PAVING PLANT INSPECTION

GENERAL

The following instruction is to be used when inspecting the operation of a PC Concrete paving plant.

Materials and proportions must be controlled in accordance with the specifications and the following detailed instructions.

The plant inspector will normally be assigned the following duties:

1. Inspection or monitoring of proportioning and plant operation

2. Gradation determination of the aggregates used

3. Identification and tabulation of materials received and used

4. Protection, curing, and testing of the strength specimens, and care of the specimen forms

5. Maintenance of a daily diary and preparation of the Daily Plant and Strength Reports

Certified Plant Inspectors will assume a number of duties, as specified in IM 213.

The contract documents provide for the class of concrete to be used in a given project. Standard and slip form are the two types of pavement specified. All classes of concrete contain entrained air to improve durability. Unit absolute volume proportions for the four classes of concrete and the various mix numbers are provided in IM 529. The class of concrete is designated in the contract documents and the Contractor may use any of the numbered mixes designated in the respective class of concrete. The gradation of the coarse aggregate must comply with the requirements of the mix number chosen.

The Engineer will see that the inspector is provided with proper equipment for carrying on the work, except the Certified Plant Inspectors will provide their own equipment. Furnished equipment will be provided upon request from the Ames Laboratory and the Inventory Management storerooms. Requests for equipment or supplies to be checked out must be made on Iowa Department of Transportation Stock Issue Form #133005.

The following statement shall apply to all phases of equipment and material testing and/or examinations:

> Tests and/or examinations must be made at least as frequently as described herein or in other applicable memorandums. All test and examination results are to be recorded in the Plant Inspector Field Book. All field books and records shall become the property of the Contracting Authorities at the completion of the project.

If a test result on a project verification sample indicates specification noncompliance, appropriate action in accordance with the applicable specifications, instructional memorandums, and resident engineer instructions shall be taken. (See IM 204.) Normally, the Contracting Authority will issue a

Form #830246, Noncompliance Notice.

If a test result on a project quality control sample indicates specification noncompliance, the Contractor must take corrective action. It must be noted that the Contractor is responsible for deciding what corrective action must be taken, for directing that it be taken and for the results. The inspector must not in any way assume responsibility for the corrective action or its results.

It is the inspector's responsibility, based on prescribed tests and examinations, to monitor the progress of the work, to make available to the Contractor the results of tests and examinations on a continuing basis and to inform the Engineer and Contractor when tests show noncompliance. The Contractor is responsible for furnishing compliant material and finished work.

A checklist of the detailed plant inspection duties is included as part of these instructions. Refer to this checklist before the work begins, and periodically thereafter, to be certain that all the required tests and inspection procedures are being included in the routine activities.

SAFETY

Safety should be uppermost in the minds of those working in a concrete plant. In the past there have been injuries and even deaths, because proper attention was not given to safety details. Certain requirements have been made a part of the contract documents as safety measures. It is not possible, however, to remove all unsafe conditions from a paving plant situation.

The plant inspector must make certain all contractual requirements are met, including those related to safety. The inspector should encourage the elimination of hazards not specifically covered by the specifications. Some hazards will be impractical to remove. The inspector should be familiar with these hazards and thus be better able to protect against them. Protective headgear should be worn when working around bins and other plant equipment.

Safety considerations mandate that stopped belt sampling locations must be equipped with an on-off switch near and in plain view of the sampling point. This switch must have sole control of the sampling belt when the switch is in the off position.

EQUIPMENT

1. BINS

   The following requirements shall apply to bins used in connection with the production and delivery of materials and to bins used in connection with the proportioning of materials for mixtures. Standard Specifications in Article 2001.06 authorize the Engineer to examine the bin each time it is erected for use.

The Contractor shall maintain any stress-carrying parts of the bin frame, which support the load in proper working condition. No stress-carrying member shall be absent while the bin is in use. All members must be straight and full-size. If any member has become bent or deformed, it shall be straightened by methods, which will not injure the material, or a new member must replace it. Piles of aggregate shall be kept from introducing stresses into the bin legs caused by lateral pressure against the legs. If all footings under one bin settle uniformly after the bin has been loaded, the settlement is not considered a problem. However, if the settlement differential of the footings under one bin exceeds 1/10 foot (30 millimeters), the District Materials Engineer must be informed.

The Contractor shall periodically observe the bin for settlement after the bin has been loaded. Before concrete proportioning at a new plant installation, the bins should have been fully-loaded for at least 12 hours and the amount of settlement determined by the contractor. Checks of settlement by the contractor shall be furnished to the Engineer. If a scale is affected by the above unequal settlement, its operation must also be re-evaluated.

All conveyers and other plant machinery shall meet current OSHA Standards. The Contractor shall be responsible for complying with these requirements for both design and erection. The Contractor shall furnish a certification or design calculations to the Engineer to confirm compliance, if requested to do so.

2. PROPORTIONING EQUIPMENT

Requirements for scales or meters for proportioning aggregates, cement, fly ash, water, or admixtures are found in Article 2001.20 of the Standard Specifications. These essential requirements are in addition to the safety requirements referred to in Section 1 above for bins.

When a proportioning plant has been moved and set up, it is essential that the proportioning scales are test loaded and the proportioning meters are tested for specification compliance.

Proportioning scales and meters shall be test loaded to the maximum load expected during production. Proportioning during production shall not exceed the maximum load tested during calibration.

It is the duty of the District Materials Engineer or designated staff to witness calibration of all proportioning and plant equipment before concrete work begins. The plant inspector is encouraged to be present while the scales and other equipment are being tested and evaluated.

When it has been determined that all proportioning devices and plant equipment comply with the specification requirements, a Plant Calibration Report, Form #820917, will be prepared by the contractor's representative and signed by the District Materials Engineer, or representative, as a witness to the calibration. This report authorizes the use of the plant to which it applies and the materials and proportions listed thereof. It is to remain at the plant in the inspector's files during progress of the work. A sample copy of Form #820917 is shown later in Appendix C and a calibration checklist is shown in Appendix D. The plant inspector must be familiar with all features of the plant operation before the work begins. While the inspector must not personally make any of the plant manipulations or adjustments, understanding the basic machinery operation and being able to recognize the significance of a malfunction is important.

The proportioning equipment must be examined at least at **3-hour intervals** for correctness of the **amount being batched** and for damage of the equipment. Special attention must be given to the empty balance and the position of the poises for beam and dial scales. The normal plant operation causes vibration, which tends to change these adjustments.

