingredients, water and liquid admixture, are generally measured by volume. Any measuring device used to proportion the ingredients must have been checked for accuracy and certified. Specifications for batching of concrete are contained in AASHTO M 157 Ready-Mixed Concrete.

WEIGH SCALES

Scales for weigh hoppers can be the beam, springless dial, or load cell type. Today most modern scales are equipped with a load sensor that measures the weight electronically. The load sensor transmits the weight of the material directly to the scale house where it is displayed as a LED readout.

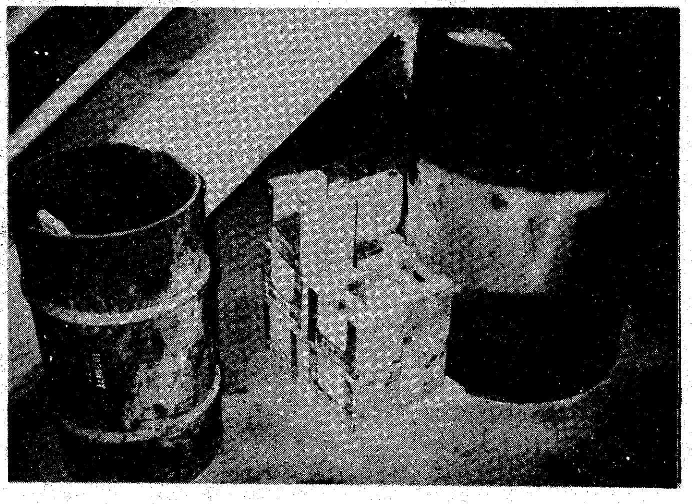


Those plants that do not use load cells will have a primary scale that indicates the weight. The operator must be able to easily read the scale from inside the control house.

Plant scales will need to be certified as accurate before production begins. Certification can be by the State's Bureau of Weights and Measures or by an independent certified scale technician. A certified scale will have a current tag or decal showing when and by whom the scale was certified and the calibration date. The certification tag is usually found attached to the scale readout device in the control house. Scales are normally calibrated on an annual basis.

Scale calibration is done by placing a known weight on the scale and noting the actual scale reading. This is done over the range of weights that the scale will encounter. The scale must be accurate within 0.4% throughout the range of use.

Each concrete plant should be equipped with ten 50 pound (25 kg.) weights to be used for calibration.

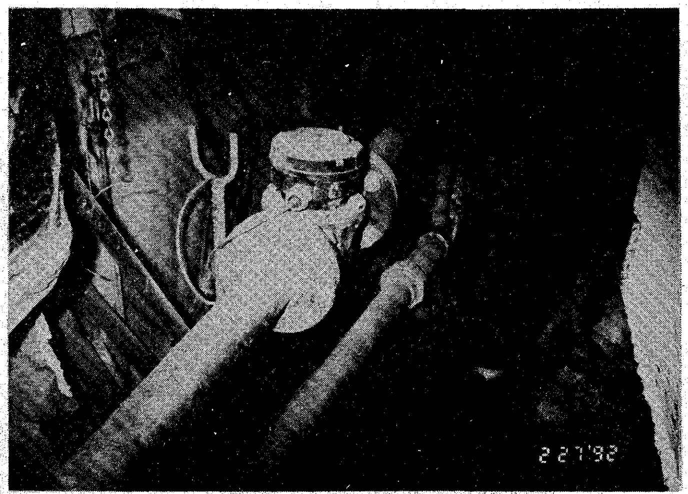


Scales should be periodically checked for sensitivity. This is done by loading the scale to a weight normally used in production, and then placing a known weight on the scale. The scale should be able to accurately indicate the addition of this weight to 0.1% of the capacity of the scale.

Scales should also be inspected to ensure that they are clean, able to move freely and that the knife edges are in good condition.

WATER METER

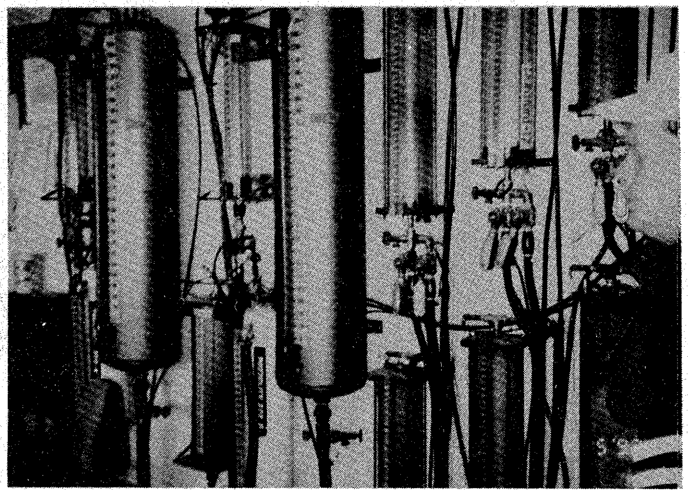
Water that is used for concrete construction is usually measured by volume through a flow meter and is pumped either directly to the mixing truck or to a storage tank.



