PORTLAND CEMENT CONCRETE
LEVEL I
INSTRUCTION MANUAL

2023-2024



TECHNICAL TRAINING AND CERTIFICATION PROGRAM

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Ashley Buss	Bituminous Materials Engineer	515-233-7837	515-239-1092
Todd Hanson	PCC Materials Engineer	515-239-1226	515-239-1092
Mahbub Khoda	Prestressed Concrete Engineer	515-239-1649	515-239-1092
Elijah Gansen	PCC Field Engineer	515-239-1769	515-239-1092
Kyle Frame	Structures Group Manager	515-239-1619	515-239-1092
Jesse Peterson	Structures Field Engineer	515-239-1585	515-239-1092
Chris Brakke	Pavement Management Engineer	515-239-1882	515-239-1092
Jeffrey Schmitt	Bituminous Field Engineer	515-239-1013	515-239-1092
Bob Dawson	Chief Geologist	515-239-1339	515-239-1092
Melissa Serio	Soils & Grading Field Engineer	515-239-1280	515-239-1092
Mike Lauritsen	District 1 Materials Engineer	515-357-4350	515-239-1943
Robert Welper	District 2 Materials Engineer	641-422-9421	641-422-9463
Vacant	District 3 Materials Engineer	712-239-4713	712-239-4970
Timothy Hensley	District 4 Materials Engineer	712-243-7629	712-243-6788
Allen Karimpour	District 5 Materials Engineer	641-469-4040	641-469-3427
Shane Neuhaus	District 6 Materials Engineer	319-366-0446	319-730-1565

ORGANIZATIONS CONTACT INFORMATION

Asphalt Paving Association of Iowa
1606 Golden Aspen Drive Ste 102
Ames, IA 50010
Scott Dockstader 515-233-0015
www.apai.net

Iowa Concrete Paving Association
360 SE Delaware Ave.
Ankeny, Iowa 50021
Greg Mulder 515-963-0606
www.concretestate.org

Iowa Prestress Association
Dennis Drews 402-291-0733

Iowa Limestone Producers Association
4438 114th St
Urbandale, IA 50322
Randy Olson 515-262-8668
www.limestone.org

Iowa Ready Mix Concrete Association
380 SE Delaware Ave.
Ankeny, Iowa 50021
Greg Mulder 515-965-4575
www.iowareadymix.org

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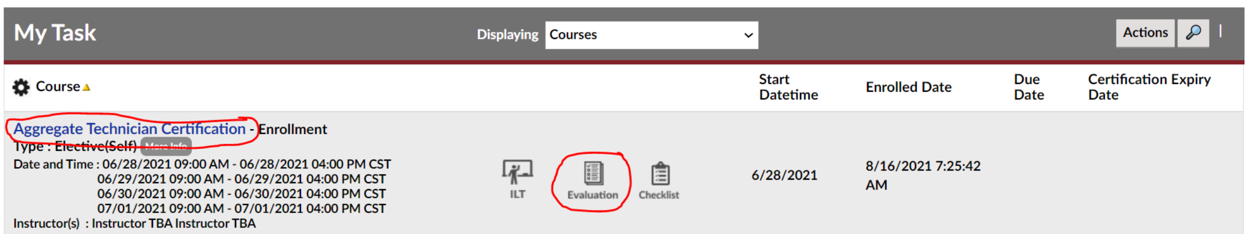
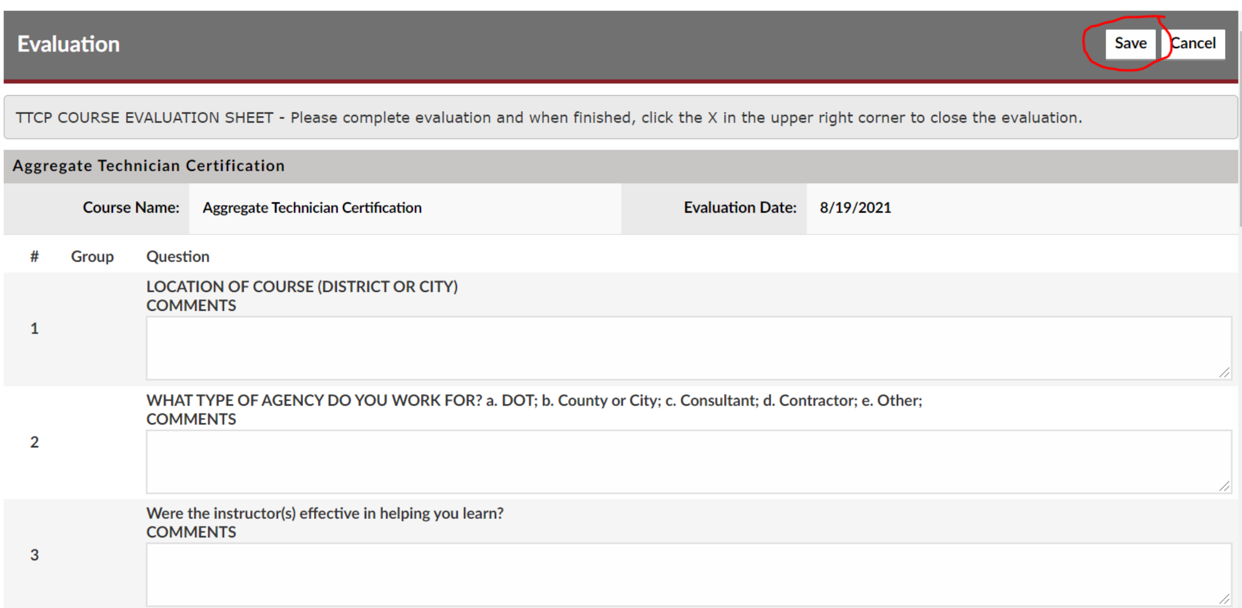
CLASS EVALUATIONS

Evaluations will now be completed outside of the classroom. They are available in IowaDOTU and can be found at this web address: https://learning.iowadot.gov/

Please login to the system and then scroll down to where you see the "My Task" line. Locate the class that you were enrolled in and completed. To the right of the class name, you will see an icon for the Evaluation. Click the Evaluation icon and it will open the evaluation for you to complete electronically.



Once you have completed the 11 questions on the evaluation, scroll to the top of the page and click the "Save" button. Thank you for completing this evaluation!



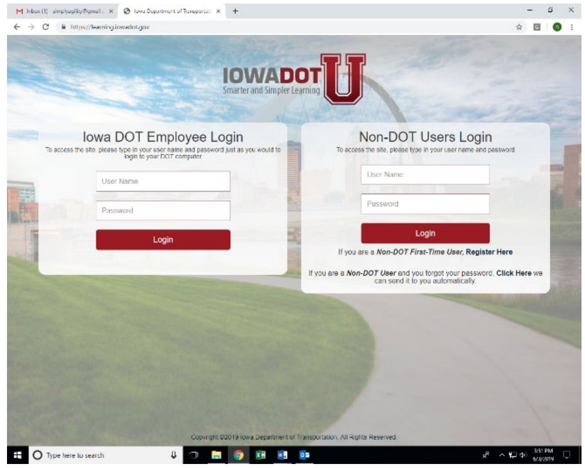
WEBSITES USED IN TTCP CLASSES

There are 2 websites you will use as a TTCP Student. You will set yourself up as a user of each of these websites. It's important that you remember your user name and password for each site (hint: since you are setting each of them up yourself, you could use the same password for each site.)

IOWADOTU

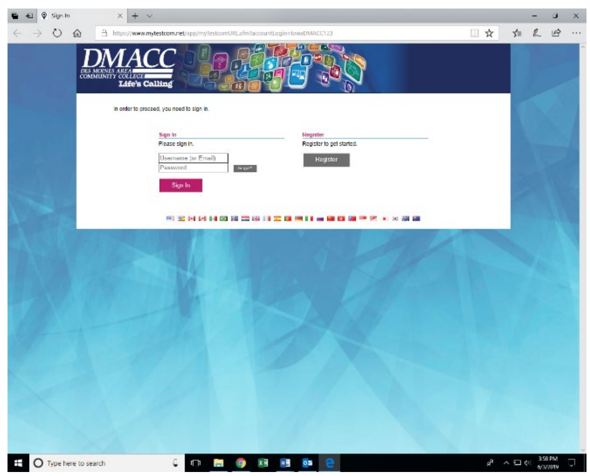
https://learning.iowadot.gov/

This is where you register for classes and take web-based training. You can also print your training records transcripts here. Step-by-step instructions are available at https://iowadot.gov/training/technical-training-and-certification-program



COMPUTER TESTING

All TTCP Exams will be done on the computer. Your instructor will guide you to the Test.Com website and assist with any registration requirements. Questions are multiple choice, and you will be able to see your score immediately as well as the questions that you missed.



CONCRETE TESTS SUMMARY

CONCRETE TESTS SUMMARY

Test	IM	Importance	Requirement	Specifications
Sampling Concrete	327	To properly secure concrete samples to ensure accurate readings of air, slump, and strength.	When possible, sample from last point of placement. Air contents and slump vary depending on type and point of placement.	Varies with type of work, i.e., paving vs ready mix.
Temperature	385	To determine temperature of concrete being placed. Concrete in cold weather must attain a minimum strength to be able to withstand one freeze thaw cycle without cracking. Concrete in hot weather must be cured properly to prevent plastic shrinkage cracking.	During hot weather conditions, temperature of concrete may attribute to high w/c ratio, workability problems, and difficulty entraining air. Possible solutions include using ice in water, paving at night, place curing as soon as possible, etc. During cold weather, temperature may attribute to slow strength gain and indicate a need for protection. Generally, concrete hydrates best at 55 F. Temperatures below 40 F and above 90 F require attention to curing and protection.	2301.19 Pavement 2403.11 Structures
Slump	317	To determine the batch-to-batch consistency of a particular mix. It is not a measure of workability. May give an indication of the w/c ratio of a particular mix. Increasing slump by adding water may cause mix to segregate during placement.	In general, 3 to 4” slump is a maximum for normal concrete mixes. Testing not required in slipform paving because too much slump will cause the pavement edge to slump. HRWR’s may be used to increase slump (8” or more) and prevent segregation. Rule of Thumb: Adding 1 gallon of water per cubic yard increases slump 1”.	Slipform paving – none Varies with type of work IM 204

CONCRETE TESTS SUMMARY

Air	318	To determine if adequate air is entrained in concrete to provide freeze thaw resistance for long-term durability. Concrete is porous and water travels in and out of pores. Since water expands 9% when frozen, air voids provide pressure relief, otherwise the frozen water will crack the concrete.	In general, 6% air content for in-place concrete is required to provide protection. Specifications require higher amounts to account for loss during placement, especially with vibration. Generally, high air contents do not affect durability as air content being too low does. Main affect of higher air content is reduced strength. Rule of thumb: A 1% increase in air content decreases compressive strength approximately 5%.	Varies with type of work IM 204
Unit Weight	340	To determine unit weight of concrete. Unit weight gives an indication of problems in batch weights and yield. Since air weighs nothing, but occupies a volume, air content may be determined from unit weight. It may also be used to give an indication of an air meter problem and used to help with correlation problems.	Ensure concrete is properly consolidated, struck off, and sides are cleaned. Improperly striking off surface and excess material on container will affect results. Rule of thumb: A 1% change in air content approximately equals change in unit weight of 0.5 lbs/ ft3.	
Making and Curing Beams	328	To cast and cure flexural strength beams and ensure accurate strength test. Beams used for payment or QMC should be consolidated in accordance with AASHTO T23, by rodding or vibration.	Ensure proper consolidation, entrapped air and voids in concrete will reduce beam strength. **Improper curing will increases moisture loss in beam causing lower strengths.** Since specimens are small, improper protection from cold or hot weather affects early and later strengths. Beams delivered any distance should be protected from impact loading and wrapped in wet burlap and plastic to prevent moisture loss.	IM 204

CONCRETE TESTS SUMMARY

Testing Beams Center Point Third Point	316 ASTM C 78 AASHTO T 97	To determine if a pavement may be loaded or structural forms may be removed and loaded in flexure.	Ensure proper loading rate for accurate reading on load. Generally, 500 psi center point loading is required to open pavement to traffic. 575 psi is required for flexural loading of structural concrete. A 28 day strength of 640 psi third point loading is required for QMC paving.	2301.31 Pavement 2403.18 & 19 Structures
Making and Curing Cylinders	315	To cast and cure cylinders and ensure accurate compressive strength test.	Ensure proper consolidation, entrapped air and voids in concrete will reduce cylinder strength. Improper curing will increases moisture loss in beam causing lower strengths. Since specimens are small, improper protection from cold or hot weather affects early and later strengths. Cylinders delivered any distance should be protected from impact loading and wrapped in wet burlap and plastic to prevent moisture loss.	IM 204
Testing Cylinders	315	To determine compressive strength of structures. Determining accurate compressive strength is essential to prevent failure.	Majority of bridges and structures designed for a minimum of 3500 psi. HPC bridges designed for a minimum of 5000 psi. Precast and prestress concrete require minimum strengths before removing from beds and transporting.	

CONCRETE TESTS SUMMARY

Maturity	383	To determine strength of in-place concrete, non-destructively, using curing temperature. Since concrete gains strength with time and temperature, the time and temperature a given mix is subjected to can be related to the strength. Maturity method involves 3 steps 1) Strength maturity relationship developed on first day paving. 2) Temperature is monitored in pavement or structure and maturity (TTF) calculated. 3) Validate curve every 90 calendar days.	General TTF values range from 900 to 2000°C•hr. Values of TTF are generally higher when using blended cements due to the slower setting characteristics. Since w/c ratio has biggest impact on strength, curve development should be performed with concrete at highest w/c ratio anticipated. Since specimens are small, beams should be protected during curve development. Temperature of beam is important, refer to IM 383. Opening of pavement or structure responsibility of engineer.	

ROUNDING & DECIMALS

Rounding is uniform throughout the certification training. You would look at the place to the right of the number you are rounding to and if it is 5 or above round up or 4 and below round down.

Examples:

Rounding to whole numbers-
130.5 = 131   130.4 = 130   130.46 = 130

Rounding to tenths-
130.55 = 130.6   130.54 = 130.5   130.646 = 130.6

Rounding to hundredths-
130.555 = 130.56   130.544 = 130.54   130.5545 = 130.55

Rounding to thousandths-
130.5555 = 130.556   130.5544 = 130.554   130.55546 = 130.555

Rounding to nearest 5-
553.6 = 555   551.9 = 550   552.5 = 555

GLOSSARY

PORTLAND CEMENT CONCRETE GLOSSARY

Acceptance program - All factors that comprise the State Highway Agency's (SHA) determination of the quality of the product as specified in the contract requirements. These factors include verification sampling, testing, and inspection and may include results of quality control sampling and testing.

Ambient temperature - Temperature of the surrounding air.

Beam Machine - A machine used to test flexural strength specimens.

Beam Mold - A container, typically 6 x 6 x 22 inches or 4 X 4 X 14 inches, used to cast concrete specimens for flexural strength testing.

Compressive Strength - The maximum resistance of concrete, or mortar, to axial loading in a compression testing machine, expressed as a force per unit area, such as pounds per square inch (psi).

Concrete Core Testing Apparatus (9-point testing machine) - A machine used to measure the length of cut concrete cores.

Concrete Cylinder - A cylindrical specimen of concrete, typically cast in a 4 x 8 inch or 6 x 12 inch mold, used for compressive strength testing.

Density/Unit Weight - The ratio of mass to volume of a substance. Usually expressed in lbs/ft^3•

Flexural Strength - A concrete property measured by an unreinforced concrete beam and the ability to resist failure in bending. Flexural strength, or Modulus of Rupture (MR), is expressed as a force per unit area, such as pounds per square inch (psi) either by third point or center point loading.

Flowable Mortar - A self-consolidating, low strength material used for backfilling as an alternative to granular materials.

Hydration in concrete - The process in which a chemical reaction occurs between cement particles and water.

Independent assurance - Unbiased and independent evaluation of all the sampling and testing procedures, equipment, and technicians involved with Quality Control (QC) and Verification/Acceptance.

Maturity Method - A method of estimating concrete strength based on the principle that concrete strength is directly related to age and temperature history.

MIT Scan - A device that uses pulse induction technology to non-destructively determine pavement thickness by detecting the depth of a metal target placed on the base beneath the pavement.

Portland cement concrete (PCC) - A controlled mix of aggregate, Portland cement, and water, and possibly other admixtures.

PCC batch plant - A manufacturing facility for producing Portland cement concrete.

Quality assurance - Planned and systematic actions necessary to provide confidence that a product or service will satisfy given requirements for quality. The overall system for providing quality in a constructed project, including Quality Control (QC), Verification/ Acceptance, and Independent Assurance (IA).

Quality control (QC) - Operational, process control techniques or activities that are performed or conducted to fulfill contract requirements for material or equipment quality.

Quality Management Concrete (QMC) - A system of paving where the design, testing, placement, and monitoring of a concrete mixture is done by a contractor in partnership with the agency.

Random sampling - Procedure for obtaining non-biased, representative samples.

Slump - Measurement of the relative consistency of concrete.

Verification/Acceptance - Process of sampling and testing performed to validate Quality Control (QC) sampling and testing and, thus, the quality of the product. Sometimes called Acceptance.

Yield - Volume of concrete produced per cubic yard.

Various Types of Concrete Placements

Slipform Paving

Slipform Paving

Fixed Form Paving

Full Depth Patching

Partial Depth Patching

Bridge Deck Placement (Superstructure)

Pier Concrete Placement (Sub Structure)

Bridge Deck Overlay

Bridge Deck Overlay

Slipform Barrier Rail

Portable Plant

Ready Mix Dry Batch

FEDERAL CODE 1020 and IOWA CODE 714.8

I.M. 213 discusses the Unsatisfactory Notice that Certified Technicians are given when they are not performing their job duties satisfactorily. This can be given for a number of reasons including, improper sampling and/or testing, not performing their duties and reporting in the time frame required, reporting incorrect information, etc. The technician is given one written notice, the second notice is three-month certification suspension, and the third notice is decertification. According to I.M. 213 the Certified Technician can automatically be decertified for false statements without going through the Unsatisfactory Notice procedure. The Certified Technician also needs to be aware of the false statement clause that is applicable to all federal-aid projects and the fraudulent practice clause that applies to all non-federal aid projects. **Certified Technicians need to read and be aware of U.S.C. 1020 and Iowa Code 714.8 since these do apply to them.** They read as follows:

FEDERAL AID PROJECTS

IX. FALSE STATEMENTS CONCERNING HIGHWAY PROJECTS

In order to assure high quality and durable construction in conformity with approved plans and specifications and a high degree of reliability on statements and representations made by engineers, contractors, suppliers, and workers on Federal-aid highway projects, it is essential that all persons concerned with the project perform their functions as carefully, thoroughly, and honestly as possible. Willful falsification, distortion, or misrepresentation with respect to any facts related to the project is a violation of Federal law. To prevent any misunderstanding regarding the seriousness of these and similar acts, the following notice shall be posted on each Federal-aid highway project (23 CFR 635) in one or more places where it is readily available to all persons concerned with the project:

NOTICE TO ALL PERSONNEL ENGAGED ON FEDERAL-AID HIGHWAY PROJECTS
18 U.S.C. 1020 reads as follows:

"Whoever, being an officer, agent, or employee of the United States, or of any State or Territory, or whoever, whether a person, association, firm, or corporation, knowingly makes any false statement, false representation, or false report as to the character, quality, quantity, or cost of the material used or to be used, or the quantity or quality of work performed or to be performed, or the cost thereof in connection with the submission of plans, maps, specifications, contracts, or costs of construction on any highway or related project submitted for approval to the Secretary of Transportation; or

Whoever knowingly makes any false statement, false representation, false report or false claim with respect to the character, quality, quantity, or cost of any work performed or to be performed, or materials furnished or to be furnished, in connection with the construction of any highway or related project approved by the Secretary of Transportation; or

Whoever knowingly makes any false statement or false representation as to material fact in any statement, certificate, or report submitted pursuant to provisions of the Federal-aid Roads Act approved July 1, 1916, (39 Stat. 355), as amended and supplemented;

Shall be fined not more than $10,000 or imprisoned not more than 5 years or both"

NON-FEDERAL AID PROJECTS

Iowa Code 714.8, subsection 3, defines fraudulent practices. "A person who does any of the following acts is guilty of a fraudulent practice. Subsection 3, Knowingly executes or tenders a false certification under penalty of perjury, false affidavit, or false certificate, if the certification, affidavit, or certificate is required by law or given in support of a claim for compensation, indemnification, restitution, or other payment." Depending on the amount of money claimed for payment, this could be a Class C or Class D felony, with potential fines and/or prison.

The above codes refer to the individual making the false statement. **Standard Specification Article 1102.03, paragraph C. section 5 refers to the Contractor.**

Article 1102.03, paragraph C, section 5 states, "A contractor may be disqualified from bidder qualification if or when: The contractor has falsified documents or certifications, or has knowingly provided false information to the Department or the Contracting Authority."

IM 213 - TRAINING & CERTIFICATION

TECHNICAL TRAINING & CERTIFICATION PROGRAM

GENERAL

The purpose of the Technical Training & Certification Program is to ensure Quality Control (QC)/Quality Assurance (QA) and Acceptance of Aggregates, Hot Mix Asphalt (HMA), Portland Cement Concrete (PCC), Soils, Erosion Control, Precast and Prestressed Concrete, and Pavement Profiles and to ensure proper documentation of quality control/quality assurance and acceptance procedures and test results by industry and Contracting Authority personnel.

This Instructional Memorandum (IM) explains the requirements to become certified and to remain certified to perform inspection and testing in the State of Iowa. This IM also describes the duties, responsibilities and the authority of persons assigned the position of Certified Technician in any of the above areas for construction or maintenance projects. Appendix C of this IM lists what tests and procedures the technician is qualified to perform for each level of certification they obtain.

Through a cooperative program of training, study, and examination, personnel of the construction industry, State DOT, and other Contracting Authorities will be able to provide quality management and certified inspection. Quality control/quality assurance and acceptance sampling, testing and inspection will be performed by certified personnel and documented in accordance with the IMs.

A technician who is qualified and holds a valid certification(s) shall perform quality control/quality assurance and acceptance at a production site, proportioning plant, or project site. Responsibilities cannot be delegated to non-certified technicians. The duties of a Certified Technician may be assigned to one or more additional Certified Technicians.

The Technical Training & Certification Program will be carried out in accordance with general policy guidelines established or approved by the Highway Division Director. A Board of Certification composed of the following members will advise the Director:

Director – Construction and Materials Bureau
Representative of District Materials Engineers**
Representative of District Construction Engineers**
Representative of Associated General Contractors (AGC of Iowa)
Representative of Iowa Concrete Paving Association (ICPA)
Representative of Asphalt Paving Association of Iowa (APAI)
Representative of Iowa Ready Mixed Concrete Association (IRMCA)
Representative of Iowa Limestone Producers Association (ILPA)
Representative of County Engineers
Representative of American Council of Engineering Companies (ACEC-Iowa)
Coordinator of Technical Training & Certification Program**

** Appointed by Program Director

The Director of the Construction and Materials Bureau will be the Program Director. Coordinators will be appointed by the Program Director to assist in administration of the program and to handle such planning, administration, and coordinating functions as may be needed.

TRAINING

The Iowa DOT will provide the training necessary to become certified. Producers/Contractors are encouraged to conduct their own pretraining program. A complete listing of training opportunities is available at the Technical Training & Certification Program website, https://iowadot.gov/training/technical-training-and-certification-program.

CERTIFICATION REQUIREMENTS

1. A candidate must attend Iowa DOT course instruction and pass the examination(s) for all levels of certification prepared and presented by the Program Director or someone designated by the Program Director. If the new candidate fails the examination, they will have one opportunity to retake the examination. The retake must be completed within six months of the original exam. If they fail the retake of the examination, they will need to attend the training again before taking the examination the third time. If an individual is recertifying they will have only one opportunity to take the examination. If they fail the examination they must take the applicable training before retaking the examination.

2. All prerequisites shall be met before the applicant may attend the next level of training for the certification desired. A listing of certification levels and prerequisites is located in Appendix A.

3. Once the candidate has met all the criteria and has received certification, it is recommended the Certified Technician work under the supervision of an experienced technician until they become efficient in the inspection and testing methods they will be performing.

   An individual requesting to become certified as a Precast/Prestress Concrete Technician is required to obtain forty hours of experience assisting in quality control inspection at an approved plant before certification will be issued. The experience must be documented and shall be approved by the District Materials Engineer. This experience must be completed within two years from the date the individual attended the training.

4. Registered Professional Engineers, engineering graduates, and geology graduates from accredited institutions will be exempt from the training requirement in the areas they have had instruction. It is, however, strongly recommended that they attend the certification classes. In order to obtain certification for any technical level, these persons must pass all applicable written examinations for the level of certification they wish to obtain. If the written examination attempt does not meet the required score, the candidate must take the certification class before another attempt can be made. All certificates issued in accordance with these requirements will be subject to the same regulations concerning expiration, recertification, etc., as applies to certificates obtained via training and examinations.

5. Technicians will be issued certifications by reciprocity when the following criteria are met:

   a. The applicant must be certified in another state or certification program determined equivalent by the Program Director or someone designated by the Program Director, in each level of certification they are requesting.

   b. The applicant must pass an examination for each level of certification desired, which will be administered by the Iowa Department of Transportation. Failure of the examination shall require the applicant to take the applicable schooling before they can retake the exam.

c. The applicant must follow the prerequisite requirements of the Technical Training & Certification Program.

Reciprocity requests should be made through the Technical Training and Certification office in Ames. Copies of all the applicant's certifications will be required.

CERTIFICATION

Upon successfully completing the requirements for certification, the Program Director will issue a pocket certification card. The certification is not transferable. A certification shall be valid for five years.

CERTIFICATION IDENTIFICATION

The certification card will identify the certificate holder, their certification number, the level(s) of certification, and the expiration date of each level.

RENEWAL OF CERTIFICATION

A certification shall be valid through December 31st of the fifth year. A 90-day grace period will be allowed. If the individual has not renewed their certification within the 90-day grace period, they are automatically decertified. The individual may obtain certification by taking the examination for the level of certification they are requesting. If the individual does not take the examination within one year after their certification(s) expire, i.e., 12/31/expiration year, they must retake all applicable schooling and pass the examinations. If an applicant becomes decertified in any level of certification and that certification is a prerequisite for other levels of certification the applicant will also be decertified in those related levels of certification.

All certified technicians will be required to pass an examination in each level of certification they hold before recertification will be issued. Failure of any level shall require the applicant to retake the applicable schooling and pass the test.

The certificate holder shall be responsible for applying for certification renewal and for maintaining a current address on file.

PROVISIONAL CERTIFICATION

Provisional certification will be allowed through a special request to the TTCP Director. The request can be mailed or emailed to the TTCP Director and must include the need for a provisional certification, such as, company technician quit and they need to replace, an unforeseen workload, etc. Provisional certifications will only be granted to contractors. If the request is granted the following requirements will apply.

1. The provisional certification applicant must work under the direct supervision of a certified technician until such time that the applicant is competent in the required skills of the certification and has taken the written exam. The applicant must also take the web based review offered by the TTCP in the area they are seeking provisional certification.
2. The applicant must take and pass the written exam for the provisional certification they are requesting. There will be a testing fee in the amount of the TTCP recertification fee due at the time of the exam. CIT funds may not be used for provisional certification testing. The exams will be offered at the District Materials offices or the TTCP office in Ames.
3. The technician must demonstrate proficiency to an Iowa DOT certified technician at the first available opportunity.

4. After the provisional certification applicant has successfully completed the steps in 1 and 2, they will become provisionally certified until the end of the calendar year in which they obtained certification.
5. If the provisional certified technician wishes to keep their certification they must attend the full class at the full class cost for the certification during the training season immediately following their provisional certification.
6. A provisional certification is not intended to be an annual request. The provisional certification will only be allowed for one construction season. Repeated requests for provisional certifications for the technician will be denied.
7. Any prerequisites for the certification must be met prior to number 2 above.
8. HMA Basic Tester is a new certification that may only be used as a provisional certification. This certification follows all the requirements previously listed and the technician will be required to take Level I HMA at the first available opportunity after the provisional expires.
9. Provisional Certification will be offered for:
    a. Aggregate Sampler
    b. Aggregate Technician
    c. Level I PCC
    d. HMA Sampler
    e. HMA Basic Tester

UNSATISFACTORY PERFORMANCE NOTICE
A certified technician failing to perform the required specified duties or inadequately performing these duties, will receive an Unsatisfactory Notice (Materials IM 213, Appendix B). The notice will be from the District Materials Engineer in the District where the failure occurred. This notice and all supporting documentation will be placed in the technician's permanent file with the District Materials Office in which the technician resides. The notice will also be placed on the statewide computer file. The notice will remain in their file for five years. The notice may be removed prior to the five years upon the recommendation of the District Materials Engineer.

SUSPENSION
A technician receiving two Unsatisfactory Work Performance Notices for work performed under a specific certification will be given a three-month suspension of the applicable certification. Suspended technicians shall not perform any duties governed by the suspended certification, including any duties which require the suspended certification as a prerequisite.

Technicians are eligible to be reinstated after the three-month suspension and successful completion of the applicable recertification test(s).

Technicians are subject to decertification when they receive a third Unsatisfactory Performance Notice.

The suspension will be effective on the date the Program Director issues the suspension.

DECERTIFICATION
Certified Technicians will be decertified for any of the following reasons:

Certifications will be revoked for the following reasons:
1. Failure of the certificate holder to renew the certificate prior to regular expiration as described above.

2. Use of false or fraudulent information to secure or renew a certificate.

3. Use of false or fraudulent documentation by the certificate holder.

4. Use of misleading, deceptive, untrue or fraudulent representations by the certificate holder.

5. Cheating on certification exams or performance evaluations. This includes removing, or attempts to remove, exam questions, answers, or other exam materials from the testing location.

6. Receipt of 3 Unsatisfactory Performance notifications, as stated above under suspension.

The Program Director, or designee, will notify an individual in writing of the intent to suspend or revoke the individual's certification(s). Notice will also be sent to the technician's last known employer. For DOT employees, notice will also be sent to their immediate supervisor.

An individual's certifications will be suspended during the appeal process, and the individual can't perform any duties governed by the certification during this time, until the first day following the end of the appeal process described below.

Technicians that are decertified shall not perform any duties requiring certification.

APPEALS & REINSTATEMENT REQUESTS

An individual has 10 business days to respond to the revocation notice. If the individual fails to respond with an appeal within 10 days of receipt of the original revocation notice, the suspension or revocation becomes effective on the 10^{th} day.

Appeal step 1: First step appeals will be heard by the program director and a representative panel. The individual will have an opportunity to present information to support their continued certification to the panel. The Program Director and representative panel will then render a written decision, taking into account the technician's actions or omissions, the existence of past infractions, and any mitigating factors. This step 1 appeal will become final if further action is not taken as described in appeal step 2 and the suspension or revocation will become effective on the day the decision is issued by the panel.

Appeal step 2: If the individual is not satisfied with the decision of the Program Director and representative panel, the individual shall, within 10 days of receipt of the written decision, submit a request for further review to the Program Director. This appeals request will be considered by the entire Certification Board. The decision of the Certification Board will be the final decision on behalf of Technical Training & Certification Program.

Any violation will remain on the violator's record for five years, at which time the violation will be removed from their record.

A technician may request reinstatement after one year of being decertified unless the Program Director authorized a shorter period of time, which shall not be less than three months. If a reinstatement is authorized, the individual must attend and successfully complete the applicable certification courses.

FUNCTIONS & RESPONSIBILITES

A certificate holder at each production site, project site, proportioning plant, or laboratory will perform duties. The certified technician shall perform quality control testing in accordance with specified frequencies and submit designated reports and records.

The specification requirement for materials testing by a certified technician does not change the supplier's responsibilities to furnish materials compliant with the specification requirements.

The District Materials Engineer and/or Project Engineer will be responsible for monitoring the sampling, testing, production inspection activities and quality control performed by the contractor. A monitor shall have satisfactorily completed the training and be certified for the level of technician they are monitoring.

The District Materials Engineer and/or Project Engineer will have authority and responsibility to question and, where necessary, require changes in operations and quality control to ensure specification requirements are met.

QUALITY CONTROL, TESTING, & DOCUMENTATION

The QC Technician shall be present whenever construction work related to production activity, such as stockpiling or other preparatory work, requires record development and/or documentation is in progress. The QC Technician's presence is normally required on a continuing basis beginning one or more days before plant operation begins and ending after plant shut down at the completion of the project. The work shall be performed in a timely manner and at the established frequencies.

The QC Technician's presence is not normally required during temporary plant shut downs caused by conditions, such as material shortages, equipment failures, or inclement weather.

All quality control activities and records shall be available and open for observation and review by representatives of the contracting authority.

Reports, records, and diaries developed during progress of construction activities will be filed as directed by the Contracting Authority and will become the property of the Contracting Authority.

Quality control activities, testing, and records will be monitored regularly by Contracting Authority representatives. The Project Engineer or District Materials Engineer will assign personnel for this function.

Monitor activities will be reported and filed at prescribed intervals with the Project Engineer, District Materials Engineer, producer, contractor, and the contractor's designated producer.

At no time will the monitor inspector issue directions to the contractor, or to the QC Technician. However, the monitor inspector will have the authority and responsibility to question, and where necessary, reject any operation or completed product, which is not in compliance with contract requirements.

ACCEPTANCE

Completed work will be accepted on the basis of specification compliance documented by acceptance test records, and monitor inspection records. Specification noncompliance will require corrective action by the producer, contractor, or by the contractor's designated producer, and review of events and results associated with noncompliance by the Project Engineer.

CERTIFICATION LEVELS

CERTIFICATION LEVEL	TITLE	PRE-REQUISITES
	AGGREGATE	
Aggregate Sampler	Certified Sampling Technician	None
Aggregate Technician	Certified Aggregate Technician	None
	CONTRACT ADMINISTRATION	
Level II Contract Admin.	Level II Contract Admin. Tech	Level I Contract Admin.
Level III Contract Admin.	Level III Contract Admin. Tech	Level II Contract Admin., Level I HMA, Level II PCC
	EROSION CONTROL	
Erosion Control	Erosion Control Technician	None
	HOT MIX ASPHALT	
HMA Sampler	HMA Sampler	None
Level I HMA	HMA Technician	Aggregate Technician
Level II HMA	HMA Mix Design Technician	Level I HMA
	PORTLAND CEMENT CONCRETE	
Level I PCC**	PCC Testing Technician	None
Level II PCC	PCC Plant Technician	Agg. Technician & Level I PCC
Level III PCC	PCC Mix Design Technician	Level II PCC

**American Concrete Institute (ACI) Grade I certification will be acceptable as a portion of the Level I PCC training.

CERTIFICATION LEVEL	TITLE	PRE-REQUISITES
	PRESTRESS	
Prestress	Prestress Technician	Level I PCC or ACI Grade I If the technician will be performing gradations, they will need to be Aggregate Technician certified.
	RIDE QUALITY	
Ride Quality	Ride Quality Technician	None
	SOILS	
Soils	Soils Technician	None

UNSATISFACTORY PERFORMANCE NOTICE

Issued To: ____________________________ Date: ____________________

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This notice is to inform you that your performance as a Certified Inspector/Technician was unsatisfactory for the reason(s) listed below.

This notice will be placed in your permanent file with the District Materials Office in which you reside. It will also be placed on the statewide computer file.

The goal of the Technical Training and Certification Program (TTCP) is to work with contractors, producers, cities, and counties to continually improve the quality of Iowa's construction projects. We hope you will work with us to achieve this goal.

Unsatisfactory Performance:

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District Materials Engineer

cc: Program Director – Construction and Materials Engineer, Ames
TTCP Coordinator
Resident Construction Engineer

CERTIFIED TECHNICIANS QUALIFICATIONS

Tests and Procedures the Certified Technician is qualified to perform for each level of certification.

AGGREGATE SAMPLER

- IM 204 - Inspection of Construction Project Sampling & Testing (when material is incorporated)
- IM 209, App. C - Aggregate Specification Limits & Sampling & Testing Guide (when material is produced)
- IM 301 - Aggregate Sampling Methods
- IM 336 – Methods of Reducing Aggregate Field Samples to Test Samples

AGGREGATE TECHNICIAN

- IM 204 - Inspection of Construction Project Sampling & Testing (when material is incorporated)
- IM 209, App. C - Aggregate Specification Limits & Sampling & Testing Guide (when material is produced)
- IM 210 – Production of Certified Aggregate From Reclaimed Roadways
- IM 216 - Guidelines for Verifying Certified Testing Results
- IM 301 - Aggregate Sampling Methods
- IM 302 - Sieve Analysis of Aggregates
- IM 306 - Determining the Amount of Material Finer Than #200 (75µm) Sieve in Aggregate
- IM 307 - Determining Specific Gravity of Aggregate
- IM 308 - Determining Free Moisture & Absorption of Aggregate
- IM 336 - Methods of Reducing Aggregate Field Samples to Test Samples
- IM 344 - Determining the Amount of Shale in Fine Aggregate
- IM 345 - Determining the Amount of Shale in Coarse Aggregate
- IM 368 – Determining the Amount of Clay Lumps & Friable Particles in Coarse Aggregate
- IM 409 – Source Approvals for Aggregate

LEVEL II CONTRACT ADMINISTRATION

- N/A

LEVEL III CONTRACT ADMINISTRATION

- IM 101 – Review of Materials Used in Construction & Maintenance Projects
- IM 103 – Inspection Services Provided to Counties, Cities, and Other State Agencies
- IM 204 – Inspection of Construction Project Sampling & Testing

HMA BASIC TESTER (This is for Provisional Certification Only)

- IM 321 - Method of Test for Compacted Density of Hot Mix Asphalt (HMA) (Displacement Method)
- IM 322 - Method of Sampling Uncompacted Hot Mix Asphalt
- IM 323 - Method of Sampling Asphaltic Materials
- IM 325G - Method of Test for Determining the Density of Hot Mix Asphalt (HMA) Using the Superpave Gyratory Compactor (SGC)
- IM 350 - Maximum Specific Gravity of Hot Mix Asphalt (HMA) Mixtures

- IM 357 - Preparation of Hot Mix Asphalt (HMA) Mix Samples for Test Specimens
- All forms must be signed by an HMA I or HMA II certified technician

HMA SAMPLER
- IM 320 – Method of Sampling Compacted Asphalt Mixtures
- IM 321 – Method of Test for Compacted Density of Hot Mix Asphalt (HMA) (Displacement Method)
- IM 322 - Method of Sampling Uncompacted Hot Mix Asphalt
- IM 323 - Method of Sampling Asphaltic Materials

LEVEL I HMA
- IM 204 - Inspection of Construction Project Sampling & Testing
- IM 208 - Materials Laboratory Qualification Program
- IM 216 - Guidelines for Verifying Certified Testing Results
- IM 320 - Method of Sampling Compacted Asphalt Mixtures
- IM 321 - Method of Test for Compacted Density of Hot Mix Asphalt (HMA) (Displacement Method)
- IM 322 - Method of Sampling Uncompacted Hot Mix Asphalt
- IM 323 - Method of Sampling Asphaltic Materials
- IM 325G - Method of Test for Determining the Density of Hot Mix Asphalt (HMA) Using the Superpave Gyratory Compactor (SGC)
- IM 337 - Determining Thickness of Completed Courses of Base, Subbase, & Hot Mix Asphalt
- IM 350 - Maximum Specific Gravity of Hot Mix Asphalt (HMA) Mixtures
- IM 357 - Preparation of Hot Mix Asphalt (HMA) Mix Samples for Test Specimens
- IM 501 - Asphaltic Terminology, Equations & Example Calculations
- IM 508 - Hot Mix Asphalt (HMA) Plant Inspection
- IM 509 - Tank Measurement & Asphalt Cement Content Determination
- IM 511 - Control of Hot Mix Asphalt (HMA) Mixtures

LEVEL II HMA
- IM 380 - Vacuum-Saturated Specific Gravity & Absorption of Combined or Individual Aggregate Sources
- IM 510 - Method of Design of Hot Mix Asphalt (HMA) Mixes
- AASHTO T176 - Plastic Fines in Graded Aggregate & Soils by use of Sand Equivalent Test
- AASHTO T304 - Uncompacted Void Content of Fine Aggregate
- ASTM D 4791 - Flat Particles, Elongated Particles, or Flat & Elongated Particles in Coarse Aggregate
- AASHTO T283 Resistance of Compacted Hot Mix Asphalt (HMA) to Moisture-Induced Damage

LEVEL I PCC
- IM 204 - Inspection of Construction Project Sampling & Testing
- IM 208 - Materials Laboratory Qualification Program
- IM 216 - Guidelines for Verifying Certified Testing Results
- IM 315 - Method of Protecting, Curing, Making & Testing Concrete Cylinders
- 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, and Curing Concrete Flexural Specimens
- IM 340 - Weight Per Cubic Foot, Yield, & Air Content (Gravimetric) of Concrete
- IM 347 – Measuring Length of Drilled Concrete Cores
- IM 383 - Testing the Strength of PCC Using the Maturity Method
- IM 385 - Temperature of Freshly-Mixed Concrete
- IM 525 - Designing Flowable Mortar
- AASHTO T97 - Third Point Loading

LEVEL II PCC
- IM 527 - Paving Plant Inspection
- IM 528 - Structural Concrete Plant Inspection
- IM 529 - PC Concrete Proportions

LEVEL III PCC
- IM 530 - Quality Management & Acceptance of PC Concrete Pavement
- IM 531 - Test Method for Combining Aggregate Gradations
- IM 532 - Aggregate Proportioning Guide for Portland Cement Concrete Pavement

PRESTRESS
- IM 570 - Precast & Prestressed Concrete Bridge Units

RIDE QUALITY
- IM 341 - Determining Pavement & Bridge Ride Quality

SOILS
- IM 309 – Determining Standard Proctor Moisture Density Relationship of Soils
- IM 312 – Sampling of Soils for Construction Project
- IM 335 – Determining Moisture Content of Soils
- ASTM D-2937 – Field density by drive-cylinder method

AGGREGATE SAMPLING TECHNICIAN DUTIES

Duties of the Aggregate Sampling Technician are detailed in IM 209 and the IM 300 Series and consist of, but are not limited to the following:

A. Sampling

1. Obtain representative samples by approved method(s).

2. Sample at required frequencies.

3. Identify samples with pertinent information such as:

    a. Type of material

    b. Intended use

    c. Production beds working depth

    d. Sampling method

4. Reduce samples by approved method(s).

AGGREGATE TECHNICIAN DUTIES

Duties of the Aggregate Technician are detailed in IM 209 and the IM 300 Series and consist of, but are not limited to the following:

A. Sampling

1. Obtain representative samples by approved method(s).
2. Sample at required frequencies.
3. Identify samples with pertinent information such as:
   a. Type of material
   b. Intended use
   c. Production beds working depth
   d. Sampling method
4. Reduce samples by approved method(s).