Accumulation of material clinging to the inside of the hopper can also cause these adjustments to drift. Small amounts of material accumulation clinging to the inside of the hopper are not considered objectionable. If the amount exceeds one percent of the material batch mass, however, it must be removed and the indicator on the empty hopper readjusted to indicate a zero load within ± 0.5% (See Article 2001.20). The **scale sensitivity** shall be checked **at least twice during a normal working day** by placing a mass equal to 1/10 percent of the batch on the fully-loaded scales and observing the movement of the indicator. A properly sensitive scale will exhibit a visible indicator movement when so tested. If no indicator movement is visible and immediate corrective action by the Contractor does not yield successful results, the District Materials Engineer must be informed.

The following procedure is required for setting or adjusting the various items of proportioning equipment in order that they will deliver the proper amount of material to the batch:

1. The plant superintendent or other authorized contractor representative must make all necessary scale and equipment settings and/or adjustments. The plant inspector is specifically directed not to participate in this activity.

2. Before the plant operation begins or resumes, the plant inspector will independently determine that the settings and/or adjustments are accurate and that the masses of material being delivered to the batch are correct. Errors must be corrected immediately.

Strict adherence to the above procedure is necessary to maintain a proper division of authority and responsibility between the Contractor and the Contracting Authority and to minimize the possibility of operating with erroneous proportions.

Suitable wind protection on all sides of the scales is required by the specification. This protection, if not provided by the plant design, can be fabricated from burlap, Masonite, plywood or other suitable material and should provide adequate room for the scale operator to work unobstructed.

a. CEMENT & FLY ASH SCALES. Cement and fly ash scales at the contractor proportioning plant are usually required to be automatic. (See Article 2001.20 and 2301.02) The scales must be **accurate** to within **plus or minus 0.5%** of the load and must operate (**delivery tolerance**) within **plus or minus 1%** of the required batch.

   The scale accuracy is determined prior to the beginning of concrete work by the District Materials Engineer or representative and in most cases will need no further attention.

The delivery tolerance, however, can be determined only when the automatic device is in operation. A number of suitable procedures for determining delivery tolerance have been devised. While one procedure may not be suitable for all scale installations, the following is suggested, because it can be applied to the majority of the cement proportioning equipment used. Modifications of the procedure are permitted providing the delivery tolerance is determined.

1) With the hopper loaded to the correct amount for one batch, the addition of material to the hopper equal to one percent of the correct batch must cause the "over" limit switch to function and prevent automatic discharging of the batch.

2) With the hopper loaded to the correct amount for one batch, the removal of material from the hopper equal to one percent of the correct batch must cause the "under" limit switch to function and prevent automatic discharging of the batch.

Check scale operations to determine **delivery tolerance** conformance at least **once** during **each day** of normal operation.

Minor adjustments of numerous phases of the automatic batching cycle are normally required on a continuing basis because of changing weather and material conditions. The inspector must become intimately familiar with the automatic scale operation to be able to recognize when these minor adjustments are needed. As a general rule, if the operator has to manually adjust the amount of material in the hopper or charge or discharge manually more often than once in each ten batches the automatic measuring device needs repair, adjustment, or servicing. A 24-hour grace period is provided during which manual operation is permissible. Specific approval of the engineer is required for continued manual operation beyond the 24-hour grace period. The engineer's approval should be based on a consideration of the following:

- Immediate steps were taken to repair the automatic malfunction.
- If repair within the 24-hour period is not possible and beyond the control of the Contractor and the malfunction could not reasonably have been anticipated.
- Manual measuring is within the accuracy required for automatic scales.
- It would be to the advantage of the contracting authority for the paving operation to continue.

Manual measuring of cement shall be under the constant surveillance of the inspector. The empty scales must be tare-balanced after discharging each batch and before charging another.

Cement Yield Check

The Standard Specification requires that the cement shipment yield determination must be made at intervals of approximately 10,000 cubic yards (10,000 cubic meters) after the original determination made near the end of the first full day of production. When a permanent, commercial-ready mix plant is dedicated to furnish greater than 10,000 cubic yards of continuous concrete production, cement yield determinations are required. When a permanent, commercial-ready mix plant furnishes greater than 10,000 cubic yards on an intermittent basis, cement yield determinations shall be at the option of the District Materials Engineer. If fly ash is batched on the same scale as cement, no yield determination is needed for the fly ash.

The purpose of the cement yield test is to compare the amount of cement, which is measured, on the contractor's batch scales with the amount, which is measured on the scales at the cement manufacturing plant. The assumption is made that the mass shown by the manufacturer (billed amount) is correct.

The cement storage bin or bins must be empty and free of cement before the test is started. In the event a bin is partially filled with cement left over from a previous project, it should be used and the bin completely empty before the yield determination is started. The removal of all cement from the bins provides the necessary starting point in addition to assurance that cement lumps and foreign debris have been eliminated.

Make the first cement yield near the end of the first full day of production, being sure each cement car or truck is completely empty after unloading into the storage bin.

At the end of the test the storage bin must be completely empty again. Estimating the amount of cement in a storage bin is not suitable and by doing so the test result is virtually meaningless.

A careful record must be made of the total batches used and from this figure calculate the total cement batched. Also calculate the yield expressed as a percent of the billed total.

If the yield percent is less than 99.0, or greater than 101.0, refer to the section entitled, General, in this IM for special action required. If the results of the first test are within the above limits no special action is necessary. Follow the same procedure for following yield tests, except extend the test over about 10,000 cubic yards (10,000 cubic meters) intervals of work. For the longer interval tests, the amount of cement in a bin at the beginning and ending can be estimated without introducing appreciable error. Report each cement yield test performed on Form #820912, Portland Cement Shipment Yield Report. (See sample Yield Report in Appendix C).

b. AGGREGATE SCALES. Aggregate scales may be operated either manually or automatically and must operate within a **delivery tolerance** of plus or minus **one percent** of the required batch amount. If the scales are operated automatically, the delivery tolerance can be determined in the same manner described in 2a, Cement Scales. If it is operated manually note the location of the balance indicator or dial indicator when a one percent over and under load is added to and subtracted from the correct amount in the hopper. Aggregate delivered to the batch must be within the above limits. Check scale operation to determine **delivery tolerance** conformance at least **once during a normal working day**.