The flow meter should be calibrated annually or before the start of concrete production. Calibration of the meter is done by filling up a tank of known volume and comparing this with the reading of the water meter. This should be done through the full range of volumes anticipated. The water meter should be accurate to 1% of the added mixing water.

LIQUID ADMIXTURE MEASUREMENT

Liquid admixtures are pumped into a measuring device, normally a graduated cylinder, and added to the concrete with water. Admixtures are measured by volume and measuring devices should be located in the control house where the materials are measured or batched. Liquid admixture cylinders must be loacted so that the operator can visually verify the amount. The graduated cylinders should also be checked for accuracy on an annual basis. Accuracy should be within 3% of the total amount of liquid admixture required.



MEASURING THE MATERIALS

Each of the materials should be accurately measured. AASHTO M 157 Ready-Mixed Concrete, provides tolerances for the measurement of each of the ingredients. These values will be different then those values specified for scale or meter calibration. The following is a summation of this specification:

- Cement/Pozzolan : 1% of the required weight.
- Aggregates : 2% of the required weight when weighed individually or, 1% for each size aggregate when weighed together.

- Water : 1% of the amount added or, 3% of the required total amount including aggregate surface moisture, liquid admixtures and any wash water.
- Mineral Admixtures: 3% of the total amount required.
- Liquid Admixtures: 3% of the total amount required.

A batch ticket will be prepared that should include the following:

- Plant Name
- Ticket Number
- Date
- Truck Number
- Purchaser
- Specific destination (name and location)
- Type of concrete
- Amount of batch
- Time of batching
- Amount of water added

Other information that could also be included:

- Counter reading at first addition of water
- Type, brand and amount of cement
- Type, brand and amount of admixture
- Maximum amount of water that can be added and not exceed the maximum W/C

- Actual weight of all batched materials
- Signature of plant official.

The ticket should be given to the truck driver and made available to the purchaser at the project site.

HOT OR COLD WEATHER CONCRETE

Some concrete plants will be equipped with heating or cooling elemnts to heat or cool the water. AASHTO M 157 Ready-Mixed Concrete, provides recommended minimum concrete temperartures for cold weather concrete. Cold weather is defined as a period when the mean daily temperature falls below 40 degrees F for three consecutive days. Heated aggregates or heated water can be used to raise the temperature of the concrete. Care should be taken when using hot water as rapid stiffening will occur if the hot water is brought into direct contact with the cement

Frozen aggregate should not be used when batching concrete. Steam pipes located in the bottom of the stockpiles have been used to prevent the aggregates from freezing.

Cold water or even ice can be used to mitigate some of the problems associated with hot weather concrete. For most applications concrete temperatures should be maintained below 90 degrees F. Problems associated with concrete produced during periods of hot weather include loss of slump, increased water demand, rapid curing, and increased tendancy for plastic shrinkage cracking.

The temperature of the concrete can be reduced by the addition of chilled water or ice, or by controling the temperature of the aggregates. Aggregate temperatures can be reduced by sprinkling water over the aggregate stockpiles. The entire mix or any mix component can also be cooled using liquid nitrogen.

CHARGING

Once the materials have been batched, the charging of the truck begins. Charging is the addition of the materials into the mixer.

Water is usually the first material added ,followed by the aggregates and then the cement. The operator should monitor the scales, admixture cylinders, and the water meter to ensure that the material is flowing smoothly.

As water continues to be added, admixtures are added with the water toward the end of the charging cycle. It is important that admixtures are added separately and are not mixed. Mixing of admixtures can alter their characteristics and produce unexpected results.

After each of the materials has been discharged it is important to assure that the scales go back to zero before the next batch is weighed. For a manual plant, the actual scale should return to zero. For automatic plants, the operator will not be able to weigh the next batch unless the scales return to zero. However, each scale is allowed a certain tolerance of material that is allowed to remain in the hopper. This tolerance should be set as low as possible to prevent continual shorting of the material being weighed.

If a scale does not return to zero it can mean that some material is hung up in the weigh hopper. Weigh hoppers are equipped with a vibration device that can be activated to assure that all the material is cleared from the hopper.

MIXING

Once all materials have been added to the truck, mixing of the materials may begin. Each truck should have been inspected before being charged with concrete. Some agencies have a periodic inspection program to assure that mixing trucks are performing as required. These inspections are typically on an annual basis. What follows are items that should be examined during this annual inspection.