B. Gradation Testing

1. Follow appropriate testing methods.
2. Maintain current applicable specifications.
3. Post test results within 24 hours of sampling.

C. Other Testing as required (specific gravity, moisture, deleterious material, etc.)

1. Follow appropriate testing methods.
2. Maintain current applicable specifications.
3. Complete required reports.

D. Sampling & Testing Equipment

1. Clean and check testing sieves for defects.
2. Assure scale accuracy.
3. Maintain sampling and testing equipment.

E. Communication

1. Notify the District Materials office for production start-up or changes.

2. Relay test results to appropriate production or supervisory personnel.

3. Report failing test results immediately to appropriate personnel (including District Materials office) and assure remedial actions are taken.

F. General

1. Monitor stockpiling procedures to avoid contamination and excess segregation.

2. Assure proper identification of stockpiles.

3. Assure specification requirements for intended use are met before shipment.

4. Assure sampling locations are safe.

5. Assure proper bedding planes or production depths are maintained.

G. Documentation

1. Report all production test results of certified aggregates on Form #821278 and distribute as required.

2. Assure "plant production log" is maintained.

CONTRACT ADMINISTRATION TECHNICIAN DUTIES

Levels II and III perform duties described in Article 1105.06 “Authority & Duties of Inspector”. Duties of the Contract Administration Technician consist of, but are not limited to the following:

Level I

A. Field inspection on a single, or few, projects.

1. Conduct measurements.
2. Collect materials certifications.
3. Perform inspection on small/medium projects.
4. Daily log of contractor’s activities.
5. Measure contract quantities for pay.

Level II

A. Lead inspector of medium-sized project or multiple small projects.

1. Ensure work is completed according to contract documents.
2. Ensure proper materials certifications.
3. Coordinate and review inspector activities.
4. Maintain project records.
5. Prepare authorization for project progress reports and pay vouchers.
6. Identify and report non-complying materials or activities.

Level III

A. Manages the inspection and documentation of large, complex highway construction projects and/or several small highway projects.

1. Ensure work is done according to applicable contract documents, permits, laws, and other government regulations.
2. Review project daily to ensure adequate inspection and compliance of work.
3. Coordinate solution when contract documents do not completely and accurately address site conditions. Assists in negotiating change orders.

4. Make timely decisions to prevent non-complying work, avoid delays in project completion, and avoid potential claims due to loss of production by the contractor.

5. Perform end of project audit on incorporated materials.

6. Prepare project documents for final review.

7. Make determination on necessity of interest payment to the contractor and calculate that value.

EROSION CONTROL TECHNICIAN DUTIES

Duties of the Erosion Control Technician consist of, but are not limited to the following:

A. Carefully review and be familiar with the details in the contract documents.

B. Assign erosion and sediment control monitoring responsibilities to Erosion & Sediment Control (ESC) Basics trained field staff.

C. Review copies of storm water inspection reports.

D. Provide input on initial Erosion Control Implementation Plan (ECIP) submittal and ECIP updates.

E. Provide onsite reviews when requested by Contracting Authority or Contractor field staff.

HOT MIX ASPHALT (HMA) SAMPLING TECHNICIAN INSPECTION DUTIES

Duties of the Hot Mix Asphalt Sampling Technician consist of, but are not limited to the following:

A. Plant Sampling. (Article 2303.04, IM 204 & 511)

1. Obtain asphalt binder samples as directed by Contracting Authority personnel per IM 323 and IM 204.

B. Field Sampling (Article 2303.04, IM 204 & 511)

1. Obtain uncompacted mix random samples as directed by Contracting Authority personnel, and identify time, station, lift and side.

2. Obtain compacted mix core random samples as directed by Contracting Authority personnel.

HOT MIX ASPHALT (HMA) TECHNICIAN INSPECTION DUTIES

The following is a list of the duties that must be performed by the Certified Level I HMA Technicians doing quality control work for the Contractor on all projects where the Quality Management-Asphalt (QM-A) specification applies. The Quality Control Technician shall have no other duties while performing certified inspection duties.

These duties consist of, but are not limited to, the following:

A. Aggregate Stockpiles.

1. Assure proper stockpiling of aggregate deliveries. (stockpile build & additions) (IM 508)
    a. Prevent intermingling of aggregates.
    b. Check for and prevent contamination.
    c. Prevent segregation.
    d. Check for oversize material.

2. Document certified aggregate deliveries. (each delivery) (IM 508). When the aggregate supplier can provide a summary document of all deliveries, do not enter into Plant Book.

    a. Obtain truck tickets.
    b. Check for proper certification.
    c. Check for proper approved source.
    d. Enter deliveries in Plant Book Program when other documentation cannot be provided, Aggregate Certification page.

3. Observe loader operation. (daily) (IM 508)

    a. Check for proper stockpile to bin match-up.
    b. Check that loader does not get stockpile base material in load.
    c. Check that loader does not intermingle aggregate by overloading bins.

B. Asphalt Binder Delivery. (each delivery) (IM 508 & 509)

1. Check that material is pumped into correct tank.

2. Document Deliveries.

    a. Obtain truck tickets.
    b. Check for proper approved source.
    c. Check for proper certification.
    d. Check for proper grade.
    e. Check for addition of liquid anti-strip if required.
    f. Check if weight per gallon or specific gravity has changed.
    g. Enter deliveries into Plant Report Program.

C. Plant Operations. (daily)

1. Prepare Plant Report Program for daily entries. (IM 511)

   a. Enter Date.
   b. Enter Report Number.
   c. Enter expected tonnage for the day.
   d. Enter any proportion or target changes that apply.

2. Aggregate Delivery System. (IM 508)

   a. Check for proper cold feed gate settings.
   b. Check for proper cold feed belt speed settings.
   c. Check for proper moisture setting (drum plants).
   d. Monitor RAP proportions.

3. Mixing System. (Article 2303.03, IM 508)

   a. Check for proper asphalt binder delivery setting.
   b. Check for proper interlock operation.
   c. Monitor coating of aggregates.
   d. Monitor mixing time (batch plants).

4. Loading System. (Article 2303.03 & 2001.01, IM 508)

   a. Check hopper/silo gates for proper open/close
   b. Check trucks for proper loading and possible segregation.
   c. Check trucks for diesel fuel contamination in box and remove contaminated trucks from service (5 hrs with box raised).

5. Asphalt Binder Quantity Determination.

   a. Obtain totalizer printout readings and periodically check against tank stick readings.
   b. If using batch count for quantity, obtain printouts of each batch and add up the asphalt binder used for total quantity.

D. Plant Operations. (2 hour intervals) (IM 508)

1. Temperatures.

   a. Monitor and record mix temperature at discharge into truck box.
   b. Monitor and record asphalt binder temperature.
   c. Monitor and record air temperature.

2. Observe plant operation for any irregularities.

E. Weighing Equipment.

1. Proportioning scales (batch plants). (min. 1/day) (Articles 2001.07 & 2001.20) (IM 508)
    a. Perform sensitivity checks of scales.
    b. Check for interference at scale pivot points.

2. Pay Quantity Scales. (min. 1/day) (Articles 2001.07 & 2001.20, IM 508)
    a. Regularly perform check weighing comparisons with a certified scale as necessary. (min. 1st day and one additional if >5000 tons, and as directed by Engineer)
    b. Perform sensitivity checks of scales.
    c. Check for interference at scale pivot points.
    d. Perform verification weighing (truck platform scales).

3. Weigh Belts. (daily)

    a. Check weigh belt for excess clinging fines that effects speed reading.
    b. Check weigh belt for interference at bridge pivot points.
    c. Check for proper span setting.

4. Enter scale checks in Plant Report Program. (daily)

F. Plant Sampling. (daily) (Article 2303.04, IM 204 & 511)

1. Obtain cold-feed gradation samples as directed by Contracting Authority personnel per IM 301and IM 204.

2. Obtain asphalt binder samples as directed by Contracting Authority personnel per IM 323 and IM 204.

3. Obtain cold-feed moisture samples at a minimum of every ½ day (drum mix plants).

G. Field Sampling (if not performed by others). (daily) (Article 2303.04, IM 204 & 511)

1. Obtain uncompacted mix random samples as directed by Contracting Authority personnel, and identify time, station, lift and side.

2. Obtain compacted mix core random samples as directed by Contracting Authority personnel.

H. Testing. (daily) (Article 2303.04, IM 204 & 511)

1. Field cores.

    a. Provide properly calibrated equipment for Contracting Authority technician's use.
    b. Obtain and record core location station and offset information.

c. Obtain copy of core thickness measurements from Contracting Authority Technician.
d. Obtain copy of core weights from Contracting Authority technician.
e. Record weights and thickness in Plant Report Program.

2. Uncompacted mix.

a. Properly store Contracting Authority secured portion of paired sample.
b. Split Contractor half of paired sample into test portions as per IM 357.
c. Perform gyratory compaction as per IM 325G.
d. Perform bulk specific gravity test of laboratory-compacted specimen as per IM 321.
e. Perform maximum specific gravity test as per IM 350.
f. Enter test data into Plant Report Program.
g. Submit secured samples to DOT District Lab.

3. Aggregate.

a. Split one sample each day as directed by Contracting Authority personnel and provide half for testing by Contracting Authority.
b. Perform gradation analysis as per IM 302 and enter weights into Plant Report Program.
c. Perform moisture tests and produce results upon request.

4. Testing Lab Qualification. (as needed) (IM 208 & 511)

a. Record all HMA sample validations with DOT on form 235.
b. Document corrective actions taken when not correlating.
c. Document all test equipment calibrations.
d. Update IM's, test procedures and specs as required.

I. Documentation. (daily) (Article 2303.04, IM 204, 511 & 508)
The Plant Report, Chart, Plant Book, and other HMA worksheets are available on the following website: https://iowadot.gov/construction_materials/Hot-mix-asphalt-HMA

1. Prepare computerized Daily Plant Report.
   a. Check that all data is correct.
   b. Check that all data is complete.
   c. Compute tons of mix used to date.
   d. Enter mix adjustment data on report.
   e. Check for spec compliance.
   f. Immediately report non-complying results.
   g. Obtain and record mat temperatures and stationing.
   h. Provide electronic daily Plant Report to DME.

2. Maintain a daily diary of work activity in Plant Report Program.

a. Record weather conditions.

b. Record daily high and low temperatures.
c. Record sunrise and sunset times.
d. Record any interruptions to plant production.
e. Record any other significant events.

3. Import daily data into charting program.

4. Enter tack shipment quantities in Plant Report Program.

5. Total all truck tickets delivered to project and deduct any waste to determine HMA pay quantity.

6. Complete Daily Check List

J. Miscellaneous. (daily) (IM 208 & 511)

1. Clean lab.

2. Back-up computer files.

3. Dispose of samples as directed by District Lab.

4. Clean and maintain lab equipment.

K. Independent Assurance Duties. (Every 3 months) (IM 205 & 216)

1. Pick up HMA and aggregate proficiency sample from District Lab.

2. Test aggregate proficiency sample for gradation per IM 302.

3. Test HMA proficiency sample per IM 357, 325G, 321 & 350.

4. Report test results on proficiency samples to Construction Materials Bureau per IM 205.

L. Project Duties. (1/project) (IM 508 & 511)

1. Be in possession of appropriate mix design.

2. Be present during plant calibration.

3. Observe scale calibrations.

4. Perform plant site and set-up inspection and fill out Plant Site Inspection List.

5. Set up Plant Report Program and enter all project information to create Project Master files at beginning of project.

6. Check that release agents used in truck boxes are on the approved list in MAPLE.

7. Copy all computer files and provide to the Contracting Authority at completion of project.

8. Copy all paperwork and control charts and provide to the Contracting Authority at completion of project.

PORTLAND CEMENT CONCRETE (PCC) TECHNICIAN DUTIES
PAVING & STRUCTURAL CONCRETE

The Quality Control Technician shall have no other duties while performing certified inspection duties. Refer to IM 528 for exceptions. The District Materials Engineer may approve all quality control activities be performed by a single certified technician for low production situations.

Many of the duties of the PCC Level II Technician are detailed in IM 527 (Paving) and IM 528 (Structural) and consist of, but are not limited to the following:

A. Stockpiles

1. Assure proper stockpiling procedures.
2. Prevent intermingling of aggregates.
3. Prevent contamination.
4. Prevent segregation.

B. Plant Facilities

1. Assure safe sampling locations.
2. Check for equipment compliance.
3. Assure proper laboratory location and facilities.

C. Calibration

1. Be present during calibration (paving).
2. Check plant calibration (structural).
3. Assure proper batch weights.

D. Cement (Fly Ash) & Aggregate Delivery

1. Check for proper sources and certification.
2. Document quantities delivered.
3. Monitor condition of shipments.

E. Plant Sampling

1. Check aggregate gradations by obtaining, splitting, and testing samples.

2. Check aggregate moistures and specific gravity.

F. Proportion Control

1. Check scale weights and operation.
2. Check admixture dispensers.
3. Check mixing time and revolutions.
4. Check cement yield. (Paving plant only, unless over 10,000 cu. yds.)

G. Concrete Tests

1. Cure flexural test specimens.
2. Test flexural specimens (Contract agency will perform test in structural plant).
3. Conduct maturity testing.

H. Test Equipment

1. Clean and maintain scales, screens, pycnometers and beam molds, and laboratory facility.

I. Documentation

1. Prepare daily plant reports (paving), weekly plant reports (structures).
2. Document all checks and test results in the field book.
3. Maintain daily diary of work activity.

PRESTRESS TECHNICIAN DUTIES

Duties of the Prestress Technician are detailed in IM 570 and consist of, but are not limited to the following:

A. Pre-pour

1. Identify and document materials requiring outside fabrication inspection.
2. Identify potential fabrication or production problems and notify Iowa DOT inspectors.
3. Verify that all materials incorporated meet the requirements of the contract documents.
4. Review concrete placement documents for strand locations.
5. Check tension calculations.
6. Measure elongation and gauge pressure during tensioning.
7. Check hold down and insert locations.
8. Check stress distributions.
9. Check steel reinforcement and placement.
10. Check strand position.
11. Check condition of pallet.
    a. Level
    b. Holes
    c. Gaps
    d. Other deformities
12. Determine moisture of aggregates.
13. Check form condition and placement.
    a. Oil
    b. Line alignment level
    c. Tightness

B. Concrete Placement

1. Check on use of an approved mix design and batching operations (sequence).
2. Assure appropriate placement and proper vibration techniques.
3. Measure and record concrete temperature.
4. Assure test cylinders are properly made.
5. Assure appropriate finish.
6. Assure appropriate curing operations.

C. Post-pour

1. Check temperature and record during curing process.
2. Assure concrete strength has been met prior to releasing the line.
3. Assure proper detensioning procedure.
4. Check unit for defects and obtain approval for repairs.
5. Identify and store cylinders with the respective units.
6. Check beam ends for fabrication in accordance with the plans.
7. Assure exterior sides of facia beams are grouted.
8. Inspect after patching and desired surfacing.
9. Measure and record overall dimensions of beam.
10. Measure and record camber at release and compare to design camber.
11. Check and/or measure and record lateral sweep before shipping.
12. Assure proper cylinder cure.

RIDE QUALITY TECHNICIAN DUTIES

Duties of the Ride Quality Technician are detailed in IM 341 and consist of, but are not limited to the following:

A. Test pavement and bridge surfaces for ride quality.

B. Evaluate the test data.

   1. Indentify bumps and dips.

   2. Summarize the roughness into segments and sections.

   3. Identify the segments for incentive, disincentive, or grind.

   4. Retest and evaluate bumps, dips, and must grid segments for specification compliance.

C. Documentation

   1. Document the evaluation on a test report. A copy is sent to the Project Engineer, District Materials Engineer, and Central Materials.

   2. Notify the Project Engineer if the daily average profile index exceeds the specification tolerance.

   3. Submit the profilograms to the Project Engineer for all areas tested.

SOILS TECHNICIAN DUTIES

A certified Soils Technician is required for all projects with Compaction with Moisture Control, Compaction with Moisture and Density Control, or Special Compaction of Subgrade (including for Recreation Trails). Refer to contract documents for Contractor QC testing requirements. Duties of the Soils Technician consist of, but are not limited to the following:

A. Sampling: Obtain samples at required frequencies per IM 204.

B. Proctor Testing

C. Other Testing as Required

   1. For projects with Compaction with Moisture Control: Determine moisture content per frequencies in IM 204.

   2. For projects with Compaction with Moisture and Density Control or Special Compaction of Subgrade: Determine moisture content and in-place density per frequencies in IM 204.

D. Sampling & Testing Equipment

   1. Clean and check testing sieves for defects.

   2. Assure scale accuracy.

   3. Check and maintain other testing equipment.

E. Evaluate the test data.

   1. For projects with Compaction with Moisture Control: Confirm soils are being placed within required moisture content range.

   2. For projects with Compaction with Moisture and Density Control or Special Compaction of Subgrade: Confirm soils are being placed within required moisture content range and soil is compacted to density equal to or greater than density requirement.

F. Documentation and Communication

   1. Document test data. A copy is sent to the Project Engineer.

   2. Relay test results to appropriate supervisory personnel.

   3. Notify the Project Engineer if any test results do not meet contract requirements and assure corrective actions are taken.

IM 216 - GUIDELINES FOR VERIFYING TEST RESULTS

GUIDELINES FOR DETERMINING THE ACCEPTABILITY OF TEST RESULTS

GENERAL

Criteria for determining the acceptability of test results is an integral part of the Quality Assurance Program. The comparison between two different operator's results is used in the independent assurance program and sometimes in the validation process. The tolerances in this IM are for comparing individual test results except in the case of the profile index where averages are used. When criteria for comparing test results is not established in this IM or any other IM, use of the AASHTO or ASTM test procedure precision criteria is appropriate for determining acceptability of test results.

When the tolerances are exceeded, an immediate investigation must be made to determine possible cause so that any necessary corrections can be made. Below are some steps that may be used to identify the possible cause:

1. Check all numbers and calculations.
2. Review past proficiency and validation data.
3. Review sampling and testing procedures.
4. Check equipment operation, calibrations and tolerances.
5. Perform tests on split samples or reference samples.
6. Involve the Central Materials Laboratory.

TOLERANCES

TEST NAME	TEST METHOD	TOLERANCE
Slump of PC Concrete		
1" or less on IA or Verification	IM 317	1/4 in.
More than 1" on IA or Verification		3/4 in.
Air Content of PC Concrete	IM 318	0.4%
Length of Concrete Cores	IM 347	0.10 in.)
NDT Pavement Thickness (MIT)		<=0.15 in.
Free Moisture in Aggregate, by Pycnometer	IM 308	0.2%
Specific Gravity of Aggregate, by Pycnometer	IM 307	0.02
Moisture in Aggregate, by Hot Plate		0.3%
Moisture in Soil	IM 335, IM 334	1.5%
Proctor Optimum Moisture Content	IM 309	2.0%
Proctor Maximum Dry Density	IM 309	5.0 lb./ft^3

In-Place Wet Density, Soils & Bases	IM 334, 326, other approved	2.0 lb./ft³
G_{mm} Maximum Specific Gravity	IM 350	0.010
G_{mb} Density of HMA Concrete, by Displacement	IM 321	0.020
G*/Sin Delta	T315	17% of mean
% Binder, Ignition Oven	IM 338	0.33%
G_{sa} Apparent Specific Gravity	IM 380	0.010
G_{sb} Bulk Specific Gravity	IM 380	0.028
Percent Absorption	IM 380	0.37%
Fine Aggregate Angularity	T304	2.0%
Sand Equivalency	T176	10 % of mean
Pavement Profile Index (0.2" blanking band)	IM 341	
Verification Profile Index Test Result		
Inches/mile		
6.0 or less		1.0 in./mi.
6.1 to 20.0		2.0 in./mi.
20.1 to 40.0		3.0 in./mi.
More than 40.0		5.0 in./mi.
Pavement Profile Index (0.0" blanking band)	IM 341	
Verification Profile Index Test Result		
Inches/mile		
25.0 or less		3.0 in./mi.
25.1 to 40.0		4.0 in./mi.
More than 40.0		5.0 in./mi.
Bridge Profile Index (0.2" blanking band)	IM 341	
Verification Profile Index Test Result		
Inches/mile		
6.0 or less		2.0 in./mi.
6.1 to 20.0		3.0 in./mi.
20.1 to 40.0		4.0 in./mi.
More than 40.0		6.0 in./mi.
Pavement International Roughness Index (IRI)	IM 341	
Verification IRI Test Result		
Inches/mile		
50.0 or less		10.0% of mean
50.1 to 150.0		8.0% of mean
More than 150.0		7.0% of mean

TOLERANCES FOR AGGREGATE GRADATIONS

Determining the precision of an aggregate sieve analysis presents a special problem because the result obtained with a sieve is affected by the quantity of material retained on the sieve and by results obtained on sieves coarser than the sieve in question. Tolerances are, therefore, given for different ranges of percentage of aggregate passing one sieve and retained on the next finer sieve used.

Comparisons of test results are made on each fraction of the sample, expressed in percent that occurs between consecutive sieves.

NOTE: Unless otherwise noted, tolerances for aggregate gradations are only valid if the two tests were made on a split sample. Experience has shown that improper sample reduction, as well as differences in test procedures can contribute to results being out of tolerance. When a comparison exceeds the tolerance limits, a review of the test procedures and equipment will be performed. Where practical, additional comparisons will be done with similar equipment and methods.

Table 1 Tolerances for All Aggregates Except HMA-Combined Aggregate

	Size Fraction Between Consecutive Sieves, %*	Tolerance, %
Coarse Portion:	0.0 to 3.0	2
#4 Sieve and larger	3.1 to 10.0	3
	10.1 to 20.0	5
	20.1 to 30.0	6
	30.1 to 40.0	7
	40.1 to 50.0	9
Fine portion:	0.0 to 3.0	1
#8 Sieve and smaller	3.1 to 10.0	2
	10.1 to 20.0	3
	20.1 to 30.0	4
	30.1 to 40.0	4

Table 2 Tolerances for All HMA-Combined Aggregate

Size Fraction Between Consecutive Sieves, %*	Tolerances(1)
0.0 to 3.0	2
3.1 to 10.0	3
10.1 to 20.0	5
20.1 to 30.0	6
30.1 to 40.0	7
40.1 to 50.0	9

(1) Minimum tolerance of 5% is applied to all size fractions coarser than the #4 sieve when comparing cold feed to ignition oven as shown on page 3 of Appendix A.
*The verification test analysis fraction is used to find the proper tolerance.

COMPARISON OF AGGREGATE GRADATIONS

Use of these tolerances is explained in the following examples. Computer spreadsheets to perform the analysis are available on the Iowa DOT Materials Office website. Use of the spreadsheets is preferred when possible. Appendix A contains a copy of the printouts from the spreadsheets.

Example 1 - PC Concrete Coarse Aggregate

Sieve Size	DOT Coarse Aggr Percent Passing	Prod./CPI Coarse Aggr Percent Passing	DOT Coarse Aggr Percent Retained	Prod./CPI Coarse Aggr Percent Retained	Fraction Difference	Applicable Tolerance	Complies
1.5"	100.0	100.0	0.0	0.0	0.0	2	Yes
1"	97.1	99.1	2.9	0.9	2.0	2	Yes
3/4"	72.2	65.1	24.9	34.0	9.1	6	No
1/2"	38.1	34.9	34.1	30.2	3.9	7	Yes
3/8"	12.0	8.8	26.1	26.1	0.0	6	Yes
#4	0.6	0.2	11.4	8.6	2.8	5	Yes
#8	0.5	0.2	0.1	0.0	0.1	1	Yes
Minus #200	0.3	0.2	0.3	0.2	0.1	1	Yes

The size fraction between consecutive sieves is found by calculating the difference between the percent passing reported for the two sieves. For example, the fraction between the 1.5 in. and 1 in. sieves for the above verification test is 100.0 - 97.1 = 2.9%. Between the 1/2 in. and 3/8 in. sieves it is 38.1 – 12.0 = 26.1%. Since nothing passes the pan, the size fraction between the #200 sieve and the pan is equal to the percent passing the #200.

The example shows the fraction between each pair of consecutive sieve sizes for both tests and the difference between these fractions for both tests. The difference is compared with the applicable tolerance to determine a disposition. In this example, a suspect result is found in the fraction between the 1 in. and 3/4 in. sieves. Since the suspect difference is due primarily to the percent passing results on the 3/4 in. sieves, it is these results that should at least be investigated first. Only further investigation can determine which 3/4 in. sieve, if any is faulty.

NOTE: The applicable tolerance changes between #4 and #8 size fractions.

Example 2 - PC Concrete Fine Aggregate

Sieve Size	DOT Fine Aggregate Percent Passing	Prod./CPI Fine Aggregate Percent Passing	DOT Fine Aggregate Percent Retained	Prod./CPI Fine Aggregate Percent Retained	Fraction Difference	Applicable Tolerance	Complies
3/8"	100.0	100.0	0.0	0.0	0.0	2	Yes
#4	95.0	95.0	5.0	5.0	0.0	3	Yes
#8	87.8	86.3	7.2	8.7	1.5	2	Yes
#16	72.0	71.5	15.8	14.8	1.0	3	Yes
#30	44.0	43.8	28.0	27.7	0.3	4	Yes
#50	12.2	13.0	31.8	30.8	1.0	4	Yes
#100	1.5	1.3	10.7	11.7	1.0	3	Yes
Minus #200	0.4	0.4	0.4	0.4	0.0	1	Yes

Example 3 - HMA Combined Aggregate

		Sieve Sizes										
		1"	3/4"	1/2"	3/8"	4	8	16	30	50	100	200
	Specs.											
	D.O.T.		100	99.1	87.3	68.8	54.2	41.4	28.2	15.5	9.1	6.9
	Prod./C.P.I.		100	98.8	86.1	74.9	56.1	41.9	28.7	15.1	10.9	8.6

D.O.T. FBR: _______

D.O.T. % Retained	Prod./C.P.I. % Retained	Diff.	Tol. %	Comply (Y/N)
NA	NA	0.0	2	Y
0.9	1.2	0.3	2	Y
11.8	12.7	0.9	5	Y
18.5	11.2	7.3	5	N
14.6	18.8	4.2	5	Y
12.8	14.2	1.4	5	Y
13.2	13.2	0.0	5	Y
12.7	13.6	0.9	5	Y
6.4	4.2	2.2	3	Y
2.2	2.3	0.1	2	Y
6.9	8.6	1.7	3	Y

Sieve Fraction Between Consecutive Sieves, %			Tolerance, %
0.0	To	3.0	2
3.1	To	10.0	3
10.1	To	20.0	5
20.1	To	30.0	6
30.1	To	40.0	7
40.1	To	50.0	9

NOTE: The applicable tolerance for this combined aggregate sample is from Table 2. In this example, the suspect fractions would indicate a possible problem for two pairs of consecutive sieve sizes involving the #4 sieves. This evidence and the difference in the test values found for the #4 sieves, strongly point to an error in one of the #4 sieve results.

When RAP mixes are used, the comparison data is of the composite gradation results and not of the cold feed.

Example 4 HMA Cold-Feed to Ignition Oven Comparison

			Sieve Sizes - Percent Passing											
			1 1/2"	1"	3/4"	1/2"	3/8"	#4	#8	#16	#30	#50	#100	#200
		Specs.	**100**	100	100	90-100	76-90	50-64	30-40		20-28			3.0-7.0
Sample ID		Ign. Oven	100.0	100.0	100.0	92.0	82.0	62.0	40.0	30.0	20.0	15.0	9.0	5.0
Sample ID		Cold-Feed	100.0	100.0	100.0	90.0	80.0	60.0	35.0	27.0	22.0	13.0	7.0	3.0
	Correction Factor		0.0	0.0	0.0	0.0	-0.3	-0.5	-0.5	-0.3	-0.3	-0.2	-0.3	-0.3

Sieves	Ign. Oven % Retained	Cold-Feed % Retained	Diff.	Tol. %	Comply (Y/N)
1 1/2 - 1	0.0	0.0	0.0	2	Y
1 - 3/4	0.0	0.0	0.0	2	Y
3/4 - 1/2	8.0	10.0	2.0	3	Y
1/2 - 3/8	10.3	10.0	0.3	5	Y
3/8 - 4	20.2	20.0	0.2	6	Y
4 - 8	22.0	25.0	3.0	6	Y
8 - 16	9.8	8.0	1.8	3	Y
16 - 30	10.0	5.0	5.0	3	N
30 - 50	4.9	9.0	4.1	3	N
50 - 100	6.1	6.0	0.1	3	Y
100 - 200	4.0	4.0	0.0	3	Y
200	4.7	3.0	1.7	3	Y

Corrected Ign. Oven SA:	5.6	Film Thickness:	7.3
Cold-Feed Surface Area:	4.7	Film Thickness:	8.7
Correction Factor:	-0.1		

Sieve Fraction Between Consecutive Sieves, %			Tolerance, %
0.0	To	3.0	2
3.1	To	10.0	3
10.1	To	20.0	5
20.1	To	30.0	6
30.1	To	40.0	7
40.1	To	50.0	9
+#4 sieves minimum tolerance =			5

When comparing an ignition oven extracted gradation to a cold-feed gradation a correction factor must be applied to the ignition oven extracted gradation before comparing it to the cold-feed gradation. The correction factor is determined by calculating the difference between a cold-feed gradation and an ignition oven gradation on the first day of HMA production according to IM 501. The correction factor is then applied to all subsequent comparisons. In the example above, the correction factor was determined on a previous sample. The District Materials Engineer may establish new or average correction factors when needed.

PC CONCRETE GRADATION COMPARISON REPORT

(Computer Spreadsheet Available on Iowa DOT Office of Materials Web Site)

Rev 05/03 | Form 200

Iowa Department Of Transportation

Reported Gradation & IM 216 Comparison Report

Project No.:____________________ Intended Use: ____________________ (Paving, Structure, Patching, Incidental

Contract ID:____________________

County:____________________

	Good	Fair	Poor
Care of Equipment:	______	______	______
Sampling Procedure:	______	______	______
Splitting Procedure:	______	______	______
Sieving to Completion:	______	______	______
Computations:	______	______	______
Reporting:	______	______	______

Contractor/Producer:____________________

Design No.:____________

Coarse Agg. T203 A No.: ________

Fine Agg. T203 A No.: ________

Proper Equipment:________

Applicable Specs.:________

DOT Tested By: ____________________ Cert. No.:__________ Date:__________

Contr./Prod. Tested By:____________________ Cert. No.:__________ Date:__________

			Sieve Sizes - Percent Passing											
			1 1/2"	**1"**	**3/4"**	**1/2"**	**3/8"**	**#4**	**#8**	**#16**	**#30**	**#50**	**#100**	**#200**
Grad No.	Sample ID	**Specs**												
		DOT												
		Contr./Prod.												

Grad No.	Sample ID						**Specs**							
		DOT												
		Contr./Prod.												

Sieves	DOT % Retained	Contr./Prod. % Retained	Diff.	Tol. %	Comply (Y/N)
1 1/2 - 1	NA	NA	0.0	2	Y
1 - 3/4	NA	NA	0.0	2	Y
3/4 - 1/2	0.0	0.0	0.0	2	Y
1/2 - 3/8	0.0	0.0	0.0	2	Y
3/8 - 4	0.0	0.0	0.0	2	Y
4 - 8	0.0	0.0	0.0	1	Y
8 - 200	0.0	0.0	0.0	1	Y
200	0.0	0.0	0.0	1	Y

3/8 - 4	0.0	0.0	0.0	2	Y
4 - 8	0.0	0.0	0.0	1	Y
8 - 16	0.0	0.0	0.0	1	Y
16 - 30	0.0	0.0	0.0	1	Y
30 - 50	0.0	0.0	0.0	1	Y
50 - 100	0.0	0.0	0.0	1	Y
100 - 200	0.0	0.0	0.0	1	Y
200	0.0	0.0	0.0	1	Y

	Size Fraction Between Consecutive Sieves, %			Tolerance, %
Coarse Aggregate:				
	0.0	to	3.0	2
	3.1	to	10.0	3
	10.1	to	20.0	5
	20.1	to	30.0	6
	30.1	to	40.0	7
	40.1	to	50.0	9
Fine Aggregate:				
	0.0	to	3.0	1
	3.1	to	10.0	2
	10.1	to	20.0	3
	20.1	to	30.0	4
	30.1	to	40.0	4

Remarks:____

Distribution________ Central Materials________ Dist. Materials________ Contr./Producer________ Proj. Engineer________ Technician________

HMA GRADATION COMPARISON REPORT

(Computer Spreadsheet Available on Iowa DOT Office of Materials Web Site)

Rev 05/03

Iowa Department Of Transportation

Form 201

Reported Gradation & IM 216 Comparison Report

Project No.: ______________________

Contract ID: ______________________ Intended Use: ______________________

County: ______________________

Contractor/Producer: ______________________

Mix Design No.: ______________________

	Good	Fair	Poor
Care of Equipment:	______	______	______
Sampling Procedure:	______	______	______
Splitting Procedure:	______	______	______
Sieving to Completion:	______	______	______
Computations:	______	______	______
Reporting:	______	______	______

Mix Change (Y/N): ______

Date of Change: ______

Total, % Asphalt (Pb): ______

Effective % Asphalt (Pbe): ______

Proper Equipment: ______

Applicable Specs.: ______

DOT Tested By: ______________________ Cert. No.: __________ Date: __________

Contr./Prod. Tested By: ______________________ Cert. No.: __________ Date: __________

			Sieve Sizes - Percent Passing											
			1 1/2"	1"	3/4"	1/2"	3/8"	#4	#8	#16	#30	#50	#100	#200
		Specs.												
Sample ID		DOT												
Sample ID		Contr./Prod.												