c. WATER MEASURING DEVICE. Scales or volume meters are permissible for measuring water. Scales may be operated manually or automatically. Regardless of the type of measuring equipment used, the amount of water delivered to the batch must be **accurate** to **2.2 lbs. (1 kg)** or within plus or minus **one percent** of the amount shown by the indicator whichever is greater. If water is measured with a scale, the **delivery tolerance** must be determined at least **once for each day** of normal operation as described in 2b, Aggregate Scales. If a volume meter is used, the delivery tolerance need not be determined other than during the original calibration or at such time that a water-measuring problem is indicated. Testing a water meter is the duty of the District Materials Engineer or his/her representative.

d. ADMIXTURE DISPENSING EQUIPMENT. Admixtures (air or water reducing) may be proportioned manually or by automatic equipment. If they are proportioned manually, the method and procedure must be approved by the engineer and should be performed by a person having no other duties. If they are proportioned automatically, the dispensers must be equipped with a transparent chamber that will permit visual observation of the admixtures as they are introduced into the batch. The visual inspecting chamber requirement may be waived in lieu of admixture dispensing systems utilizing positive electronic flow metering and computer controlled delivery that prevents improper admixture incorporation into the mix. Equipment for dispensing liquid admixtures shall be accurate within plus or minus 3.0 percent of the quantity required. The operation of the dispenser when operated either manually or automatically must be observed for uniform **delivery** at least **once during each 3 hours** of normal operation. The dispensing equipment must be flushed with water at least once daily to minimize the possibility of material accumulation that will impair the equipment performance. The use of malfunctioning dispenser equipment will be discontinued immediately upon detection of the malfunction and its use must not be resumed until the malfunction has been eliminated. If a problem with the air agent dispenser develops, the first indication of it will likely appear as a problem controlling the air content in the plastic concrete. The air content may be variable from one batch to another or it may be uncontrollable in either the high or low range. If immediate corrective action does not yield satisfactory results the engineer in charge and/or the District Materials Engineer must be informed. Concrete work must not be permitted to continue if air test results show specification non-compliance. There are no such indicators in plastic concrete for water-reducing admixtures. Therefore, as mentioned above, the dispenser operation must be observed regularly.

3. MIXING EQUIPMENT

Central mixer is the most popular, and is the type normally used when high production is desired, ready mix trucks are used for limited amounts of pavement, and mobile mixers are typically used in bridge deck overlays.

Mixing equipment for paving projects will be one of the following types as described in Article 2001.21:

a. CENTRAL MIXERS. For central mixers, the maximum batch size and the mixing speed recommended by the manufacturer are shown on the Mixer Manufacturer Bureau (MMB) rating plate that is attached to the mixer. The batch size shall not exceed that recommended on the MMB plate and the rotational speed of the mixer drum shall be at least equal to that shown on the MMB plate. After all materials are in the mixer, the mixing time shall be a minimum of 60 seconds and a maximum of 5 minutes.

   The following is the recommended method for determining mixing time:

   There are three parts of the batch cycle; the charging of the drum, the mixing, and the discharge. In order to check the mixing time; first determine the time required to add all ingredients to the mixing drum. Then determine the time to discharge, from the time the first concrete falls out of the drum into the delivery vehicle until the drum is back into the mixing position and material begins to be charged into the drum. The charge time plus discharge time plus a minimum mixing time of 60 seconds is the minimum batch cycle time.

   The mixing time must be determined and recorded at least once per day by the Certified Plant Inspector. By timing the batch cycle and subtracting the charge time and discharge time, the mixing time can be determined. Determining the average cycle times over a number of batches where the batching operation is running uninterrupted is preferable. The total batch cycle time, as well as the time needed for charging and discharging, should also be recorded initially for a given batch size. This enables mixing time to be determined through timing of the total batch cycle.

   The batch cycle time may change if the size of the batch changes. The size of the batch should be noted if changes in the cycle time are found.

   The monitor inspector should check the mixing time when visits are made to the project. The monitor should then compare the determined mixing time to those recorded by the Certified Plant Inspector. The contractor is required to furnish individual batch tickets or a daily summary of the materials in each batch and the time the batching begins or in the case of batch tickets, the time of discharge of each batch.

   If the mixing time is less than 60 seconds, an immediate correction must be made.

b. READY MIX. The maximum size of the batch and the mixing speed recommended by the manufacturer for ready mix trucks shall be shown on a plate attached to the mixer. The Truck Mixer Manufacturer's Bureau (TMMB) may issue the plate; if not, an independent, recognized laboratory, shall determine compliance as defined in Article 4103, and complete test results may be required. The batch size must not exceed that shown on the plate and the mixing speed must be in the range shown. Determine and record the mixing speed for each mixer at least once daily. The batch must be mixed from 70 to 90 revolutions at mixing speed unless otherwise directed by the engineer. All mixers must be equipped with a revolution counter. If the counter is one that counts revolutions only when the drum is turning at mixing speed, mixing may be permitted while the truck is in transit. If the counter is a simple re-settable counter, which counts all revolutions regardless of the drum speed, mixing must be accomplished at a location where it can be observed by the inspector. It is permissible for the mixing to be done either at the plant or the project site. A clear understanding must exist between the plant and grade inspectors as to where the mixing will be done.

Ready mix trucks must carry, in the vehicle; a current certification signed by a responsible company representative stating that the mixer condition has been examined during the previous 30 days, and is free of hardened concrete and is in proper working condition. Mixers not carrying the required certification must not be used.

4. TRANSPORTATION VEHICLES

a. CENTRAL MIXING. When the concrete is centrally mixed it may be transported in either agitating or non-agitating hauling units. If non-agitating units are used, the fresh concrete must be placed on the grade within 30 minutes after it has been discharged from the mixer. If agitating units are used, the fresh concrete must be placed on the grade within 90 minutes after the water and cement have made contact with each other (See Article 2301.02).

When approved by the engineer, an approved retarding admixture may be used at the rate prescribed in IM 403, and the mixed-to-placed time period, for concrete transported <u>without</u> agitation, may be extended an additional 30 minutes.

b. READY MIX. When the concrete is mixed in ready mix trucks and agitated thereafter, the fresh concrete must be placed on the grade within 90 minutes after the water and cement have made contact with each other. If continuous agitation is not used, the time limit is 30 minutes (See Article 2301.02.). For pavement patching, ready mix concrete must be delivered and placed within 60 minutes or 90 minutes when retarder is used. Concrete must be placed within 30 minutes after calcium choride is added. (See Articles 2529.02 and 2530.02). Concrete, which has been mixed, agitated or held in excess of the above time limits, must not be used.

Determine and record the cement to **water contact time** at least **once during each day** of normal operation.