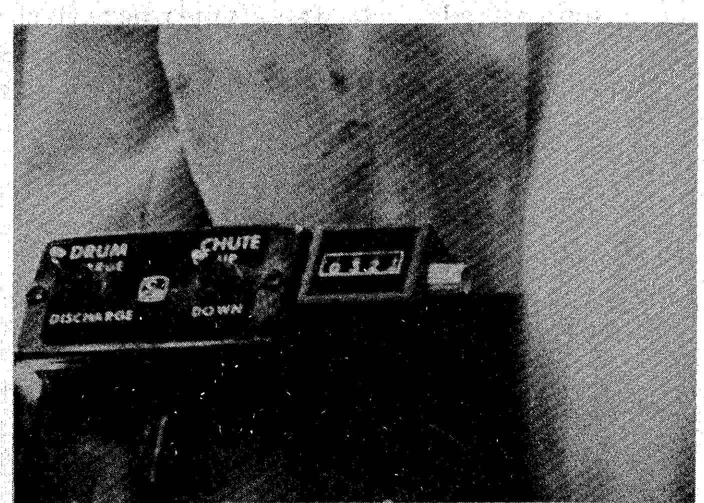
TRUCKS

Rating Plate

Truck mixers are required to have a manufacturers' rating plate located somewhere on the truck. This rating plate gives the rated mixing capacity, agitating capacity and the mixing and agitating speeds.

Counter

Each truck must also be equipped with a means to verify the number of drum revolutions. This is generally accomplished through the use of a counter mechanism.



Sometimes this counter has a remote sensor and the readout mechanism can be found inside the truck. Other times it is a simple counter mechanism attached to the drum. In either case, the counter should be set to zero before charging begins.

Water Gauge

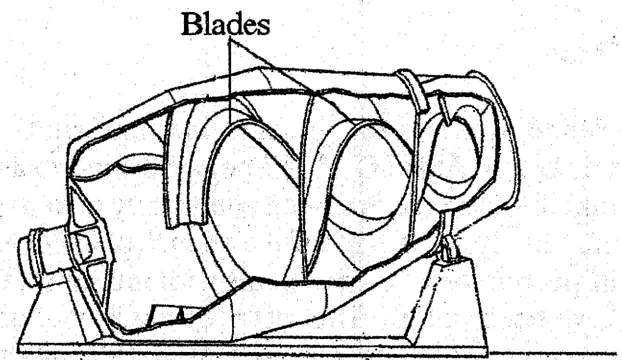
Another item that should be checked on the truck is the water gauge. The water gauge should be properly calibrated if water is to be added at the construction site. The mixers should be located on level ground prior to the addition of water. Sight glasses, normally used as a water measuring device on concrete mixing trucks, will not register properly when the truck is not located on level ground.

Any water that is used by the truck should be accounted for. This includes wash water, cleaning of trucks, filling of water tanks, etc. One common source of additional water is the truck driver washing down the truck after charging. Excessive addition of water to the mix while washing down the chute should not be allowed.

Blade Wear

As part of an annual plant inspection, the blade wear for the trucks will need to be checked. Each truck has a manufacturers' rating for the amount of wear that is acceptable. Excessive blade wear will require that the blades be modified or replaced. Inspection is done by opening the hatch and climbing inside the drum. The inspector also should look for any concrete that has built up in the drum.

Concrete build up will reduce mixing efficiency and will add unnecessary weight to the truck.



Drum of a Typical Concrete Mixing Truck

Mixing Time

The time or number of revolutions required to complete the mixing process is specified by the contracting agency. AASHTO M 157 recommends 70 to 100 revolutions at the manufacturers rated rpm (usually 6-18 rpm). Once the concrete has been thoroughly mixed, the speed of the drum should be reduced to the agitating speed (2-6 rpm). Excessive mixing of the concrete can degrade the aggregates, producing additional fine material. This fine material can act like mortar, reducing slump. Excessive mixing can also drive out the entrained air. AASHTO M 157 limits the time to discharge to 1 1/2 hours or 300 revolutions, after the addition of water. During hot weather, the time to discharge and number of revoultions may be reduced.

rated mixing speed to thoroughly mix the concrete. Additional water should not be added to partial loads of concrete.