Sieves	DOT % Retained	Contr./Prod. % Retained	Diff.	Tol. %	Comply (Y/N)
1 1/2 - 1	NA	NA	0.0	2	Y
1 - 3/4	NA	NA	0.0	2	Y
3/4 - 1/2	NA	NA	0.0	2	Y
1/2 - 3/8	NA	NA	0.0	2	Y
3/8 - 4	NA	NA	0.0	2	Y
4 - 8	NA	NA	0.0	2	Y
8 - 16	NA	NA	0.0	2	Y
16 - 30	NA	NA	0.0	2	Y
30 - 50	NA	NA	0.0	2	Y
50 - 100	NA	NA	0.0	2	Y
100 - 200	NA	NA	0.0	2	Y
200	NA	NA	0.0	2	Y

DOT Gyratory Filler/Bitumen Ratio
0.00

Sieve Fraction Between

Consecutive Sieves, %			Tolerance, %
0.0	To	3.0	2
3.1	To	10.0	3
10.1	To	20.0	5
20.1	To	30.0	6
30.1	To	40.0	7
40.1	To	50.0	9

Remarks: ____

Distribution________ Central Materials________ Dist Materials________ Contr./Producer________ Proj. Engineer________ Technician________

Rev 05/08 | Form 201 Modified

Iowa Department Of Transportation

Cold-Feed & Ignition Oven Gradation & I.M. 216 Comparison Report

Project No.: ____________________

Contract ID: ____________________ Intended Use: ____________________

County: ____________________

Contractor/Producer: ____________________

Mix Design No.: ____________________

Mix Change (Y/N): __________

Date of Change: __________

Total, % Asphalt (Pb): __________

Effective % Asphalt (Pbe): __________

Proper Equipment: __________

Applicable Specs.: __________

	Good	Fair	Poor
Care of Equipment:			
Sampling Procedure:			
Splitting Procedure:			
Sieving to Completion:			
Computations:			
Reporting:			

Ignition Oven Tested By: ____________________ Cert. No.: __________ Date: __________

Cold-Feed Tested By: ____________________ Cert. No.: __________ Date: __________

			Sieve Sizes - Percent Passing											
			1 1/2"	1"	3/4"	1/2"	3/8"	#4	#8	#16	#30	#50	#100	#200
		Specs.												
Sample ID		Ign. Oven												
Sample ID		Cold-Feed												
	Correction Factor		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Sieves	Ign. Oven % Retained	Cold-Feed % Retained	Diff.	Tol. %	Comply (Y/N)
1 1/2 - 1	NA	NA	0.0	5	Y
1 - 3/4	NA	NA	0.0	5	Y
3/4 - 1/2	NA	NA	0.0	5	Y
1/2 - 3/8	NA	NA	0.0	5	Y
3/8 - 4	NA	NA	0.0	5	Y
4 - 8	NA	NA	0.0	2	Y
8 - 16	NA	NA	0.0	2	Y
16 - 30	NA	NA	0.0	2	Y
30 - 50	NA	NA	0.0	2	Y
50 - 100	NA	NA	0.0	2	Y
100 - 200	NA	NA	0.0	2	Y
200	NA	NA	0.0	2	Y

Corrected Ign. Oven SA:		Film Thickness:	
Cold-Feed Surface Area:		Film Thickness:	
Correction Factor:			

Sieve Fraction Between Consecutive Sieves, %			Tolerance, %
0.0	To	3.0	2
3.1	To	10.0	3
10.1	To	20.0	5
20.1	To	30.0	6
30.1	To	40.0	7
40.1	To	50.0	9

+#4 sieves minimum tolerance = 5

Remarks: ____

Distribution________ Central Materials________ Dist Materials________ Contr./Producer________ Proj. Engineer________ Technician________

QMC GRADATION COMPARISON REPORT

(Computer Spreadsheet Available on Iowa DOT Office of Materials Web Site)

QMC Gradation Correlation I.M. 216

Project No.: ____________________

Plant Name: ____________________

Contract ID: ____________ Date Sampled: ____________

County: ____________ Gradation Date: ____________

Contractor: ____________________ Mix Design Number: ____________ Design No.: ____________

Coarse Agg. Source: ____________ Intermediate Agg. Source: ____________ Fine Agg. Source: ____________

Monitor: ____________ Cert. No.: ____________ Proper Equipment: ____________

C.P.I.: ____________ Cert. No.: ____________ Specification: ____________

Sieve Size	D.O.T. Coarse Agg Percent Passing	Prod. / C. P. I. Coarse Agg Percent Passing	D.O.T. Coarse Agg Percent Retained	Prod. / C. P. I. Coarse Agg Percent Retained	Fraction Difference	Applicable Tolerance	Complies
1.5" / 37.5mm							
1" / 25.0mm							
3/4" / 19.0mm							
1/2" / 12.5mm							
3/8" / 9.5mm							
#4 / 4.75mm							
#8 / 2.36mm							
Minus #200							

Sieve Size			D.O.T. Intermediate Aggregate Percent Retained	Prod. / C. P. I. Intermediate Aggregate Percent Retained	Fraction Difference	Applicable Tolerance	Complies
1.5" / 37.5mm							
1" / 25.0mm							
3/4" / 19.0mm							
1/2" / 12.5mm							
3/8" / 9.5mm							
#4 / 4.75mm							
#8 / 2.36mm							
Minus #200							

Sieve Size	D.O.T. Fine Aggregate Percent Passing	Prod. / C. P. I. Fine Aggregate Percent Passing	D.O.T. Fine Aggregate Percent Retained	Prod. / C. P. I. Fine Aggregate Percent Retained	Fraction Difference	Applicable Tolerance	Complies
3/8" / 9.5mm							
#4 / 4.75mm							
#8 / 2.36mm							
#16 / 1.18mm							
#30 / 600um							
#50 / 300um							
#100 / 150um							
Minus #200							

Care of Equipment	☐ GOOD	☐ FAIR	☐ POOR
Sampling Procedure	☐ GOOD	☐ FAIR	☐ POOR
Splitting Procedure	☐ GOOD	☐ FAIR	☐ POOR
Sieving to Completion	☐ GOOD	☐ FAIR	☐ POOR
Computations	☐ GOOD	☐ FAIR	☐ POOR
Reporting	☐ GOOD	☐ FAIR	☐ POOR

Comments: ____________________

cc: ____________________

Review Questions
Guidelines for Verifying Test Results
IM 216

1. If Joe from District Materials, Independent Assurance, comes out to the grade and tests an air test of 7.0% Air, you are the Verification test (RCE/Consultant) and tested a 7.2% Air.
   Does the test comply with IM216 tolerances?

2. If Brandon from District Materials, Independent Assurance, comes out to the grade and tests an air test of 7.0%, You are the Verification test (RCE/Consultant) and tested a 7.5% Air.
   Does the test comply with IM216 tolerances?

3. If on the grade of a paving project. Contractor tests an 8.0% Air and the Verification (RCE/Consultant) tests 8.5% Air, Does the test comply with IM216 tolerances?
   Whose result is correct?

   What would you do?

Do not get confused with IM318 when Calibrating Air Pot-Tolerances

IM 204 - SAMPLING & TESTING FREQUENCIES

INSPECTION OF CONSTRUCTION PROJECT SAMPLING & TESTING

INTRODUCTION

The Iowa Department of Transportation (DOT) has established a Quality Assurance Program (IM 205) to assure that the quality of materials and construction workmanship incorporated into all highway construction projects is in reasonable conformity with the requirements of the approved plans and Specifications, including approved changes. It consists of an Acceptance Program and an Independent Assurance Program (IAP), both of which are based on test results obtained by qualified persons and equipment.

The acceptance portion of the program covers quality control (QC) sampling and testing and verification sampling and testing. The IAP portion of the program covers the evaluation of all sampling and testing procedures, personnel, and equipment used as part of an acceptance decision (includes contractor, contracting agency, and consultant).

ACCEPTANCE PROGRAM FOR MATERIALS

To fulfill the materials acceptance requirements, several methods are used by the DOT.

Sampling & Testing (Test Report)
Certification
Approved Brands
Approved Sources
Approved Shop Drawings
Approved Catalog Cut
Inspection Report
Visual Approval by the Engineer

The Instructional Memorandum IM 204 Appendices A through W contain the material acceptance information for the type of work being done. If there is a conflict in wording between the appendix and another Instructional Memorandum or appendix Z, the appendix A through W will supersede the others.

In many cases more than one method may be required for acceptance in the 204 Appendices and tables in the back of this guide. For some new or special materials, the District Materials Engineer may need to determine the most appropriate acceptance requirements.

In order to provide the Contractor the opportunity to construct a project with minimal sampling and testing delays, inspection is performed at the source for many materials. Source inspection may consist of inspecting process control, sampling for laboratory testing or a combination of these procedures. All source-inspected or certified materials are subject to inspection at the project site prior to being incorporated into the work. Project site inspections are for identification of materials with test reports and for any unusual alterations of the characteristics of the material due to handling or other causes. Verification samples secured by project agency personnel of source-inspected, certified, or project processed materials are also required for some materials in order to secure satisfactory validation for acceptance.

When certification procedures are required, the Contractor may, on the Contractor's own responsibility and at the Contractor's risk, incorporate these materials into the work. Acceptance will be based on satisfactory certification and compliance of the test results of any verification samples. When verification samples are not taken, acceptance will be based on satisfactory certification.

A. SAMPLING & TESTING (TEST REPORT)

When a material is sampled and tested, the results will be documented on a construction form or a test report. There is quality control sampling and testing done by the Contractor or producer and verification sampling testing done by the Project Engineer, the District Materials Engineer, the Central Materials Laboratory, or an independent laboratory.

In many cases, in addition to sampling and testing, some other type of acceptance method will also be required. Sampling and testing may be done at the project, supplier, or source depending on which is the most appropriate.

B. CERTIFICATION OF COMPLIANCE

For many materials, a fabricator, manufacturer, or supplier is required to provide the Project Engineer with a certification document stating that the material meets the requirements of the plans and specifications. In most cases, the fabricator, manufacturer, or supplier must also be on an approved list in the Materials Approved Products Listing Enterprise (MAPLE). For some of these materials, sampling and testing is also required before final acceptance. The certification comes in a variety of forms:

- Stamped or preprinted on truck tickets as with aggregates,
- Stamped or preprinted on invoices as with Portland Cement and asphalt binder,
- Stamped or printed on the Mill Analysis as with reinforcing steel, structural steel, and other metals,
- Furnished as a separate document with each shipment as with zinc-silicate paint, engineering fabrics, epoxy coatings, and dowel baskets,
- Stamped or printed on a list of materials for each shipment as with CMP, concrete pipe, and corrugated plastic subdrain,

The inspector will verify that the certification has been entered into DocExpress.

C. APPROVED SOURCE

(May also be referred to as "Approved Producer, Approved Supplier, Approved Fabricator, or Approved Brand") The source, producer, and the material must be evaluated and approved by the Office of Construction and Materials according to the appropriate Materials IM in order to be used on a project. Once a letter of approval is issued, the source or producer is approved for use on projects (with the exception of steel fabricators and precast concrete plants). Approved products, sources, and producers are listed in the Materials Approved Products Listing Enterprise (MAPLE). Approval for a source or producer may be rescinded at any time if it no longer meets the requirements of the IM. The plans, developmental specifications, and special provisions may also contain lists of approved sources.

The project inspector will document information about this material such as product name, source, date, producer, and lot number in the project files.

Most approved sources also require a certification.

D. APPROVED WAREHOUSE STOCK

For some items made up of miscellaneous materials, inspection and approval will be done by the District Materials Engineer at the supplier's warehouse.

E. APPROVED SHOP DRAWING & APPROVED CATALOG CUT

This information must be submitted to, and reviewed by the Iowa DOT Design Office or Bridges and Structures Office, before the material can be incorporated in the project.

F. INSPECTION REPORT

The project inspector must have a copy of the final inspection report prior to incorporating the item into the project. The report will vary depending on the Materials IM requirements for the item fabricated. Final acceptance is by construction personnel at the project site, and is based on the proper documentation and the condition of the component.

G. VISUAL APPROVAL BY PROJECT ENGINEER

(May also be referred to as "As Per Plan, Approved By RCE, or Manufacturer Recommendations") The project inspector must document information about this material such as product name, source, producer, lot number and date produced in the project files. The inspector will make sure the material meets the requirements of the plans, the Engineer, or the manufacturer before the material is used. Visual approval requires construction personnel to visually inspect the material to determine if it complies with the specifications. Visual approval is appropriate for non-critical items such as sod stakes, where compliance can be readily determined by visual means. If there are questions on specification compliance, samples will be taken for testing.

INDEPENDENT ASSURANCE PROGRAM

The IAP evaluates all sampling and testing procedures, personnel, and equipment used as part of an acceptance decision (Includes Contractor, Contracting Agency, and consultant). Independent assurance includes evaluation based on:

Calibration checks
Split samples
Proficiency samples
Observation of sampling and testing performance

The test method and the frequency of test are in the Appendices. Calibration checks and proficiency samples testing is covered in IM 208.

SMALL QUANTITIES

The FHWA allows and encourages alternative acceptance methods for small quantities of non-critical materials. Appendix X contains a list of those materials and maximum quantities for which alternative acceptance methods may be appropriate. The Project Engineer or District Materials Engineer may still require the normal acceptance method for a material when it is considered critical in the intended application.

IM 204 APPENDIXES

Appendix A	Roadway & Borrow Excavation & Embankments
Appendix B	Soil Aggregate Subbase
Appendix C	Modified Subbase
Appendix D	Granular Subbase
Appendix E	Portland Cement Concrete Pavement, Pavement Widening, Base Widening, Curb & Gutter & Paved Shoulders
Appendix F	Asphalt Mixtures
Appendix H	Structural Concrete, Reinforcement, Foundations & Substructures, Concrete Structures, Concrete Floors, & Concrete Box, Arch & Circular Culverts
Appendix I	Concrete Drilled Shaft Foundations
Appendix K	Cold-In-Place Recycled Asphalt Pavement
Appendix L	Granular Surfacing/Driveway Surfacing
Appendix M	Concrete Bridge Floor Repair & Overlay & Surfacing
Appendix P	Surface Treatment (Seal Coat, Microsurfacing, Slurry, Joint Repair, Crack Filling & Fog Seal)
Appendix T	Base Repair, Pavement Repair
Appendix U	Granular Shoulders
Appendix V	Subdrains
Appendix W	Water Pollution Control, Erosion Control
Appendix X	Acceptance of Small Quantities of Materials
Appendix Z	Supplemental Guide, Basis of Acceptance

Sampling & Testing Guide-Minimum Frequency

PORTLAND CEMENT CONCRETE PAVEMENT, PAVEMENT WIDENING, BASE WIDENING CURB & GUTTER, & PAVED SHOULDERS

Section 2122, 2201, 2213, 2301, 2302, 2310, Quality Management Concrete (QM-C)

MATERIAL OR CONSTRUCTION ITEM	TESTS	METHOD OF ACCEPTANCE & RELATED IMs	QUALITY CONTROL					INDEPENDENT ASSURANCE & VERIFICATION S&T						REMARKS
			SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPT.	S&T TYPE	SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	
SOURCE INSPECTION														
Aggregates-Fine (4110)		AS 209												
Aggregate-Coarse (4115), Intermediate		AS 209												
Portland Cement (4101)	Quality	AS 401												
Fly Ash (4108)	Quality	AS 491.17												
GGBFS (Ground Granulated Blast Furnace Slag)	Quality	AS 491.14												
Curing Compounds (4105)	Lab Tested	405												
Clear Curing Compounds (4105)		AB 405.07												
Air Entraining Admixture (4103)	Quality	AB 403												
Water Reducing Admix. (4103)	Quality	AB 403												
Retarding Admixture (4103)	Quality	AB 403												
Joint Sealer (4136.02)	Lab Tested	436.01, 436.02,436.03												
Backer Rod (4136.02)	Lab Tested	AB 436.04												
Mixing Water (4102)	Lab Tested							V	RCE/ CONTR	1/ source	1 pint	CTRL		Not required for potable water from municipal supply (1)

AS-Approved Source
ASD-Approved Shop Drawing
S&T-Sampling & Testing
AB-Approved Brand

Cert- Certification Statement

RCE-Resident Construction Engineer/Project Engineer
DME-District Materials Engineer
CTRL-Central Laboratory
CONTR-Contractor

IA-Independent Assurance
V-Verification
M-Monitor
QMC-Quality Management Concrete

(1) DME may waive sampling of water from an established well that has shown past compliance.

NOTE: RCE/CONTR indicates that the contractor shall assist in the sampling at the direction of and witnessed by the project engineer.

April 20, 2021
Supersedes October 15, 2019

PORTLAND CEMENT CONCRETE PAVEMENT, PAVEMENT WIDENING, BASE WIDENING CURB & GUTTER, & PAVED SHOULDERS

Section 2122, 2201, 2213, 2301, 2302, 2310, Quality Management Concrete (QM-C)

Matls. IM 204
Appendix E (US) Units

MATERIAL OR CONSTRUCTION ITEM	TESTS	METHOD OF ACCEPTANCE & RELATED IMs	QUALITY CONTROL					INDEPENDENT ASSURANCE & VERIFICATION S&T						REMARKS
			SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	S&T TYPE	SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	
SOURCE INSPECTION														
Steel Reinforcement (4151)														
Dowels	Quality	AS 451												
Tie Bars	Quality	AS 451												
General Use	Quality	AS 451												
PLANT INSPECTION														
Aggregates-Fine (4110/4111)	Grad QMC	302 306 336	CONTR	1/1500cy	IM 301	CONTR	800240	V IA	RCE/ CONTR	Sample 1/day, test 1st day + 2/week	IM 301	RCE DME		IM 530 for intermittent production
	Grad Non-QMC	302 306 336	CONTR	1/day	IM 301	CONTR		V IA	RCE/ CONTR	Sample 1/day, test 1st day + 1/-week	IM 301	RCE DME		IM 527 for intermittent or low production
	Moist	308, 527	CONTR	IM 527	1000 gm	CONTR								Not applicable with probe
	Sp. Gr.	307	CONTR	IM 527	1000 gm	CONTR								
	Quality	AS 209												

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NOTE: IA may be accomplished by system approach or on a per project basis (IA at 1 per 100,000 sy of concrete) at the discretion of the DME.
NOTE: When Certified Plant Inspection is not provided, the engineer is responsible for performing quality control sampling and testing.
NOTE: RCE/CONTR indicates that the contractor shall assist in the sampling at the direction of and witnessed by the project engineer.
NOTE: For Local agency projects with no Federal Funds Independent Assurance, IA, tests are not required.
NOTE: For Local agency projects with no Federal funding, verification samples or monitor samples sampled by the DME are not required. These samples may be sampled by the contracting authority. With prior approval, these samples may be tested by the Iowa Department of Transportation Central Laboratory.

Sampling & Testing Guide-Minimum Frequency

PORTLAND CEMENT CONCRETE PAVEMENT, PAVEMENT WIDENING, BASE WIDENING CURB & GUTTER, & PAVED SHOULDERS

Section 2122, 2201, 2213, 2301, 2302, 2310, Quality Management Concrete (QM-C)

MATERIAL OR CONSTRUCTION ITEM	TESTS	METHOD OF ACCEPTANCE & RELATED IMs	QUALITY CONTROL					INDEPENDENT ASSURANCE & VERIFICATION S&T						REMARKS
			SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	S&T TYPE	SAMPLE BY	FREQ.	SAMP. SIZE	TEST BY	REPORT	
PLANT INSPECTION														
Aggregates-Coarse (4115), Intermediate	Grad QMC	302 306 336	CONTR	QMC 1/1500 cy	IM 301	CONTR	800240	V IA	RCE/ CONTR	Sample 1/day,test 1st day+2/-week	IM 301	RCE DME		IM 530 for intermittent production
	Grad Non-QMC	302 306 336	CONTR	1/day	IM 301	CONTR		V IA	RCE/ CONTR	Sample 1/day, test 1st day + 1/week	IM 301	RCE DME		IM 527 for intermittent or low production
	Moist	308	CONTR	IM 527	IM 301	CONTR								
	Sp. Gr.	307	CONTR	IM 527	IM 301	CONTR								
	Quality	AS 209						V	DME	1/100,000 sy	50 lb	CTRL		
Portland Cement (4101)	Quality	AS Cert		Each Load				V	DME	1/100,000 sy	15 lb	CTRL		
	Cement Yield		CONTR	1/10,000 cy		CONTR	820912							
Fly Ash	Quality	AS Cert		Each Load			800240	V	DME	1/100,000 sy	15 lb	CTRL		
GGBFS(Ground Granulated Blast Furnace Slag)	Quality	AS Cert		Each Load				V	DME	1/100,000 sy	15 lb	CTRL		
Air Admixture	Quality	AB 403						M	DME	1/project	1 pint	CTRL		Sample batches not previously reported or as required by DME
Water Reducer	Quality	AB 403						M	DME	1/project	1 pint	CTRL		
Retarding Admixture	Quality	AB 403						M	DME	1/project	1 pint	CTRL		

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NOTE: IA may be accomplished by system approach or on a per project basis (IA at 1 per 100,000 sy of concrete) at the discretion of the DME.
NOTE: When Certified Plant Inspection is not provided, the engineer is responsible for performing quality control sampling and testing.
NOTE: Quality samples not required when mix quantity is less than 2000 sq. yds., except for curing compound.
NOTE: RCE/CONTR indicates that the contractor shall assist in the sampling at the direction of and witnessed by the project engineer.
NOTE: For Local agency projects with no Federal Funds Independent Assurance, IA, tests are not required.
NOTE: For Local agency projects with no Federal funding, verification samples or monitor samples sampled by the DME are not required. These samples may be sampled by the contracting authority. With prior approval, these samples may be tested by the Iowa Department of Transportation Central Laboratory.

PORTLAND CEMENT CONCRETE PAVEMENT, PAVEMENT WIDENING, BASE WIDENING CURB & GUTTER, & PAVED SHOULDERS

Section 2122, 2201, 2213, 2301, 2302, 2310, Quality Management Concrete (QM-C)

MATERIAL OR CONSTRUCTION ITEM	TESTS	METHOD OF ACCEPTANCE & RELATED IMs	QUALITY CONTROL					INDEPENDENT ASSURANCE & VERIFICATION S&T						REMARKS
			SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPT.	S&T TYPE	SAMP. BY	FREQ.	SAMPLE SIZE	TEST BY	REPT.	
GRADE INSPECTION														
Chloride Solution	Concentration	373	RCE	1/day										
Steel Reinforcement:														
Dowels	Quality	AS 451.03B						V	DME	1/Source/Yr	1 dowel bar	CTRL		
Dowel Basket Assembly	Quality	AS 451 Cert 451.03B												
Tie Bars	Quality	AS 451						V	DME	1/Source/Yr	1 tie bar	CTRL		
General Use	Quality	AS 451						V	DME	1/Source/Yr	48 in	CTRL		
Curing Compound (4105)	Quality	Tested 405						V	DME	1/batch	1/qt	CTRL		Sample batches not previously reported or as required by DME

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M-Monitor
QMC-Quality Management Concrete

*IA thickness cores sent to Central Lab for additional project information testing (Interstate and Primary only.) **None required when maturity is used.
NOTE: IA may be accomplished by system approach or on a per project basis (IA at 1 per 100,000 sy of concrete or as noted in the table) at the discretion of the DME.
NOTE: Quality samples not required when mix quantity is less than 2000 sq. yds., except for curing compound.
NOTE: RCE/CONTR indicates that the contractor shall assist in the sampling at the direction of and witnessed by the project engineer.
NOTE: Form #E115 available from the Construction & Materials Bureau.
NOTE: For Local agency projects with no Federal Funds Independent Assurance, IA, tests are not required.
NOTE: For Local agency projects with no Federal funding, verification samples or monitor samples sampled by the DME are not required. These samples may be sampled by the contracting authority. With prior approval, these samples may be tested by the Iowa Department of Transportation Central Laboratory.

Sampling & Testing Guide-Minimum Frequency

April 20, 2021 — Matls. IM 204

Supersedes October 15, 2019 — Appendix E (US) Units

PORTLAND CEMENT CONCRETE PAVEMENT, PAVEMENT WIDENING, BASE WIDENING CURB & GUTTER, & PAVED SHOULDERS

Section 2122, 2201, 2213, 2301, 2302, 2310, Quality Management Concrete (QM-C)

MATERIAL OR CONSTRUCTION ITEM	TESTS	METHOD OF ACCEPTANCE & RELATED IMs	QUALITY CONTROL					INDEPENDENT ASSURANCE & VERIFICATION S&T						REMARKS
			SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPT.	S&T TYPE	SAMP. BY	FREQ.	SAMPLE SIZE	TEST BY	REPT.	
GRADE INSPECTION														
Plastic Concrete	Air QMC	318 327	CONTR	1/350 cy, 1/100 cy ready mix		CONTR	E115	V IA	RCE	1/700 cy,1/200 cy ready mix 1/100,000 sy		RCE DME		Min. 1 test/pour
	Air Non-QMC	318 327					E115	V IA	RCE	1/700 cy,1/100 cy ready mix 1/100,000 sy		RCE DME		Min. 1 test/pour
	Slump	317						V	RCE	1/700 cy,1/100 cy ready mix		RCE		For hand finish or fixed form only. Min. 1/pour
	Grade Yield		RCE	1/1000 cy		RCE								
	Beams**	316, 327, 328	RCE	2/day		RCE	E115							
	Beams QMC	327, 328, 530	RCE	1/10000 cy		CTRL								Maximum 3 sets
Hardened Concrete	Thickness*	346, 347						V IA V IA	RCE/ CONTR	1/2000 sy 10% MIT 1/2000 sy# 10 locations#		RCE DME RCE DME		See IM 396 for Bid item <3500 SY #Minimum
	Smoothness	341	CONTR		100%	CONTR		V	DME		10%	DME		

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V-Verification
M-Monitor
QMC-Quality Management Concrete

*IA thickness cores sent to Central Lab for additional project information testing (Interstate and Primary only.) **None required when maturity is used.

NOTE: IA may be accomplished by system approach or on a per project basis (IA at 1 per 100,000 sy of concrete or as noted in the table) at the discretion of the DME.

NOTE: Quality samples not required when mix quantity is less than 2000 sq. yds., except for curing compound.

NOTE: RCE/CONTR indicates that the contractor shall assist in the sampling at the direction of and witnessed by the project engineer.

NOTE: Form #E115 available from the Construction & Materials Bureau.

NOTE: For Local agency projects with no Federal Funds Independent Assurance, IA, tests are not required.

NOTE: For Local agency projects with no Federal funding, verification samples or monitor samples sampled by the DME are not required. These samples may be sampled by the contracting authority. With prior approval, these samples may be tested by the Iowa Department of Transportation Central Laboratory.

NOTE: For Local agency projects with no Federal funding, smoothness verification testing may be tested and evaluated by the DME.

STRUCTURAL CONCRETE, REINFORCEMENT, FOUNDATIONS & SUBSTRUCTURES, CONCRETE STRUCTURES, CONCRETE FLOORS, & CONCRETE BOX, ARCH & CIRCULAR CULVERTS

MATERIAL OR CONSTRUCTION ITEM	TESTS	METHOD OF ACCEPTANCE & RELATED IMs	QUALITY CONTROL					INDEPENDENT ASSURANCE & VERIFICATION S&T						REMARKS
			SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	S&T TYPE	SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	
SOURCE INSPECTION														
Aggregate-Fine (4110)		AS 209												
Aggregate-Coarse (4115)		AS 209												
Granular Backfill (4133)		AS 209												
Portland Cement (4101)	Quality	AS 401												
Fly Ash (4108)	Quality	AS 491.17												
Mixing Water (4102)	Quality							V	RCE	1/source	1pt	CMB		Not required for potable water from Municipal Supply (2)
GGBFS (Ground Granulated Blast Furnace Slag)	Quality	AS 491.14												
Air Entraining Admixture	Quality	AB 403												
Retarding Admixture	Quality	AB 403												
Water reducing Admixture	Quality	AB 403												
Curing Compound, White (4105)	Lab Tested	AS 405						V	DME	1/batch	1qt	CMB		Sample batches not previously reported or as required by DME
Curing Compound, Clear (4105)		AB 405.07												

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IA-Independent Assurance
V-Verification
M-Monitor

(2) DME may waive sampling of water from an established well that has shown past compliance.
NOTE: RCE/CONTR indicates that the Contractor shall assist in the sampling at the direction of and witnessed by the Project Engineer.
NOTE: For Local agency projects with no Federal funding, Independent Assurance, IA, tests are not required.
NOTE: For Local agency projects with no Federal funding, verification samples or monitor samples sampled by the DME are not required. These samples may be sampled by the contracting authority. With prior approval, these samples may be tested by the Iowa Department of Transportation Central Laboratory.

Sampling & Testing Guide-Minimum Frequency

STRUCTURAL CONCRETE, REINFORCEMENT, FOUNDATIONS & SUBSTRUCTURES, CONCRETE STRUCTURES, CONCRETE FLOORS, & CONCRETE BOX, ARCH & CIRCULAR CULVERTS

Sections 2403, 2404, 2405, 2406, 2412, & 2415

MATERIAL OR CONSTRUCTION ITEM	TESTS	METHOD OF ACCEPTANCE & RELATED IMs	QUALITY CONTROL					INDEPENDENT ASSURANCE & VERIFICATION S&T						REMARKS
			SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	S&T TYPE	SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	
SOURCE INSPECTION														
Pre-formed Joint Sealer (4136)	Lab-Tested	AB 436.02 436.05												
Reinforcing Steel Bars (4151)	Quality	AS 451 451.03B												
Steel Pile (4167)	Quality	467												
Concrete Pile (4166)	Quality	AS 570												
Timber Pile (4165)	Quality	Cert 462 AS												
Timber (4162) & Lumber (4163		Treated-Cert 462 AS												
Concrete Anchors	Quality	AB 453.09												
Epoxy Grout	Quality	AB 491.11												
Concrete Sealer	Quality	AB 491.12												
Subdrain Pipe (4143)	Quality	AS 443, 448												
Neoprene Bearing Pads (4195)		AS 495.03												
Bronze Bearing Plates (4190.03)		AS Cert												

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ASD-Approved Shop Drawing
S&T-Sampling & Testing
AB-Approved Brand

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NOTE: RCE/CONTR indicates that the Contractor shall assist in the sampling at the direction of and witnessed by the Project Engineer.

Sampling & Testing Guide-Minimum Frequency

STRUCTURAL CONCRETE, REINFORCEMENT, FOUNDATIONS & SUBSTRUCTURES, CONCRETE STRUCTURES, CONCRETE FLOORS, & CONCRETE BOX, ARCH & CIRCULAR CULVERTS

Sections 2403, 2404, 2405, 2406, 2412, & 2415

MATERIAL OR CONSTRUCTION ITEM	TESTS	METHOD OF ACCEPTANCE & RELATED IMs	QUALITY CONTROL					INDEPENDENT ASSURANCE & VERIFICATION S&T						REMARKS
			SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	S&T TYPE	SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	
SOURCE INSPECTION														
Steel Masonry Plate (4152)		AS Cert												
Prestress Units, Precast Units (2407)	Quality	AS Cert Inspection Report 570												
Precast Units (2419)	Quality	AS Cert 445												
Anchor Bolts (lighting, signing, handrail, structures) (4153)	Lab Tested	ASD												
Structural Steel (4152)	Quality	Cert												Monitor Sample According to plans or other instructions
Aluminum & Steel Bridge Rail & Anchor Assembly		ASD												
Conduit (Electrical) (4185.10)) Steel		AS												
Conduit (Plastic) (4185.10)	Lab Tested							V	DME	1/size	4'	CMB		
Bentonite		Visual												
Flowable Mortar	Lab Tested	Approved 525, 375 Trial Mix												Tested by DME
Fabric Formed Revetment		Approved 375 Trial Mix												Tested by DME

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ASD-Approved Shop Drawing
S&T-Sampling & Testing

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NOTE: RCE/CONTR indicates that the Contractor shall assist in the sampling at the direction of and witnessed by the Project Engineer.
NOTE: For Local agency projects with no Federal funding, Independent Assurance, IA, tests are not required.
NOTE: For Local agency projects with no Federal funding, verification samples or monitor samples sampled by the DME are not required. These samples may be sampled by the contracting authority. With prior approval, these samples may be tested by the Iowa Department of Transportation Central Laboratory.

Sampling & Testing Guide-Minimum Frequency

STRUCTURAL CONCRETE, REINFORCEMENT, FOUNDATIONS & SUBSTRUCTURES, CONCRETE STRUCTURES, CONCRETE FLOORS, & CONCRETE BOX, ARCH & CIRCULAR CULVERTS

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MATERIAL OR CONSTRUCTION ITEM	TESTS	METHOD OF ACCEPTANCE & RELATED IMs	QUALITY CONTROL					INDEPENDENT ASSURANCE & VERIFICATION S&T						REMARKS
			SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	S&T TYPE	SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	
PLANT INSPECTION														
Aggregate- Fine (4110)	Gradation Deck	302, 306 336	CONTR	IM 528	IM 301	CONTR	800240	V IA	RCE/ CONTR	Sample & Test 1/deck pour	IM 301	RCE DME	Plant Monitor Workbook	See IM 528
	Gradation All other		CONTR	IM 528	IM 301	CONTR		V IA	RCE/ CONTR 1/project	Sample 1/wk Test 1st day +20%	IM 301	RCE DME	Plant Monitor Workbook	See IM 528 Systems approach applicable
	Moisture	308, 528	CONTR	IM 528	IM 301	CONTR								See IM 528 if Moisture Probe is used
	Sp. Gr.	307	CONTR	IM 528	IM 301	CONTR								
	Quality	AS 209												
Aggregate- Coarse (4115)	Gradation Deck	302, 306 336	CONTR	IM 528	IM 301	CONTR		V IA	RCE/ CONTR	Sample & Test 1/deck pour	IM 301	RCE DME	Plant Monitor Workbook	See IM 528
	Gradation All other		CONTR	IM 528	IM 301	CONTR		V IA	RCE/ CONTR 1/project	Sample 1/wk Test 1st day +20%	IM 301	RCE DME	Plant Monitor Workbook	See IM 528 Systems approach applicable
	Moisture	308, 528	CONTR	IM 528	2000gm	CONTR								
	Sp. Gr.	307	CONTR	IM 528	2000gm	CONTR								
	Quality	AS 209						V	DME	1/1000 cy	50 lb	CMB		(1)
Portland Cement	w/c ratio	528	CONTR	1/pour		CONTR								
	Quality	AS Cert						V	DME	1/1000 cy	15 lb	CMB		(1)

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S&T-Sampling & Testing

Cert – Certification Statement

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CMB-Construction Materials Bureau
CONTR-Contractor

IA-Independent Assurance
V-Verification
M-Monitor

(1) These verification samples for concrete materials not required when mix quantity is less than 50 cu. yd. For placements greater than 1000 cu. yd., sample 1/placement.

NOTE: IA may be accomplished by system approach or on a per project basis (IA at 1 per 1000 cy of concrete) at the discretion of the DME according to IM 207.

NOTE: RCE/CONTR indicates that the Contractor shall assist in the sampling at the direction of and witnessed by the Project Engineer.

NOTE: For Local agency projects with no Federal funding, Independent Assurance, IA, tests are not required.

NOTE: For Local agency projects with no Federal funding, verification samples or monitor samples sampled by the DME are not required. These samples may be sampled by the contracting authority. With prior approval, these samples may be tested by the Iowa Department of Transportation Central Laboratory.

Sampling & Testing Guide-Minimum Frequency

STRUCTURAL CONCRETE, REINFORCEMENT, FOUNDATIONS & SUBSTRUCTURES, CONCRETE STRUCTURES, CONCRETE FLOORS, & CONCRETE BOX, ARCH & CIRCULAR CULVERTS

MATERIAL OR CONSTRUCTION ITEM	TESTS	METHOD OF ACCEPTANCE & RELATED IMs	QUALITY CONTROL					INDEPENDENT ASSURANCE & VERIFICATION S&T						REMARKS
			SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	S&T TYPE	SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	
PLANT INSPECTION														
Fly Ash	Quality	AS Cert		Each Load			800240							
GGBFS(Ground Granulated Blast Furnace Slag)	Quality	AS Cert		Each Load										
Air-Entraining Admixture (4103)		AB 403						M	DME	1/project	1pt	CMB		(1) Sample lots/batches not previously reported or as required by DME
Retarding Admixture		AB 403						M	DME	1/project	1pt	CMB		
Water Reducing Admixture (4103)		AB 403						M	DME	1/project	1pt	CMB		
GRADE INSPECTION														
Plastic Concrete	Air Content	318, 327					E145*	V IA	RCE	1/30 cy, min. 1/day		RCE DME		If >350 cy placement, DME may increase to 1/50 cy, if consistent during first 90 cy
	Slump	317, 327						V IA	RCE	1/30 cy, min. 1/day		RCE DME		DME may adjust
	Beams	316, 327, 328							RCE	2/placement		RCE		If required per 2403
	Cylinders								DME			DME		See Note

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(1) These verification samples for concrete materials not required when mix quantity is less than 50 cu. yd. For placements greater than 1000 cu. yd., sample 1/placement.
(2) **NOTE:** IA may be accomplished by system approach or on a per project basis (IA at 1 per 1000 cy of concrete) at the discretion of the DME according to IM 207.

NOTE: RCE/CONTR indicates that the Contractor shall assist in the sampling at the direction of and witnessed by the Project Engineer.
NOTE: Cylinders for strength on primary project bridge decks only and where specifically called for in the plans or specifications.
NOTE: For Local agency projects with no Federal funding, Independent Assurance, IA, tests are not required.
NOTE: For Local agency projects with no Federal funding, verification samples or monitor samples sampled by the DME are not required. These samples may be sampled by the contracting authority. With prior approval, these samples may be tested by the Iowa Department of Transportation Central Laboratory.
*Available from the Construction and Materials Bureau.

Sampling & Testing Guide-Minimum Frequency

STRUCTURAL CONCRETE, REINFORCEMENT, FOUNDATIONS & SUBSTRUCTURES, CONCRETE STRUCTURES, CONCRETE FLOORS, & CONCRETE BOX, ARCH & CIRCULAR CULVERTS

MATERIAL OR CONSTRUCTION ITEM	TESTS	METHOD OF ACCEPTANCE & RELATED IMs		QUALITY CONTROL					INDEPENDENT ASSURANCE & VERIFICATION S&T						REMARKS
				SAMPLE BY	FREQ.	SAMPLE SIZE	TES BY	REPORT	S&T TYPE	SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	
GRADE INSPECTION															
Reinforcing Steel (4151)	Quality	AS	Cert		Each Shipment			Field Book	V	DME	IM 451	6 ft	CMB		
Reinforcing Steel Epoxy Coated (4151)	Quality	AS	Cert		Each Shipment			Field Book	V	DME	1 bar	6 ft	CMB		Will be verification tested for coating
Reinforcing Stainless Steel (4151)	Quality	AS	Cert		Each Shipment			Field Book	V	DME	IM 452	6 ft	CMB		
Steel Pile (4167)	Quality	AS	Cert		Each Heat			Field Book		DME	IM 467		CMB		
Timber Pile (4165)	Quality	AS	462 Cert						V	DME	IM 467		CMB		No grade requirement Charge numbers on butt end.
Anchor Bolts (lighting, signing, handrail, structures)	Lab Tested	ASD							V	DME	1/diameter/ source/year	1 bolt w/nut & washer	CMB		Sample only if not source inspected
Steel Masonry Plates (4152)		ASD	Cert		Each Shipment			Field Book							Approved by Materials Department
Bronze Bearing Plates (4190.03)	Lab Tested								V	DME	1/project	1 only	CMB		Sample only if not source inspected
Neoprene Bearing Pads (4195)		AS	495.03		Each Shipment			820905							
Alum. Bridge Rail & Anchor Assembly		ASD			Each Shipment			Field Book							Approved By Materials Dept.
Drains (Std Steel Pipe)(as per plan)	Dimensions Galvanized	ASD	Visual 332						V	DME	1/project		DME		

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NOTE: For Local agency projects with no Federal funding, Independent Assurance, IA, tests are not required.

NOTE: For Local agency projects with no Federal funding, verification samples or monitor samples sampled by the DME are not required. These samples may be sampled by the contracting authority. With prior approval, these samples may be tested by the Iowa Department of Transportation Central Laboratory.

STRUCTURAL CONCRETE, REINFORCEMENT, FOUNDATIONS & SUBSTRUCTURES, CONCRETE STRUCTURES, CONCRETE FLOORS, & CONCRETE BOX, ARCH & CIRCULAR CULVERTS

MATERIAL OR CONSTRUCTION ITEM	TESTS	METHOD OF ACCEPTANCE & RELATED IMs	QUALITY CONTROL					INDEPENDENT ASSURANCE & VERIFICATION S&T						REMARKS
			SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	S&T TYPE	SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	
GRADE INSPECTION														
Timber (4162) & Lumber (4163)	Quality	AS Treated-Cert 462												
Subdrain Pipe (4143)	Quality	AS Cert 443, 448		Each Shipment										
Flowable Mortar (2506)	Flow Test	375						V	RCE	1/4 hours (critical) Visual (noncritical)		RCE	Plant Report	Mix Design approval by DME Lab mix for critical flow only
Grout for Stone Revetment 2507 and Fabric Formed Revetment	Air Content	318 340						V	RCE	1/half day			Plant Report	Fabric Formed Mix Design approval by DME
	Flow Test	375						V	RCE	1/half day				Fabric Formed Revetment Only
	Compressive Strength	315												Only when required by the DME
Foamed Cellular Concrete	Density		CONTR	Each Load										RCE Witness density test by CONTR
Bentonite	Flow Test	Visual 375				RCE								
Hardened Concrete	Smoothness	341	CONTR	100%		CONTR	821301	V	DME	10%		DME		

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NOTE: RCE/CONTR indicates that the Contractor shall assist in the sampling at the direction of and witnessed by the Project Engineer.
NOTE: For Local agency projects with no Federal funding, Independent Assurance, IA, tests are not required.
NOTE: For Local agency projects with no Federal funding, verification samples or monitor samples sampled by the DME are not required. These samples may be sampled by the contracting authority. With prior approval, these samples may be tested by the Iowa Department of Transportation Central Laboratory.
NOTE: For Local agency projects with no Federal funding, smoothness verification testing may be tested and evaluated by the DME.