MATERIAL

1. IDENTIFICATION

Arriving shipments of material must be examined for damage and contamination. Before material is incorporated into the project, the inspector must be assured that approval reports for the material have been received or will be received shortly.

For shipments of cement and fly ash the inspector shall examine the invoice or bill of lading that is attached to the tanker when shipments arrive. When nighttime delivery occurs, the inspector shall examine the invoice or bill of lading before production begins on the next working day. The inspector must be ensured the proper material is placed in the proper storage unit.

An orderly record showing when the shipment arrived, the amount and identification of material involved and the laboratory report number, invoice number, ticket number, on which the material has been approved is necessary for documenting that material used has been tested and approved. Telephone conversations regarding material approval must also be summarized in this record. Keep a similar record for aggregates, and admixtures.

The inspector will not permit any material to be used or stored with accepted material until the inspector is satisfied the material is acceptable.

a. AGGREGATES. Certified aggregate may be incorporated into a project on the basis of the certified truck ticket. When the material represented is non-proportioned aggregate the project number must show on the truck ticket and a copy furnished for project inspection personnel. When the material represented is proportioned aggregate, the project number is preferred when practical as in the case when shipping to a paving plant site and not required when impractical as in the case when shipping into warehouse stock at a ready mix plant. A file of proportioned aggregate tickets will be maintained by the contractor and made available for inspection at each plant or project site during the project period. The plant inspector shall verify that all material incorporated in the project is properly certified and document this verification and quantity on each of the appropriate daily or periodic construction reports. No other project documentation for the incorporated aggregate is required (See IM 209).

b. CEMENTITIOUS MATERIAL. Cement, fly ash, and Ground, Granulated, Blast Furnace Slag (GGBFS) may be incorporated into the project on the basis of the manufacturer certification. (See IM 401, 491.17, and 491.14.)

c. WATER. Water secured from streams, lakes, and other non-potable sources will be tested and approved by the Central Laboratory before it is used. Water from municipal supply systems and other potable sources may be used without testing provided the source is documented.

d. ADMIXTURES. Admixtures may be incorporated into the project without further sampling and testing if they are listed in IM 403.

e. Approved brands of water reducing admixtures, retarding admixtures, and dosage rates are in IM 403. Any admixtures suspected of being frozen and materials older than 18 months shall not be used before being tested and approved. These admixtures shall be **mixed** thoroughly **once a day** prior to proportioning to maintain the solids in suspension. The mixing shall be done in such a way that the solution in the holding or storage tank is circulated for a minimum of 5 minutes each day per 100 gallons (380 liters) of solution or any fraction thereof. A circulating pump with 250 watts (1/3 hp) pump motor and a 5/8-in. (16-mm) inside diameter hose will be considered as a minimum requirement. The engineer shall approve the method of mixing and the plant inspector shall witness the mixing process.

NOTE: A stream of air bubbles will not be acceptable. Proper storage of the admixtures during the winter months is recommended to avoid freezing of the material.

2. STORAGE & HANDLING OF MATERIALS

The contractor shall notify the Engineer of the stockpiling procedures to be used and of the date when stockpiling will begin. This shall be done ahead of commencement of stockpiling in order to allow discussion of procedures and inspection of the stockpile sites and dumping areas. District Materials personnel may also be a part of this review and inspection.

The storage and handling of all aggregates must comply with Article 2301.02. If alternate methods are used as permitted and the required sampling and testing indicates non-specification aggregate gradation, the District Materials Engineer must be informed immediately. The responsibility of and the authorization for proper changes, if necessary, lies with the District Materials Engineer. It is important that the moisture content of the aggregates be uniform. Fine aggregate must be drained at least 24 hours before it is placed in the batch. For both coarse and fine aggregate, moisture content of successive batches must not vary more than 0.5 percent or this will be considered non-compliant. In such a case, the engineer and the contractor must be immediately informed. The problem must be corrected within a reasonable amount of time, generally one day. The work must not be permitted to progress when such a problem is not corrected. Unless aggregates are stored on platforms or other smooth hard surfaces some material in the bottom of the pile will be unfit for use because of contamination by the underlying soil. (See Article 2301.02.)

Aggregates may become contaminated or degraded from a number of sources. Examples of these are foreign material from the pit or quarry, foreign material in the rail cars or other hauling units, boards or bags used to plug holes in rail cars, and degradation from handling or prolonged storage. When aggregates are being taken from the lower portion of the pile, particularly when the work is approaching completion and the stockpiles are small, the inspector must be continually alert and forbid the use of contaminated aggregates. The inspector must understand that all of the above sources and numerous others can furnish objectionable contaminants. If contamination does occur, the aggregates affected must not be used.

Cement, fly ash, and GGBFS must be stored in weatherproof enclosures, which will protect against dampness. If lumps develop in the cement or fly ash it must not be used until it has been reprocessed, re-tested and approved as provided in Articles 4101 and 4108. Cement, fly ash, and GGBFS, which has been in storage more than 60 days at the project site or in the producer silo for more than a year must also be re-tested and approved.

SAMPLING & TESTING

1. AGGREGATES

The explanation below describes the sampling and testing required for proper plant inspection. IM 204 describes the minimum sampling and testing frequencies required for the inspection of construction projects.

a. SAMPLES. Aggregate samples are necessary to determine moisture content, specific gravity, and gradation. Care must be taken to ensure that the samples are representative of the materials being used. Secure fine and coarse aggregate samples as prescribed in IM 301.

The Contractor is required to furnish, at the proportioning plant site, facilities for collecting representative samples of the coarse aggregate from a ribbon or stream. Refer to Article 2001.20. Do not attempt to secure samples in dangerous locations. Under no circumstance should samples be secured from a partially opened clam bucket or from the discharge end of a belt where proper walkways and stairs do not exist. Refer to Article 2001.06.

Secure and test aggregate samples at least as frequently as described in IM 204.

b. GRADATION. Determine the fine and coarse aggregate sieve analysis in accordance with IMs 302 and 306. These Instructional Memorandums prescribe the test sample size and the procedures for fine and coarse aggregate sieve analysis and for determining the amount of material finer than the No. 200 (75 µm) sieve. Sample calculations are included.

Article 4109 of the Standard Specifications allows an increase of the minus No. 200 (75 µm) material from 1.5% to 2.5% with certain restrictions. Determination to allow this increase shall be made by consultation with the District Materials Engineer.