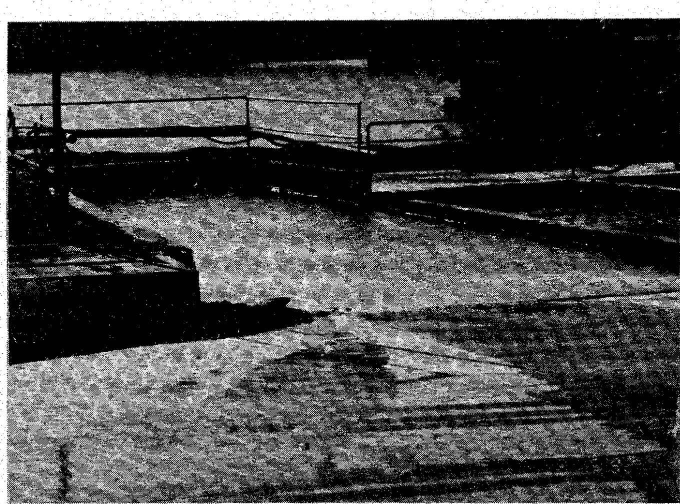
Tests

Some agencies require that the uniformity test found in AASHTO M 157 be performed to assure that the concrete has been adequately mixed. This may be done as part of an annual plant or truck inspection or when problems with mix consistency have been noted. The test procedure is to obtain two samples of concrete, one after 15% discharge and one after 85% discharge. The samples are kept separate and tested for specific properties. Test results for the two samples should be within the following values:

• Weight/volume	16 kg/m^3 (1.0 lb/ft^3)
• Air content (by volume)	1%
• Slump	25 mm (1 inch)
• 7 day compressive strength	7.5%

CLEAN UP

The inspector should assure that each concrete truck is cleaned and any excess water removed from the truck before another batch is added. Concrete plants will be equipped with settlement ponds to separate the cement and aggregate from the water before it is discharged into the storm water system. Excess concrete and wash water should be disposed of in these settlement ponds and not discharged directly into the storm water system or into flowing streams or channels.



PORTLAND CEMENT CONCRETE - PLANT INSPECTION CHECK LIST

I. Materials

A. Cementitious materials (cement, mineral admixtures)

1. Evidence of cement or mineral admixture acceptability (certification, test results)?

2. Bins or silos tight and provide for free movement to discharge opening?

3. Bins or silos periodically emptied to check for caking of the cement or mineral admixture?

4. Where storage is provided for more than one type of cement or cementitious material, the materials should be isolated to prevent intermingling or contamination?

B. Aggregates

1. Evidence of source approval?

2. Are aggregates stockpiled to prevent segregation and degradation?

3. Are stockpiles adequately separated to prevent intermingling?

4. Aggregates tested for gradation and moisture content?

5. Separate storage bins or compartments for each size or type of aggregate?

C. Water

1. Adequate supply with pressure sufficient to prevent interference with accuracy of measurement?

2. No evidence or history of contaminants in supply?

D. Liquid Admixtures

1. Evidence of source approval?

2. Admixtures and dispensing equipment protected from freezing, contamination, or dilution? Admixtures periodically agitated?

3. Admixture metering and dispensing equipment periodically cleaned?

II. Batching Equipment

A. Scales

1. Scales shall indicate weight by means of a beam with balance indicator, full range dial, or digital display?

2. For all types of batching systems the weighing devices must be readable by the batchman and the inspector from their normal stations?

3. Scales shall be certified or shall be calibrated with a certified scale?

4. Ten 25 kilogram (50 pound) test weights shall be available at the plant at all times?

5. Scale accuracy should be within plus or minus .4% of the scale capacity?

6. Water meters must be calibrated to 1% of total added amount?

7. Liquid admixture measuring devices calibrated to 3% of required total amonut?

B. Batchers

1. Cementitious material shall be weighed on a scale that is separate and distinct from other materials?

2. Bins with adequate separation shall be provided for fine aggregate and each size coarse aggregate?

3. Weigh hoppers shall not allow the accumulation of materials and all material shall be fully discharged into the mixer?

4. Batchers shall be capable of completely stopping the flow of material and water batchers shall be capable of leak-free cut off?

5. Separate dispensers will be provided for each admixture?

6. Each volumetric admixture dispenser shall be an accurately calibrated container that is visible to the batchman from his normal position?

7. Aggregate shall be measured to plus or minus 2% of the desired weight. Cement to 1%, water to 1% and admixtures to 3%?

8. Semi-automatic and automatic control mechanisms shall be appropriately interlocked?

III. Mixing

A. Truck Mixers

1. Mixers shall be equipped with a metal plate that indicates mixing speed, mixer capacity, agitating speed and agitating capacity?

2. Mixers shall be equipped with a revolution counter?

3. Mixers are to be examined to determine satisfactory interior condition, that is no appreciable accumulation of hardened concrete and no excessive blade wear? A copy of the manufacturer's design, showing dimensions and arrangements of blades, shall be available at the plant at all times?

4. Charging and discharge openings and chutes should be in good condition?

IV. Weather

A. Hot Weather

1. When concreting during hot weather, is plant equipped to cool ingredients or mix (maximum concrete temperature 90 degrees F)?

B. Cold Weather

1. Check aggregates for signs of freezing.

2. When concreting during cold weather, is plant equipped to heat ingredients to produce concrete of applicable minimum temperature?

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