CONCRETE BRIDGE FLOOR REPAIR & OVERLAY & SURFACING

Section 2413

MATERIAL OR CONSTRUCTION ITEM	TESTS	METHOD OF ACCEPTANCE & RELATED IMs		QUALITY CONTROL					INDEPENDENT ASSURANCE & VERIFICATION S&T						REMARKS
				SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	S&T TYPE	SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	
SOURCE INSPECTION															
Aggregates-Fine (4110)		AS	209												
Aggregates-Coarse (4115)		AS	209												
Portland Cement (4101)	Quality	AS	401												
GGBFS (Ground Granulated Blast Furnace Slag)	Quality	AS	491.14												For HPC-O
Fly Ash (4108)	Quality	AS	491.17												For HPC-O
Mixing Water (4102)	Quality	Lab Tested							V	RCE	1/source	1 qt.	CTRL		Not needed for potable Municipal Water
Air Entraining Admixture (4103)	Quality	AB	403												
Water Reducing Admixture (4103)	Quality	AB	403												
Retarding Admixture (4103)		AB	403												
Curing Compound (4105)	Lab Tested		405						V	DME	1/batch	1 pt	CTRL		Sample lots not previously reported
PLANT INSPECTION															
Aggregate-Fine (4110)	Gradation	AS	Cert	CONTR	IM 528		CONTR			RCE	1/project	20 lb	RCE		When ready mixed concrete is used
Aggregate-Coarse (4115)	Quality	AS	Cert						V	DME	1/project	50 lb	CTRL		DME may adjust frequency
	Gradation			CONTR	IM 528		CONTR		V	RCE	1/project	20 lb	RCE		When ready mixed concrete is used
Portland Cement (4101)	Quality	AS	Cert						V	DME	1/project	15 lb	CTRL		Sample bulk cement only. Mill test report for bagged.

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NOTE: For Local agency projects with no Federal funding, Independent Assurance, IA, tests are not required.

NOTE: For Local agency projects with no Federal funding, verification samples or monitor samples sampled by the DME are not required. These samples may be sampled by the contracting authority. With prior approval, these samples may be tested by the Iowa Department of Transportation Central Laboratory.

CONCRETE BRIDGE FLOOR REPAIR & OVERLAY & SURFACING

Section 2413

MATERIAL OR CONSTRUCTION ITEM	TESTS	METHOD OF ACCEPTANCE & RELATED IMs		QUALITY CONTROL					INDEPENDENT ASSURANCE & VERIFICATION S&T						REMARKS
				SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	S&T TYPE	SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	
PLANT INSPECTION (cont)															
GGBFS(Ground Granulated Blast Furnace Slag)	Quality	AS	Cert		Each Load										For HPC-O
Fly Ash	Quality	AS	Cert		Each Load										For HPC-O
Air Entraining Admixture (4103)		AB	403						M	DME	1/project	1 pt	CTRL		Sample if not previously reported
Water Reducing Admixture (4103)		AB	403						M	DME	1/project	1 pt	CTRL		Sample if not previously reported
Retarding Admixture (4103)		AB	403						M	DME	1/project	1 pt	CTRL		Sample if not previously reported

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NOTE: For Local agency projects with no Federal Funding, Independent Assurance, IA, tests are not required.
NOTE: For Local agency projects with no Federal funding, verification samples or monitor samples sampled by the DME are not required. These samples may be sampled by the contracting authority. With prior approval, these samples may be tested by the Iowa Department of Transportation Central Laboratory.

CONCRETE BRIDGE FLOOR REPAIR & OVERLAY & SURFACING

Section 2413

MATERIAL OR CONSTRUCTION ITEM	TESTS	METHOD OF ACCEPTANCE & RELATED IMs	QUALITY CONTROL					INDEPENDENT ASSURANCE & VERIFICATION S&T						REMARKS
			SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	S&T TYPE	SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	
GRADE INSPECTION														
Plastic Concrete (2413)	Air	318, 327						V IA	RCE	1/100 sy (2) 1/project		RCE DME		1/ 30yd^3 for ready mix, min 1/day
	Slump	317, 327						V IA	RCE	1/100 sy (2) 1/project		RCE DME		1/ 30yd^3 for ready mix, min 1/day
	Density	358						V	RCE	See Note		RCE		For Class O PCC only.(1)
	Thickness								RCE	3/50 sy		RCE		
Concrete Sealer (2413.03, G)	Quality	AS 491.12												
Hardened Concrete	Smooth-ness	341	CONTR	100%		CONTR		V	DME	10%		DME		

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(1) Nuclear density testing frequency for each placement shall be one test within 5 feet of the beginning and end of the placement and additional tests shall be equally spaced a maximum of 100 feet throughout the length of the placement. Each placement shall have a minimum of three nuclear density tests.

(2) For Class O on daily pours of more than 300 square yards, the minimum frequency will be 1 test per 100 square yards for the first 300 square yards, then 1 test for every 300 square yards for the remainder of the day's pour.

NOTE: For Local agency projects with no Federal funding, Independent Assurance, IA, tests are not required.
NOTE: For Local agency projects with no Federal funding, verification samples or monitor samples sampled by the DME are not required. These samples may be sampled by the contracting authority. With prior approval, these samples may be tested by the Iowa Department of Transportation Central Laboratory.
NOTE: For Local agency projects with no Federal funding, smoothness verification testing may be tested and evaluated by the DME.

Concrete Specifications Summary - October 2023
(U.S. Units)

Caution: Consult the applicable specifications for required air content and slump before using this chart.

		Slump (in.)			% Air Content			
Paving	**Type of Concrete**	**Min.**	**Target**	**Max.**	**Min.**	**Target**	**Max**	**Specification Reference**
Slip form	A~~B~~C, QMC				6	8	10	2301.02 B
Non-slip form	A~~B~~C, QMC	0.5		4	5.5	7	8.5	2301.02 B
Concrete Base (Non-slip form)	A, C	0.5		4	5.5	7	8.5	2301.02 & 2201
Curb and gutter (slip form)	C				6	8	10	2512.02 & 2301.02
Curb and gutter (Non-slip form)	C	0.5		4	5.5	7	8.5	2512.02 & 2301.02
Sidewalk	~~B,~~ C			4	5.5	7	8.5	2511.02 & 2301.02
Intakes and manholes	C			4	5.5	6.5	8.5	2403.02

Repair

		Slump Min.	Slump Target	Slump Max.	Air Min.	Air Target	Air Max	Specification Reference
Patches with $CaCl_2$	M	1	2.5	3	3	5	7	2530.02 B & 2529.02 B
		(prior to addition of $CaCl_2$)						
Patches without $CaCl_2$	M	1	3	4	5	6.5	8	2530.02 B & 2529.02 B
		1	4	5				
		(when Mid-Range WR used)						
Underseal and grouting, flowing mortar		By Flow Cone						2539.02 B & 2506

Overlays

		Slump Min.	Slump Target	Slump Max.	Air Min.	Air Target	Air Max	Specification Reference
Unbonded, white topping Bonded	C, QMC	same as specified concrete						2310.02

Lighting & Highway Signing

		Slump Min.	Slump Target	Slump Max.	Air Min.	Air Target	Air Max	Specification Reference
Foundation	C	1	4	5	5.5	6.5	8.5	2403.02 A & B

Concrete Specifications Summary - October 2023
(U.S. Units)

Caution: Consult the applicable specifications for required air content and slump before using this chart.

Structures	Type of Concrete	Slump (in.) Min.	Slump (in.) Target	Slump (in.) Max.	% Air Content Min.	% Air Content Target	% Air Content Max	Specification Reference
Seal Coat	X	0		8				2405.02 D
Sub-Structure & Super-structure	C HPC	1	4	5	5.5 5.5	6.5 7.5	8.5 9.5	2403.02 A & B 2412.02
					(when placed by pumping/belting)			
Slope Protection	C	1		3	5.5	6.5	8.5	On the Plan Sheet
Piling encased & Piling brg. (encased)	C	1	4	5	5.5	6.5	8.5	2403 - 2501.03 E
Bridge Deck Overlay	O	0	0.75	1	5.5	6.5	8.5	2413.02 D.1
	HPC	1	4	5				2413.02 D.2
Bride Deck - Class B Repair	O or D	1		3	5.5	6.5	8.5	2403.02 B, 2412 (2413.03 D)
Barrier Rail - Cast in place	C	1	4	5	6	7	8.5	2513.03 A 2403 2414.02
Barrier Rail - Slipform	BR				6	7	8.5	2513.03 A 2403 2414.02

Guardrail

Structures	Type of Concrete	Slump (in.) Min.	Slump (in.) Target	Slump (in.) Max.	% Air Content Min.	% Air Content Target	% Air Content Max	Specification Reference
End anchors	C	1	4	5	4		7	2403.02 & 2505.03 B

Concrete Specifications Summary - October 2023
(U.S. Units)

Caution: Consult the applicable specifications for required air content and slump before using this chart.

Paving	Type of Concrete	Slump (in.) Min.	Slump (in.) Target	Slump (in.) Max.	% Air Content Min.	% Air Content Target	% Air Content Max	Specification Reference
Slip form	A~~B~~C, QMC				6	8	10	2301.02 B
Non-slip form	A~~B~~C, QMC	0.5		4	5.5	7	8.5	2301.02 B
Concrete Base (Non-slip form)	A, C	0.5		4	5.5	7	8.5	2301.02 & 2201
Curb and gutter (slip form)	C				6	8	10	2512.02 & 2301.02
Curb and gutter (Non-slip form)	C	0.5		4	5.5	7	8.5	2512.02 & 2301.02
Sidewalk	~~B,~~ C			4	5.5	7	8.5	2511.02 & 2301.02
Intakes and manholes	C			4	5.5	6.5	8.5	2403.02

Repair

Repair	Type of Concrete	Slump (in.) Min.	Slump (in.) Target	Slump (in.) Max.	% Air Content Min.	% Air Content Target	% Air Content Max	Specification Reference
Patches with $CaCl_2$	M	1	2.5	3	3	5	7	2530.02 B & 2529.02 B
		(prior to addition of $CaCl_2$)						
Patches without $CaCl_2$	M	1	3	4	5	6.5	8	2530.02 B & 2529.02 B
		1	4	5				
		(when Mid-Range WR used)						
Underseal and grouting, flowing mortar		By Flow Cone						2539.02 B & 2506

Overlays

Overlays	Type of Concrete	Slump (in.) Min.	Slump (in.) Target	Slump (in.) Max.	% Air Content Min.	% Air Content Target	% Air Content Max	Specification Reference
Unbonded, white topping Bonded	C, QMC	same as specified concrete						2310.02

Lighting & Highway Signing

Lighting & Highway Signing	Type of Concrete	Slump (in.) Min.	Slump (in.) Target	Slump (in.) Max.	% Air Content Min.	% Air Content Target	% Air Content Max	Specification Reference
Foundation	C	1	4	5	5.5	6.5	8.5	2403.02 A & B

Concrete Specifications Summary - October 2023
(U.S. Units)

Caution: Consult the applicable specifications for required air content and slump before using this chart.

Structures	Type of Concrete	Slump (in.) Min.	Slump (in.) Target	Slump (in.) Max.	% Air Content Min.	% Air Content Target	% Air Content Max	Specification Reference
Seal Coat	X	0		8				2405.02 D
Sub-Structure & Super-structure	C HPC	1	4	5	5.5 5.5	6.5 7.5	8.5 9.5	2403.02 A & B 2412.02
					(when placed by pumping/belting)			
Slope Protection	C	1		3	5.5	6.5	8.5	On the Plan Sheet
Piling encased & Piling brg. (encased)	C	1	4	5	5.5	6.5	8.5	2403 - 2501.03 E
Bridge Deck Overlay	O	0	0.75	1	5.5	6.5	8.5	2413.02 D.1
	HPC	1	4	5				2413.02 D.2
Bride Deck - Class B Repair	O or D	1		3	5.5	6.5	8.5	2403.02 B, 2412 (2413.03 D)
Barrier Rail - Cast in place	C	1	4	5	6	7	8.5	2513.03 A 2403 2414.02
Barrier Rail - Slipform	BR				6	7	8.5	2513.03 A 2403 2414.02

Guardrail

Structures	Type of Concrete	Slump (in.) Min.	Slump (in.) Target	Slump (in.) Max.	% Air Content Min.	% Air Content Target	% Air Content Max	Specification Reference
End anchors	C	1	4	5	4		7	2403.02 & 2505.03 B

Review Questions
Inspection of Construction Project Sampling and Testing
IM 204

1. What is the minimum testing frequency for an air test for the Quality Control on the grade for a QMC Paving out of a Central Batch Plant?

   What is the minimum testing frequency for an air test for the Quality Control on the grade for a QMC Paving out of a Ready Mix Plant?

2. What is the minimum testing frequency for a slump test for the Verification (RCE/Consultant) test on the grade for a Bridge Deck project?

   If we batched 303CYs of mix, how many tests are required?

3. What is the minimum testing frequency for an air test for the Verification test on the grade for a Bridge Overlay project from a Ready Mix plant?

IM 327 - SAMPLING
FRESHLY MIXED CONCRETE

SAMPLING FRESH CONCRETE

IM 327 explains the proper sampling procedure for fresh concrete.

Concrete can be sampled by contractors, producers, and/or agencies for testing air content, slump, unit weight, and strength. Concrete can be sampled at a variety of locations depending on the type of placement and equipment being used. Sampling from five types of mixers or placement systems will be covered in detail in IM 327.

Concrete samples need to be properly obtained, protected, and be representative of the concrete being placed. To ensure a concrete sample is representative of the concrete being placed it is critical that it be sampled only after all water and admixture additions have been made. Concrete should be sampled from the last safe practical point before incorporation and consolidation.

Failure to sample concrete correctly can result in incorrect results which potentially could lead to difficulty in correlating, rejection or penalty of complying material, incorporation of non-complying material, and additional testing/investigative work.

Specific times for starting or completing tests after the sample is taken are as follows:

- COMPLETE temperature within 5 minutes
- START slump test within 5 minutes
- START air content test within 5 minutes
- START molding strength specimens within 15 minutes

SAMPLING FRESHLY MIXED CONCRETE

SCOPE

This procedure provides instruction for obtaining samples of fresh concrete for new construction or repair. Sources covered include grade, ready mix truck, mobile mixer, pump or conveyor placement systems, and concrete slab as placed.

SIGNIFICANCE

Testing fresh concrete in the field begins with obtaining and preparing the sample to be tested. Standardized procedures for obtaining a representative sample from various types of mixing and/or agitating equipment have been established. Specific time limits regarding when tests for temperature, slump, and air content must be started and for when the molding of test specimens must begin are also established.

Technicians must refrain from obtaining the sample too quickly. Doing so would be a violation of the specifications under which the concrete is being supplied and it may result in a nonrepresentative sample of concrete. Every precaution must be taken to obtain a sample that is truly representative of the entire batch and then to protect that sample from the effects of evaporation, contamination, and physical damage.

PROCEDURE

A. Apparatus

1. Wheelbarrow or other nonabsorbent container
2. Cover for wheelbarrow or container (plastic, canvas, or burlap)
3. Shovel
4. 5-gallon bucket for water

B. Testing Procedure

For acceptance testing, obtain representative samples from the last practical point before incorporation, but before consolidation. The DME may adjust sample location and target air content, to ensure safe sampling location and adequate in place air content is achieved for freeze-thaw durability.

1. Sampling from Grade

Sample after the concrete in the transport vehicle has been discharged onto the grade. To ensure a representative sample, obtain concrete from at least five different locations in the pile and combine into one test sample. Avoid contamination with subgrade material or prolonged contact with absorptive subgrade.

2. Sampling from Ready Mix Truck

   Sample the concrete after a minimum of 1/2 yd.^{3} of concrete has been discharged. Do not obtain samples until after all of the water has been added to the mixer. Do not obtain samples from the very first or last portions of the batch discharge. Sample by repeatedly passing a receptacle through the entire discharge stream or by completely diverting the discharge into a sample container. Regulate the rate of discharge of the batch by the rate of revolution of the drum and not by the size of the gate opening.

3. Sampling from Mobile Mixer

   Discharge the concrete into a container or power buggy sufficiently large enough to accommodate the entire batch. Secure a representative sample after the batch has been deposited by obtaining one shovel full, more or less, from each of at least three different positions in the container or power buggy.

4. Sampling from Pump or Conveyor Placement Systems

   Sample after a minimum of 1/2 yd.^{3} of concrete has been discharged. Do not obtain samples until after all of the pump slurry has been eliminated. Sample by repeatedly passing a receptacle through the entire discharge system or by completely diverting the discharge into a sample container. Do not lower or raise the pump arm from the placement position ~~to ground level~~ for ease of sampling, as it may modify the air content of the concrete being sampled. Do not obtain samples from the very first or last portions of the batch discharge. To reduce variability in air tests, ensure that the pump configuration is such that sufficient back pressure is achieved and a constant flow is being discharged before sample is obtained.

5. Sampling from Concrete Slab as Placed

   Mark the approximate location of concrete placed on grade and sampled for air content. After the paver has passed the marked location, remove the sample from the slab, approximately in line with a vibrator and within an 18 in. x 18 in. square area to a depth approximately two-thirds of the pavement thickness. The sample should be obtained a minimum of 12 in. from the edge of slab to prevent extra handwork in maintaining the pavement edge.

Transport samples to the place where fresh concrete tests are to be performed and specimens are to be molded. Protect the sample from direct sunlight, wind, rain, and sources of contamination.

Complete test for temperature within five minutes of obtaining the sample. Start tests for slump and air content within five minutes of obtaining the sample. Complete tests as quickly as possible. Start molding specimens for strength tests within 15 minutes of obtaining the sample.

Review Questions
Sampling Freshly Mixed Concrete
IM 327

1. This method covers sampling from five types of mixers or placement systems, which are ___________________, ___________________, ___________________, ___________________, and _____________________.

2. When sampling from a ready mix truck how must the concrete be sampled during discharge of the batch?

3. The concrete sample must be protected from contamination, __________________, ________________________, and _______________________.

4. Where do you get the sample from the slab?

5. What time limits are specified for testing after obtaining a sample?

6. How many sample locations are needed for concrete samples on the grade?

IM 385 - TEMPERATURE OF FRESHLY MIXED CONCRETE

CONCRETE TEMPERATURE

IM 385 explains the proper procedure for testing the temperature of fresh concrete.

The temperature of fresh concrete is taken at placement and is typically done by the agency but may also be checked by the contractor or producer. Concrete temperature requirements are described in General Specification 2301.03 S for paving, 2403.03 F for structures, 2412.03 C for decks, and 2406 for slab decks. The specification should always be consulted for exact contractual requirements, but the following table summarizes concrete temperature requirements:

	Paving	Structure	Deck	Slab Deck
Maximum Concrete Temperature	None Specified	None Specified	90°F	None Specified
Minimum Concrete Temperature	40°F	45°F	45°F	45°F

Special attention to concrete temperatures should occur during times of the years when ambient and material temperatures are extreme, such as early or late season paving or decks, mid-summer decks, and winter structures.

In cold weather, exceeding minimum concrete temperatures at placement will help to ensure that concrete hydration can occur and allow the concrete to gain strength. Additionally, meeting this minimum temperature will typically allow for more efficient and effective cold weather protection and ensure the concrete is not subjected to a freeze-thaw cycle before achieving adequate strength.

In hot weather, not exceeding maximum concrete temperatures at placement will help to ensure the concrete does not stiffen rapidly resulting in constructability issues and the potential for increasing w/c ratios, adding water to the surface to aid in finishing, and over vibrating.

The temperature of the concrete must be taken properly to get an accurate reading. The base of the thermometer must be inserted, closed, and covered with concrete of adequate depth. Failure to do so will result in a reading that is influenced by the ambient temperature.

TEMPERATURE OF FRESHLY MIXED CONCRETE

SCOPE

This test method covers the determination of temperature of freshly mixed Portland Cement Concrete.

This standard may involve hazardous materials, operations, and equipment. This standard does not address all of the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices.

SIGNIFICANCE & USE

This test method provides a means for measuring the temperature of freshly mixed concrete. It may be used to verify conformance to a specified requirement for temperature of concrete. For specification compliance, temperature shall be measured by means of an immersion temperature-measuring device. Infrared thermometers may be used for information purposes only.

PROCEDURE

A. Apparatus

1. Container. The container shall be made of nonabsorptive material and large enough to provide at least 3 in. (75 mm) of concrete in all directions around the sensor of the temperature-measuring device; the concrete cover shall also be at least three times the nominal maximum size of the coarse aggregate.

2. Temperature-measuring Device. The temperature-measuring device shall be capable of reading the temperature of the freshly mixed concrete to ±1°F (±0.5°C) throughout the entire temperature range likely to be encountered in the fresh concrete. Liquid-in-glass thermometers having a range of 0°F to 120°F (-18°C to 49°C) are satisfactory. Other thermometers of the required accuracy, including the metal immersion type, are acceptable.

3. Thermometer Marking. Partial-immersion liquid-in-glass thermometers (and possibly other types) shall have a permanent mark to which the device must be immersed without applying a correction factor.

4. Reference Temperature-measuring Device. The reference temperature-measuring device shall be a liquid-in-glass thermometer readable to 0.5°F (0.2°C) that has been verified and calibrated. The calibration certificate or report indicating conformance to ASTM E77 requirements shall be available for inspection. Other temperature-measuring devices may be used if the calibration is certified.

B. Calibration of Temperature-measuring Device

1. Each temperature-measuring device used for determining the temperature of freshly mixed concrete shall be calibrated before initial use, or whenever there is a question of

accuracy. This calibration shall be performed by comparing the readings on the temperature-measuring device at two temperatures at least 27°F (15°C) apart.

C. Sampling Concrete

1. The temperature of freshly mixed concrete may be measured in the transporting equipment providing the sensor of the temperature-measuring device has at least 3 in. (75 mm) of concrete cover in all directions around it.

2. If the transporting equipment is not used as the container, a sample shall be prepared as follows:

    a. Immediately prior to sampling the freshly mixed concrete, dampen (with water) the sample container.

    b. Sample the freshly mixed concrete in accordance with IM 327.

    c. Place the freshly mixed concrete into the container. (**NOTE:** When concrete contains a nominal maximum size of aggregate greater than 3 in. (75 mm), it may require 20 minutes after mixing before the temperature is stabilized.)

    d. Complete the temperature measurement of the freshly mixed concrete within five minutes after obtaining the sample.

D. Test Procedure

1. Place the temperature-measuring device in the freshly mixed concrete, so the temperature-sensing portion is submerged in a minimum of 3 in. (75 mm) of concrete. Gently press the concrete around the temperature-measuring device at the surface of the concrete so the ambient air temperature does not affect the reading.

2. Leave the temperature-measuring device in the freshly mixed concrete for a minimum period of two minutes or until the temperature reading stabilizes, then read and record the temperature.

3. Complete the temperature measurement of the freshly mixed concrete within five minutes of obtaining the sample.

4. Record the measured temperature of the freshly mixed concrete to the nearest 1°F (0.5°C).

Review Questions
Temperature of Freshly Mixed Concrete
IM 385

1. Why is the temperature of concrete generally taken?

2. The temperature measuring device shall be calibrated ___________________, or whenever there is a question of _______________________.

3. Is an infrared temperature measuring device acceptable for taking concrete temperatures?

4. How soon after your sample is taken do you need to have the temperature test completed?

IM 317 - SLUMP OF CONCRETE

SLUMP

IM 317 gives the proper procedure for performing a slump test.

The slump of concrete measures the consistency of the freshly mixed concrete. Another way to think of consistency is how easily the concrete flows. Slump may also be used to determine the load to load uniformity of concrete supplied to a pour. Slump is not an indicator of the amount water in the mix as it can be increased with the use of a water reducer.
Slump tests are typically performed by the agency, but they may also be checked by the contractor or producer. There will be different slump requirements for different types of placements. Placements that are congested with steel and constrained by forms will typically have higher allowable slumps compared to placements that have little steel and are more open. Slump specification requirements have been provided at the end of the IM 204 section in the Concrete Specification Summary.

The slump test needs to be performed properly to ensure accurate results. Time requirements to start the test after sampling as well as to complete the test once started must be met to ensure stiffening does not influence the result. Care must also be taken to limit impacts from outside influences such as a sloped surface, vibration from traffic or equipment, and jarring the base with the inverted cone.

When using ready mix, slump may be increased by adding water or reduced by spinning the drum additional revolutions. While this is acceptable practice, ensure that all water additions are accounted for and that the maximum w/c ratio and the maximum time limit are not exceeded. Typically, when one gallon of water is added per cubic yard of concrete, the slump will increase by approximately one inch.

SLUMP OF HYDRAULIC CEMENT CONCRETE

SCOPE

This procedure provides instructions for determining the slump of hydraulic cement concrete. It is not applicable to non-plastic or non-cohesive concrete, nor when the maximum size of the coarse aggregate is over 2 in.

SIGNIFICANCE

The slump test is used to determine the consistency of concrete. Consistency is a measure of the relative fluidity or mobility of the mixture. Slump does not measure the water content or workability of the concrete. While it is true that an increase or decrease in the water content will cause a corresponding increase or decrease in the slump of the concrete, many other factors can cause slump to change without any change to water content. One cannot assume that the water/cement ratio is being maintained simply because the slump is within specification limits.

PROCEDURE

A. Apparatus

1. Slump Cone. The slump cone shall conform to AASHTO T 119: The mold shall be provided with foot pieces and handles. The mold may be constructed either with or without a seam. The interior of the mold shall be relatively smooth and free from projections such as protruding rivets. The mold shall be free of dents. A mold that clamps to a rigid non-absorbent base plate is acceptable provided the clamping arrangement is such that it can be fully released without movement of the mold.

2. Tamping Rod. The tamping rod shall be 5/8 in. in diameter and approximately 24 in. in length, having a hemispherical tip.

3. Scoop.

4. Tape Measure or Ruler. These should have at least 1/8 in. gradations.

5. Base. The base shall be rigid with a non-absorbent surface on which to set the slump cone.

B. Test Procedure

1. Obtain the sample in accordance with IM 327.

2. Dampen the inside of the cone and place it on a dampened, rigid, non-absorbent surface that is level and firm.

3. Stand on both foot pieces in order to hold the mold firmly in place or clamp the cone to the base and stand on the base to secure.

4. Fill the cone 1/3-full in volume, to a depth of 2 5/8 in. in depth.

5. Consolidate the layer with 25 strokes of the tamping rod, using the rounded end. Distribute the strokes evenly over the entire cross section of the concrete. For this bottom layer, incline the rod slightly and make approximately half the strokes near the perimeter, and then progress with vertical strokes, spiraling toward the center.

6. Fill the cone 2/3-full in volume, to a depth of 6 1/8 in. in depth.

7. Consolidate this layer with 25 strokes of the tamping rod, penetrating the bottom layer approximately 1 inch. Distribute the strokes evenly.

8. Fill the cone to overflowing.

9. Consolidate this layer with 25 strokes of the tamping rod, penetrating the second layer approximately 1 inch. Distribute the strokes evenly. If the concrete falls below the top of the cone, stop, add more concrete, and continue rodding for a total of 25 strokes. Keep an excess of concrete above the top of the mold at all times. Distribute strokes evenly as before.

10. Strike off the top surface of concrete with a screeding and rolling motion of the tamping rod.

11. Clean the overflow concrete away from the base of the mold.

12. Remove the mold from the concrete by raising it carefully in a vertical direction. Raise the mold 12 in. in 5 ± 2 seconds by a steady upward lift with no lateral or torsional motion being imparted to the concrete.

    The entire operation from the start of the filling through removal of the mold shall be carried out without interruption and shall be completed within an elapsed time of 2 1/2 minutes.

13. Invert the slump cone and set it next to the specimen.

14. Lay the tamping rod across the mold so it is over the test specimen.

15. Measure the distance between the bottom of the rod and the displaced original center of the top of the specimen to the nearest 1/4 in.

NOTE: If a decided falling away or shearing off of concrete from one side or portion of the mass occurs, disregard the test and make a new test on another portion of the sample. If two consecutive tests on a sample of concrete show a falling away or shearing off of a portion of the concrete from the mass of the specimen, the concrete probably lacks the plasticity and cohesiveness necessary for the slump test to be applicable.

Air and Slump Tests

Line No.: ____________ **Page No.:** ___________

Contractor: ______________________ **Category No.:** ___________

Project No.: ______________________________ **Contract ID:** _______________

Date	Location	Mix Type	Air (%)	Slump (In)	Application	Remarks	By

Review Questions
Slump of Hydraulic Cement Concrete
IM 317

1. Describe the mold used for making the slump test.

2. The surface on which the slump cone will be placed must be ___________________.

3. The approximate concrete depth (in inches) after placing the first layer is __________________ and the second layer is _____________________.

4. When rodding the bottom layer, the tamping rod must be _________________ to uniformly distribute the strokes.

5. If, while rodding the top layer, the concrete drops below the top of the slump cone, what must be done?

6. The measurement for slump is made from the top of the mold to what point of the concrete specimen?

7. While the technician is checking the slump of the concrete, there is a decided falling away or shearing off of the concrete from one side of the sample. What should the technician do?

8. How soon after your sample is taken do you need to start the slump test?

IM 318 - AIR CONTENT OF CONCRETE

AIR CONTENT BY PRESSURE METHOD

IM 318 gives the proper procedure for performing an air test using the pressure method.

The air content test measures the volume of entrained air in plastic concrete. Air is introduced into the concrete through mixing and is stabilized in the paste by air entraining admixtures. Concrete without air entraining admixtures will typically contain 1 to 2 percent air content while concrete with air entraining admixtures will have much higher air contents in the range of 6 to 10 percent.

Entrained air is required in concrete that is exposed to freezing and thawing. When concrete freezes, water in the concrete will also freeze and expand by approximately 9 percent. Entrained air provides a space for the expanding freezing water to move into, relieving pressure and preventing cracking.

Air content tests are typically performed by the agency, but they may also be checked by the contractor or producer. There will be different air content requirements for different types of placements. Higher air contents and wider ranges are typically specified for placements that use a pump or are machine vibrated. Air specification requirements have been provided at the end of the IM 204 section in the Concrete Specification Summary.

The air content test needs to be performed properly to ensure accurate results. Proper rodding and consolidation eliminates defects/voids and ensures only entrained air is measured. Proper cleaning of the rim ensures a tight seal without leaks. Purging the system of air by injecting water into the petcocks eliminates measuring non-entrained air. Tapping the bowl and gauge when pressurizing the system helps to equalize pressure and remove internal constraints.

Air meters contain many working parts, seals, and gaskets. They should be properly cleaned after use and stored and transported in a case. When storing, the lid should not be attached to the base to prevent damage to the seal. The lid should never be lifted by the gauge, but instead held by the base or canister. Air meters should be thoroughly cleaned and calibrated annually. Calibrating or conducting correlation testing prior to project startup and periodically during production is a recommended practice.

When using ready mix, air may be increased by adding air entraining agent, water, and spinning the drum additional revolutions. Air may be reduced by continued spinning of the drum at a high speed.

Coarse aggregates with a high amount of voids can cause the air content test to be erroneously high. To account for these voids, an aggregate correction factor will be subtracted from the gauge reading. Coarse aggregates requiring an aggregate correction factor are provided in IM 318. The District Materials Office should be contacted for the correction factor.

AIR CONTENT OF FRESHLY MIXED CONCRETE BY PRESSURE

SCOPE

This test method describes the procedure for determining the air content of freshly mixed concrete by one form of pressure method.

PROCEDURE

NOTE: Certain coarse aggregates in eastern Iowa with large interconnected pores in the aggregate will cause air meter readings to indicate higher air content than is actually in the concrete because air is compressed in the aggregate pores just as the air is compressed in the paste. An aggregate correction factor must be applied to correct the air content. AASHTO T152 requires an aggregate correction factor for all concrete; however, it typically is not large enough for most aggregates to require adjustment. A list of aggregates that typically require a correction factor is included as well as the procedure to determine aggregate correction factor.

A. Apparatus

1. Measure bowl and cover assembly: All apparatus used shall incorporate the requirements of AASHTO Designation T-152 Section 4, for a Type B Washington-type meter.

2. Tamping Rod: 5/8 in. diameter, having a hemispherical tip.

3. Scoop

4. Strike-off bar

5. Rubber mallet

6. Rubber syringe or polyethylene unitary wash bottle

B. Test Procedure (For use with Washington-Type Air Meter)

NOTE: All meters shall be calibrated annually. Check calibration prior to use on a project and periodically throughout the construction season.

1. Calibration of Apparatus
   Calibration Canisters (Plug method)
   The volume of the calibration canister should be 0.0125 ft^3. The effective air volume of the canister depends on the volume of the air meter being calibrated.

   Effective Air Volume =100 X 0.0125 ft^3/(air meter pot volume)
   Below is the effect air volume for the range of meters in service.

Air Meter Base Volume ft3	Effective air volume one canister	two canisters
0.245	5.10%	10.2%
0.246	5.10%	10.2%
0.247	5.05%	10.1%
0.248	5.05%	10.1%
0.249	5.00%	10.0%
0.250	5.00%	10.0%
0.251	5.00%	10.0%
0.252	4.95%	9.9%
0.253	4.95%	9.9%
0.254	4.90%	9.8%
0.255	4.90%	9.8%

2. Calibration Plug Procedure

a. Fill the air meter with water. The water should be about the same temperature as the air temperature.

   Note: Many faucets will mix air into the water. This air can be enough to affect the calibration. In this case, the water should be drawn and left to sit for several hours.

b. Put the lid on and using a plastic bottle provided or a rubber syringe, inject water through one petcock until all the air is expelled through the opposite petcock. Jar the base to insure removal of all air. Leave petcocks open.

c. Stabilize the dial hand at proper initial pressure line by pumping or bleeding off, as needed, while lightly tapping the backside of the dial with the fingers. Inject water through the petcock again to make sure all the air is expelled.

d. Close both petcocks and press down on the thumb lever exhausting air into the base. The dial should read 0.0%. If the dial does not read 0.0%, the test should be repeated. If two or more tests are off by the same amount, a new initial pressure line should be established, and the test repeated to confirm a 0.0% reading.

e. Open the petcocks to relieve the pressure and remove the lid.

f. Make sure the calibration canisters have no water inside and that the bottom hole is clear of debris. Place the canister in the water making sure not to release air from the canister. Repeat step b and c. Close both petcocks and press down on the thumb lever exhausting air into the base. While holding the lever, lightly tap the gage to stabilize the dial reading. The dial should read the effective air volume of the canister (5.0% for air meters with a 0.25 ft^3 volume).

g. If the dial reading variation is +/- 0.2% or more from the effective air volume, repeat the test. If the dial reading variation is within +/- 0.2% or less from the effective air volume, the air meter is in proper calibration. To check at 10%, repeat with two calibration canisters. If the dial reading variation is within +/-0.25% (½ scale reading for dials with 0.5% graduations) or less from the effective air volume, the air meter is in proper calibration.

h. If the dial readings are beyond the tolerance for either or both air volumes, the test should be repeated. If after two or more tests, the variation is the same and/or beyond the tolerances, the air meter gauge needs adjustment or replacement. Adjustment of the air meter gauge should only be attempted by trained personnel. For DOT, county, and city owned air meters, the trained personnel include the District Materials staff and the Central Laboratory Testing Support Personnel

See Iowa Test Method 405 for Water Method Calibration

3. Operation of Apparatus (Determination of Air Content of Concrete)

a. Fill the base with a sample of fresh concrete placing the concrete in the base in three equal layers. Rod each layer twenty-five times with the tamping rod provided with the meter. For slumps less than 1 in., the sample may need to be consolidated by internal vibration.

b. Do not allow the rod to forcibly strike the bottom of the base while rodding the bottom layer. For each upper layer, the rod shall penetrate 1 inch into the underlying layer. Care should also be taken to avoid hitting the top edge of the base with the tamping rod.

c. Tap the sides of the base 10-15 times with a rubber mallet after rodding each layer to close the holes left by the rod.

d. A clean, smooth surface on the top edge of the base is necessary to insure a tight seal with the cover. Strike off base, level full, with the straight edge furnished. Wipe the top edge of the base clean to insure a tight seal with the cover.

e. Clamp cover on with petcocks open.

f. With the built in pump, pump air into the air chamber atop the cover until the pressure indicator points to the proper initial pressure line on the gauge. **NOTE:** The pump stem may need a light coat of oil to slide freely. Too much oil on the stem will fill the pump chamber and block the air valve causing the pump to fail.

g. Using a rubber syringe, inject water through one petcock until all the air is expelled through the opposite petcock. Jar the base to insure removal of all air. Leave petcocks open. **NOTE:** Use care if injecting water through opposite petcock to not add air bubbles. When jarring the base to remove the air, the base shall not be tilted more than 2 inches from horizontal.

The sequence of Steps f. and g. may be interchanged without adversely affecting the test result.

i. Stabilize dial hand at the proper initial pressure line by pumping or bleeding off, as needed, while lightly tapping the backside of the dial with the fingers. Inject water through the petcock again to make sure all the air is expelled.

i. Close both petcocks. Press down on lever to release air into the base. Tap the sides of the measuring bowl with the rubber mallet to relieve local constraints. Hold lever down a few seconds lightly tapping the backside of the dial with your fingers until the dial stabilizes. Observe the dial reading before letting up on the lever. Record the dial reading. Report the air content to the nearest 0.1% for air contents up to 8%, or the nearest 1/2 scale division at 8% or higher air content.

j. Open petcocks to release pressure, and then remove cover. Empty the concrete from base, clean up base, cover with petcocks left opened.

4. Determination of Aggregate Correction Factor

a. The aggregate correction factor is determined independently by applying the calibrated pressure to a sample of inundated fine and coarse aggregate in approximately the same moisture condition, amount and proportions occurring in the concrete sample under the test.

b. Calculate the sample weights of the fine and coarse aggregate as follows:

$F_s = (S/B) \times F_b$
$C_s = (S/B) \times C_b$

Where:
F_s = weight of fine aggregate in concrete test sample, lb.
S = volume of measuring bowl, ft^3
B = volume of concrete produced per batch, ft^3
F_b = weight of fine aggregate in the moisture condition used in batch, lb.
C_s = weight of coarse aggregate in concrete sample under test, lb.
C_b = weight of coarse aggregate in the moisture condition used in batch, lb.

Example of C-3WR Mix

Coarse aggregate wet batch weight = 1597
Fine aggregate wet batch weight = 1421
Container volume = 0.248 ft^3
Coarse Aggregate Weight (C_s) = (0.248/27) X 1597 = 14.67 lbs. (6653 grams)
Fine Aggregate Weight (F_s) = (0.248/27) X 1421 = 13.05 lbs. (5920 grams)

c. Mix representative samples of the coarse and fine aggregate, and place in a measuring bowl one-third full of water. Add the mixed aggregate to the bowl, introducing each scoopful in a manner which minimizes entrapped air. If necessary, add additional water to inundate the aggregate. Stir, rod and tap the sides of the bowl to eliminate entrapped air.