For projects requiring certified plant inspection, the certified inspector results shall be quality control tests. Quality control testing is performed to ensure the proper material is being delivered to the plant from the source and identify stockpile changes. Verification sampling and testing will be performed by the Engineer at the frequency described below. IM 205 describes the agency responsibility to randomly select sample location and time, and witness sampling with the contractor providing assistance in obtaining the samples.

For continuous construction operation, a verification lot is defined as a week of paving. Lots less than three days of paving will be grouped with the previous or subsequent lot. A verification lot may include a minimum of three days up to eight days. Quality control sampling and testing shall be performed daily. Verification sampling and testing will be performed the first day of paving. Thereafter, verification sampling will be performed daily and tested once per lot. If production on a given day is less than 500 cubic yards, verification sampling may be grouped with the previous or subsequent full day of paving.

Intermittent construction operation involving small quantities, less than 500 cubic yards per day, shall be grouped to establish a lot not to exceed one week. A minimum of one quality control sample shall be obtained and tested during the week. A minimum of one verification sample will be obtained and tested during the week.

When a quality control gradation test does not comply with the gradation requirements of Article 4109, the certified plant inspector shall contact the Engineer. After corrections have been made, the Engineer will obtain and test another verification sample.

When a verification gradation test does not comply with the gradation requirements of Article 4109, the Engineer will contact the contractor and the District Materials Engineer. The District Materials Engineer may investigate sampling and testing procedures, stockpiling, source material, etc. After corrections have been made, the Engineer will obtain and test another verification sample.

A lot is accepted when a verification test result by the Contracting Authority is determined to be in compliance. The Engineer will retain the samples until the lot is accepted. The Contractor may elect to run a split sample when the verification samples are obtained. The Engineer will witness the splitting and secure their portion of the sample. Since the contracting authority tests are verification, correlation with IM 216 is not required, but may be performed as a check of sampling and testing procedures only.

c. SPECIFIC GRAVITY. Determine in accordance with IM 307 and IM 308. The W-W_1 chart, IM T215A, which shows the corresponding moisture content values, is also included. It must be noted that the mass of the sample for determining both W and W_1 must be 1000 to 2000 grams respectively for the fine and coarse aggregate for the W-W_1 chart to be valid.

   Minimum testing will be one sample per day for both coarse and fine aggregates for the first three days of normal operation and one for each three days of normal operation for both coarse and fine thereafter, assuming the first three days' results are consistent.

   The specific gravity should not vary more than 0.02 from the tabular value (T203-General Aggregate Source Information) or from one day's test to the next. If the above variations are greater then 0.02, inform the Engineer and the District Materials Engineer immediately. The District Materials Engineer may adjust the specific gravity used to determine batch weights.

d. MOISTURE. Tables T214A, showing the Moisture Reciprocals (multiplication factors) that can be used for adjusting the aggregate batch amounts for the moisture content are included. The method most preferred for adjusting batch amounts is located in the Proportions section of this instruction.

   Document all original test result information in the field book or other permanent records. Record the following for each test:

   - All W and W_1 determinations
   - The mass retained on each sieve for gradation
   - All calculations for arriving at the final test result, i.e., moisture and gradation

   The Specifications (Article 2301.02) provide that coarse aggregate with absorption of 0.5% or more shall be wetted in the stockpile or cars, and methods of handling shall be such that change in moisture content in excess of 0.5% between successive batches must be prevented.

The use of materials that have varying amounts of moisture shall not be permitted. When the moisture content varies more than one-half percent from one batch to the next, the material must not be used unless something can be done to make the moisture uniform. It is the responsibility of the plant operator to devise remedial measures.

When the moisture content in either aggregate is high enough that water can be observed dripping from the bin between batches, or when the water will drip from the sample as described in Article 2301.02, the moisture cannot be measured successfully with the pycnometer nor can it be uniformly controlled. Materials with too much free water as described above must not be used until the moisture content has stabilized. It is the plant inspector's responsibility to recognize when this condition occurs and to secure the necessary corrective measures. Close communication with the grade inspector will inform the plant inspector when difficulties caused by moisture variation arise. When proportioning equipment is equipped with features, which allow instantaneous moisture content measurement of an aggregate, the following shall apply:

1. The acceptance of this system will be based on a correlation of the aggregate moisture content in a batch as determined by the proposed system and the moisture content determined by tests described in IM 308. The proposed system should be able to accurately determine the moisture content within 0.5 percent when compared to a sample obtained from a point in the plant as close as possible to the point of measurement used by the proposed system.

2. Prior to project startup, the contractor shall provide the engineer with the current calibration range data for the proposed system. The calibration range shall be used to establish the upper and lower limits of the range. After plant calibration, a check between the moisture content obtained by the system and the moisture content determined the test described in IM 308 shall be made prior to production.

3. Batch weights for the aggregates proportioned using this proposed system may be adjusted automatically on an individual batch basis. Moisture content results outside the upper and lower range limits of system shall not be used to adjust batch weights.

4. The limit in moisture content variation between successive batches will not apply. (Ref. Standard Specification Article 2301.02 and IM 527)

5. Moisture contents determined by the test described in IM 308 shall be performed at the frequency prescribed in IM 204 to establish correlation with results from the moisture determination system as per Paragraph 1. After correlation is demonstrated, the Engineer may reduce the frequency of moisture testing (IM 308) to a minimum of once per week for verification of the system.

6. The proposed system will provide a batch by batch record of the material weights, percent of moisture of the aggregates, time, date, batch number, truck number, mix type, water in aggregate, total water in batch and end tares for all scales and meters. This may be in the form of a printed summary report or as a ticket to be sent to the project, provided the ticket includes the required information as shown on Form #830212 and described in IM 527.

2. STRENGTH

   Test specimens shall be cast, cured, and tested as per the appropriate IM (i.e., IM 315, IM 316, and IM 328).

PROPORTIONS

The following procedure is required for determining basic proportions of dry materials in order that the proportions used in the work are correct:

1. The Contractor representative must make the calculations necessary to determine the quantities of dry ingredients and water necessary to comply with the mix proportions specified.

2. Before the plant operation begins or resumes the plant inspector (if certified plant inspection does not apply) or the monitor inspector will independently determine the batch quantities and cross check them with those made by the contractor representative.

3. Batching operations shall not commence until both independent determinations have been made and documented in the field records.

The proportions in the Standard Specifications are stated in terms of absolute volume per unit volume of freshly mixed concrete. Refer to IM 529. To obtain the weight (mass) of aggregate or cement per batch, the specified absolute volume per unit volume must be multiplied by the number of cubic feet (cubic meters) of concrete per batch, and this product multiplied by the mass of saturated surface dry aggregate or dry cement per cubic foot (cubic meter). The weight (mass) per cubic foot (cubic meter) of aggregate will be determined using the aggregate specific gravities shown in Table T203, General Aggregate Source Information.

Table T203 is revised annually, and care must be taken to use the table, which is current. Follow the same procedure for determining the cement batch weight. However, the specific gravity for Type 1 Portland Cement is constant for all brands at 3.14 (3.17 for Type III).

The following is an example of a basic mix without fly ash.

Determine the mass of the cement and aggregate batch for a C-3 mix using crushed stone from B.L. Anderson's Montour Quarry and sand from Manatt's at Tama.

abs. vol. x kilograms of water/cubic meter x sp.gr. = kilograms/cubic meter
(abs. vol. x cubic feet/cubic yard x sp.gr. x lbs. of water/cubic foot = lbs./cubic yard)

Cement - specific gravity 3.14
Specified unit absolute volume, From IM 529, 0.114.

(0.114) (1000) (3.14) = 358 kilograms
[(0.114) (27) (3.14) (62.4) = 603 lbs.]

Fine aggregate - specific gravity 2.66
Specified unit absolute volume, from IM 529, 0.302.

(0.302) (1000) (2.66) = 803 kilograms
[(0.302) (27) (2.66) (62.4) = 1353 lbs.]

Coarse aggregate - specific gravity 2.63
Specified unit absolute volume, From IM 529, 0.370.
(0.370) (1000) (2.63) = 973 kilograms
[(0.370) (27) (2.63) (62.4) = 1639 lbs.]

The above masses are for one cubic yard (cubic meter) of concrete and would have to be multiplied times the total cubic yards (cubic meters) being batched.

The Batch Tables contain the masses of the batch including cement predetermined for the respective mixes using the above calculation procedure. These aggregate amounts must be corrected for the amount of moisture determined by the pycnometer method. While the plant inspector is instructed to make specific gravity determinations in the field, these determinations are for the cross checking the tabular value and must not be used for batch calculations. THE SPECIFIC GRAVITY VALUES FURNISHED IN THE CURRENT TABLE T203, AGGREGATE SOURCE INFORMATION, MUST BE USED FOR CALCULATING THE DRY BATCH.

1. ADJUSTMENTS FOR MINERAL ADMIXTURE SUBSTITUTION & CEMENT MODIFICATION

   Fly ash or GGBFS may be substituted for cement at the contractor's option within certain restrictions. Article 2301.02 specifies the substitution rates as they relate to time of the year.

   IM 529 lists each standard concrete mix. These mixes contain only cement but may be adjusted to accommodate fly ash or GGBFS substitution. Explanation of how those adjustments are to be performed is discussed later. The procedure to make necessary adjustments for increasing cement content in a mix is also explained later in the IM.

2. PROPORTIONING A MIX FOR A MINERAL ADMIXTURE SUBSTITUTION

   a. To adjust a standard mix for fly ash or GGBFS substitution, the amount of cement specified for a basic mix is multiplied by the percentage of fly ash that is to be substituted. This product will give the kilograms (pounds) of fly ash in the mix. To calculate the adjusted cement in the mix, subtract the fly ash or GGBFS amount from the basic cement weight (mass). The basic water must also be adjusted. This is done by taking the design w/c, which is found in IM 529, and multiplying that number by the total amount of cementitious material in the mix. The product of that calculation will be the adjusted kilograms (pounds) of basic water.

   b. The absolute volumes must also be adjusted for the new mix. This is done by multiplying the specific gravity of the material by the kilograms of water per cubic meter or 1000 (pounds of water per cubic yard times cubic feet in a cubic yard or 62.4 x 27), then dividing the kilograms per cubic meter (pounds per cubic yard) by that amount. This procedure is used for the cement, fly ash, GGBFS, and water. Those absolute volumes plus the absolute volume of air, which is designated as 0.060, must be summed and subtracted from 1.000. The remaining volume is the aggregate portion of the mix.

   c. To determine the volumes of the coarse and fine aggregate, the number from the difference above would be multiplied by the percentage of each aggregate used in the mix. The percentage would depend on the mix number being used, for example, a C-4 mix would have 50% coarse aggregate and 50% fine aggregate, a C-3 mix would have 55% coarse aggregate and 45% fine aggregate. After the absolute volumes of the fine and coarse aggregate are determined, the kilograms of each shall be determined. This is done by multiplying the absolute volumes of the aggregate by the specific gravity of that aggregate and by kilograms of water in a cubic meter (pounds of water in a cubic foot x cubic feet in a cubic yard).

      Example A, in Appendix B, shows the process of adjusting a mix for 15% fly ash usage in a C-mix using the form provided.

3. PROPORTIONING A MIX FOR ADDITIONAL CEMENT

   Adjusting a mix for additional cement would be accomplished by the same procedure as above. To find the basic cement the formula on page 18 would be used. To add 15% more cement in the mix, the basic cement would be multiplied by 115%. This figure is the adjusted cement in kilograms (pounds). The rest of the procedure would be identical to the procedure used for the addition of fly ash to a mix.

   The above dry aggregate batch amounts must be adjusted to account for moisture or lack of moisture in the aggregates. If additional moisture is present above the amount for the saturated and surface-dry condition (SSD), refer to IM 308. The aggregate dry batch amount must be increased an amount equal to the mass of the water in the aggregate batch. If aggregates have less moisture than is present for the SSD condition, the aggregate dry batch amount must be reduced an amount equal to the mass of the water in the batch, below what is required for the SSD condition. When the latter condition occurs, the aggregate is described as having absorption. It occurs infrequently and for short duration and will generally be found during or at the end of a prolonged hot dry period in mid or late summer. The maximum permissible absorption limit is 0.5 percent. If the absorption exceeds 0.5 percent refer to the section entitled, “General” in this IM for the special action necessary.

The District Materials Engineer must authorize proportion adjustments (changing material amounts), if any are necessary.

There are two procedures that can be used for adjusting the dry aggregate batch amount to account for the free moisture in the aggregates. If a system with instantaneous moisture content measurement equipment is used to automatically adjust individual batch weights, see previous section, **Sampling & Testing/Moisture,** for instructions on an approval, use, and monitoring of the system.

The following example illustrates one of the methods used:

Assume the fine aggregate contains 3.4 percent and the coarse aggregate contains 0.7 percent of free moisture.