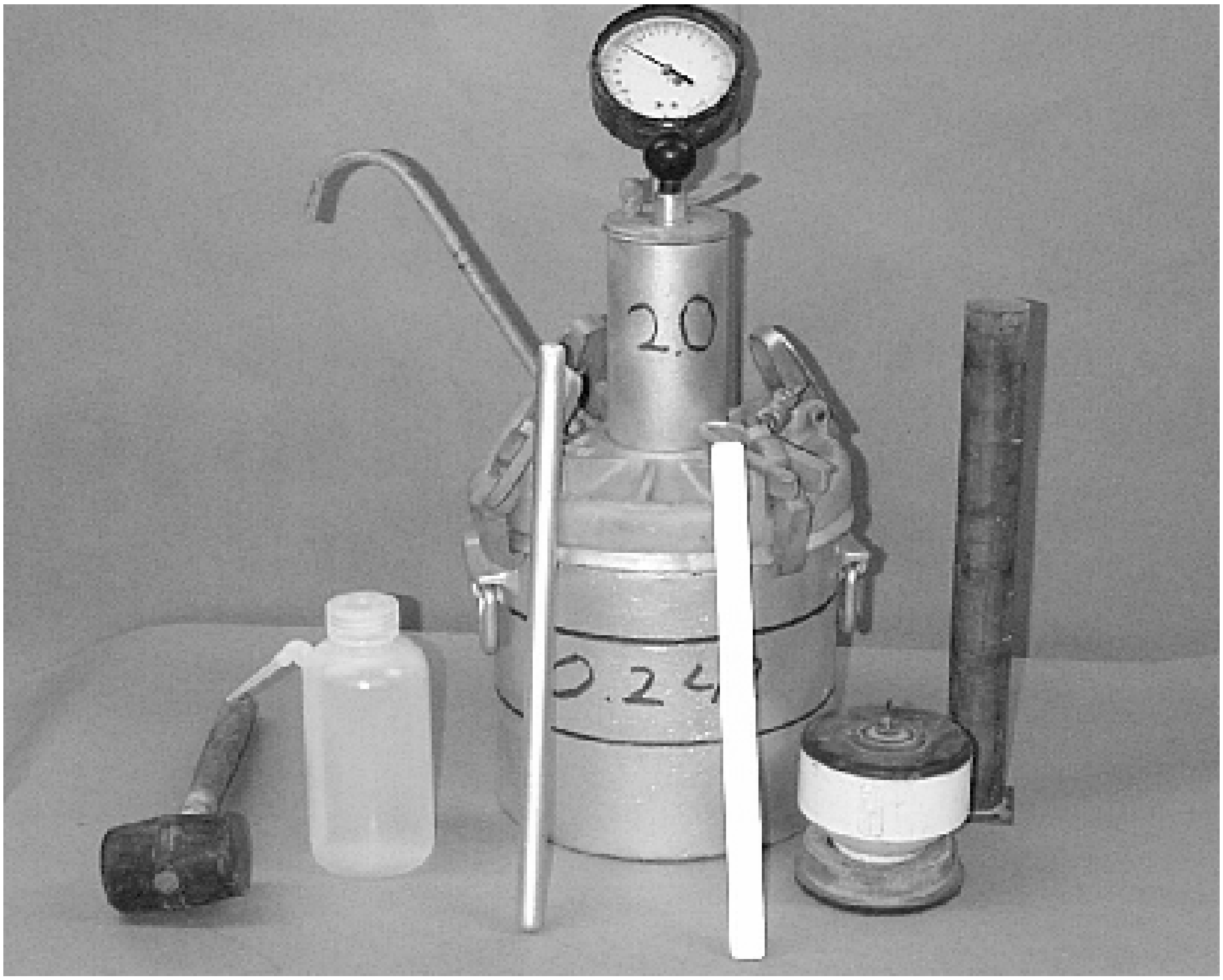
d. Soak the aggregate for a time period approximately equal to the amount of time between the introduction of the water into the mixer and the time of performing the test for air content.

e. Follow steps e, f, g, h, and i in paragraph 3. Operation of Apparatus

f. The air content reading is the aggregate correction factor. For ease of determining plastic concrete air in the field, the aggregate correction factor will be rounded down to the nearest 0.5%.

g. Actual concrete air content = Air meter reading - Aggregate correction factor

NOTE: If performing test by removal of a measured amount of water, the inside calibration tube may need to be cut short to prevent drawing sand into the water. When using this method the aggregate correction factor will be the air content reading minus volume of water removed expressed as percent volume of the bowl.



Air Meter and Calibrating Accessories

NOTE: The following is a list of aggregate sources, including bed numbers, that will typically need an aggregate correction factor applied. When these aggregates are used without an aggregate correction factor applied, excessive bleeding is commonly noted, especially on bridge decks. There is a fairly good correlation of aggregate sources with an Iowa Pore Index primary load greater than 100 may require an aggregate correction factor. Contact the District Materials Engineer when using these aggregates.

Source #	Name	Beds
A07008	Morgan	5, 9
A09006	Tripoli Platte	1-5
A10008	Oelwein	4-5
A10010	Hazelton	4
A10016	Oelwein #2	13-16
A10030	S. Aurora	1-3
A16006	Stonemill	4
A23004	Behr	1-2
A23006	Shaffton	16-17
A42002	Alden	0-3, 3
A44006	Leeper	8-11
A45008	Dotzler	7-10A
A49020	Preston	7-10
A49024	Maquoketa	1-8
A50002	Sully Mine	36-41
A52004	Conklin	23-24
A52006	Klein	23-24
A53002	Behrends	1-5
A53010	Ballou-Olin	3, 2-3
A53016	Stone City	2B-3
A54002	Keswick	13-15
A57008	Bowser-Springville	6-7, 8-9
A57018	Cedar Rapids	2-9
A57028	Beverly	6-7
A58002	Columbus Junction	16-19
A63002	Durham	101
A82002	McCausland	17-19, 1-16
A89002	Douds Mine	6-13
A92002	Westchester	14-16

Air and Slump Tests

Line No.: ______________________ **Page No.:** ______________

Contractor: ______________________ **Category No.:** ______________

Project No.: ______________________ **Contract ID:** ______________

Date	Location	Mix Type	Air (%)	Air After Correction (%)	Witnessed Quality Control Test (X)	Slump (In)	Application	Remarks

Review Questions
Air Content of Freshly Mixed Concrete by the Pressure Method
IM 318

1. How many times is each layer of concrete rodded?

2. What care should be taken when rodding each layer?

3. After rodding each layer, what should be done to the measure before adding another layer of concrete?

4. How soon after your sample is taken do you need to start the air test?

IM 340 - WEIGHT, YIELD & AIR CONTENT

UNIT WEIGHT AND YIELD

IM 340 gives the proper procedure and calculations for determining unit weight and yield.

The unit weight (density) test involves measuring the weight of concrete for a given volume. It is used as an input during yield calculation and as a quality control tool in validating air content testing for a given mix. Yield is calculated by comparing the mix design unit weight to the actual unit weight. It is used as a quality control technique to identify problems with batch weights.

Unit weight and yield are typically determined by the contractor but can also be performed by the agency if a problem is suspected. Unit weight is typically determined in conjunction with air content testing using the air pot base which has a known volume.

The unit weight test needs to be performed properly to ensure accurate results. Proper rodding and consolidation must be done to eliminate defects/voids and ensure only concrete with entrained air is weighed. The air pot and scale must be cleaned thoroughly to ensure only the concrete in the air pot base is being weighed. Proper strike-off of the top surface ensures that a bulge of concrete does not exist resulting in excess concrete being weighed.

Typical unit weights for normal weight concrete are 140 to 150 pounds per cubic foot. Under ideal conditions the tolerance for yield is approximately +/- 2 percent for air entrained concrete. This results in an acceptable yield range of 0.980 to 1.020.

WEIGHT PER CUBIC FOOT, YIELD & AIR CONTENT (GRAVIMETRIC) OF CONCRETE

SCOPE

This procedure covers the determination of density, or unit weight of freshly mixed concrete. It also provides formulas for calculating the volume of concrete produced from a mixture of known quantities of component materials.

SIGNIFICANCE

The unit weight is a useful tool in determining the concrete batch yield and air content. Since air adds no weight to the concrete and only occupies a volume, the unit weight of the concrete gives a very good indication of the air content of the concrete. Normal weight concrete is in the range of 140 - 150 lbs./cu. ft. For normal weight concrete, a change in unit weight of 1.5 lbs./cu. ft. relates to approximately a 1 percent change in air content. Using the unit weight to indicate air content can also prevent any discrepancies between air meters.

PROCEDURE

A. Apparatus

1. Measure: May be the base of the air meter used for determining air content from IM 318. Otherwise, it shall be a metal container meeting the requirements of AASHTO T-121. The capacity and dimensions of the measure shall conform to those specified in Table 1.

2. Balance or scale: Accurate to 0.3 percent of the test load at any point within the range of use.

3. Tamping Rod: 5/8 in. diameter, having a hemispherical tip.

4. Vibrator: 7000 vibrations per minute, 0.75 in. to 1.50 in. in diameter, at least 3 in. longer than the section being vibrated for use with low slump concrete.

5. Scoop

6. Strike off bar

7. A glass or acrylic strike off plate at least 1/2 in. thick, with a length and width at least 2 in. greater than the diameter of the measure. The edges of the plate shall be straight and smooth within tolerance of 1/16 in.

8. Rubber Mallet

Table 1 - Dimensions of Measures

Capacity (ft. ³)	Inside Diameter (in.)	Inside Height (in.)	Minimum Thickness (in.)		Nominal Maximum Size of Coarse Aggr. (in.)
			Bottom	Wall	
1/4	8.0 ± 0.1	8.4 ± 0.1	0.20	0.12	1

Measure may be the base of the air meter used in IM 318.

B. Calibration of Measuring Bowl

1. Determine the weight of the dry measure and strike-off plate.
2. Fill the measure with water at a temperature between 60ºF and 85ºF and cover with the strike-off plate in such a way as to eliminate bubbles and excess water.
3. Wipe dry the measure and cover plate, being careful not to lose any water from the measure.
4. Determine the weight of the measure, strike-off plate, and water in the measure.
5. Determine the weight of the water in the measure by subtracting the weight in Step 1 from the weight in Step 4.
6. Measure the temperature of the water and determine its density from Table 2, interpolating as necessary.
7. Calculate the volume of the measure, V_m, by dividing the weight of the water in the measure by the density of the water at the measured temperature, from Table 2.

Example: $V_m = 15.57 / 62.274 = 0.250$ ft^3 ,
Where,
weight measure, plate, & water = 25.64 lbs
weight measure & plate = 10.07 lbs
weight water = 25.64-10.07 = 15.57 lbs.
Density of Water @73.5 ºF = 62.274 lbs/ft^3

ºF	lb./ft.^{3}	ºF	lb./ft.^{3}	ºF	lb./ft.^{3}
60.0	62.366	68.0	62.315	77.0	62.243
61.0	62.361	69.0	62.309	78.0	62.234
62.0	62.355	70.0	62.301	79.0	62.225
63.0	62.349	71.0	62.294	80.0	62.216
64.0	62.343	72.0	62.286	81.0	62.206
65.0	62.336	73.0	62.278	82.0	62.197
66.0	62.330	74.0	62.270	83.0	62.187
66.0	62.330	75.0	62.261	84.0	62.177
67.0	62.323	76.0	62.252	85.0	62.166

C. Testing Procedure

NOTE: There are two methods of consolidating the concrete – rodding and vibration. If the slump is greater than 3 in., consolidation is by rodding. When the slump is 1 to 3 in., internal vibration or rodding can be used to consolidate the sample, but the method used must be that required by the agency in order to obtain consistent, comparable results. For slumps less than 1 in., the sample may be consolidated by internal vibration.

1. Determine the weight of the dry measure.

2. Obtain the sample in accordance with IM 327. Testing may be performed in conjunction with IM 318. When doing so, this test should be performed prior to IM 318. **NOTE:** If the two tests are being performed using the same sample, this test shall begin within five minutes of obtaining the sample.

3. Dampen the inside of the measure.

4. Fill the measure approximately 1/3-full with concrete.

5. Consolidate the layer with 25 strokes of the tamping rod, using the rounded end. Distribute the strokes evenly over the entire cross section of the concrete. Rod throughout its depth without hitting the bottom too hard.

6. Tap the sides of the measure smartly 10 to 15 times with the mallet to close voids and release trapped air.

7. Add the second layer, filling the measure about 2/3-full.

8. Consolidate this layer with 25 strokes of the tamping rod, penetrating about 1 in. (25 mm) into the bottom layer.

9. Tap the sides of the measure smartly 10 to 15 times with the mallet.

10. Add the final layer, slightly overfilling the measure.

11. Consolidate this layer with 25 strokes of the tamping rod, penetrating about 1 in. (25 mm) into the second layer.

12. Tap the sides of the measure smartly 10 to 15 times with the mallet.

    NOTE: The measure should be slightly over full, about 1/8 in. (3 mm) above the rim. If there is a great excess of concrete, remove a portion with the scoop. If the measure is under full, add a small quantity. This adjustment may be done only after consolidating the final layer and before striking off the surface of the concrete.

13. Press the strike-off plate on the top surface of the measure to cover about two thirds of the surface and withdraw the plate with a sawing motion. Next, place the plate on the top of the measure to cover the original two thirds of the surface and advance it with a vertical pressure and a sawing motion to cover the whole surface of the measure and continue to advance it until it slides completely off the measure. Incline the plate and perform final strokes with the edge of the plate to produce a smooth surface. **Note:** For quality control testing, striking the surface with the strike-off bar preparing for an air test in accordance with IM 318 may be utilized.

14. Clean off all excess concrete from the exterior of the measure including the rim.

15. Determine and record the weight of the measure and the concrete.

16. If the air content of the concrete is to be determined, proceed to Step 3. e of IM 318.

D. Calculations

Unit Weight (density) – Calculate the net weight, W_3, of the concrete in the measure by subtracting the weight of the measure, W_2, from the gross weight of the measure plus the concrete, W_1. Calculate the density, ρ, by dividing the net weight, W_3, by the volume, V_m, of the measure as shown below.

$W_1 - W_2 = W_3$ Example: 42.8 – 7.6 = 35.2 lb.

$\rho = W_3 / V_m$ Example: ρ = 35.2 lb / 0.249 cu. ft. = 141.4 lbs/cu. ft.

Theoretical unit weight (air-free basis) – The theoretical unit weight, T, is the total weight of materials batched divided by the absolute volume of materials batched on an air-free basis.

Using the actual batch weights and absolute volumes, sum the following:

	Weight	SpGr	Abs. Vol.	Example Abs. Vol. Calc.
Cement	477	3.14	0.090	= 477/(3.14 x 62.4 x 27)
Fly Ash	84	2.68	0.019	
Total Water	220	1.00	0.131	(Plant, aggr., grade)
Fine	1246	2.65	0.279	Aggregate, SSD Dry Batch Weights
Intermediate	364	2.57	0.084	
Coarse	1451	2.57	0.335	
Total	3842		0.938	

$$\text{Theoretical unit weight (cu. Ft.)} = \frac{\text{Batch weight}}{\text{Abs. Vol.} \times 27}$$

$$= \frac{3842}{0.938 \times 27}$$

$$= 151.7 \text{ lbs./cu. ft.}$$

Air Content – Air content is calculated by subtracting the unit weight, ρ, from the theoretical unit weight, T, divided by the theoretical unit weight, *T*, multiplied by 100 as shown below.

$$A = (T - \rho) \times 100 / T$$

Example: $A = \frac{(151.7 \text{ lbs/cu. ft.} - 141.4 \text{ lbs/cu. ft.}) \times 100}{151.7 \text{ lbs/cu. ft.}} = 6.8\%$

~~Theoretical Unit Weight = 151.7 lbs./cu. ft.~~

~~The theoretical unit weight, T, is the total weight of materials batched divided by the absolute volume of materials batched on an air free basis.~~

Relative Batch Yield – Calculate the yield, *Y*, or volume of concrete produced per cubic yard, by dividing the total weight of the cubic yard batched, W_t, by 27, then dividing by the density, ρ, of the concrete as shown below.

$$Y = (W_t \div 27) / \rho$$

Example: $Y = (3842 \text{ lbs batched per cu. yd} \div 27 \text{ lbs/cu. ft.}) / 141.4 \text{ lb/cu. ft} = 1.006$

E. Density of Foamed Cellular Concrete

Foamed cellular concrete density may be determined as above using a smaller 1/10 cubic foot measure, or using a 400 ml cup and the following procedure.

1. Apparatus

   a. Measure: A cylindrical measure meeting the requirements of ASTM C 185. Otherwise, any cylindrical container of a known volume, made of steel or other suitable metal container, not readily attacked by Portland cement.

   b. Balance or scale: Accurate to 0.3 percent of the test load at any point within the range of use.

   c. Scoop or spoon

   d. A strike off bar

   e. A metal or glass plate at least 1/4 in. thick, with a length and width at least 1 in. greater than the diameter of the measure.

2. Testing Procedure

   a. Determine the weight of the dry measure. Include the glass plate when using the 400 ml cup

   b. Obtain the sample of the foamed concrete. Testing shall begin within five minutes of obtaining the sample.

   c. Dampen the inside of the measure.

   d. Fill the measure in one layer, slightly overfilling the measure. Do not strike sides of measure. An excess of concrete protruding approximately 3 mm [$^1/_8$ in.] above the top of the mold is optimum.

e. Strike off the surface of the concrete and finish it smoothly with a screening action of the strike off bar (sawing action of the strike-off plate) using great care to leave the pot just full. The surface should be smooth and free of voids.

f. Press the glass plate down on the surface of the concrete to ensure the surface free of voids. Clean off all excess concrete from the exterior of the measure including the bottom of the plate. Determine and record the weight of the measure, plate, and concrete.

3. Calculations

Wt Cup + Plate + Conc. (gms)=	1069.00	
Wt. Mortar Cup + Plate (gms)=	741.50	
Weight of Concrete (gms)=	327.50	
Volume of 400 ml container (l)=	0.400	
Actual Unit Weight =	327.50/0.400	= 818.75 kg/m^3

Convert kg/m^3 to lb/ft^3

818.75 kg/m^3 / 16.0185 kg/m^3 /lb/ft^3 = 51.1 lb/ft^3

Unit Weight, Yield and Air Content Equation Summary

Unit Weight

Equation as shown in IM 340: $\rho = \frac{W_3}{V_m}$ **Where** $W_3 = W_1 - W_2$

Or in other words: $\text{Unit Weight} = \frac{\text{Weight of Pot \& Concrete} - \text{Weight of Empty Pot}}{\text{Volume of Pot}}$

Example:

Weight of the air pot filled with concrete 43.6 lbs

Weight of the empty air pot 8.1 lbs

Volume of the air pot 0.248 ft

$$\text{Unit Weight} = \frac{43.6\text{ lbs} - 8.1\text{ lbs}}{0.248\text{ft}_3} = \frac{35.5\text{ lbs}}{0.248\text{ ft}_3} = 143.15\ \frac{\text{lbs}}{\text{ft}^3}$$

Yield

Equation as shown in IM 340: $Y = \frac{W_t \div 27}{\rho}$

Or in other words: $\text{Yield} = \frac{\text{Weight of the batched concrete per cubic yard} \div 27\ \frac{\text{ft}^3}{\text{yd}^3}}{\text{Unit Weight}}$

Example Continued:

Total weight of the batched concrete on the truck: 27,475 lbs

Total cubic yards of batched concrete on the truck: 7 yd^3

$$\text{Yield} = \frac{3925\ \frac{\text{lb}}{\text{yd}^3} \div 27 \frac{\text{ft}^3}{\text{yd}^3}}{143.15\ \frac{\text{lb}}{\text{ft}^3}} = \frac{145.37}{143.15} = 1.016$$

Air Content

Equation as shown in IM 340: $A = \frac{T - \rho}{T} x100$

Or in other words: $\text{Air Content} = \frac{\text{Maximum Theoretical Weight} - \text{Unit Weight}}{\text{Maximum Theoretical Weight}}\ x100$

Example Continued:

Maximum Theoretical Unit Weight from the concrete plant 151.10 $\frac{\text{lbs}}{\text{ft}^3}$

$$\text{Air Content} = \frac{151.1\frac{\text{lb}}{\text{ft}^3} - 143.15\frac{\text{lb}}{\text{ft}^3}}{151.10\ \frac{\text{lb}}{\text{ft}^3}}\ x\ 100 = \frac{7.95\ \frac{\text{lb}}{\text{ft}^3}}{151.10\ \frac{\text{lb}}{\text{ft}^3}}\ x\ 100 = 5.3$$

Review Questions
Weight Per Cubic Foot, Yield, and Air Content
(Gravimetric) of Concrete
IM 340

1. Why is the unit weight of concrete determined?

2. What is the required shape of the tamping end of the rod?

3. After completing the strike-off procedure, what must be done before determining the weight of the measure and sample?

4. What is the weight range for a cubic foot of normal weight concrete?

Unit Weight, Yield and Air
Problem #1

Given the following information, calculate Unit Weight, Yield and Air Content:

- Weight of the air pot filled with concrete — 87.5 lbs
- Weight of the empty air pot — 16.4 lbs
- Volume of the air pot — 0.496 ft^3
- Total weight of the batched concrete on the truck — 24,086 lbs
- Total cubic yards of batched concrete on the truck — 6 yd^3
- Maximum Theoretical Unit Weight from the concrete plant — 151.5 $\frac{lbs}{ft^3}$

$$\textbf{Unit Weight} = \frac{\textbf{Weight of Pot \& Concrete} - \textbf{Weight of Empty Pot}}{\textbf{Volume of Pot}}$$

$$\textbf{Yield} = \frac{\textbf{Weight of the batched concrete per cubic yard} \div 27\ \frac{\mathbf{ft^3}}{\mathbf{yd^3}}}{\textbf{Unit Weight}}$$

Unit Weight, Yield and Air
Problem #2

Given the following information, calculate Unit Weight, Yield and Air Content:

• Weight of the air pot filled with concrete	44.0 lbs
• Weight of the empty air pot	7.7 lbs
• Volume of the air pot	0.250 ft^3
• Total weight of the batched concrete on the truck	19,407 lbs
• Total cubic yards of batched concrete on the truck	5 yd^3
• Maximum Theoretical Unit Weight from the concrete plant	150.7 $\frac{lbs}{ft^3}$

$$\textbf{Unit Weight} = \frac{\textbf{Weight of Pot \& Concrete} - \textbf{Weight of Empty Pot}}{\textbf{Volume of Pot}}$$

$$\textbf{Yield} = \frac{\textbf{Weight of the batched concrete per cubic yard} \div \textbf{27} \ \frac{\textbf{ft}^3}{\textbf{yd}^3}}{\textbf{Unit Weight}}$$

IM 328 - MAKING, PROTECTING & CURING FLEXURAL SPECIMENS

MAKING AND CURING
FLEXURAL SPECIMENS (CONCRETE BEAMS)

IM 328 explains the proper procedure for making and curing concrete beams.

Concrete beams are used to determine the flexural strength of concrete. They can be made in 4 X 4 or 6 X 6 inch molds with varying consolidation methods.

Beams may be used for opening of pavements and structures as well as maturity curve development. Beams for opening will be made and cured by the agency while those used for maturity curve development will be made and cured by the contractor or producer.

It is extremely important that beams be properly fabricated and cured. If done improperly, flexural strengths can be significantly reduced. Proper consolidation is required to eliminate voids/defects and ensure weakened areas do not exist. When handling and transporting beams, they should be protected from moving around and impacts of any type. Beams should be cured in a way that keeps them moist and at proper temperatures from fabrication through testing, ensuring complete hydration.

MAKING, PROTECTING & CURING
CONCRETE FLEXURAL STRENGTH FIELD SPECIMENS

SCOPE

This method covers procedures for making, protecting and curing flexural strength field specimens sampled from concrete being used in construction.

PROCEDURE

A. Apparatus

1. 6 in. x 6 in. x 20 in. minimum length or 4 in. x 4 in. x 14 in. minimum length beam mold. The molds provided will comply with the requirements of AASHTO T-23 for dimensions, construction, materials, smoothness and straightness.

2. Shovel (square point).

3. Rubber hammer or equivalent

4. Wood float or equivalent.

5. 3/8" or 5/8" tamping rod

6. Vibrator

B. Test Procedure

Specimens molded for determination of compliance with strength specifications shall be cast and cured according to AASHTO T-23.

1. Secure the concrete sample in accordance with IM 327, Method of Sampling Concrete for Slump, Air Content and Strength Testing. Specimens shall be molded on a level, rigid, horizontal surface as near as practicable to the place where they will be stored during the first 20 ± 4 hours. All jarring, striking, tilting or scarring of the specimen surface shall be avoided if moving immediately after striking off is necessary. Place the concrete in the mold in two equal layers and thoroughly spade each layer with the shovel. Use special care consolidating the sides and after spading each layer strike the sides of the form with a rubber hammer or equivalent until the spading marks are closed. Strike off the excess concrete and smooth the surface with as little manipulation of the concrete as possible. Excessive spading and smoothing must be avoided. Spading does not consolidate concrete as well as other methods and may be used for six inch beams only.

   When consolidating by vibration, fill concrete in one layer. Slowly insert the vibrator avoiding the sides and bottom of the mold. Insert the vibrator at intervals not exceeding 6 in. along the centerline of the long dimension of the specimen, avoiding the exact center of the beam. Sufficient vibration is achieved as soon as the surface has become relatively smooth. Slowly withdraw the vibrator so no large air pockets are left in the specimen. Avoid overvibration which may cause segregation. After vibrating, strike the sides of the form with a rubber hammer 10 to 15 times to release any air bubbles that may have been trapped.

Beam Mold	Vibrator Diameter	No. of Layers	Approximate No. Insertions
4 x 4	¾ to 1 inch	1	3-4
6 x 6	¾ to 1 ½ inch	1	4-5

When consolidating by rodding, specimens shall receive the proper number of roddings evenly distributed per layer as indicated in the table, or one per 2 in^2 of surface area. The bottom layer shall be rodded throughout its depth. For the upper layer, the rod shall penetrate 1 in. into the underlying layer. After rodding each layer, strike the sides of the form with a rubber hammer 10 to 15 times to release any air bubbles that may have been trapped.

Beam Mold	Rod Size	No. of Layers	No. of Roddings per Layer
4 x 4 x 14 in.	3/8 in.	2	28
6 x 6 x 20 in.	5/8 in.	2	60
6 x 6 x 22 in.	5/8 in.	2	66

2. Immediately after smoothing protect the freshly made beam against <u>moisture loss</u> by <u>evaporation</u>, against <u>rapid temperature increase</u> caused by the combined effects of hot weather, bright sun, and the chemical hydration process and against freezing or near freezing temperature. It is generally practical to apply the same protection to the test specimen that is applied to the represented pavement or structure. This is not absolutely necessary, however, so long as the three conditions outlined above are satisfied.

3. On the day after the specimens are made and when they have reached an age of 16 to 24 hours, move the specimens while still in the molds to the location of final storage and curing, generally the concrete plant inspector's laboratory. The beams, even with the molds in place, must be handled carefully to avoid injury. A slight jar or bump may cause cracking which may be invisible at the time but which may become apparent with later handling or as premature failure during testing.

4. Remove the specimens from the molds (generally at the plant), clean, oil, reassemble and return the molds to the sampling location (generally at the direction of the paving or grade inspector).

5. Assign a chronological number, which corresponds with the day the beam was made to each beam. Begin with number 1. When more than one beam is made on a given day use capital letters A, B, C, etc., following the number which identifies the day to identify the daily making sequence. When two or more mixers are operated on separate sections of a project use a separate letter identification preceding the number assigned to the beams made from each respective mixer. If there is a need to mark multiple beams cast while plastic, mark the numbers on the finished side of the beam as cast, using a nail or knife. The numbers should be neat, as small as possible, and leave very little indentation. The

numbers should be 4 to 8 inches from the end of the six inch beam (2 to 4 inches for a 4 inch beam). Do not mark the middle portion of the beam. Otherwise, the preferred method is to mark the beam with a grease pencil or a permanent marker after form removal with date cast, county, and project paren number.

6. Store the specimens in a wetted sand filled pit of adequate size to accommodate all specimens made on the project or in lime saturated water. A pit 4' x 6' x 18" is normally adequate. Place the specimens on a reasonable smooth bed of sand and cover them completely with additional sand. If the temperature in the sand-filled pit drops below 40°F remove the specimens and place them under wetted burlap in a heated enclosure or in lime saturated water. Maintain the specimens in a continually wet condition, and above 40°F until they are tested. **NOTE:** Lime-saturated water is prepared by mixing 0.4 ounces of hydrated lime with 1 gallon of water. Hydrated lime should be a minimum of 90 percent calcium hydroxide (CaOH).

Concrete Beam Molds

Review Questions
Making, Protecting, and Curing
Concrete Flexural Strength Field Specimens
IM 328

1. What size mold(s) can be used to make flexural strength specimens?

2. Immediately after smoothing the beam, it needs to be protected from what?

   1. ______________________________
   2. ______________________________
   3. ______________________________

3. At what age do the beams need to be so they can be moved to storage?

4. How should the specimens be maintained until they are tested?

5. How soon after your sample is taken do you need to start molding specimens for strength testing?

IM 316 - TESTING FLEXURAL SPECIMENS

CENTER POINT TESTING
FLEXURAL SPECIMENS (CONCRETE BEAMS)

IM 316 explains the proper procedure for center point testing of concrete beams.

Center point testing of concrete beams involves placing a load using a hydraulic ram at the mid-point of the beam until the beam breaks. Equations or lookup tables are then used to convert the load into a flexural strength which is measured in pounds per square inch. This accounts for the cross-sectional area of the beam and results in an equivalent flexural strength regardless of the beam size.

Specific beam breakers are used for 4 by 4 and 6 by 6 beams. All beam breakers must be calibrated annually using a load cell. During calibration a corrected load sheet specific to the beam breaker will be generated. Corrected loads can be looked up on this sheet and will be used for all calculations.

It is extremely important that beams be properly tested. If done improperly, flexural strengths can be significantly reduced. Beams must be orientated correctly and accurately centered in the machine and contact edges must be clean and knocked down to prevent uneven or impact loading. Specified loading rates for the beam size must be maintained for the final 50 percent of the load applied. Beams must be tested in a wet condition.

Third point testing will not be covered in this certification class. For QMC paving projects requiring third point testing, beams must be transported to the Central Materials Laboratory for testing following AASHTO T97-97 and ASTM C 78-94.

FLEXURAL STRENGTH OF CONCRETE

SCOPE

This test method is used for determining the flexural strength of concrete by the use of a simple beam with center-point loading. The flexural strength is expressed as modulus of rupture in psi.

PROCEDURE

A. Apparatus

1. Hydraulic testing machines provided on Portland Cement Concrete paving projects shall conform to AASHTO T-177. The hydraulic machine consists of a frame to hold the specimen, a hand-operated hydraulic jack, and a pressure gauge to read the load. Practically all of the hydraulic machines have a micro pump in the loading line to facilitate control of the last half of the load within specifications, and without pause in loading. A calibration sheet is included with each machine of this type. Additional equipment needed includes a caliper, plastic ruler and a tri-square. The hydraulic test machine needs to be calibrated annually by the DOT Central Laboratory. Calibration sheets with each machine will indicate the date last calibrated.

B. Test Specimen

1. The test specimen shall have approximate dimensions of 6 in. x 6 in. x 20 in. minimum length or 4 in. x 4 in. x 14 in. minimum length. The test specimen shall be kept wet until the time of the test.

C. Test Procedure

1. The top of the beam as cast will be turned on the side when placed in the machine. A reference line may be drawn centered across the top as cast side to help center the beam in the testing machine.
2. Insert the stirrup pins in the slots at the bottom of the stirrups to prevent the stirrups from swinging while the beam is being placed in the machine. This also assures that the support bearings are in the correct position.
3. Place the beam in the testing machine so that the reference line on the as cast top side of the beam is directly under the centerline of the center bearing. The maximum fiber stress during application of the load will occur in the outer fiber across the bottom of the beam directly under the load.
4. Rotate the micro pump handle counter-clockwise to expose the maximum number of threads and close the loading valve on the pump.
5. Apply a small initial load and remove the stirrup pins.

6. The load may be applied rapidly up to approximately 50 percent of the estimated breaking load with the pump handle. The final half of the loading is accomplished by turning the crank of the micro pump, at a rate that the extreme fiber stress does not exceed 150 psi per minute. This is approximately 1200 pounds per minute on the test gauge for six inch beams and approximately 500 pounds per minute for four inch beams.

7. Using one of the fractured faces, take one measurement at each edge and one at the center of the cross section for each direction (width and depth). Make measurements to the nearest 0.05 in.. Average the three readings to determine the average width and average depth of the specimen at the section of failure. (see Figure 1)

D. Calculations

1. From the calibration sheet furnished with each machine, determine the corrected load placed upon the beam. The machine should be calibrated annually.

2. Calculate the modulus of rupture as follows:

$$R = \frac{3Pl}{2bd^2}$$

<u>Where:</u>

R = Modulus of rupture, MPa or psi.
P = Corrected load indicated, N or lb.
l = Span length, mm or in., between supports (12 in. (4x4) or 18 in. (6x6))
b = Width of beam at point of fracture, mm or in.
d = Depth of beam at point of fracture, mm or in.

The modulus of rupture may also be calculated by using the coefficients in Figure 3 or 4. and the following formula:

R (psi) = P (lbs) X Coefficient ($1/in^2$).

3. The typical range of modulus of rupture should be from 300 psi to 700 psi. Report the modulus of rupture to the nearest 5 psi.

E. The following figure shows the beam as it should be placed in the flexural testing machine, with the finished top as cast turned on its side.

Figure 1

Figure 2. Six Inch Concrete Specimen in Hydraulic Testing Machine

Figure 3. Hydraulic Testing Machine for Testing Four Inch Beams

F. Precautions - Always make sure the pointers on the gauge are set at zero before any loading begins.

Concrete Beam Coefficients - US Units

	Width (in.)							
Depth (in.)	**5.80**	**5.85**	**5.90**	**5.95**	**6.00**	**6.05**	**6.10**	**6.15**
5.80	0.138382	0.137199	0.136037	0.134893	0.133769	0.132664	0.131576	0.130507
5.85	0.136027	0.134864	0.133721	0.132597	0.131492	0.130406	0.129337	0.128285
5.90	0.133731	0.132588	0.131464	0.130360	0.129273	0.128205	0.127154	0.126120
5.95	0.131493	0.130369	0.129264	0.128178	0.127110	0.126059	0.125026	0.124009
6.00	0.129310	0.128205	0.127119	0.126050	0.125000	0.123967	0.122951	0.121951
6.05	0.127182	0.126095	0.125026	0.123976	0.122942	0.121926	0.120927	0.119944
6.10	0.125105	0.124036	0.122985	0.121951	0.120935	0.119936	0.118953	0.117986
6.15	0.123079	0.122027	0.120993	0.119977	0.118977	0.117994	0.117026	0.116075
6.20	0.121102	0.120067	0.119050	0.118049	0.117066	0.116098	0.115146	0.114210

Modulus of Rupture = Total Load X Coefficient
R (psi) = P (lbs.) X Coefficient (in-2)

Figure 4. Concrete Beam (6 in. x 6 in.) Coefficients

Concrete Beam Coefficients - US Units

	Width (in.)							
Depth (in.)	3.80	3.85	3.90	3.95	4.00	4.05	4.10	4.15
3.80	0.328036	0.323776	0.319625	0.315579	0.311634	0.307787	0.304034	0.300370
3.85	0.319571	0.315421	0.311377	0.307435	0.303593	0.299844	0.296188	0.292619
3.90	0.311429	0.307385	0.303444	0.299603	0.295858	0.292205	0.288642	0.285164
3.95	0.303595	0.299652	0.295811	0.292066	0.288415	0.284855	0.281381	0.277991
4.00	0.296053	0.292208	0.288462	0.284810	0.281250	0.277778	0.274390	0.271084
4.05	0.288788	0.285037	0.281383	0.277821	0.274348	0.270961	0.267657	0.264432
4.10	0.281787	0.278128	0.274562	0.271086	0.267698	0.264393	0.261169	0.258022
4.15	0.275038	0.271466	0.267986	0.264594	0.261286	0.258060	0.254913	0.251842
4.20	0.268528	0.265041	0.261643	0.258331	0.255102	0.251953	0.248880	0.245881

Modulus of Rupture = Total Load X Coefficient
R (psi) = P (lbs.) X Coefficient (in-2)

Figure 5. Concrete Beam (4 in. x 4 in.) Coefficients

Rev 12/18

PC Concrete Beam Record

Form E114

Line No.: ____________

Item Code: ____________

Description: ____________

Project No.: ____________

*Measured span length between test apparatus supports - typically 12" for 4"x4" beams or 18" for 6"x6" beams.

Page No.: ____________

Category No.: ____________

Contract ID: ____________

Beams Made Information							Beam Break Information								
Date Made	Mix Number	Beam No.	Time	Air %	Slump (in)	W/C Ratio	Age (Days)	*Length (in)	Depth (in)	Width (in)	Indicated Load (lbs)	Actual Load (lbs)	Comp. Factor	Mod. Of Rupture (psi)	Spec. psi
														0	
														0	
														0	
														0	
														0	
														0	
														0	
														0	
														0	
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Review Questions
Flexural Strength of Concrete
Using Simple Beam with Center-Point Loading
IM 316

1. The top of the beam as cast will be ____________________ when placed in the machine.

2. The load may be applied rapidly up to approximately what percent of the estimated breaking load?

3. On the final half of the loading, the crank should be turned not to exceed how many pounds per minute on the test gauge?

   A: 4” Beam _____________

   B: 6” Beam _____________

Calculate the modulus of rupture as follows:

$$R = \frac{3PL}{2bd^2}$$

Where:

R = Pxcoefficient
P = Maximum applied load indicated in lb., or newtons
l = Span length in inches, or millimeters between supports
b = Width of beam in inches, or millimeters
d = Depth of beam in inches, or millimeters

P = 4800

$$R = \frac{3x4800x18}{2x6.00x5.80^2} \qquad \frac{259200}{403.68} = 642 \text{ psi}$$

Using coefficient from table: 4800 x .133769 = 642 psi

Using the following information, determine modulus of rupture.

Given:

1. Width of beam = 6.10
   Depth of beam = 6.05
   Corrected load = 5020

2. Width of beam = 6.00
   Depth of beam = 6.05
   Corrected load = 4810

3. Width of beam = 4.05
   Depth of beam = 4.00
   Corrected load = 2500

4. Width of beam = 4.05
   Depth of beam = 4.05
   Corrected load = 2340

IM 315 - MAKING, PROTECTING, CURING & TESTING CYLINDERS

MAKING AND CURING CONCRETE CYLINDERS

IM 315 covers the proper procedure for making and curing concrete cylinders.

Concrete cylinders are used to determine the compressive strength of concrete. They can be made in 4 X 8 or 6 X 12 inch molds with varying consolidation methods.

Cylinders are used to evaluate compressive strength for prestressed and precast units, primary bridge decks, and high strength concrete. Compressive strength requirements will be shown in the contract documents. At a minimum, three cylinders should be made for each testing age. Prestressed and precast units will typically have compressive strength requirements for form removal, de-tensioning, moving, and shipping. Primary bridge deck concrete will be tested for informational purposes and high strength concrete will have a required compressive design strength that will be used for acceptance.

Cylinders for prestressed and precast units as well as high strength concrete will be made and cured by the contractor. Primary bridge deck cylinders will made and cured by the agency.

It is extremely important that cylinders be properly fabricated and cured. If done improperly, compressive strengths can be significantly reduced. Proper consolidation is required to eliminate voids/defects and ensure weakened areas do not exist. When handling and transporting cylinders, they should be protected from moving around and impacts of any type. Cylinders should be cured in a way that keeps them moist and at proper temperatures from fabrication through testing, ensuring complete hydration.

Testing concrete cylinders will not be covered in this certification class. Cylinders should be tested at a qualified laboratory following AASHTO T 22.

METHOD OF MAKING, PROTECTING, CURING & TESTING CONCRETE CYLINDERS

SCOPE

This method covers procedures for making, protecting, and curing, according to AASHTO T23. This method also covers testing concrete cylinder specimens for compressive strength, according to AASHTO T22. This test procedure is a supplement and not a replacement for the beam test to determine when a structure may be put in service.

I. MAKING, PROTECTING & CURING SPECIMENS

A. Apparatus for Making Specimens

1. 6 in. x 12 in. or 4 in. x 8 in. steel, brass, or single-use plastic vertical molds meeting the requirements of AASHTO M205.

2. Molds shall be the vertical type.

3. Tamping rods shall comply with AASHTO T23 and the following:

Mold Size	Tamping Rod Diameter
4 in. x 8 in.	3/8 in.
6 in. x 12 in.	5/8 in.

4. Internal or external vibrators may be used. They shall comply with AASHTO T23 with the exception that the diameter of the vibrating element of the internal vibrator shall vary for each specimen size, as stated below. External vibrators shall be either a table type or a plank type.

5. Rubber hammer

6. Wood float or equivalent

B. Making Test Specimens

1. The concrete shall be sampled in accordance with IM 327, Sampling Freshly Mixed Concrete.

2. Before casting specimens, the inside surfaces of the steel or brass molds should be clean and treated with a thin coating of light grease or form oil.

3. Consolidation may be rodding with a tamping rod, or by vibration, either internal or external. Concrete with slump greater than 3 inches shall be consolidated by rodding. Concrete with slump of 1 inch to 3 inches shall be consolidated by rodding or vibration. Concrete with slump of less than 1 inch shall be consolidated by vibration.

a. Rodding. Specimens shall receive the proper number of roddings evenly distributed per layer as indicated in the table. The bottom layer shall be rodded throughout its depth. For each upper layer, the rod shall penetrate 1 inch into the underlying layer. After rodding each layer, the sides and ends of the mold shall be tapped with a rubber hammer until the surface of the concrete is relatively smooth. Use an open hand to tap the single-use molds. After consolidation, strike off the horizontal surface and finish with a float or trowel.

Mold Size	No. of Equal Depth Layers	No. of Roddings per Layer
4 in. x 8 in.	2	25
6 in. x 12 in.	3	25

b. Internal Vibration. Specimens shall receive the required number of insertions of a vibrator layer as indicated in the table. If more than one insertion is required, distribute the insertion uniformly in each layer. Each layer shall be vibrated only long enough to make the surface relatively smooth. The time required will vary with the consistency of the concrete. Over vibration may cause segregation. In compacting the concrete, the vibrator shall not rest on or touch the sides of the mold. When vibrating the top layer, the element shall penetrate about 1/2 inch into the bottom layer. After vibrating, tap the sides of the mold with a rubber hammer to ensure removal of entrapped air bubbles at the surface of the mold. Use an open hand to tap the single-use molds. When consolidation is complete, strike off and finish with a wood float or trowel.

Mold Size	Vibrator Diameter	No. of Equal Depth Layers	No. of Insertions per Layer
4 in. x 8 in.	¾ to I inch	2	1
6 in. x 12 in.	¾ to I 1/2 inch	2	2

c. External Vibration. Each layer shall be vibrated only until the surface is relatively smooth. Take care to ensure that the mold is rigidly attached or securely held against the vibrating table or vibrating surface. After consolidation, strike off and finish with a trowel or float.

C. Protecting & Curing

1. Initial Curing. During the first 24 hours after molding, specimens shall be stored under conditions that maintain the temperature immediately adjacent to the specimens in the range of 50°F to 80°F and prevent loss of moisture from the specimens. This may be done by covering specimens with wet burlap and placing a plastic sheet over the burlap, or use other suitable methods to ensure that the foregoing requirements are met. For concrete with minimum specified strength of 6000 psi or greater, initial curing shall be between 68°F and 78°F and maintained in a satisfactory moisture environment. A satisfactory moisture environment may be a bucket with lid filled with

lime saturated water to cover the specimens, immediately immersed after molding for up to 48 hours. Or other methods described in AASHTO T 23 may be utilized.

2. Curing to Determine Form Removal Time or When a Structure May be Put in Service. Cure test specimens as nearly as practicable in the same manner as the concrete in the structure. After 48 ± 4 hours, remove specimens from the molds. They shall be stored as near as possible to the point in the structure they represent and shall be afforded the same temperature protection and moisture environment as the structure until the time of testing. Specimens shall be tested while in the moisture condition resulting from the curing they receive.

3. Curing To Check the Adequacy of Laboratory Mix Proportions for Strength or As a Basis For Acceptance or For Quality Control. For this purpose, specimens are to be removed from the molds at the end of 16 to 24 hours and stored in a moist condition at 68°F to 81.5°F until the time of test. For concrete with minimum specified strength of 6000 psi or greater, store in a moist condition at 73.5°F ± 3.5°F until time of test. This condition can be met by immersion in saturated limewater. **NOTE:** Lime-saturated water is prepared by mixing 0.4 ounces of hydrated lime, with 1 gallon of water. Hydrated lime should be a minimum of 90 percent calcium hydroxide (CaOH).

4. Steam Curing. When artificial heat is used to accelerate curing, concrete specimens shall be placed with the unit being cured and shall receive the same curing as the concrete they represent. Prior to testing the specimens, the temperature of the concrete shall be lowered to the temperature of the surrounding air at a rate not to exceed 40°F per hour.

5. Special care must be given to ensure that specimens are not damaged during handling. For 16 to 24 hours after molding, specimens shall not be moved.

II. TESTING CONCRETE SPECIMENS FOR COMPRESSION

A. Apparatus

1. The testing machine shall conform to AASHTO T22. Manually operated testing machines will be accepted.

B. Time of Testing

1. Make compression tests of moist cured specimens as soon as practicable after removal from curing. Keep specimens moist by use of wet burlap or other suitable covering, which will ensure similar protection until actual time of testing.

2. The time to test specimens otherwise cured will be as directed by the engineer.

C. Test Specimens

1. Neither end of compressive test specimens when tested shall depart from the perpendicularity to the axis by more than 0.5 degrees (approximately 1/8 in. in 12 in.)

2. The ends of the specimens that are not plane within 0.002 in. shall be capped. The planeness of the ends of every tenth specimen should be checked by means of a straightedge and feeler gauge, making a minimum of three measurements on different diameters, to insure that the end surfaces do not depart from a plane by more than 0.002 in.

3. The top surface of vertically cast specimens shall be capped.

D. Capping

1. Capping equipment and procedures shall comply with that described in AASHTO T231.

2. Unbonded caps and equipment shall comply with ASTM C1231.

   Unbonded caps are permitted to be used on one or both ends of a cylinder. Neoprene pads used shall meet the requirement listed in the Table 1 of C1231. Pads shall be ½ ±1/16 in. thick and diameter shall not be more than 1/16 in. smaller than inside diameter of the retaining ring. Replace pads that do not meet the dimensional requirements or exceed the maximum reuse limits specified in the Table 1 of C1231. Insert pad in the retainer before it is placed on the cylinder.

   The height of the retaining ring shall be 1.0 ± 0.1 in. The inside diameter of the retaining ring shall not be less than 102 % or greater than 107 % of the diameter of the cylinder. The thickness of the retaining ring shall be at least 0.47 in. for 6 in. diameter retainers and at least 0.35 in. for 4 in. diameter retainers.

E. Test Procedure

1. Placing Specimen

   a. Place the plain (lower) bearing block with its hardened face up, on the table or platen of the testing machine directly under the spherically seated (upper) bearing block.

   b. Wipe clean the bearing faces of the upper and lower bearing blocks and of the test specimen.

   c. Carefully align the axis of the specimen with the center thrust of the spherically seated block.

   d. As the spherically seated block is brought to bear on the specimen, rotate its moveable portion gently by hand so that uniform seating is obtained.

2. Rate of Loading

   a. Apply the load continuously and without shock. Apply the load at a constant rate within the range of 20 to 50 psi per second. During the application of the first half of the estimated maximum load, a higher rate of loading may be permitted.

b. Do not make any adjustment in the controls of the testing machine while the specimen is yielding, especially in the period just before failure.
c. Increase the load until the specimen yields or fails, and record the maximum load carried by the specimen during test.

d. Note the type of failure (Figure 1) and the appearance of the concrete if the break appears to be abnormal.

F. Calculations

1. Calculate the compressive strength of the specimen by dividing the maximum load carried by the specimen during the test by the cross sectional area, and express the result to the nearest 10 psi. The attached tables may be used to facilitate these computations.

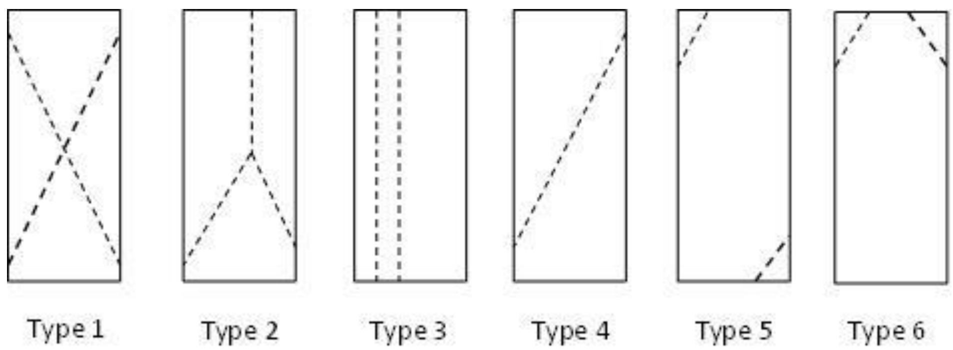


Figure 1. Compressive Fracture Types

Figure 2. Compression Testing Machine

(Load in Thousands)

Table for Computing lb./in.² on 6 in. x 12 in. Cylinders
Area = 28.2744 in.²

Load	Psi	Load	Psi	Load	Psi	Load	Psi	Load	Psi
40	1410	90	3180	140	4950	190	6720	240	8490
41	1450	91	3220	141	4990	191	6760	241	8520
42	1490	92	3250	142	5020	192	6790	242	8560
43	1520	93	3290	143	5060	193	6830	243	8590
44	1560	94	3320	144	5090	194	6860	244	8630
45	1590	95	3360	145	5130	195	6900	245	8670
46	1630	96	3400	146	5160	196	6930	246	8700
47	1660	97	3430	147	5200	197	6970	247	8740
48	1700	98	3470	148	5230	198	7000	248	8770
49	1730	99	3500	149	5270	199	7040	249	8810
50	1770	100	3540	150	5310	200	7070	250	8840
51	1800	101	3570	151	5340	201	7110	251	8880
52	1840	102	3610	152	5380	202	7140	252	8910
53	1870	103	3640	153	5410	203	7180	253	8950
54	1910	104	3680	154	5450	204	7220	254	8980
55	1950	105	3710	155	5480	205	7250	255	9020
56	1980	106	3750	156	5520	206	7290	256	9050
57	2020	107	3780	157	5550	207	7320	257	9090
58	2050	108	3820	158	5590	208	7360	258	9120
59	2090	109	3860	159	5620	209	7390	259	9160
60	2120	110	3890	160	5660	210	7430	260	9200
61	2160	111	3930	161	5690	211	7460	261	9230
62	2190	112	3960	162	5730	212	7500	262	9270
63	2230	113	4000	163	5760	213	7530	263	9300
64	2260	114	4030	164	5800	214	7570	264	9340
65	2300	115	4070	165	5840	215	7600	265	9370
66	2330	116	4100	166	5870	216	7640	266	9410
67	2370	117	4140	167	5910	217	7670	267	9440
68	2410	118	4170	168	5940	218	7710	268	9480
69	2440	119	4210	169	5980	219	7750	269	9510
70	2480	120	4240	170	6010	220	7780		
71	2510	121	4280	171	6050	221	7820		
72	2550	122	4310	172	6080	222	7850		
73	2580	123	4350	173	6120	223	7890		
74	2620	124	4390	174	6150	224	7920		
75	2650	125	4420	175	6190	225	7960		
76	2690	126	4460	176	6220	226	7990		
77	2720	127	4490	177	6260	227	8030		
78	2760	128	4530	178	6300	228	8060		
79	2790	129	4560	179	6330	229	8100		
80	2830	130	4600	180	6370	230	8130		
81	2860	131	4630	181	6400	231	8170		
82	2900	132	4670	182	6440	232	8210		
83	2940	133	4700	183	6470	233	8240		
84	2970	134	4740	184	6510	234	8280		
85	3010	135	4770	185	6540	235	8310		
86	3040	136	4810	186	6580	236	8350		
87	3080	137	4850	187	6610	237	8380		
88	3110	138	4880	188	6650	238	8420		
89	3150	139	4920	189	6680	239	8450		

(Load in Thousands)

Table for Computing lb./in.² on 4 in. x 8 in. Cylinders

Area = 12.5666 in.²

Load	Psi	Load	Psi	Load	Psi	Load	Psi
10	800	50	3980	90	7160	130	10350
11	880	51	4060	91	7240	131	10420
12	950	52	4140	92	7320	132	10500
13	1030	53	4220	93	7400	133	10580
14	1110	54	4300	94	7480	134	10660
15	1190	55	4380	95	7560	135	10740
16	1270	56	4460	96	7640	136	10820
17	1350	57	4540	97	7720	137	10900
18	1430	58	4620	98	7800	138	10980
19	1510	59	4700	99	7880	139	11060
20	1590	60	4770	100	7960	140	11140
21	1670	61	4850	101	8040	141	11220
22	1750	62	4930	102	8120	142	11300
23	1830	63	5010	103	8200	143	11380
24	1910	64	5090	104	8280	144	11460
25	1990	65	5170	105	8360	145	11540
26	2070	66	5250	106	8440	146	11620
27	2150	67	5330	107	8520	147	11700
28	2230	68	5410	108	8590	148	11780
29	2310	69	5490	109	8670	149	11860
30	2390	70	5570	110	8750	150	11940
31	2470	71	5650	111	8830	151	12020
32	2550	72	5730	112	8910	152	12100
33	2630	73	5810	113	8990	153	12180
34	2710	74	5890	114	9070	154	12260
35	2790	75	5970	115	9150	155	12330
36	2860	76	6050	116	9230	156	12410
37	2940	77	6130	117	9310	157	12490
38	3020	78	6210	118	9390	158	12570
39	3100	79	6290	119	9470	159	12650
40	3180	80	6370	120	9550	160	12730
41	3260	81	6450	121	9630	161	12810
42	3340	82	6530	122	9710	162	12890
43	3420	83	6610	123	9790	163	12970
44	3500	84	6680	124	9870	164	13050
45	3580	85	6760	125	9950	165	13130
46	3660	86	6840	126	10030	166	13210
47	3740	87	6920	127	10110	167	13290
48	3820	88	7000	128	10190	168	13370
49	3900	89	7080	129	10270	169	13450

IOWA DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS

CEMENT
R. KINKADE

CONCRETE COMPRESSION

Project ____________ Contract # ________ County ____________ Lab No. ________ thru ________

____________ Plant ____________ Contractor ____________

____________ Producer ____________ Mix Type: ____________

____________ Unit of Material 4 x 8 Cylinders Description ____________

Sampled by ____________ Date Received ____________ Date Reported ____________

C-231Tested by ____________ C-143 Tested by ____________ C-39 Tested by ____________

Lab No.	Senders No.	Date Made	Cylinder No.	% Air Content ASTM C-231	Slump (in.) ASTM C-143	Date Tested	Age (days)	Diameter (in.)	Cross Sectional Area (sq.in.)	Total Load (lbs)	Strength (psi) ASTM C-39	Type of Failure

REMARKS ____________

Signed ____________

13-11

Review Questions
Making & Testing Concrete Cylinders
IM 315

1. To consolidate the concrete in the cylinder if the slump is greater than 3 inches, a ____________ should be used.

2. When rodding, if the cylinder is 6 in. x 12 inches the concrete should be put into the mold in _______ equal layers. How many layers if using vibration?

3. During initial curing, how should the specimens be stored for the first 24 hours?

4. It is important that the specimen be kept ________________ until testing.

IM 383 - MATURITY TESTING

MATURITY TESTING

IM 383 explains the proper procedure for maturity testing.

Maturity testing is a non-destructive method for estimating concrete strength. It is based on the concept that concrete strength is dependent on hydration time and temperature. Maturity can be used on pavements or structures, but it is predominantly used on pavements.

Maturity testing is comprised of two steps. The first step involves establishing a maturity curve to determine a time temperature factor (TTF). This is accomplished by making strength specimens and then breaking them while continually monitoring their age and temperature. Data is then input into a spreadsheet to establish a curve and TTF for a desired strength. The second step involves monitoring the age and temperature of field placed concrete and determining the TTF. Once the TTF for the field placed concrete meets or exceeds the TTF from the maturity curve, the field placed concrete can be put into service.

Maturity curves are specific to the mix materials and proportions as well as the plant. They must be developed with concrete at the maximum anticipated production w/c ratio and with a minimum of 5.5 percent air content. Changes in materials or exceeding the production w/c ratio may require development of a new curve. Curves need to be validated every 90 calendar days.

Developing and validating a maturity curve is the responsibility of the contractor or producer. The agency is responsible for witnessing curve development and validation as well as reviewing and approving all maturity submittals. In addition, the agency must be consulted and will verify if field placed concrete can be put into service.

For the maturity concept to work, it is critical that all strength specimens be properly cast, handled cured, and broken and that all calculations be correct. The w/c ratio used when developing the curve cannot be exceeded for field placed concrete as this will significantly affect strength development and invalidate the TTF. Probes must be properly inserted in the concrete and monitored at the required intervals.

ESTIMATE OF PORTLAND CEMENT CONCRETE STRENGTH BY MATURITY METHOD

GENERAL

This IM outlines the procedure for using the maturity concept as a nondestructive method to estimate concrete strength.

Determination of concrete maturity (time temperature factor (TTF)) and estimating in place concrete strength is a two-step procedure as follows:

1. Maturity Curve - A relationship must be established between the maturity (TTF) and the concrete strength as measured by destructive methods (that is, through testing of beams or cylinders). The development of the maturity-strength curve shall be done at the plant site at the beginning of construction using project materials and the project proportioning and mixing equipment.
2. Field Maturity - The second step is the temperature monitoring of the placed concrete. Temperature probes are installed in the concrete and the temperature is measured. From those measurements, along with the age at which the measurements were taken, the maturity (TTF) is calculated and used to estimate the concrete strength. A maturity meter may also be used to determine the maturity value (TTF).

For concrete furnished from a construction or stationary mixer, which is in place prior to construction of the specified project, a maturity curve may be established ahead of actual construction of the specified project. The test specimens shall be cast with concrete made from the same plant and using the same materials source as will be used in the specified project. The agency shall be informed and have an opportunity to observe the development of the maturity curve and validation.

THE MATURITY CONCEPT

The hydration of cement and gain in strength of the concrete is dependent on both curing time and temperature. Thus, the strength of the concrete may be expressed as some function of time and temperature. This information can then be used to determine the strength of concrete without conducting physical tests. The time-temperature function commonly used is the maturity concept proposed by Nurse-Saul (ASTM C1074),

$$M\ (^{o}C \times \text{hours}) = \sum [(T - T_0)\ \Delta t]$$

Where M is the maturity in ^{o}C-hours [M is also termed the time-temperature factor (TTF)], Δt is the time interval in hours (or days), T is the average concrete temperature during the time interval Δt, and T_0 is the datum temperature at which concrete ceases to gain strength with time. The value of T_0 = (-10^{o}C) is most commonly used. As a result, Equation 1 becomes:

$$M\ (^{o}C \times \text{hours}) = \sum [(T + 10)\ \Delta t] \quad \text{Equation 2}$$

EQUIPMENT

- 12 - 6 in. x 6 in. x 20 in. or 4 in. x 4 in. x 14 in. beam molds
- 1 each shovel (square point), rubber hammer or equivalent, and wood float or equivalent
- Hydraulic testing machine – center point loading flexural

- Maturity meter – a device that automatically measures, records, and displays the maturity (TTF) value
- Hand-held thermometer - a temperature measuring device with a thermocouple wire or probes readable to the nearest 0.1°C and accurate to 1°C.
- Temperature data logger – a device that measures temperature and electronically stores the readings a minimum of once per hour

ESTABLISHMENT OF MATURITY-STRENGTH RELATIONSHIP - MATURITY CURVE

To establish a maturity-strength relationship for a concrete mix, a maturity meter and a hydraulic testing machine are needed. The following procedure shall be used: **(NOTE: Before using any maturity meter, check to be sure the datum temperature is set to -10°C.)**

1. Cast a minimum of twelve beams, as per IM 328. Test the entrained air content of the concrete being used to cast the beams, as per IM 327. Record these values. The concrete shall meet specifications, with a minimum air content of 5.5%. There is a direct relationship between w/c ratio and strength. **The concrete used to develop the maturity-strength relationship shall be at the maximum w/c ratio expected during production, or within 0.02 of the maximum w/c ratio of the mix design.** The beams shall be cast from a batch of at least 3 cu. yd.

2. When using thermocouple wire, strip ½" to ¾" of the coating from each end of the two wires and twist ends. Embed a thermocouple wire near each end of a test beam (when flexural strength is to be determined) to monitor the temperature. This beam will be the last to be tested. A probe shall be inserted near each beam end to the approximate mid-depth and such that they are approximately 3 in. from each side and each end of a 6 inch beam (or 2 inches for a 4 inch beam). Loop the wire around the beam box handles to prevent the wire from being inadvertently pulled out of the beam. The average of the two readings will be used in the development of the maturity-strength curve. A maturity meter shall be used to develop the curve. A temperature data logger may be used to develop the curve and the maturity (TTF) shall be calculated from hourly readings.

3. At the plant site, cast beams according to IM 328 and test them according to IM 316. Concrete used for casting beams must have a temperature above 50°F. Immediately after casting, cover the beams with wet burlap and plastic to prevent moisture loss. At an age of 16 to 24 hours remove forms and store the specimens in a wetted sand filled pit of adequate size to accommodate all specimens made. Place the specimens on a reasonably smooth bed of sand and cover them completely with additional sand. The meter can be stored in a lab trailer or vehicle with the probes run outside to the beam in the sandpit. The DME may allow concrete produced at a ready mix to be delivered and tested at a central laboratory, as long as specimens are cast and cured within 90 minute time limit.

   It is critical that the specimens be maintained in a continually wet condition, and above 40°F after casting until they are tested. They may be protected while in the forms by placing foam board or plywood underneath them and covering with insulating blankets or by placing them inside a heated enclosure. If the temperature in the sand filled pit cannot be maintained above 40°F, remove the specimens and place them under wetted burlap in a heated enclosure or in lime saturated water controlled between 60 and 80 °F. **NOTE:** Lime-saturated water is prepared by mixing 0.4 ounces of hydrated lime with 1 gallon of water. Hydrated lime should be a minimum of 90 percent calcium hydroxide (CaOH).

4. Determine maturity (TTF) and strength values at four different ages. Test three specimens for strength at each age and calculate the average strength at each age. The maturity (TTF) value shall be calculated from a temperature reading at the time the specimen is tested for strength. The tests shall be spaced such that they are performed at somewhat consistent intervals of time and span a range in strength that includes the opening strength desired. Ideally, there would be at least two sets of strength values below the opening strength. For Class C or QMC mixtures, the first set of beams will typically be tested at an age of approximately 8 to 12 hours, depending on concrete temperature. Test age may need to be increased when concrete temperature is below 50 °F, when retarders are used, or when high replacement mixes are used. Test age may need to be decreased at higher temperatures above approximately 80°F. The average strength of the first set of beams must be less than 425 psi for the curve to be valid.

   If the maturity curve is intended for use in determining the time to begin joint sawing, additional test specimens will need to be cast and strength testing must begin at lower maturity values.

   For pavements, a minimum flexural strength of 500 psi is required for opening. (See Article 2301.03). For structural concrete, a minimum flexural strength of 575 psi is required before forms may be removed and concrete may be subjected to flexural loading. Strength requirements vary for determining when forms for roofs of culverts may be removed (See Article 2403.03). Testing intervals may need to be increased over those for paving.

   For structural concrete where compressive strength of 4500 psi or greater is required, develop a maturity curve utilizing cylinders for compressive strength. Ensure the last set of cylinders is greater than the required design strength. Cast and cure, in accordance with IM 315, a minimum of 15 cylinders and place probes in two of the cylinders. Test a set of three cylinders at each age of 1, 3, 7, 14, and 28 days (or earlier if already above design strength). This maturity curve may be utilized for other units with lower compressive strength requirements. The DME may also approve this curve for items with flexural strength requirements.

5. Plot the measured strength against the corresponding values of maturity at different ages, as determined by the maturity meter or by hand methods. Use the spreadsheet provided by the District Materials Concrete Technician to determine maturity-strength relationship. The maturity (TTF) value corresponding to the required opening strength shall be used to determine when the pavement or structure may be loaded. An example of the Maturity-Strength Development form, generated by the computer program, is included at the end of this IM. This form shall be reviewed by the DME. Copies will be provided to the Project Engineer, DME, Concrete Materials Engineer, and the contractor.

FIELD MATURITY (TTF) PROCEDURE – ESTIMATE IN PLACE CONCRETE STRENGTH

Placement of the Temperature Probes

Strip ½” to ¾” of the coating from each end of the two wires and twist the ends together before inserting them into the fresh concrete.

Pavements

For pavements, insert the temperature probe into the concrete until the end is at approximately the pavement mid-depth and 1.5 feet from the edge of the pavement. The wire ends are the points at which the temperature measurement is taken. Insertion may be accomplished by attaching the wire ends to a wooden dowel and embedding it into the slab. Check to ensure the concrete is consolidated around the dowel. The portion of the dowel that protrudes above the pavement should be cut or broken off after the testing is completed.

Probes may be placed at any point along the pavement slab. A minimum of two probes shall be placed in each day's placement with one at the end of the days run. On days when there is a large difference between daytime high temperatures and nighttime low temperatures, placing additional probes near the beginning of the day's run and at a point near the midday location provides useful information. The concrete placed during the middle of the day can gain strength faster than the concrete placed at the beginning of the day because of daytime heating. Place probes at side roads, or other locations, where opening to traffic is critical.

Structures

For structures, a minimum of two probes shall be attached to the reinforcing steel near the edge at the upper corner of the exposed surface. (See Figure 1 at the end of this IM.) The probe should be wrapped around the rebar and taped with approximately 1 to 2 inches extending below the rebar to prevent the probe from damage and removal during concrete placement. The rebar should also be taped 2 to 3 inches on both sides of the probe location to prevent contact with the reinforcing steel. (See Figure 2 at the end of this IM.)

Temperature Data Collection and Maturity (TTF) Calculation
Handheld thermometers (Pavements)

Typically, a handheld thermometer is used to collect temperature readings for pavements. The probe wire ends, extending out from the concrete, may be connected to a plug. A plug with thermocouple wires and clips attached to the handheld thermometer may also be used to connect to the wires extending from the concrete. Be careful to connect the copper wire to the copper plug prong (+).

Once the wires are placed, an initial temperature of the concrete shall be taken and recorded. Temperature readings should be taken in the morning and late afternoon as a minimum for standard A, B and C mixtures. For the fast-setting mixtures, readings should be taken every few hours, depending on weather conditions and mixture.

A Maturity Data Recording Sheet, provided at the end of this IM, may be used to record the temperature readings and calculate the maturity values.

A continuous temperature data logger is required for monitoring structures. The maturity value shall be calculated based on hourly readings obtained from the device. The device may also be used for monitoring pavements.

If a maturity meter is being used to monitor either pavements or structures, it should be connected to the probe as soon as possible to begin data collection. The maturity (TTF) value may be read directly from the maturity meter. Some maturity meters are not moisture proof and will be permanently damaged if not protected from water or moisture.

It is the responsibility of a Level I PCC technician to place probes, perform all calculations, and submit forms to the Engineer. The Level I PCC technician may supervise other personnel to place probes, obtain temperature readings or read maturity values.

Implementation
For pavements, it is the intent of the procedure to use the maturity method to open the pavement to traffic from the first day of paving, including the days of development of new curves.

During maturity curve development, a preliminary maturity TTF value may be used to determine opening strength of pavement placed during the first day of paving.

The preliminary TTF will be the TTF value, at a particular age when the average strength of the three beams used for development of the strength-maturity curve meets or exceeds the required opening strength.

After curve has been established and approved by the DME, only the approved maturity TTF value shall be used to open pavement sections. When commercial maturity sensors are used, submit reports displaying time versus TTF.

In all cases, the Engineer will determine if adequate strength has been achieved and the time when a pavement may be opened to traffic based on TTF measurements collected from that pavement.

When multiple plants are being used in accordance with Article 2301.02.C,4,a, use the most conservative curve (highest opening TTF) to determine when the pavement may be opened. Use the most conservative curve if multiple cement changes have occurred.

A maturity curve developed at a plant from the same company may be transferred to another plant of the same company provided identical sources of materials are used. The transferred curve shall be validated at other plants within the company. Central batch plants from the same company shall develop a maturity curve.

For structures, since maturity is to be used on units exposed to flexural loading, the maturity curve should be developed early in the project during placement of concrete exposed to compressive stress. If this is not possible, concrete placed on the same day as development of the strength-maturity curve may be loaded at a particular age using either of the first day placement criteria required for pavements.

Curve Validation
A curve validation is required once every 90 calendar days during normal plant production. If the plant has not supplied concrete to the project for a period of greater than 90 days, the curve may begin on the first day of startup. The validation tests shall be conducted to determine if concrete strength is being represented by the current maturity curve. Cast and cure three (3) beams using the same procedure and manner as used to develop the current maturity curve. Test all three beams as close as possible to the maturity value determined to represent the opening strength of the pavement or the flexural loading strength or form removal strength of the structure. Normal production concrete may be used for curve validation.

Pavements and Structures Flexural Strength

For pavements and structures, if the average calculated strength value at the TTF the validation beams were tested is within the range of ±50 psi of the original curve, the original curve shall be considered validated.

Structures – Compressive Strength up to 4000 psi

For structures, if the average calculated strength is greater than the original curve at the TTF the validation beams were tested, the original curve shall be considered validated.

Structures – Compressive Strength 4500 psi or greater

A curve validation is required once every month during placement of concrete with compressive strength requirement of 4500 psi or greater. If the average calculated compressive strength is greater than the original curve represented by the cylinders tested, the original curve shall be considered validated.

An example of the Validation of the Maturity Curve is included at the end of this IM. Copies shall be provided to the RCE, DME, and the contractor.

This validation procedure is a check to ensure the mix is basically the same as originally tested. If the test results indicate a new curve must be developed, this should be done in a timely manner. The curve currently being used shall be continued until new beams can be cast and at that point the implementation procedure described above shall be followed.

Factors Requiring a New Curve

Changes in material sources, proportions, and mixing equipment all affect the maturity value of a given concrete mixture. Examples: Mixes with Type IS or IP cements exhibit slower strength gain than with Type I or II cements and mixes with Class F fly ash exhibit slower strength gain than with Class C fly ash. Development of a new maturity curve due to material source or proportion changes in a concrete mix may be waived by use of the validation procedure. Note: C-3WR and C-4WR mixes are similar enough that separate curves are not required. DME may allow C-WR curves to be utilized for C-3 or C-4 mixes.

The following will require a new curve to be developed:

- For the validation beams tested, the average calculated strength at the TTF tested is below the minimum range (-50 psi) of the original maturity curve.
- The w/c ratio of the production concrete exceeds the w/c ratio of the concrete used to develop the strength-maturity curve by more than 0.02.

Maturity Meter Calibration

The four channel Type T thermocouple (Humboldt or Gilson type) maturity meters shall be calibrated yearly to ensure proper temperature sensing. The calibration may be performed at the Central Laboratory, before the start of each construction season. To ensure accurate temperature measurement, ~~all other maturity meters and~~ handheld thermometers should also be checked at least yearly against a certified thermometer or other calibrated meter at the District or Central Laboratory. Some maturity meters may need to be sent to the manufacturer for calibration.

For commercial maturity meter sensors or temperature sensors used directly in the pavement or structure, submit calibration records from the manufacturer, for the sensors used, to the engineer.

Iowa Department of Transportation — **Maturity - Field Data** — 3/27/2017

Project : FMX-CO74(68)--55-74
County : Palo Alto
Contractor: Cedar Valley

Date Placed: 4/26/2009
Mix: C-3WR-C20
Certified Tech: John Smith ANE999

Maturity Curve #: CV-2

TTF Required for Opening or Loading : 1253

SITE 1 — *Section of Pavement for Opening or Structural Unit for Loading by Maturity* — 1 — **Probe #** 2

Structual Unit or Probe Location From: — **Probe Location To:**

Date and Time (AM or PM) *Enter*	Age (hours)	Temp (deg C) *Enter*	TTF at age (deg C-hr)	Sum TTF (deg C-hr)	Air Temp (deg C) *Enter*
4/26/09 12:30 PM	0.00	22	0	0	
4/26/09 7:30 PM	7.0	27	242	242	24
4/27/09 8:00 AM	12.5	25	450	692	21
4/27/09 5:00 PM	9.0	19	288	980	22
4/28/09 9:00 AM	16.0	22	488	1468	20
Total Time (hrs):	**44.5**				

$$TTF_i = \left(\frac{Temp_i + Temp_{i-1}}{2} + 10\right)(Age_i - Age_{i-1})$$

TTF: **1468** — Value in box should be greater than or equal to required TTF.

SITE 2 — *Section of Pavement for Opening or Structural Unit for Loading by Maturity* — **Probe #**

Structual Unit or Probe Location - From: — **To Probe Location:**

Date and Time (AM or PM) *Enter*	Age (hours)	Temp (deg C) *Enter*	TTF at age (deg C-hr)	Sum TTF (deg C-hr)	Air Temp (deg C) *Enter*
	0.00		0	0	
Total Time (hrs):	**0.0**				

$$TTF_i = \left(\frac{Temp_i + Temp_{i-1}}{2} + 10\right)(Age_i - Age_{i-1})$$

TTF: — Value in box should be greater than or equal to required TTF.

cc: RCE

9/21/2015

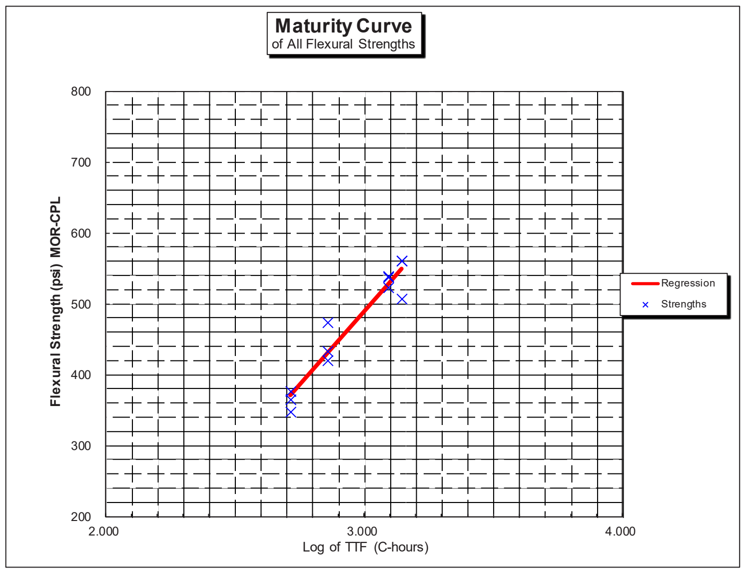
MATURITY - STRENGTH DEVELOPMENT MOR-CPL

COUNTY:	Warren	MONITOR:	Jane Doe		
CURVE #:	IC051109	REP/CONTRACTOR:	Concrete Contractor	INSPECTOR:	Jon Smith
PROJ. #:	IMX-035-4(999)--13-91	PLANT LOCATION:	AAA Ready Mix	DATE:	05/11/14

BEAM #	LOAD AT BREAK (lbs)	TABLE VALUE (lbs)	BREAK LOCATION (in)	WIDTH (in)	DEPTH (in)	FLEXURAL COEFFICIENT	FLEXURAL STRENGTH CPL (psi)	AGE AT BREAK (hours)	TTF CH 1	TTF CH 2	AVERAGE TTF	BEAM TEMP (AVG)
	Enter	Enter	Enter	Enter	Enter			Enter	Enter	Enter		Enter
1	3000	3080	1	6.12	6.00	0.122549	377	15	521	519	520	17
2	3000	3080	0.25	6.16	6.08	0.118570	365	15	521	519	520	17
3	2800	2880	0.75	6.18	6.02	0.120554	347	15	521	519	520	17
4	3400	3470	0.25	6.20	6.00	0.120968	420	22.5	723	721	722	21
5	3900	3950	1.5	6.20	6.02	0.120165	475	22.5	723	721	722	21
6	3500	3560	0.5	6.12	6.02	0.121736	433	22.5	723	721	722	21
7	4400	4410	0.25	6.10	6.02	0.122135	539	40.5	1245	1242	1244	18
8	4400	4410	0.25	6.20	6.06	0.118584	523	40.5	1245	1242	1244	18
9	4400	4410	0.75	6.20	5.98	0.121778	537	40.5	1245	1242	1244	18
10	4600	4600	0.25	6.20	5.98	0.121778	560	46	1400	1398	1399	20
11	4500	4510	1	6.16	5.94	0.124225	560	46	1400	1398	1399	20
12	4300	4320	1.5	6.18	6.10	0.117413	507	46	1400	1398	1399	20

MIX INFORMATION	Enter
AIR:	7.5
SLUMP:	3
w/c:	0.452
MIX:	C-4WR-C20
FLY ASH SOURCE:	FA013C
GGBFS SOURCE:	
CEMENT SOURCE:	PC0802
COARSE AGGREGATE SOURCE:	A63002
INTERM. AGGREGATE SOURCE:	
FINE AGGREGATE SOURCE:	A25518
WATER REDUCER BRAND:	KB-1000
Add. Rate:	18oz/yd
AIR ADMIXTURE BRAND:	Polychem SA
Add. Rate:	4.0 oz/yd
METHOD OF DEVELOPMENT:	Maturity Meter
Desired Flexural Strength (MOR-CPL):	500 psi

REQUIRED TTF:	**1060**



Contractor Certified Technician- Jon Smith ***Cert. #-*** SE9999

Maturity Curve Reviewed - Sam Smith
District Materials Engineer

Comments:
Cast beams @2:30pm, May 11 2014. Monitor witnessed.
Broke first set @6:00am, May 12th. Monitor witness.
Broke second set @1:30pm, May 12th. Monitor unable to witness.
Broke third set @ 7:30am, May 13th. Monitor unable to witness.
Broke fourth set @ 2:00 pm, May 13th. Monitor witness.

cc: RCE, DME, Contractor

VALIDATION OF MATURITY CURVE

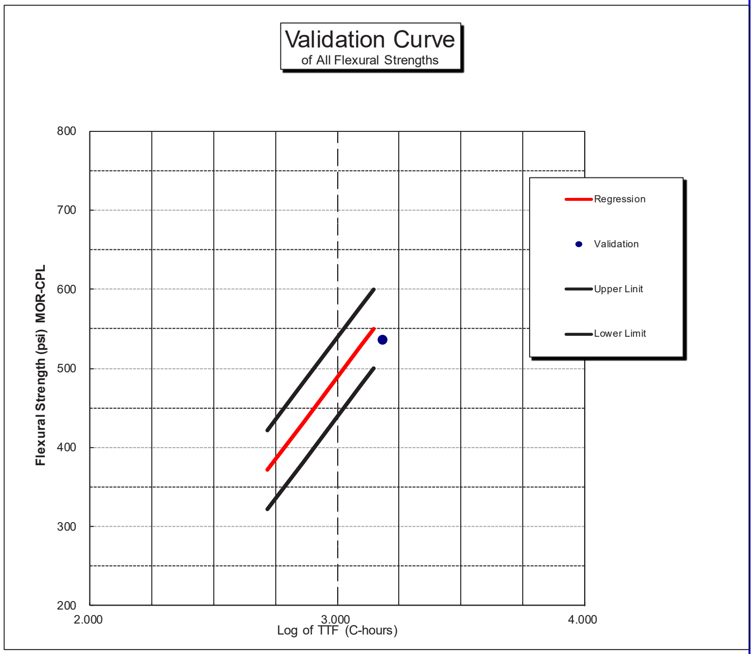
VAL. PROJ. #: NHSX-092-5(51)--3H-91
CURVE #: IC051109
Curve PROJ. #: IMX-035-4(999)--13-91

MONITOR: Jane Doe
CONTRACTOR: Concrete Contractor

INSPECTOR: Jon Smith
Validation DATE: 9/25/15

BEAM #	LOAD AT BREAK (lbs)	TABLE VALUE (lbs)	BREAK LOCATION (in)	WIDTH (in)	DEPTH (in)	FLEXURAL COEFFICIENT	FLEXURAL STRENGTH (psi)	AGE AT BREAK (hours)	TTF CH 1	TTF CH 2	AVERAGE TTF
	Enter	Enter	Enter	Enter	Enter			Enter	Enter	Enter	
1	4000	4050	1.25	6.18	5.90	0.125508	508	44.5	1516	1545	1531
2	4400	4380	0.25	6.05	5.90	0.128205	562	44.5	1516	1545	1531
3	4400	4380	0.75	6.10	6.00	0.122951	539	44.5	1516	1545	1531

AIR:	8	Enter
SLUMP:	3.75	Enter
w/c:	0.465	Enter
MIX:	C-4WR-C20	Mix Changes
FLY ASH:	FA013C	
GGBFS:	0	
CEMENT:	PC0802	
COARSE AGGREGATE:	A63002	
INTERM. AGGREGATE:	0	
FINE AGGREGATE:	A25518	A25514
WATER REDUCER:	KB-1000	
Add. Rate:	18oz/yd	
AIR ENTRAINER:	Polychem SA	
Add. Rate:	4.0 oz/yd	
Method of Development:	Maturity Meter	
REQUIRED TTF:	**1060**	



CURVE VALIDATION

TTF @ Break	1531
Beam 1 MOR (psi)	508
Beam 2 MOR (psi)	562
Beam 3 MOR (psi)	539
Beam Avg. MOR (psi)	536

Calculated psi @ TTF		**Range**	
	566	**Minimum**	516
		Maximum	616

Curve Validation
OK Within Range

Comments:
Monitor unable to make casting on 9-23-15
Monitor witness break on 9-25-15

Validation strength above the upper limit does not require a new curve.