Fine aggregate -- 100.0 percent minus 3.4 percent = 96.6 percent
803 ÷ 96.6 x 100 = 831 kilograms (1353 ÷ 96.6 x 100 = 1401 lbs.)

Coarse aggregate -- 100.0 percent minus .7 percent = 99.3 percent
973 ÷ 99.3 x 100 = 980 kilograms (1639 ÷ 99.3 x 100 = 1651 lbs.)

To determine the free water in the aggregates subtract the dry aggregate quantity from the adjusted dry aggregate weight for both aggregates and add the two differences.

831 kg - 803 kg = 28 kg (1401 lbs. - 1353 lbs. = 48 lbs.)
980 kg - 973 kg = 7 kg (1651 lbs. - 1639 lbs. = 12 lbs.)

28 kg + 7 kg = 35 kg (48 lbs. + 12 lbs. = 60 lbs.) of free moisture in one cubic yard (cubic meter) of concrete.

The less preferred method is to use the moisture reciprocal tables T214A in which the correction factors are for 3.4 and 0.7, 1.0351967 and 1.0070493 respectively. Multiply the dry aggregate batch weight determined previously by the respective moisture reciprocal correction factor.

Fine aggregate (803 kg)(1.0351967) = 831 kg [(1353 lbs.) (1.0351967) = 1401 lbs.]

Coarse aggregate (973 kg)(1.0070493) = 980 kg [(1639 lbs.) (1.0070493) = 1651 lbs.]

These adjusted quantities are for one cubic meter (cubic yard) and would have to be multiplied times the total cubic meters (cubic yards) being batched. To determine the free water in the aggregates, subtract the dry aggregate weight from the adjusted dry aggregate amount for both aggregates and add the two differences as you did above in the example.

Add the total free water in the aggregates to the water proportioned into the mixer to determine the total water for mixing. The **aggregate moisture tests** shall be determined and recorded at a minimum of **one test per each half day** of operation. Determine and record also at the same time the adjusted dry aggregate batch amounts, the water in the materials, the water proportioned and the total water available in the batch for mixing.

Consult with your District Materials Engineer office staff that will provide a print out of the batch amounts for varying moisture contents.

Record in the plant field book all weight determinations and calculations and sign each day's entry.

Check the aggregate scale settings, also at three-hour minimum intervals, as indicated by the adjusted dry aggregate batch weights. Refer to the section entitled Equipment, in this IM, for the procedure to follow when scale adjustments are required.

The water demand of a particular mix is dependent upon the materials used in the mix. For this reason the water batch weight is determined by trial when the mixing begins. The water batch weight is controlled indirectly by the slump requirements.

Many central mixing plants have equipment for introducing additional water into the mixer after the batch has been in the mixer and has been mixed. The additional water is added manually through a system, which is independent from the main water proportioning system. The auxiliary water meter must be read at the same interval as the moisture determinations and scale adjustments are made. The total water through the auxiliary system is reduced to the pounds per batch basis by dividing by the number of batches produced during the three hour interval and the per batch amount must be included in the total mixing water recorded per batch.

The plant inspector must keep a record in the plant field book of the total mixing water used, including the water in the aggregates, for at least each three (3) hours of normal operation to determine that the maximum permissible water content is not exceeded and to determine the batch volume.

Whenever the water demand, to achieve the desired workability, exceeds the design water/cement ratio and approaches the maximum water allowed, the Engineer and the District Materials Engineer Office should be notified. At the same time, aggregate moisture contents, batch weights, cement scales, water meter, etc., should all be immediately checked. In no circumstance should the maximum water/cement ratio be knowingly exceeded.

If, after the District Materials Engineer investigation and evaluation, additional workability above that which is attainable with the maximum permissible water content is desired, the cement content may be increased in accordance with Article 2301.02. This should be done only with the approval of the District Materials Engineer or his/her representative. The District Materials Engineer will provide the revised and adjusted mix proportions for these situations.

If the batch yield variation is less than 98 percent or greater than 102 percent for the water content being used, refer to Specification Article 2301.02 for the special action necessary. The District Materials Engineer may allow adjustments in the proportions after checking moisture contents of the material and the operation of the batching equipment.

Mixes using fly ash as a substitution for cement are permitted as a contractor option, as allowed in the specifications.

OTHER REPORTED TESTING

1. IN-PLACE AIR CONTENT

   a. Air content of vibrated, in-place concrete will be checked in accordance with Article 2301.02, Paragraph C.

   b. A concrete sample shall be taken from the in-place slab in accordance with IM 327.

   c. There are no acceptance/rejection criteria for these tests. They are for information purposes. The tests are intended to be used to measure air loss through the paver and consistency of the air content of the in-place concrete. A test result less than 5.0% would indicate that action needs to be taken, such as reducing vibrator speed, repositioning vibrators to accommodate additional vibrators, or increasing the addition rate of air entraining.

      If these efforts do not solve an air loss problem, the engineer and District Materials Engineer shall be consulted.

2. VIBRATION CHECKING

   In accordance with Article 2301.02, an electronic vibrator-monitoring device displaying the operating frequency of each individual internal vibrator is required for all Interstate and Primary paving over 50,000 square yards (40,000 m^2).

   a. The vibration speed of each internal vibrator of a slip form paver shall be checked a minimum of once per day. These tests shall be performed while the paver is in operation and concrete surrounds the vibrators.

   b. If any vibrator is found to be operating outside the limits of the specification, the vibration speed shall be immediately changed to comply with the specification. If any vibrator cannot be adjusted to operate within the specification, the paving operation shall be stopped until corrections are completed.

   c. The vibration speeds for each vibrator shall be recorded in the project records. When a vibrator is found to be operating outside the specification limits, record the vibrator speed, location of the vibrator across the pavement, and approximate beginning and ending stations of the section of pavement affected if it can be determined.

REPORTS & REPORTING

1. PLANT PAGE – FORM #240

   Plant reports are to be recorded in the computer program or on hand completed forms, both provided by the Iowa Department of Transportation. A copy of the completed PCC Plant Page shall be faxed or delivered to the District Materials Engineer on the next working day, within four hours after start-up of the plant. The CPI shall keep a copy of the PCC Plant Page and send the original to the Engineer. Copies of the files containing the project information are to be available to the engineer upon request until the project is final.

A separate report is to be made for each day concrete is placed. These reports are to be consecutively numbered for each project. A sample copy and the instructions on completing this report are in Appendix A.

When computer forms are used the CPI and Monitor shall indicate their review by marking initials by their printed name.