Contractor Certified Technican - Jon Smith SE9999

Maturity Curve Validation Reviewed - Sam Smith
District Materials Engineer

MATURITY.XLS
Sep-15

cc: RCE, Contractor

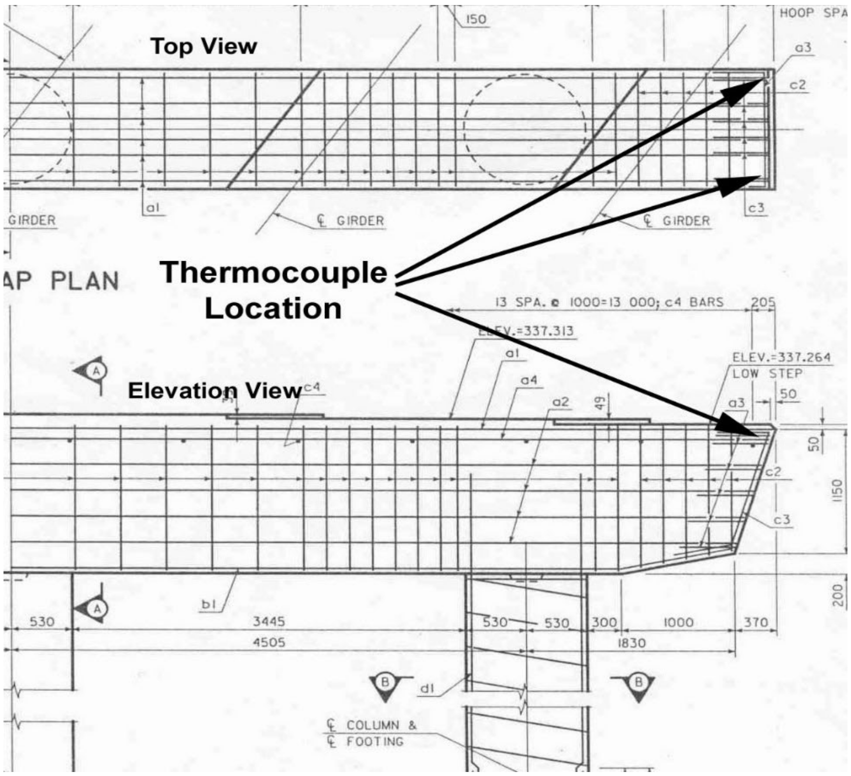


Figure 1. Typical thermocouple location placement in pier cap
Use similar method for thermocouple placement in other structural elements.

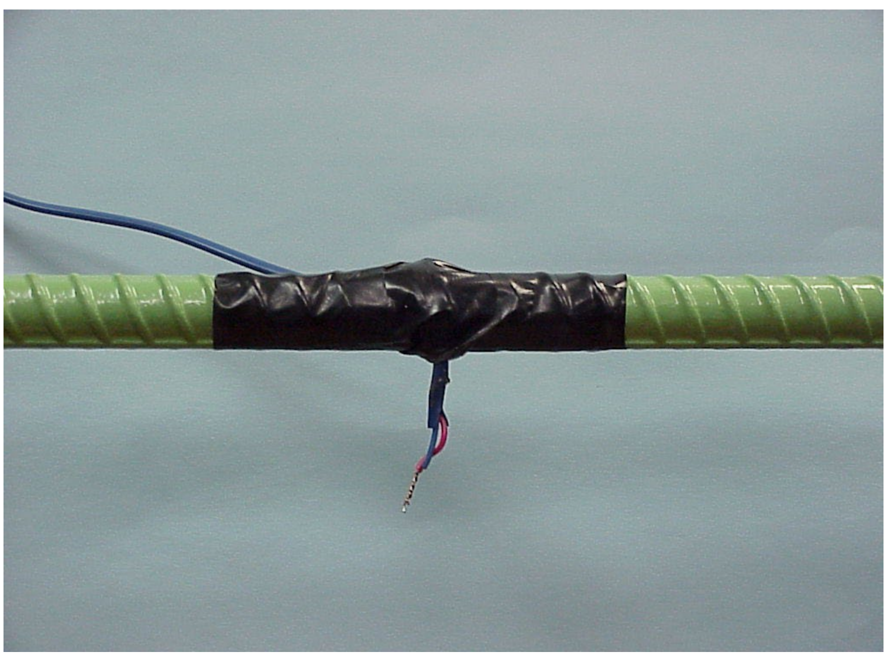


Figure 2. Typical attachment of thermocouple to reinforcing steel

Maturity - Field Data

Form M142

Project : ____________________ **Date Placed:** __________ **Maturity Curve #:** __________

County : ____________________ **Mix:** __________

Contractor: ____________________

TTF Required for Opening or Loading : __________

SITE 1	*Section of Pavement for Opening or Structural Unit for Loading by Maturity*		**Probe #**	

Structual Unit or Probe Location From: __________ **Probe Location To:** __________

Date *Enter*	Time *Enter*	Age (hours) *Enter*	Temp (deg C) *Enter*	TTF at age (deg C-hr)	Sum TTF (deg C-hr)	Air Temp (deg C) *Enter*
		0.00		0	0	

$$TTF_i = \left(\frac{Temp_i + Temp_{i-1}}{2} + 10\right)(Age_i - Age_{i-1})$$

TTF: __________ **Value in box should be greater than or equal to required TTF.**

SITE 2	*Section of Pavement for Opening or Structural Unit for Loading by Maturity*		**Probe #**	

Structual Unit or Probe Location - From: __________ **To Probe Location:** __________

Date *Enter*	Time *Enter*	Age (hours) *Enter*	Temp (deg C) *Enter*	TTF at age (deg C-hr)	Sum TTF (deg C-hr)	Air Temp (deg C) *Enter*
		0.00		0	0	

$$TTF_i = \left(\frac{Temp_i + Temp_{i-1}}{2} + 10\right)(Age_i - Age_{i-1})$$

TTF: __________ **Value in box should be greater than or equal to required TTF.**

cc: RCE, Central Materials, Contractor

____________________ *Contractor Representative*

____________________ *Agency Representative*

Maturity TTF Example Problem

Using the formula below, calculate the maturity value (TTF) for each time interval and the TTF sum value.

$$TTF_i = \left(\frac{Temp_{(i)} + Temp_{(i-1)}}{2} + 10°\right) * (Age)$$

Date	Time	Age (hrs) $Age_{(I)}$-$Age_{(I-1)}$	Temp (deg C)	TTF at age	Sum TTF
10/10/17	8:00 AM	0	34.6	0	0
10/10/17	8:00 PM		34.6		
10/11/17	7:00 AM		42.9		

Solve:

$$TTF_{8:00PM} = \left(\frac{Temp_{(8:00PM)} + Temp_{(8:00AM)}}{2} + 10°\right) * (Age)$$

$= \left(\frac{34,6° + 34,6°)}{2}\right) + 10°) * (12 \text{ hrs})$

$= (44.6°) * (12 \text{ hrs})$

= 535 deg C–hr

$$TTF_{7:00\ AM} = \left(\frac{Temp_{(7:00\ AM)} + Temp_{(8:00\ PM)}}{2} + 10°\right) * (Age)$$

$= \left(\frac{42.9° + 34,6°)}{2}\right) + 10°) * (11 \text{ hrs})$

= (48.75°) * (11 hrs)

= 536 deg C-hr

Review Questions
Strength of Portland Cement Concrete
Using the Maturity Method
IM 383

1. What are the two steps in using the maturity process?

   1. ______________________________________
   2. ______________________________________

2. What are the two factors that the strength of concrete is dependent upon?

3. How many beams are cast to develop a maturity curve?

4. What is the minimum size batch of concrete used to cast beams for maturity?

5. When developing a curve, maturity values are determined at how many different ages?

6. Where are the probes placed in the fresh concrete after it is placed on the grade?

7. What is the minimum amount of probes that shall be placed in each day's placement?

8. How often are validation tests conducted?

9. How many beams are cast for validation tests?

Maturity TTF Problem #1

Using the formula below, calculate the maturity value (TTF) for each time interval and the TTF sum value.

$$TTF_i = \left(\frac{Temp_{(i)}+Temp_{(i-1)}}{2} + 10°\right) * (Age)$$

Date	Time	Age(hrs) Age(I)-Age(I-1)	Temp (deg C)	TTF at age	Sum TTF
8/12/17	9:00AM	0	22°	0	0
8/12/17	1:00PM	4	29°		

Solve:

$$TTF_{1:00PM} = \left(\frac{Temp_{(1:00PM)} + Temp_{(9:00AM)}}{2} + 10°\right) * (Age)$$

=

Maturity TTF Problem #2

Using the formula below, calculate the maturity value (TTF) for each time interval and the TTF sum value.

$$TTF_i = \left(\frac{Temp_{(i)} + Temp_{(i-1)}}{2} + 10°\right) * (Age)$$

Date	Time	Age (hrs) $Age_{(I)}$-$Age_{(I-1)}$	Temp (deg C)	TTF at age	Sum TTF
9/16/17	6:00 AM	0	19.6°	0	0
9/16/17	8:00 PM		17.9°		
9/17/17	7:00 AM		22.9		

Solve:

$$TTF_{(8:00\ p.m.)} = \left(\frac{Temp_{(8:00 PM)} + Temp_{(6:00\ AM)}}{2} + 10°\right) * (Age)$$

=

$$TTF_{7:00\ AM} = \left(\frac{Temp_{(7:00\ AM)} + Temp_{(8:00\ PM)}}{2} + 10°\right) * (Age)$$

=

Maturity TTF Problem #3

Using the formula below, calculate the maturity value (TTF) for each time interval and the TTF sum value.

$$TTF_i = \left(\frac{Temp_{(i)} + Temp_{(i-1)}}{2} + 10°\right) * (Age)$$

Date	Time	Age (hrs) $Age_{(I)}$-$Age_{(I-1)}$	Temp (deg C)	TTF at age	Sum TTF
10/1/17	5:00 PM	0	22.2°	0	0
10/2/17	9:30 AM		19.0°		
10/2/17	4:30 PM		26.5°		
10/3/17	8:30 AM		15.9°		

Solve:

$$TTF_{(9:30\ AM)} = \left(\frac{Temp_{(9:30\ AM)} + Temp_{(5:00\ PM)}}{2} + 10°\right) * (Age)$$

=

$$TTF_{4:30\ PM} = \left(\frac{Temp_{(4:30\ PM)} + Temp_{(9:30\ AM)}}{2} + 10°\right) * (Age)$$

=

$$TTF_{8:30\ AM} = \left(\frac{Temp_{(8:30\ AM)} + Temp_{(4:30\ PM)}}{2} + 10°\right) * (Age)$$

=

Maturity TTF Problem #4

Solve the following maturity problem, using the Field Maturity Testing program found at the Iowa DOT Office of Construction and Materials web page -

https://iowadot.gov/construction_materials/portland-cement-concrete-pcc

Maturity - Field Data

Project : ______________ Date Placed: ________ Maturity Curve #: ________
County : ______________ Mix: ________
Contractor: ______________ Certified Tech: ________

TTF Required for Opening or Loading : ____

SITE 1	*Section of Pavement for Opening or Structural Unit for Loading by Maturity*		Probe #	

Structual Unit or Probe Location From: ____ Probe Location To: ____

Date *Enter*	Time *Enter*	Age (hours) *Enter*	Temp (deg C) *Enter*	TTF at age (deg C-hr)	Sum TTF (deg C-hr)	Air Temp (deg C) *Enter*
08/08/03	10:00 AM	0.00	19.7	0	0	
08/08/03	05:00 PM		20.3			
08/09/03	09:00 AM		17.6			
08/09/03	04:00 PM		18.9			
08/10/03	08:00 AM		17.4			
08/10/03	02:00 PM		19.2			

$$TTF_i = \left(\frac{Temp_i + Temp_{i-1}}{2} + 10\right)(Age_i - Age_{i-1})$$

TTF: ____ **Value in box should be greater than or equal to required TTF.**

Maturity TTF Problem #5

Solve the following maturity problem, using the Field Maturity Testing program found at the Iowa DOT Office of Construction and Materials web page -

https://iowadot.gov/construction_materials/portland-cement-concrete-pcc

Maturity - Field Data

Project : ____________ Date Placed: ________ Maturity Curve #: ________

County : ____________ Mix: ________

Contractor: ____________ Certified Tech: ________

TTF Required for Opening or Loading : ________

SITE 1	Section of Pavement for Opening or Structural Unit for Loading by Maturity		Probe #	

Structual Unit or Probe Location From: ________ Probe Location To: ________

Date Enter	Time Enter	Age (hours) Enter	Temp (deg C) Enter	TTF at age (deg C-hr)	Sum TTF (deg C-hr)	Air Temp (deg C) Enter
07/01/03	08:00 AM	0.00	18.1	0	0	
07/02/03	09:00 AM		17.3			
07/02/03	03:00 PM		21.7			
07/03/03	10:00 AM		19.6			
07/03/03	04:00 PM		22			
07/05/03	07:00 AM		17.8			

$$TTF_i = \left(\frac{Temp_i + Temp_{i-1}}{2} + 10\right)(Age_i - Age_{i-1})$$

TTF: ________ Value in box should be greater than or equal to required TTF.

IM 347 - CONCRETE CORE LENGTH

Concrete Pavement Thickness

IM 347 provides two methods for determining concrete pavement thickness.

Providing pavement consistently at or above the design thickness is essential to ensure it can withstand loading over its intended service life and therefore thickness is an incentive/disincentive (I/D) pay item. I/D payment is determined from the thickness index (TI) which is calculated based on the thickness average and standard deviation.

Method A is non-destructive and uses the MIT Scan T2 or T3 device and method B is coring. Method A will be used for interstate and primary projects and method B will be used on non-primary projects. Concrete pavement thickness is determined for bid items of the same thickness greater than 3,500 square yards. For bid items less than 3,500 square yards concrete pavement thickness will be determined by probing of the plastic concrete and the I/D payment does not apply.

Method A requires the anchoring of special steel targets every 200 feet on the subgrade/subbase. The steel targets must be located away from reinforcement and mid-way between dowel assemblies. Following paving, random targets will be selected for measurement. At the selected targets, the MIT Scan device will be rolled on top of the pavement to detect and then evaluate the depth of the target below the sensor. The thickness in mm will be recorded in the MIT Scan device. Care must be taken to avoid influences of steel in the pavement as well as steel toed shoes. If a target cannot be measured due to steel influences, another location should be selected for evaluation. When all thickness measurements are complete, they are downloaded into the evaluation spreadsheet to calculate the TI and I/D payment. The agency locates and places targets and conducts all testing and calculations for this method.

Method B requires core locations to be randomly determined by the District Materials Office. When paving is complete, the core locations are provided to the contractor. Cores are then drilled by the contractor and witnessed by the agency. Prior to drilling cores, both the contractor and agency should verify that the core bit has a 4.25 inch outer diameter in order to produce a 4 inch diameter core. The agency will take immediate possession of the cores after drilling and will then conduct measurements using a nine-point device following the procedures in IM 347. To ensure accurate thickness measurements, damaged areas of the core should be avoided, core ends should be free of subbase, and measurements should be read at the end of the brass slide and not in the V notch. The evaluation spreadsheet should be used to record all measurements as they are taken and to calculate the TI and I/D payment.

Thicknesses that are found to be deficient by more than 1 inch will require additional investigation and coring to establish the extents of the deficient area for removal.

MEASURING LENGTH OF DRILLED CONCRETE CORES

SCOPE

This method covers the procedure for determining the length of a core drilled from a PC Concrete structure, particularly from a PC Concrete pavement. The procedure is a modification of AASHTO T 148.

PROCEDURE

A. Apparatus

1. The apparatus consists of a calipering device that will measure the length of axial elements of the core.

2. The apparatus is designed so the specimen is held with its axis in a horizontal position by guide rods when making circumferential measurements, and a stand placed upon the guide rods for making a center measurement. The device is equipped with an auxiliary wheel that rests on the specimen and is calibrated such that one-half of a revolution of the wheel represents one-eighth the circumference of a 4 in. (100 mm) diameter core.

3. The device is constructed so the specimen is brought into contact with a single flat-faced probe 3/8 in. (10 mm) in diameter mounted on a fixed end of the device.

4. The measuring rod, which makes contact with the end surface of the specimen, is rounded to a radius of 1/8 in. (3 mm) and is mounted on a moveable plate, which in turn is mounted on guide rods. One guide rod is provided with a scale on which the length readings are made. The graduations of the scale are spaced at 0.10 in. (2.5 mm) intervals.

5. The apparatus provides for the accommodation of specimens of different nominal lengths over a range of 4 to 11 in. (100 mm to 275 mm).

6. The calipering apparatus is designed so it is possible to make a length measurement at the center of the specimen and at eight additional points spaced equally along the circumference of a circle whose center point coincides with the end area of the specimen and whose radius is not less than one-half, nor more than three-fourths, of the radius of the specimen.

7. The apparatus is stable and sufficiently rigid to maintain its shape and alignment without a distortion or deflection of more than 0.01 in. (0.25 mm) during all normal measuring operations.

B. Test Specimens

1. Cores used as specimens for length measurement must be in every way representative of the concrete in the structure from which they are removed. The specimen is to be drilled with the axis normal to the surface of the structure, and the ends must be free from all conditions not typical of the surfaces of the structure. A large screwdriver, hammer and wire brush may be used to force subbase material from the bottom of the core. Use enough force to remove the material, but not cause damage to the core. If the material is firmly cemented, or encased in mortar, it may not be possible to remove. (Figures 2 and 3) Cores that show abnormal defects or that have been damaged appreciably in the drilling operation should not be used.

C. Test Procedure

1. Before any measurements of the core length are made, calibrate the apparatus with suitable gauges so errors caused by mechanical imperfections are known. When these errors exceed 0.01 in. (0.25 mm), suitable corrections must be applied to the core length measurements.

2. Place the stand on the guide rods and place the specimen on the stand for the center point measurement. The smooth end of the core, that is, the end that represents the upper surface of a pavement slab or a formed surface in the case of other structures is to be positioned facing the fixed end of the measuring device. Bring the specimen into contact with the stud in the fixed end, slide the movable plate until it is in contact with the specimen and record the length.

3. Remove the stand, place the specimen directly on the guide rods and make another measurement as described in C2.

4. Place the small auxiliary wheel on the specimen so the scribed marks on the wheel are in alignment. Rotate the specimen until the marks are again in alignment (1/2 revolution of the wheel) and make another measurement. Continue in this manner until eight measurements in addition to the center measurements have been made. If the core is not 4 inches in diameter (typically 3.75 or 4.25 inches), the DME may allow alternative methods to be used.

5. Read each of the nine measurements directly to 0.10 in. (2.5 mm), and interpolate to the nearest 0.05 in. (1 mm) by estimation.

6. If, in the course of the measuring operation, it is discovered that at one or more of the eight circumferential measuring points the surface of the specimen is not representative of the general plane of the core end because of a small projection or depression, rotate the specimen slightly about its axis, and make another set of measurements with the specimen in the new position. If the center measurement is not representative of the general plane of the core end, it should not be used in computing the length of the core.

7. If some damage from drilling is apparent, no measurements are to be made in the damaged area. Reposition the core to avoid the areas when measuring the length. If these areas cannot be avoided, the length measurements made in these areas are not

to be used in computing the length of the core. In no case, are fewer than seven measurements to be used in determining the core length.

D. Report

1. The individual observations are to be recorded to the nearest 0.05 in. (1 mm) and the average of the nine measurements expressed to the nearest 0.05 in. (1 mm) and shall be reported as the length of the concrete core.

E. Precautions

1. Be careful to move the core away from the stud in the fixed end slightly when turned, so the stud will retain its proper length and shape.

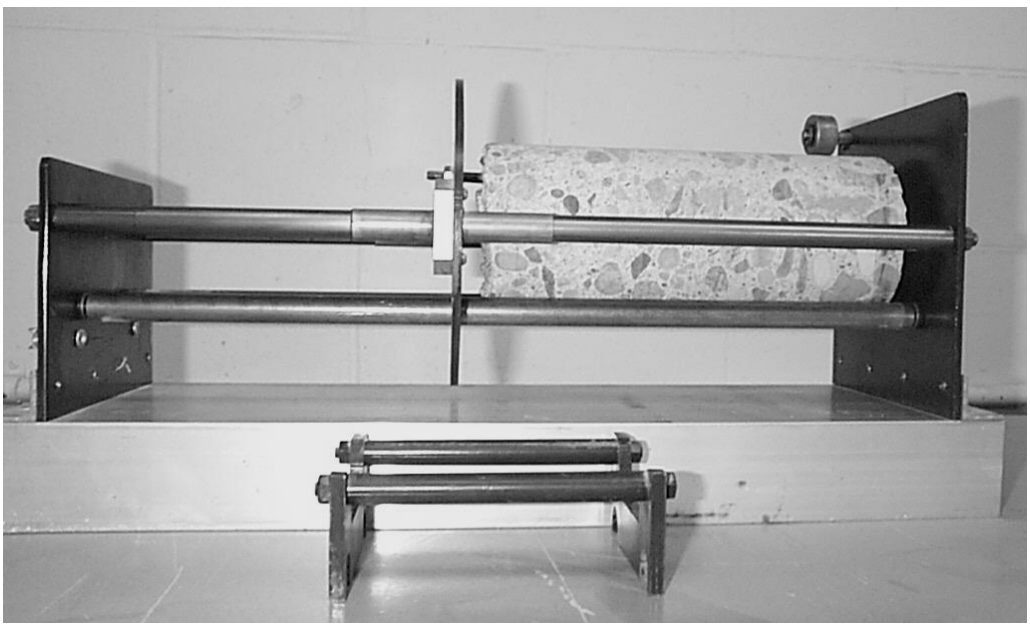


Figure 1. Concrete Core in Measuring Apparatus

Figure 2. Concrete core with granular subbase attached.

Figure 3. Concrete core with granular subbase removed.

MIT SCAN T2

OPERATION OF MIT T2 DEVICE

1. Place targets longitudinally halfway between dowel baskets (10 ft) and at least 3 feet from any tie steel.

2. Assemble device. Connect the two parts. Note: there is only one way the two parts fit together. DO NOT force the connection.

3. To turn on device press both buttons (**red** button and **trigger**) on handle and release.

4. After device is turned on, the Main Menu will appear on the LCD panel. The Main menu consists of

:

A. SEARCH / MEASUREMENT
B. LOCATION SETTINGS
C. SYSTEM
D. DATA MANAGER
E. OFF
F. DEVICE SETTINGS

B – Location Settings (in Main Menu)

Use **C** to move the cursor to what you want to change.
Use **B** to backspace.
Use **D** to use characters.

Input:

STRUCTURE: – Direction & Route using all 5 digits.
The **first digit** is the direction and **needs to be different** for **opposite direction at the same station**.

Right, left, or center **does not work** in the spreadsheet for determining the different lanes at the same stationing.

Next 4 can be project paren # or county/route.

*Example: **2**0030 for direction 2 (WB) on US 30 or*

10124 for direction (NB) on (124) project

1 for N/E on 4 lane (or 2 lane) **2** for S/W on 4 lane.
3 for N/E shoulders **4** for S/W shoulders.
5, 7 (N/E) or **6, 8 (S/W)** for multi-lane w same stations
Letters also will work **A, B, C, D**

km: & **m:** First 3 digits of Station (**km:**) & the last digit in (**m:**)
Example: ***km: 071 m:*** *300 is Station* ***0713*** *+00*
For T3 the Station is entered directly
Distance(m): – Enter 200 for English projects.
F is return key (goes back to previous menu)
E will turn the device off at any time

A – Start Testing

To start testing, in the Main Menu, select **A – SEARCH/MEASUREMENT**.

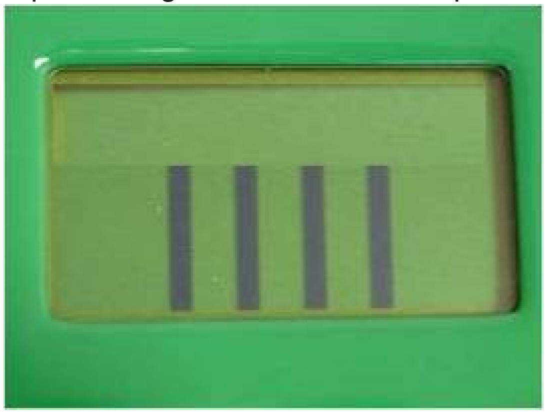
Screen will display project data.
Project ID
Milepost
Starting Station

KEYS:
A – Press **A** to increase the station by increment selected earlier.
9 –Press **9** to decrease the station by increment selected earlier.
B – Layer – n/a
C – Side – n/a
D – Shows **reflector** (target) information. Should read “**STRO30**”.

MAKE SURE **REFLECTOR** IS SET to **STR030**. **DO NOT CHANGE TO**

ANOTHER REFLECTOR or READINGS WILL BE INCORRECT.

Next, press and hold the bottom trigger over the approximate target area. With the device a 2-3 inches above the pavement surface, move from right to left and front to back until the target is located. The target is located and centered when the 4 bars appear highest and equal in length. Mark location on pavement with a lumber crayon (keel).



Place the device on the pavement with the front wheel 1-1 ½ ft behind the center of the target location. Starting further behind the location will cause errors in results. Press and release the top **red** button. You do not need to hold the red button while testing. Walk slowly to move the device over the target. Note: Avoid steel toe boots from getting near the device head.

As the device moves forward, a graph appears. As the device detects the target, a “bump” on the graph will appear. This “bump” should appear on the center to left of center on the graph.

Continue moving forward until you hear a beep. The graph will automatically end. The shape of the graph will vary depending on the intensity of the signal.

Immediately after the graph appears, the screen will change to the result screen. The thickness measurement will appear in mm.

Select **C** to store the result. Select **F** to re-test the same target without saving. Press the top button and repeat the process. **Test the same target 3 times**. All readings at a particular location should be within a range of 3 mm. (*Example 267mm, 270 mm, 269 mm.)* If the **first 3readings** are **not all within 3 mm** and have been saved, **take 2 additional readings**. Do NOT take any more than 5 readings at one location. This causes errors with the spreadsheet.

Move to next location – press **A** or **9**. The station will be increased (or decreased) by the increment previously selected and repeat above steps.

C – System (in Main Menu)

A – Date & Time (input current date and time)

Date format is **DD:MM:YY**. Do not change or data will not download from gage.
B – Battery check/voltage (check voltage)
C – Memory management – you can erase previous data from this screen
D – Boot logger – DO NOT USE for MIT use only
9 – Data logger – DO NOT USE for MIT use only

D – Data Manager (in Main Menu)

A – View data
B – Transfer data to PC using software provided on CD.
C – Print data – unable to use currently.

F – Device settings (in Main Menu)

DO NOT USE any settings in Device Settings.

For calibration use CENTRAL LAB ONLY.

STORAGE: To disassemble, pull the top out of the bottom in a straight pull. Place the two parts carefully back in the case. PLEASE HANDLE THE UNIT WITH CARE.

Review Questions
Concrete Pavement Thickness
IM 347 and MIT Scan

1. The testing apparatus will measure cores __________ inches in diameter and between ______ and ______ inches in length.

2. The ends of the core must be free from all conditions not typical of the surfaces of the structure, such as subbase materials.

   True ____________

   False ____________

3. Measurements are taken in the ___________ and at __________ additional points along the circumference.

4. If a core is damaged but you are able to get five good readings, the core measurements can be used.

   True _________

   False _________

5. What must be avoided when using the MIT Scan T2 or T3 device?

6. If a measurement cannot be obtained at a target due to influences from steel what should be done?

7. When placing a steel target it should be located ___________ between dowel bar assemblies.

8. True or false, every steel target placed is measured with the MIT Scan device.

9. Method A is used on ___________ projects and method B is used on __________ projects.

IM 375
FLOWABLE MORTAR

FLOWABLE MORTAR

IM 375 provides the proper procedure for testing flowable mortar.

The time of efflux measures the fluidity and filling ability of flowable mortar. Flowable mortar is used on both critical and non-critical placements. Critical placements are defined as inside of culverts and between beams. They require an efflux time of 10 to 16 seconds. If a break in the continuity of flow occurs prior to 10 seconds this is an indication that the mix is too thick. Adjustments to the mix water can then be made to achieve the desired efflux time. Non-critical placements are defined as open trenches and below beams under bridges. They do not require efflux time testing but should be visually monitored to ensure a level surface can be achieved without manipulation after discharge.

Flowable mortar mix designs should be provided by the contractor to the District Materials Office for review and approval. Flowable mortar testing and/or visual monitoring will be conducted by the agency.

Flowable mortar testing needs to be performed properly to ensure accurate results. The flow cone must be level and properly calibrated and the correct orifice must be used depending if flowable mortar or revetment grout is being tested. When using the ½ inch orifice, if the sand used contains plus #4 material then the flowable mortar must be passed through a #4 sieve prior to testing. This removes large particles that could clog the orifice.

DETERMINING FLOW OF GROUT MIXTURES (FLOW CONE METHODS)

SCOPE

This method of test covers the procedure to be used both in the laboratory and in the field for determining the flow of grout mixtures by measuring the time of efflux of a specified volume of grout from a standardized flow cone.

The procedure is a modification of ASTM C939 and D6449.

APPARATUS

1. Flow cone as specified in ASTM C939 with a 1/2 inch orifice for flowable mortar (See Figure 1).
2. Flow cone as specified in ASTM D6449 with a 3/4 inch orifice for concrete grout for fabric formed concrete revetment.
3. Stopwatch accurate and readable to 0.2 seconds
4. Level
5. Calibration jug or container to hold a quantity of water equal to 1725 mL

CALIBRATION OF CONE

1. The flow cone shall be firmly mounted in such a manner that the top will be level and the cone free from vibration (use level, rigid, horizontal surface).
2. Level the cone by adjusting the mounting forks.
3. Close the discharge tube of the cone by placing a finger over the lower end. (Be sure not to disturb the leveled cone.)
4. Introduce 1,725 ± 1 mL of water into the cone.
5. Adjust the pointer so that the point just comes into contact with the water.
6. Start the stopwatch and remove the finger simultaneously. Stop the stopwatch when the flow stops. The elapsed time should be 8.0 ± 0.5 seconds for the ½ inch orifice and 4.0 ± 0.5 seconds for the 3/4 inch orifice.

SAMPLE

The test sample shall consist of 1,725 ± 1 mL of grout.

PROCEDURE

1. Select the flow cone with the proper flow opening. A flow cone with a 1/2 inch orifice is for flowable mortar (ASTM C939). A flow cone with a 3/4 inch orifice is for concrete grout for fabric formed concrete revetment (ASTM D6449).

2. Moisten the inside surface of the flow cone.

3. Place a finger over the discharge opening.

4. Introduce grout into the cone until the grout surface rises into contact with the pointer.

5. Start the stopwatch and remove the finger simultaneously.

6. Stop the stopwatch at the first break in the continuous flow of grout from the discharge opening (when the cone is essentially empty).

7. Read time of efflux of the grout (which is the time indicated by the stopwatch).

   NOTE 1: If there is a break in the continuity of discharge prior to essential emptying of the cone, it is an indication that the grout is too thick to be properly tested for flow.

   NOTE 2: For the ½ inch orifice, if the sand used in the grout mixture is larger than No. 4 in size, then the sample should be sieved through a No. 4 sieve cloth prior to being introduced to the flow cone.

REPORT – (See Figure 2 for an Example.)

1. Average time of efflux to the nearest second.

2. Composition of the sample

3. Information and observation of the physical characteristics of the sample

FIGURE 1

Grout Flow Cone

FIGURE 2

IOWA DOT DISTRICT 1 LAB
FLOWABLE MORTAR

LAB NUMBER: 1AS4:008
PROJECT NUMBER: CONTRACT NUMBER:
COUNTY: POLK DESIGN:
CONTRACTOR:
MATERIAL: FINE SAND
SOURCE: HALLETT-JOHNSON
UNIT OF MATERIAL: CEMENT-LAFARGE, FLYASH-COUNCIL BLUFFS
QUANTITY: 50 LB BAG
PRODUCER: GNA CONCRETE
SAMPLED BY: SENDER'S NUMBER
DATE SAMPLED: 5/12/04 DATE RECEIVED: 5/12/04 DATE REPORTED: 5/14/04

SIEVE SIZE	PERCENT PASSING
3/8"	100
#4	99
#8	92
#16	78
#30	44
#50	8.2
#100	0.9
#200	0.5

DISPOSITION: COMPLIES WITH THE FOLLOWING PROPORTIONS: 400 LBS. FLYASH, 100 LBS. CEMENT, 2600 LBS. SAND. FLOWABILITY OF 16 SEC OBTAINED WITH 68 GAL/YD³ H20.

COPIES:
DISTRICT 1
DISTRICT 1 MATERIALS LAB
OFFICE OF MATERIALS
S. TWOHEY
J. HART
OFFICE OF CONSTRUCTION
GNA CONCRETE

SIGNED: JOHN HART
MATERIALS ENGINEER

Review Questions
Test for Flow of Grout Mixtures

1. During the testing procedure is the flow cone moistened or left dry?

2. The stop watch is stopped when ________________________________.

3. What does it mean if there is a break of continuity of the discharge before the cone is empty?

4. Describe the steps in calibrating a flow cone.

HANDS ON

Form 830212
10-95

READY MIX CONCRETE

American @ Gilmore City Plant

Truck No. 5 Ticket No. 1

Date 7/17/16 Des. No. 307

Proj. No. FSSN-015-1(7)--3T-76

Mix No. C-4WR-C20 Retarder/Water Reducer? [x] Yes [ ] No

Conc. This Truck 6 C.Y./m³

Air agent added this truck 18 oz./mL

Time Batched 7:45 am Discharged 8:30 am

Rev. Mixed *(Plant)* 70 Grade 30

Water *(gal./L or lbs./kg This Truck)* 8.33lbs./gal.

In Aggregate	49	gal./L	408	lbs./kg
Added *(Plant)*	134	gal./L	1,116	lbs./kg
Subtotal	183	gal./L	1,524	lbs./kg
Added Grade	7	gal./L	58	lbs./kg
TOTAL WATER	190	gal./L	1,582	lbs./kg

Maximum Water Allowed 209 gal./L 1,740 lbs./cy or kg/m³

Air 6.8% Slump 3"

Plant Insp. Joe Smith NW000

Receiving Insp. ______

READY MIX TICKET (Form 830212)
PROBLEM

Use the following information to fill in the Ready Mix Ticket. The ticket is from Project #STP-53-4(15)—2C-53 and from Kirk's Ready Mix.

Truck #4, Ticket#2
Batched at 8:45 AM and Discharged at 9:30 AM
Mixer Revolutions – 72 at plant, 35 at grade
Air agent added this truck – 18 ounces
Percent of air – 6.8%
Slump - 2 ¾ inches
6 c. yds. C-3WR-C15S30 batched on 8/4/10
65 lbs. water per cubic yard in the aggregates
175 lbs. water per cubic yard added at the plant
19 lbs. water per cubic yard added at the grade

The amounts given are in pounds per cubic yard. The tickets want both pounds and gallons **per truck**.

Remember: Sign the first ticket and write your certification number. Initial the rest of the tickets and write your certification number.

Form 830212
10-95

READY MIX CONCRETE

______________________________ Plant

Truck No. ______________ Ticket No. ______________

Date ______________ Des. No. ______________

Proj. No. ______________________________

Mix No. ____________ Retarder/Water Reducer? ☐ Yes ☐ No

Conc. This Truck ______________________ C.Y./m³

Air agent added this truck ____________________ oz./mL

Time Batched ______________ Discharged ______________

Rev. Mixed *(Plant)* ____________ Grade ______________

Water *(gal./L or lbs./kg This Truck)* 8.33lbs./gal.

In Aggregate ________	gal./L	________	lbs./kg
Added *(Plant)* ________	gal./L	________	lbs./kg
Subtotal ________	gal./L	________	lbs./kg
Added Grade ________	gal./L	________	lbs./kg
TOTAL WATER ________	gal./L	________	lbs./kg

Maximum Water Allowed ________ gal./L ________ lbs./cy or kg/m³

Air ______________ Slump ______________

Plant Insp. ______________________________

Receiving Insp. ______________________________

READY MIX TICKET (Form 830212)
PROBLEM

Use the following information to fill in the Ready Mix Ticket. The ticket is from Project #STP-53-4(15)—2C-53 and from Kirk's Ready Mix.

Truck #8, Ticket #4
Batched at 10:15 AM and Discharged at 11:05 AM
Mixer Revolutions – 70 at plant, 33 at grade
Air agent added this truck – 27 ounces
Percent of air - 7.2%
Slump – 3 inches
9 c. yds. C-4-C15 batched on 8/5/10
64 lbs. of water per cubic yard in the aggregates
183 lbs. water per cubic yard added at the plant
25 lbs. water per cubic yard added at the grade

The amounts given are in pounds per cubic yard. The tickets want both pounds and gallons **per truck**.

Remember: Sign the first ticket and write your certification number. Initial the rest of the tickets and write your certification number.

Form 830212
10-95

READY MIX CONCRETE

________________________________ Plant

Truck No. ____________ Ticket No. ____________

Date ____________ Des. No. ____________

Proj. No. ________________________

Mix No. ____________ Retarder/Water Reducer? ☐ Yes ☐ No

Conc. This Truck ____________ C.Y./m³

Air agent added this truck ____________ oz./mL

Time Batched ____________ Discharged ____________

Rev. Mixed *(Plant)* ____________ Grade ____________

Water *(gal./L or lbs./kg This Truck)* 8.33lbs./gal.

In Aggregate	____________	gal./L	____________	lbs./kg
Added *(Plant)*	____________	gal./L	____________	lbs./kg
Subtotal	____________	gal./L	____________	lbs./kg
Added Grade	____________	gal./L	____________	lbs./kg
TOTAL WATER	____________	gal./L	____________	lbs./kg

Maximum Water Allowed ____________ gal./L ________ lbs./cy or kg/m³

Air ____________ Slump ____________

Plant Insp. ________________________

Receiving Insp. ________________________

Max Water per cu. yd. for Common Mixes

Cubic yds batched	1	4	5	6	7	8	9	10
	Maximum water allowed per cubic yard (gals)							
C-3	35.3	141.2	176.5	211.8	247.1	282.4	317.7	353.0
C-4	36.6	146.4	183.0	219.6	256.2	292.8	329.4	366.0
C-3WR	33.5	134.0	167.5	201.0	234.5	268.0	301.5	335.0
C-4WR	34.8	139.2	174.0	208.8	243.6	278.4	313.2	348.0
M-3	37.8	151.2	189.0	226.8	264.6	302.4	340.2	378.0
M-4	39.6	158.4	198.0	237.6	277.2	316.8	356.4	396.0

PLANT COPY

IDEAL READY MIX COMPANY, INC. Call Charley

P.O. BOX 416
WEST BURLINGTON, IOWA 52655
PH. 319-754-4747

The Ideal Man!

Buyer agrees to pay a **SERVICE CHARGE** on such amounts past due computed by periodic rate of 1 ½% per month (minimum $.50) which is **AN ANNUAL PERCENTAGE RATE** of 18% applied to the past-due balance after deducting current payments or credits.
Claims for shortage will not be allowed unless made at time this material was delivered.
Not responsible for damage caused by vehicle driving in on private property when ordered to by customer.
Not responsible for imperfections or blemishes caused from deleterious material in the concrete.

FLUID CONCRETE CAN BE HAZARDOUS TO YOUR HEALTH. DIRECT OR INDIRECT CONTACT OF FLUID CONCRETE WITH SKIN MAY CAUSE BURNS, WASH AND FLUSH AFFECTED SKIN AREA PROMPTLY ON CONTACT. IF A RASH OR BURNS OCCUR CONSULT A PHYSICIAN IMMEDIATELY. MATERIAL SAFETY DATA SHEETS (MSDS) ARE AVAILABLE ON REQUEST FOR ALL PRODUCTS.

☐ Sign Lien Form on Reverse

1154540 CUSTOMER SIGNATURE

DELIVERY CODE	PROPOSAL	CUSTOMER CODE	TIME	DATE	TICKET NO.
	1956	05834	14:11	08/23/11	1154639

INVOICE TO: HERBERGER CONSTRUCTION
INDIANOLA IA

CHARGE	CASH	CUST. JOB NO.	TERMS	ACCELERATOR 1% 2%	PLANT NO.
	N				19

WATER AT JOB	FINISH TIME	DRIVER
		ADAM

HOLD-UP TIME	PAY MILES	WINTER SVC. CHG. PER YD.	PRICE PER YD.	AMOUNT

DELIVER TO:
BRS-CO20(65)--60-20
agg=66.6gl / plant=220
total=286.6gl / max=313

QUANTITY	DESCRIPTION	PRICE	AMOUNT
0g 9.00	C-4WR-C		

QUANTITY ORDERED	QUANTITY DELIVERED	NO. OF LOADS
18.00	9.00	1

SHIP VIA:		MIX PRODUCT NUMBER	TAX CODE: TAX	RESALE	GOV'T	
759		17627	22			

QUANTITY	CODE	DESCRIPTION
9.00	15586	CERT. PLT. INSP.
9.00	LB190	LARRY GIBBS SE 258
9.00	04303	HAUL CHRG

Material	Required	Batched
ROCK	12931 lb	12880 lb
SAND	14042 lb	13980 lb
CEMENT	4266 lb	4270 lb
FLYASH	1071 lb	1070 lb
WATER	220.3 gl	220.0 gl
PROCRETE	160.11 oz	[illegible]
AIR	36.00 oz	36.00 oz

TOTAL
TAX
AMOUNT

C-4WR-C mix design

- 9.0 cubic yards batched

Aggregate water

- 66.6 gals water in aggregate

Plant Water

- 220 gals plant water

Total Water

- **286.6** gals total water

MAX water

- **313** gals
- 26 gals max water allowed to be added to load
- Or 26 gals/9 cubic yards = 2.9 gals per cubic yard

PLANT COPY

IDEAL READY MIX COMPANY, INC. Call Charley

P.O. BOX 416
WEST BURLINGTON, IOWA 52655
PH. 319-754-4747

The Ideal Man!

Buyer agrees to pay a **SERVICE CHARGE** on such amounts past due computed by periodic rate of 1 ½% per month (minimum $.50) which is **AN ANNUAL PERCENTAGE RATE** of 18% applied to the past-due balance after deducting current payments or credits.
Claims for shortage will not be allowed unless made at time this material was delivered.
Not responsible for damage caused by vehicle driving in on private property when ordered to by customer.
Not responsible for imperfections or blemishes caused from deleterious material in the concrete.

FLUID CONCRETE CAN BE HAZARDOUS TO YOUR HEALTH. DIRECT OR INDIRECT CONTACT OF FLUID CONCRETE WITH SKIN MAY CAUSE BURNS, WASH AND FLUSH AFFECTED SKIN AREA PROMPTLY ON CONTACT. IF A RASH OR BURNS OCCUR CONSULT A PHYSICIAN IMMEDIATELY. MATERIAL SAFETY DATA SHEETS (MSDS) ARE AVAILABLE ON REQUEST FOR ALL PRODUCTS.

☐ Sign Lien Form on Revers

1245240 CUSTOMER SIGNATURE

DELIVERY CODE	PROPOSAL	CUSTOMER CODE	TIME	DATE	TICKET NO.
	4095	7469	14:20	08/16/11	1245240

INVOICE TO:
J&L CONSTRUCTION
1971
LEXINGTON BLVD.
WASHINGTON IA 52353

CHARGE | CASH N | CUST. JOB NO. | TERMS | ACCELERATOR 1% 2% | PLANT NO. 40 NE
WATER AT JOB | FINISH TIME | DRIVER DIRK
HOLD-UP TIME | PAY MILES | WINTER SVC. CHG. PER YD. | PRICE PER YD. | AMOUNT

DELIVER TO:
STP-ES-E-2465(614)--8T-51
BIKE TRAIL R 0.3 S 1.8
3.25 GAL IN MAT MAX 34.5

QUANTITY 9.50 | DESCRIPTION C4 WR C 20% OL. 3 G | PRICE | AMOUNT
QUANTITY ORDERED 75.00 | QUANTITY DELIVERED 9.50 | NO. OF LOADS 1

SHIP VIA: 871 | MIX PRODUCT NUMBER 17625 | TAX CODE: TAX T5 | RESALE | GOV'T

QUANTITY	CODE	DESCRIPTION
9.50	15586	CERT. PLT. INSP 4.00
9.50	04303	HAUL CHARGE

Material	Required	Actual
STATE ROCK	14597.66	14,580.00
SAND 4	14699.92	14,700.00
CEMENT	4446.00	4,425.00
FLYASH	1111.50	1,105.00
COLD	220.12	221.00
AIR	30.88	31.00
REDUCER	166.73	167.00

TOTAL
TAX
AMOUNT DUE

C-4WR-C20 mix design
•9.5 cubic yards batched

Aggregate water
•3.25 gals/ cubic yard
•3.25 x 9.5 = 30.9 gals / load

Plant water
•221 gals plant water

Total water
•**251.9** gals total water

MAX water
•34.5 gals/cubic yard
•34.5 x 9.5 = **328** gals per load
• 76.1 gals max water allowed to be added to the load
•Or 76.1 gals/9.5 cubic yards = 8.0 gals per cubic yard

Form 830212
10-95

READY MIX CONCRETE

KEOTA IDEAL Plant

Truck No.	569	Ticket No.	196542
Date	09/07/2011	Des. No.	
Proj. No.	STP-092-8 (27) --2C--54		
Mix No.	M-4	Retarder/Water Reducer?	☐ Yes ☑ No
Conc. This Truck	7.5	72.5 JOB	C.Y./m³
Air agent added this truck	3		oz./mL
Time Batched	1;10	Discharged	
Rev. Mixed *(Plant)*	70	Grade	

Water *(gal./L or lbs./kg This Truck)* 8.33lbs./gal.

In Aggregate	11.25	gal./L		lbs./kg
Added *(Plant)*	240	gal./L		lbs./kg
Subtotal	251.25	gal./L		lbs./kg
Added Grade		gal./L		lbs./kg
TOTAL WATER		gal./L		lbs./kg
Maximum Water Allowed	292.5	gal./L		lbs./cy or kg/m³

Air	6.9	Slump	4
Plant Insp.	JOHN STAUFFER SE-022 *John*		
Receiving Insp.			

M-4 mix design

- 7.5 cubic yards batched

Aggregate water

- 11.25 gals / load

Plant water

- 240 gals plant water

Total water

- **251.25** gals total water

MAX water

- **292.5** gals per load
- 41.25 gals max water allowed to be added to the load
- Or 41.25 gals/7.5 cubic yards = 5.5 gals per cubic yard

SKYLINE READY MIX
PO BOX 127
Decorah, IA 52101
Phone (800) 371-2933
Fax (563) 382-8375

Pella Plant	*Sully Plant*	*Ottumwa Plant*
2476 Hwy 163	404 6th Ave	316 S. Iowa Ave
Pella, IA 50219	Sully, IA 50251	Ottumwa, IA 52501
(641) 620-1228	(641) 594-3300	(641)684-2071
(877) 620-1228		

PLANT	TIME	DATE	ACCOUNT		TRUCK	DRIVER	TICKET
01	10:22AM	08/25/11			50	TIM	39883

CUSTOMER NAME: VERMEER MAN

DELIVERY ADDRESS: PLANT 7 EAST ENT

LOAD QTY	PRODUCT	DESCRIPTION	ORDERED	DELIVERED	UNIT PRICE	AMOUNT
29		MARI				4.00
10.00 yd	C-4WR-C20		130.00	106.00		
10.00 yd	DELIVERY	TRUCK DELIVERY	130.00	106.00		
10.00 bag	FIBER	FIBER MESH	130.00	106.00		

CONCRETE USED FOR ____________

PLANT REPRESENTATIVE ____________

NOTICE: We assume no responsibility for damage to property when required to deliver inside the curb line. Additional water added to this concrete will reduce its strength, so any water added is at the customer's own risk. The customer agrees to the terms of sale and delivery and accepts concrete as is. Due to important factors which are out of our control after delivery, this Company will not accept any responsibility for the finished results.
TERMS: All credit purchases are due and payable in full within 30 days of invoice. A delinquency charge of 1 1/2% per month (18 A.P.R.) may be added to any amount not paid when due.
CAUTION: Freshly mixed concrete can cause severe skin irritation or chemical burns. Avoid direct contact and use personal protection equipment. Wash exposed skin area promptly with water. MSDS sheet available from the driver.

SUBTOTAL
DISCOUNT
TAX

WATER ADDED ______

TOTAL
PREVIOUS TOTAL
GRAND TOTAL

Excessive Water is Detrimental to Concrete Performance
H2O added by Request/Authorized By

Notice my signature below indicates that I have read the health warning notice and supplier will not be responsible for any damage caused when delivering inside the curb line.

SIGN HERE

X ____________

OUR DELIVERY LIABILITY CEASES AT CURB LINE

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Yards Delivered   106.00                WATER ADDED_____SLUMP______  AIR%______
P.O. #29                                           DISCH TIME__________

TRUCK   USER LOGIN  DRIVER   TICKET NUM  TICKET ID  TIME   DATE
50      USER        TIM           39883      59774  10:22  08/25/2011
LOAD SIZE  MIX CODE                                 SEQ    LOAD ID
10.00 yd   C-4WR-C20                                D       62203
MATERIAL  DESIGN QTY  REQUIRED   BATCHED     VAR   % VAR  %MOISTURE ACTUAL WAT
PORTLAND    474.0 lb  4740.0 lb  4755.0 lb   15.0   0.32%
FLYASH      119.0 lb  1190.0 lb  1180.0 lb  -10.0   -.84%
ROCK         1484 lb   14944 lb   14910 lb    -34   -.23%  0.700% M  12.42 gl
SAND         1558 lb   15892 lb   15820 lb    -72   -.45%  2.000% M  37.17 gl
W/R 82      3.00 /C   177.90 oz  178.00 oz   0.10   0.06%
AIR         6.20 oz    62.00 oz   62.00 oz   0.00   0.00%
WATER      32.00 gl  #270.21 gl  270.00 gl   -.21   -.08%            270.00 gl
NON-SIMULATED    NUM BATCHES: 1
LOAD TOTAL: 38934 lb  DESIGN W/C: 0.450  WATER/CEMENT: 0.450T  DESIGN WATER: 320.0 gl  ACTUAL WATER: 319.6 gl
SLUMP:  4.00 "  WATER IN TRUCK:   0.0 gl  ADJUST WATER:   0.0 gl /load  TRIM WATER:   0.0 gl /yd
```

Max. water
from chart =
348 gals/load

C-4WR-C mix design
- 10.0 cubic yards batched

Aggregate water
- 49.6 gals water in aggregate

Plant Water
- 270 gals plant water

Total Water
- **319.6** gals total water

MAX water
- **348** gals / 10 yard load
- 28.4 gals max water allowed to be added to load
- Or 28.4 gals/10 cubic yards = 2.84 gals per cubic yard

SKYLINE READY MIX
PO BOX 127
Decorah, IA 52101
Phone (800) 371-2933
Fax (563) 382-8375

Pella Plant
2476 Hwy 163
Pella, IA 50219
(641) 620-1228
(877) 620-1228

Sully Plant
404 6th Ave
Sully, IA 50251
(641) 594-3300

Ottumwa Plant
316 S. Iowa Ave
Ottumwa, IA 52501
(641)684-2071

PLANT	TIME	DATE	ACCOUNT		TRUCK	DRIVER	TICKET
01	11:14AM	08/24/11	1		49	DON	39839

CUSTOMER NAME: TEK BUILDERS INC
201 N TAYLOR
MOUNT AYR IOWA 50854

DELIVERY ADDRESS: HWY 92

LOAD QTY	PRODUCT	DESCRIPTION	ORDERED	DELIVERED	UNIT PRICE	AMOUNT
		EXEM				4.00
5.00 yd	M-4	M-4	4.00	9.00		
5.00 yd	DELIVERY	TRUCK DELIVERY	4.00	9.00		

CONCRETE USED FOR ______________________

PLANT REPRESENTATIVE ______________________

NOTICE: We assume no responsibility for damage to property when required to deliver inside the curb line. Additional water added to this concrete will reduce its strength, so any water added is at the customer's own risk. The customer agrees to the terms of sale and delivery and accepts concrete as is. Due to important factors which are out of our control after delivery, this Company will not accept any responsibility for the finished results.

TERMS: All credit purchases are due and payable in full within 30 days of invoice. A delinquency charge of 1 1/2% per month (18 A.P.R.) may be added to any amount not paid when due.

CAUTION: Freshly mixed concrete can cause severe skin irritation or chemical burns. Avoid direct contact and use personal protection equipment. Wash exposed skin area promptly with water. MSDS sheet available from the driver.

SUBTOTAL
DISCOUNT
TAX

WATER ADDED ______

TOTAL
PREVIOUS TOTAL
GRAND TOTAL

Excessive Water is Detrimental to Concrete Performance
H2O added by Request/Authorized By

Notice my signature below indicates that I have read the health warning notice and supplier will not be responsible for any damage caused when delivering inside the curb line.

SIGN HERE
X ______________________

OUR DELIVERY LIABILITY CEASES AT CURB LINE

Yards Delivered 9.00
P.O. #

WATER ADDED_____ SLUMP_____ AIR%_____
DISCH TIME_________

TRUCK	USER LOGIN	DRIVER	TICKET NUM	TICKET ID	TIME	DATE
49	USER	DON	39839	59727	11:14	08/24/2011

LOAD SIZE	MIX CODE	SEQ	LOAD ID
5.00 yd	M-4	D	62155

MATERIAL	DESIGN QTY	REQUIRED	BATCHED	VAR	% VAR	%MOISTURE	ACTUAL WAT
PORTLAND	825.0 lb	4125.0 lb	4115.0 lb	-10.0	-.24%		
ROCK	1354 lb	6817 lb	6820 lb	3	0.04%	0.700% M	5.68 gl
SAND	1435 lb	7318 lb	7250 lb	-68	-.93%	2.000% M	17.03 gl
AIR	4.20 oz	21.00 oz	21.00 oz	0.00	0.00%		
W/R 82	3.00 /C	123.75 oz	123.00 oz	-.75	-.61%		
WATER	36.00 gl	157.13 gl	157.00 gl	-.13	-.08%		157.00 gl

NON SIMULATED NUM BATCHES: 1
LOAD TOTAL: 19505 lb DESIGN W/C: 0.364 WATER/CEMENT: 0.365T DESIGN WATER: 180.0 gl ACTUAL WATER: 179.7 gl
SLUMP: 4.00 " WATER IN TRUCK: 0.0 gl ADJUST WATER: 0.0 gl /load TRIM WATER: 0.0 gl /yd

SE357

Max. water from chart = 198 gal / load

M-4 mix design
- 5.0 cubic yards batched

Aggregate water
- 5.68 + 17.03 = 22.71 gals/load

Plant water
- 157 gals plant water

Total water
- **179.71** total water

MAX water
- **198** gals for 5 cubic yards
- 18.3 gals max water allowed to be added to the load
- Or 18.3 gals/5 cubic yards = 3.7 gals per cubic yard

Proportion Table 1
Concrete Mixes
Using Article 4110 and 4115 Aggregates
Basic Absolute Volumes of Materials Per Unit Volume of Concrete

A MIXES Basic w/c = 0.474 Max w/c = 0.532

Mix No.	Cement	Water	Air	Fine	Coarse
A-2	0.101	0.150	0.060	0.276	0.413
A-3	0.104	0.155	0.060	0.306	0.375
A-4	0.108	0.161	0.060	0.335	0.336
A-5	0.111	0.165	0.060	0.365	0.299
A-6	0.115	0.171	0.060	0.392	0.262

BR MIXES Basic w/c = 0.400 Max w/c = 0.450

Mix No.	Cement	Water	Air	Fine	Coarse
BR	0.114	0.143	0.060	*	*

C MIXES Basic w/c = 0.430 Max w/c = 0.488

Mix No.	Cement	Water	Air	Fine	Coarse
C-2	0.110	0.149	0.060	0.272	0.409
C-3	0.114	0.154	0.060	0.302	0.370
C-4	0.118	0.159	0.060	0.331	0.332
C-5	0.123	0.166	0.060	0.358	0.293
C-6	0.128	0.173	0.060	0.383	0.256

C-WR MIXES Basic w/c = 0.430 Max w/c = 0.489

Mix No.	Cement	Water	Air	Fine	Coarse
C-3WR	0.108	0.146	0.060	0.309	0.377
C-4WR	0.112	0.151	0.060	0.338	0.339
C-5WR	0.117	0.158	0.060	0.366	0.299
C-6WR	0.121	0.163	0.060	0.394	0.262

D MIXES Basic w/c = 0.423 Max w/c = 0.450

Mix No.	Cement	Water	Air	Fine	Coarse
D-57	0.134	0.178	0.060	0.314	0.314
D-57-6	0.134	0.178	0.060	0.377	0.251

M MIXES Basic w/c = 0.328 Max w/c = 0.400

Mix No.	Cement	Water	Air	Fine	Coarse
M-3	0.149	0.153	0.060	0.287	0.351
M-4	0.156	0.161	0.060	0.311	0.312
M-5	0.160	0.165	0.060	0.338	0.277

O MIXES Basic w/c = 0.327 Max w/c = ------

Mix No.	Cement	Water	Air	Fine	Coarse
O-4WR	0.156	0.160	0.060	0.312	0.312

HPC-O MIXES Basic w/c = 0.390 Max w/c =0.420

Mix No.	Cement	Water	Air	Fine	Coarse
HPC-O	0.134	0.164	0.060	0.321	0.321

HPC-S MIXES Basic w/c = 0.420 Max w/c =0.450

Mix No.	Cement	Water	Air	Fine	Coarse
HPC-S	0.118	0.156	0.060	0.333	0.333

HPC-D MIXES Basic w/c = 0.400 Max w/c =0.420

Mix No.	Cement	Water	Air	Fine	Coarse
HPC-D	0.118	0.148	0.060	*	*

QMC MIXES Basic w/c = 0.400 Max w/c =0.420

Mix No.	Cement	Water	Air	Fine	Coarse
QMC	0.106	0.133	0.060	*	*

MCM MIXES Basic w/c = 0.400 Max w/c =0.450

Mix No.	Cement	Water	Air	Fine	Coarse
MCM	0.106	0.133	0.060	0.315	0.386

X MIXES Basic w/c = 0.423 Max w/c = ------

Mix No.	Cement	Water	Air	Fine	Coarse
X-2	0.124	0.165	0.000	0.284	0.427
X-3	0.129	0.171	0.000	0.315	0.385
X-4	0.134	0.178	0.000	0.344	0.344

Above mixtures are based on Type I or Type II cements (Sp. G. = 3.14). Mixes using blended cements (Type IP, IS, IL, or IT) must be adjusted for cement gravities listed in IM 401.
*These mixes require optimized aggregate proportioning in accordance with the specifications.

Proportion Table 2
Concrete Mixes
Using Class V Aggregates Combined with Limestone
Basic Absolute Volumes of Materials Per Unit Volume of Concrete

V47B MIXES

Mix No.	Cement	Water	Air	Class V.	Coarse Limestone	Basic w/c	Max. w/c
A-V47B	0.107	0.148	0.060	0.479	0.206	0.440	0.560
C-V47BF[1]	0.113	0.145	0.060	0.477	0.205	0.430	0.488
C-V47BS[3]	0.113	0.145	0.060	0.477	0.205	0.430	0.488
M-V47B[2]	0.155	0.170	0.060	0.338	0.277	0.350	0.400

V MIXES

Mix No.	Cement	Water	Air	Class V.	Fine Limestone	Basic w/c	Max. w/c
A-V	0.135	0.188	0.060	0.586	0.031	0.444	0.467
C-V	0.135	0.188	0.060	0.586	0.031	0.444	0.467
M-V	0.160	0.196	0.060	0.555	0.029	0.390	0.420

CV-HPC MIXES

Mix No.	Cement	Water	Air	Class V.	Coarse Limestone	Basic w/c	Max. w/c
CV-HPC-D[1]	0.123	0.147	0.060	0.368	0.302	0.400	0.420
CV-HPC-S[1]	0.123	0.155	0.060	0.364	0.298	0.420	0.450

Above mixtures are based on Type I or Type II cements (Sp. G. = 3.14). Mixes using blended cements (Type IP, IS, IL, or IT) must be adjusted for cement gravities listed in IM 401.

[1]When Type IP cement is used.
[2]M-V47B mix shall use Type I/II cements for patching projects.
[3]When Type IS cement is used.

Proportion Table 3
Concrete Mixes
Using Class L Aggregates
Basic Absolute Volumes of Materials Per Unit Volume of Concrete

A-L MIXES Basic w/c = 0.474 Max w/c = 0.532

Mix No.	Cement	Water	Air	Fine	Coarse
A-L-2	0.107	0.159	0.060	0.270	0.404
A-L-3	0.111	0.165	0.060	0.299	0.365
A-L-4	0.115	0.171	0.060	0.327	0.327
A-L-5	0.118	0.176	0.060	0.355	0.291

C-L MIXES Basic w/c = 0.430 Max w/c = 0.488

Mix No.	Cement	Water	Air	Fine	Coarse
C-L-2	0.117	0.158	0.060	0.266	0.399
C-L-3	0.121	0.163	0.060	0.295	0.361
C-L-4	0.125	0.169	0.060	0.323	0.323
C-L-5	0.131	0.177	0.060	0.348	0.284

C-LWR MIXES Basic w/c = 0.430 Max w/c = 0.489

Mix No.	Cement	Water	Air	Fine	Coarse
C-L3WR	0.115	0.155	0.000	0.301	0.369
C-L4WR	0.119	0.161	0.000	0.330	0.330
C-L5WR	0.124	0.167	0.000	0.357	0.292

Above mixtures are based on Type I or Type II cements (Sp. G. = 3.14). Mixes using blended cements (Type IP, IS, IL, or IT) must be adjusted for cement gravities listed in IM 401.

Proportion Table 4
SUDAS Concrete Mixes
Using Article 4110 and 4115 Aggregates
Basic Absolute Volumes of Materials Per Unit Volume of Concrete

C-SUD MIXES Basic w/c = 0.400 Max w/c = 0.420

Mix No.	Cement	Water	Air	Fine	Coarse
C-SUD	0.106	0.133	0.060	*	*

Above mixture is based on Type I or Type II cements (Sp. G. = 3.14). Mixes using blended cements (Type IP, IS, IL, or IT) must be adjusted for cement gravities listed in IM 401. *These mixes require optimized aggregate proportioning in accordance with the specifications.

Using Class V Aggregates (4117) Combined with Limestone
Basic Absolute Volumes of Materials Per Unit Volume of Concrete

CV-SUD MIXES Basic w/c = 0.400 Max w/c = 0.420

Mix No.	Cement	Water	Air	Class V.	Coarse Limestone
CV-SUD	0.114	0.135	0.060	0.379	0.311

Above mixture is based on Type IP cements.

Concrete Specifications Summary - October 2023
(U.S. Units)

Caution: Consult the applicable specifications for required air content and slump before using this chart.

	Type of Concrete	Slump (in.) Min.	Slump (in.) Target	Slump (in.) Max.	% Air Content Min.	% Air Content Target	% Air Content Max	Specification Reference
Paving								
Slip form	A~~B~~C, QMC				6	8	10	2301.02 B
Non-slip form	A~~B~~C, QMC	0.5		4	5.5	7	8.5	2301.02 B
Concrete Base (Non-slip form)	A, C	0.5		4	5.5	7	8.5	2301.02 & 2201
Curb and gutter (slip form)	C				6	8	10	2512.02 & 2301.02
Curb and gutter (Non-slip form)	C	0.5		4	5.5	7	8.5	2512.02 & 2301.02
Sidewalk	~~B,~~ C			4	5.5	7	8.5	2511.02 & 2301.02
Intakes and manholes	C			4	5.5	6.5	8.5	2403.02
Repair								
Patches with $CaCl_2$	M	1	2.5	3	3	5	7	2530.02 B & 2529.02 B
		(prior to addition of $CaCl_2$)						
Patches without $CaCl_2$	M	1	3	4	5	6.5	8	2530.02 B & 2529.02 B
		1	4	5				
		(when Mid-Range WR used)						
Underseal and grouting, flowing mortar		By Flow Cone						2539.02 B & 2506
Overlays								
Unbonded, white topping Bonded	C, QMC	same as specified concrete						2310.02
Lighting & Highway Signing								
Foundation	C	1	4	5	5.5	6.5	8.5	2403.02 A & B

Concrete Specifications Summary - October 2023
(U.S. Units)

Caution: Consult the applicable specifications for required air content and slump before using this chart.

Structures	Type of Concrete	Slump (in.) Min.	Slump (in.) Target	Slump (in.) Max.	% Air Content Min.	% Air Content Target	% Air Content Max	Specification Reference
Seal Coat	X	0		8				2405.02 D
Sub-Structure & Super-structure	C HPC	1	4	5	5.5 5.5	6.5 7.5	8.5 9.5	2403.02 A & B 2412.02
					(when placed by pumping/belting)			
Slope Protection	C	1		3	5.5	6.5	8.5	On the Plan Sheet
Piling encased & Piling brg. (encased)	C	1	4	5	5.5	6.5	8.5	2403 - 2501.03 E
Bridge Deck Overlay	O HPC	0 1	0.75 4	1 5	5.5	6.5	8.5	2413.02 D.1 2413.02 D.2
Bride Deck - Class B Repair	O or D	1		3	5.5	6.5	8.5	2403.02 B, 2412 (2413.03 D)
Barrier Rail - Cast in place	C	1	4	5	6	7	8.5	2513.03 A 2403 2414.02
Barrier Rail - Slipform	BR				6	7	8.5	2513.03 A 2403 2414.02

Guardrail

Structures	Type of Concrete	Slump (in.) Min.	Slump (in.) Target	Slump (in.) Max.	% Air Content Min.	% Air Content Target	% Air Content Max	Specification Reference
End anchors	C	1	4	5	4		7	2403.02 & 2505.03 B

Concrete Specifications Summary - October 2023
(U.S. Units)

Caution: Consult the applicable specifications for required air content and slump before using this chart.

Paving	**Type of Concrete**	**Slump (in.) Min.**	**Slump (in.) Target**	**Slump (in.) Max.**	**% Air Content Min.**	**% Air Content Target**	**% Air Content Max**	**Specification Reference**
Slip form	A~~B~~C, QMC				6	8	10	2301.02 B
Non-slip form	A~~B~~C, QMC	0.5		4	5.5	7	8.5	2301.02 B
Concrete Base (Non-slip form)	A, C	0.5		4	5.5	7	8.5	2301.02 & 2201
Curb and gutter (slip form)	C				6	8	10	2512.02 & 2301.02
Curb and gutter (Non-slip form)	C	0.5		4	5.5	7	8.5	2512.02 & 2301.02
Sidewalk	~~B,~~ C			4	5.5	7	8.5	2511.02 & 2301.02
Intakes and manholes	C			4	5.5	6.5	8.5	2403.02

Repair

Patches with $CaCl_2$	M	1	2.5	3	3	5	7	2530.02 B & 2529.02 B
		(prior to addition of $CaCl_2$)						
Patches without $CaCl_2$	M	1	3	4	5	6.5	8	2530.02 B & 2529.02 B
		1	4	5				
		(when Mid-Range WR used)						
Underseal and grouting, flowing mortar		By Flow Cone						2539.02 B & 2506

Overlays

Unbonded, white topping Bonded	C, QMC	same as specified concrete						2310.02

Lighting & Highway Signing

Foundation	C	1	4	5	5.5	6.5	8.5	2403.02 A & B

Concrete Specifications Summary - October 2023
(U.S. Units)

Caution: Consult the applicable specifications for required air content and slump before using this chart.

Structures	Type of Concrete	Slump (in.) Min.	Slump (in.) Target	Slump (in.) Max.	% Air Content Min.	% Air Content Target	% Air Content Max	Specification Reference
Seal Coat	X	0		8				2405.02 D
Sub-Structure & Super-structure	C HPC	1	4	5	5.5 5.5	6.5 7.5	8.5 9.5	2403.02 A & B 2412.02
					(when placed by pumping/belting)			
Slope Protection	C	1		3	5.5	6.5	8.5	On the Plan Sheet
Piling encased & Piling brg. (encased)	C	1	4	5	5.5	6.5	8.5	2403 - 2501.03 E
Bridge Deck Overlay	O	0	0.75	1	5.5	6.5	8.5	2413.02 D.1
	HPC	1	4	5				2413.02 D.2
Bride Deck - Class B Repair	O or D	1		3	5.5	6.5	8.5	2403.02 B, 2412 (2413.03 D)
Barrier Rail - Cast in place	C	1	4	5	6	7	8.5	2513.03 A 2403 2414.02
Barrier Rail - Slipform	BR				6	7	8.5	2513.03 A 2403 2414.02

Guardrail

Structures	Type of Concrete	Slump (in.) Min.	Slump (in.) Target	Slump (in.) Max.	% Air Content Min.	% Air Content Target	% Air Content Max	Specification Reference
End anchors	C	1	4	5	4		7	2403.02 & 2505.03 B

PERFORMANCE EXAM CHECKLIST

TEMPERATURE OF FRESHLY MIXED CONCRETE

Participant Name______________________________________ Exam Date__________

Procedure Element	YES	NO
1. Obtain sample of concrete large enough to provide a minimum of 3 inches of concrete cover around sensor in all directions?	______	______
2. Use calibrated thermometer: • Accurate to ± 1.0º F? • Temperature range from 0 to 120º F?	______	______
3. Place thermometer in sample with a minimum of 3 inches cover around sensor?	______	______
4. Gently press concrete around thermometer?	______	______
5. Read temperature after a minimum of 2 minutes or when temperature reading stabilizes?	______	______
6. Complete temperature measurement within 5 minutes of obtaining sample?	______	______
7. Record temperature to nearest 1.0º F?	______	______

COMMENTS: Pass _____ Fail _____

PERFORMANCE EXAM CHECKLIST

SLUMP OF HYDRAULIC CEMENT CONCRETE

Participant Name_____________________________________ Exam Date____________

Procedure Element	YES	NO
1. Cone and floor base plate dampened?	_____	_____
2. Cone held firmly against the base by standing on the two foot pieces? Cone not allowed to move in any way during filling?	_____	_____
3. Representative samples scooped into the cone?	_____	_____
4. Cone filled in three approximately equal layers (by volume), the first to a depth of 2⅝ in., the second to a depth of 6⅛ in., and the third to just over the top of the cone?	_____	_____
5. Each layer rodded throughout its depth 25 times with hemispherical end of rod, uniformly distributing strokes?	_____	_____
6. Middle and top layers rodded to just penetrate into the underlying layer?	_____	_____
7. When rodding the top layer, excess concrete kept above the mold at all times?	_____	_____
8. Concrete struck off level with top of cone using tamping rod?	_____	_____
9. Cone lifted upward 12 in. in one smooth motion, without twisting the cone, in 5±2 seconds?	_____	_____
10. Slump measured to the nearest ¼" from the top of the cone to the displaced original center of the top surface of the specimen?	_____	_____
11. Test performed from the start to finish within 2½ minutes	_____	_____

COMMENTS: Pass _____ Fail _____

PERFORMANCE EXAM CHECKLIST

DENSITY AND YIELD OF CONCRETE

Participant Name ___________________________________ Exam Date ____________

Procedure Element	YES	NO
1. Weight of empty measure determined?	_____	_____
2. Measure filled in three equal layers, slightly overfilling the last layer?	_____	_____
3. Each layer rodded throughout its depth 25 times with hemispherical end of rod, uniformly distributing strokes?	_____	_____
4. Middle and top layers rodded, each throughout their depths and penetrating the previous layer by approximately 1 in. into the underlying layer?	_____	_____
5. Sides of the measure tapped 10-15 times with the mallet after rodding each layer?	_____	_____
6. Any excess concrete removed using a trowel or a scoop, or small quantity of concrete added to correct a deficiency, after consolidation of final layer?	_____	_____
7. Concrete struck off to a smooth surface with the flat strike-off plate?	_____	_____
8. All excess concrete cleaned off and weight of full measure determined?	_____	_____
9. Net weight calculated?	_____	_____
10. Density calculated	_____	_____

COMMENTS: Pass ______ Fail ______

PERFORMANCE EXAM CHECKLIST

AIR CONTENT OF FRESHLY MIXED CONCRETE BY THE PRESSURE METHOD

Participant Name ______________________________ Exam Date ____________

	Procedure Element	YES	NO
1.	Representative sample selected?	_____	_____
2.	Container filled in three equal layers, slightly overfilling the last layer?	_____	_____
3.	Each layer rodded throughout its depth 25 times with hemispherical end of rod, uniformly distributing strokes?	_____	_____
4.	Bottom layer rodded throughout it depth, without forcibly striking the bottom of the container?	_____	_____
5.	Middle and top layers rodded, each throughout their depths and penetrating 1 in. into the underlying layer?	_____	_____
6.	Sides of the container tapped 10-15 times with the mallet after rodding each layer?	_____	_____
7.	Concrete struck off level with top of container using the bar and rim cleaned off?	_____	_____
8.	Inside of cover cleaned and moistened before clamping to base?	_____	_____
9.	Both petcocks open?	_____	_____
10.	Air valve closed between air chamber and the bowl?	_____	_____
11.	Water injected through petcock until flows out the other petcock?	_____	_____
12.	Water injection into the petcock continued while jarring and tapping the meter to insure all air is expelled?	_____	_____

Procedure Element
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13. Air pumped up to initial pressure line? ______ ______

14. A few seconds allowed for the compressed air to stabilize? ______ ______

15. Gauge adjusted to the initial pressure? ______ ______

16. Both petcocks open? ______ ______

17. Air valve opened between chamber and bowl? ______ ______

18. Sides of bowl tapped with the mallet? ______ ______

19. Air percentage read after lightly tapping the gage to stabilize the hand? ______ ______

20. Air valve closed and then petcocks opened to release pressure before removing the cover? ______ ______

21. Air content recorded to 0.1 percent? ______ ______

COMMENTS: Pass ______ Fail ______

PERFORMANCE EXAM CHECKLIST

CASTING 4 X 4 FLEXURAL STRENGTH

SPECIMENS BY RODDING

Participant Name______________________________________ Exam Date ________________

Performance Element	YES	NO
1. Obtain a representative sample of concrete.	_____	_____
2. Flat, rigid surface as near as practicable to initial curing location.	_____	_____
3. Mold is properly assembled, oiled, and tight.	_____	_____
4. Place the first layer of concrete evenly across the surface area to half the mold depth.	_____	_____
5. Rod the first layer 28 times (1 per 2 in^2) evenly distributing roddings across the surface area.	_____	_____
6. Strike the sides of mold with a rubber hammer 10 to 15 times.	_____	_____
7. Place the second layer of concrete evenly across the surface area overfilling slightly.	_____	_____
8. Rod the second layer 28 times (1 per 2 in^2) evenly distributing roddings across the surface area and penetrating approximately 1 inch into the first layer.	_____	_____
9. Strike the sides of mold with a rubber hammer 10 to 15 times.	_____	_____
10. Using a strike off bar finish the surface eliminating excess concrete and finishing the concrete even with the mold and free of bumps or dips.	_____	_____
11. Clean the mold of any concrete and carefully and lightly inscribe a chronological number near the beam end.	_____	_____
12. Properly cure the for 20 +/- 4 hours before moving.	_____	_____

COMMENTS Pass_____ Fail_____

PERFORMANCE EXAM CHECKLIST

FLEXURAL STRENGTH OF CONCRETE USING SIMPLE BEAM WITH CENTER-POINT LOADING

Participant Name______________________________________ Exam Date ________________

Performance Element	YES	NO
1. Draw a reference line on the top and bottom of the beam, as cast at the midpoint from the beam ends?	_____	_____
2. Insert stirrup pins on a 6 X 6 machine.	_____	_____
3. Place beam in machine so the two reference lines are directly under the center line of center bearing?	_____	_____
4. Rotate micro pump handle		
(a) Expose the maximum thread?	_____	_____
(b) Close loading valve on pump?	_____	_____
5. Apply a small initial load. On a 6 X 6 machine remove stirrup pins.	_____	_____
6. Apply load		
(a) Rapidly to approximate 50% of estimated load with Pump handle?	_____	_____
(b) Final half of the loading is accomplished by turning crank of the micro pump, at a rate not to exceed 1200 pounds per minute for 6 X 6 beams and 500 pounds per minute for 4 X 4 beams.	_____	_____
7. Measure to nearest .05 inch to determine average width and depth of the specimen at the section of failure?	_____	_____

Pass_____ Fail_____

COMMENTS:

PERFORMANCE EXAM CHECKLIST

MEASURING CORE LENGTH (9 POINT)

Participant Name_______________________________________ Exam Date_________

Performance Element	YES	NO
1.Place stand on guide rods and place core on stand for center point measurement. Surface of core should be in contact with fixed end of device.	_____	_____
2. Slide movable plate until the stud is in contact with the specimen. Read measurement directly to the 0.10 in. and interpolate to the nearest 0.05 in. Record the length to the nearest 0.05 in.	_____	_____
3. Remove the core and stand. Place core directly on the guide rods and make another measurement.	_____	_____
4. Place the small auxiliary wheel on the core so the scribed marks are in alignment. Rotate the core until the marks are again in alignment (1/2 rotation of the wheel). Make another measurement.	_____	_____
5. Continue rotating the core until 8 total measurements around the circumference have been recorded.	_____	_____
6. The core length is the average of the 9 measurements to the nearest 0.05 in. If core has been damaged at a location, disregard that area. No fewer than 7 measurements are to be used to determine the core length.	_____	_____

COMMENTS: Pass_____ Fail______