2. PERSONAL COMPUTER

The personal computer shall be capable of running Microsoft Excel 2007 or newer version to use Iowa DOT Programs. The printer shall be capable of producing quality hard copies. That is, original printed output, which is clearly readable and remains readable after being faxed and/or copied.

3. READY MIXED CONCRETE, TRUCK TICKET FORM - FORM #830212

When concrete source for a paving project is a commercial ready mix plant, each truckload of concrete must be identified by Form #830212 or acceptable computer generated plant ticket. For continuous mainline paving, Form 830212 shall be filled out completely for the first truck. Tickets for subsequent trucks need only to have the Truck No., Ticket No., Conc. This Truck, Time Batched, Water Subtotal, and Maximum Water Allowed portion filled out. When any change in the moisture content, plant adjustments in mixing water, or any other changes to the batching or materials in the concrete are made, a complete ticket must be filled out for the first load that includes the changes.

The plant inspector or the scale operator must fill in the information pertaining to the plant, and the grade inspector must collect and record the information pertaining to the grade, assemble the tickets by day and store with the other project records. These completed tickets will contain primary information and must not be lost or destroyed. A sample is shown in Appendix C.

4. PORTLAND CEMENT SHIPMENT YIELD REPORT - FORM #820912

The cement shipment yield test is described in section 2a, Cement Scales. Report the cement yield results on Form #820912. A sample copy of Form #820912 is included in Appendix C.

IMs & SPECIFICATIONS

A list of the IMs and Specifications used in PCC Plant Inspection are located at the end of this IM.

CONCRETE PLANT INSPECTION CHECKLIST

A. The proportioning equipment must be examined at least at 3-hour intervals for correctness of the amount being delivered and for damage.

B. The scale sensitivity shall be checked at least twice during a normal working day by placing a mass equal to 1/10 percent of the batch on the fully-loaded scales and observing the movement of the indicator.

C. Check scale operation to determine cement delivery tolerance conformance at least once during

each day of normal operation.

D. The Standard Specification requires that the cement shipment yield determination must be made at intervals of approximately 10,000 cubic yards (10,000 cubic meters) after the original determination made near the end of the first full day of production.

E. Check scale operation to determine aggregate delivery tolerance conformance at least once during a normal working day and document.

F. If water is measured with a scale, the delivery tolerance must be determined at least once for each day of normal operation and document.

G. Admixture dispensers shall be observed for uniform delivery at least once during each 3 hours of normal operation and document.

H. Admixture dispensers must be flushed with water at least once daily.

I. Determine and record the mixing speed and the mixing time at least once daily by using the sweep hand of a watch and counting the drum revolutions in one minute.

J. Determine and record the time between batching and placement at least once during each day of normal operation.

K. Specific gravity - One sample per day for both coarse and fine aggregates for the first three days of normal operation and one for each three days of normal operation for both coarse and fine thereafter, assuming the first three days results are consistent.

L. Moisture - A minimum of one test per each half day of operation.

M. Gradation - Obtain and test one sample per day. Show sample number, name of sampler, and name of tester on lab work sheet.

N. If opening not determined by maturity method, cast one 20-in. (508-mm) long beam for each 2000 cu. yd. (1529 cubic meters) of concrete placed. Make flexural tests representing alternating 2000 cu. yd. (1529 cubic meters) placement units at 7 and 14 days.

O. At the plant, the plant inspector shall remove the specimens, clean the molds, oil and return the molds to the grade at the direction of the paving inspector. The plant inspector shall store the specimens until date of test. The storage space shall be a pit adequate for the project, and for normal projects it should be at least 4 ft. x 6 ft. x 18 in. (1.2 m x 1.8 m x .46 m). The specimens shall be wet at all times. If the temperature in the sand filled pit drops below 40°F (4.4°C), remove the specimens and place them under wetted burlap in a heated enclosure or in lime-saturated water. See IM 328. **NOTE:** Lime-saturated water is prepared by mixing 1 ounce (30 ml) of hydrated lime with 1 gallon (4 L) of water.

P. When opening is determined by the maturity method, casting beams every 2000 cubic yards (1529 cubic meters) is not required. The plant inspector should ensure curve development is performed according to IM 383.

Q. Other duties include:

- Close observation of stockpiling and handling of aggregates. There must be no intermingling of

aggregates and no contamination.

- Frequent check on wet batch or dry batch truck cleanliness and degree of discharge.
- Document all the above data in diary.
- Make the following report daily: Plant Reports - Form #800240
- Make the following report as prescribed: Cement Yield Report - Form #820912E
- At the end of the project, make a copy of the plant book for the Engineer, within ten days.
- When required by Article 2301.02, make a copy of vibration-monitoring device records in electronic format.

IMs/SPECIFICATIONS USED IN PCC PLANT INSPECTION BY VOLUME

Volume II IMs:

IM 527	Paving Plant Inspection
IM 528	Structural Concrete Plant Inspection
IM 529	Portland Cement (PC) Concrete Proportions
IM 401	Hydraulic Cements
IM 403	Chemical Admixtures for Concrete
IM 491.14	Ground Granulated Blast Furnace Slag (GGBFS)
IM 491.17	Fly Ash
IM 203	Consultation Provided by Materials Personnel on Construction Projects
IM 204	Inspection of Construction Project Sampling & Testing
IM 213	Technical Training & Certification Program
IM 216	Guidelines for Validating Testing Results
IM 301	Aggregate Sampling & Minimum Size of Samples for Sieve Analysis
IM 302	Sieve Analysis of Aggregate
IM 306	Determining Amount of Material Finer than the No. 200 (75 µm) Sieve in Aggregate
IM 307	Determining Specific Gravity of Aggregate
IM 308	Determining Free Moisture & Absorption of Aggregates
IM 316	Flexural Strength of Concrete
IM 317	Slump of Hydraulic Cement Concrete
IM 318	Air Content of Freshly Mixed Concrete by Pressure
IM 327	Sampling Freshly Mixed Concrete
IM 328	Making, Protecting & Curing Concrete Flexural Strength Field Specimens
IM 383	Estimate of Portland Cement Concrete Strength by Maturity Method

Volume IV IMs:

IM 209	Certified Aggregates & Approved Producer Program
IM 409	Source Approvals for Aggregates
IM T203	General Aggregate Source Information

Specifications:

2301	Portland Cement Concrete Pavement
2403	Structural Concrete
4100	General Provisions

2001 General Equipment Requirements

Supplemental or Developmental Specification that was in effect at the time of the project letting.