



Illinois Department of Transportation

PORTLAND CEMENT
CONCRETE
LEVEL II
TECHNICIAN COURSE

“Manual of Instructions for Concrete Proportioning”

Effective: November 4, 1994
Revised: December 1, 2012



Illinois Department of Transportation

Departmental Policies

MAT-17

Effective Date: December 1, 2007
Scheduled Review Date: December 1, 2013

PORTLAND CEMENT CONCRETE LEVEL II TECHNICIAN COURSE - MANUAL OF INSTRUCTIONS FOR CONCRETE PROPORTIONING

1. POLICY

It is the policy of the Department of Transportation to publish and maintain a manual which provides guidelines for proportioning concrete mixtures at the plant.

2. PURPOSE

The purpose of this Policy is to provide for the publication of a manual to serve as a guide and source of reference for the practices and procedures for those involved in the proportioning of concrete mixtures at the plant.

3. GUIDELINES FOR IMPLEMENTATION

- A. The manual is prepared with emphasis on practices and procedures currently used by the department.
- B. The manual is intended to train individuals in the proportioning of concrete mixtures at the plant.
- C. Department training classes shall utilize the current edition of this manual for all applicable procedures.
- D. The manual contains proportioning procedures that will provide uniformity of work performed by the contractor, the department or consultants retained by either.

4. RESPONSIBILITIES

The following outlines the individual and office responsibilities to ensure compliance with the provisions of this Policy and its accompanying manual.

- A. The Bureau of Materials and Physical Research (BMPR) is responsible for the issuance of this Policy.

- B. The Division of Highways' (DOH) regions/districts are responsible for ensuring compliance with this Policy.
- C. The Engineer of Concrete and Soils of the DOH's BMPR Materials Testing Section shall be contacted when questions arise regarding the application of these procedures.

5. ACCESSIBILITY

A. LOCATION

Electronic versions of this Policy and its accompanying manual are located at the Policy & Research Center site on InsideIDOT, the department's internal website. Electronic versions can also be found at <http://www.dot.il.gov/materials/guidesmanuals.html>.

Questions regarding the manual may be directed to the Bureau of Materials and Physical Research, 126 East Ash Street, Springfield, Illinois 62704-4766

B. COPIES

Hard copies of Departmental Policies may be obtained by contacting the Bureau of Business Services (BoBS), Quality and Document Management Services Section.

C. ARCHIVES & REVISION HISTORY

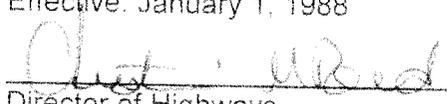
Archived versions of this Policy and its revision history may be examined by contacting BMPR.

CLOSING NOTICE

Manual: Portland Cement Concrete Level II Technician Course - Manual of Instructions for Concrete Proportioning.

Supersedes: MAT-8. Manual of Instructions for Concrete Proportioning and Testing.
Effective: January 1, 1988

Approved:



Director of Highways

12/23/08

Date

**LAKE LAND COLLEGE
INSTRUCTOR AND COURSE EVALUATION**

Course: PCC Level II Technician Course **Section:** _____ **Date:** _____

PURPOSE: The main emphasis at Lake Land College is teaching. In this regard, each instructor must be continuously informed of the quality of his/her teaching and the respects in which that teaching can be improved. As a student, you are in a position to judge the quality of teaching from direct experience, and in order to help maintain the quality of instruction at Lake Land, you are asked to complete this evaluation.

DIRECTIONS: **DO NOT SIGN YOUR NAME.** Your frankness and honesty are appreciated.

First, please record your general impressions and/or comments on the following:

Course _____

Instructor _____

For each remaining item, circle the number from the scale which seems most appropriate to you for the instructor and course that you are evaluating. You are strongly encouraged to make any comments that will clarify particular rating on the back of this form; please refer to each item you are discussing by its number.

WEAK SUPERIOR

OBJECTIVES AND APPROPRIATENESS OF THE COURSE:

- | | | | | | | | |
|----|------------------------------|---|---|---|---|---|---|
| 1. | Clarity of Objectives | The objectives of the course were clearly identified. Objectives were adequately covered. | 1 | 2 | 3 | 4 | 5 |
| 2. | Selection content | Content was relevant and met the level of the class. | 1 | 2 | 3 | 4 | 5 |

ORGANIZATION AND CONTENT OF LESSONS:

- | | | | | | | | |
|----|--------------------------------|--|---|---|---|---|---|
| 3. | Teacher preparation | Instructor was organized and knowledgeable in subject matter and prepared for each class. | 1 | 2 | 3 | 4 | 5 |
| 4. | Organization of classes | Classroom activities were well organized and clearly related to each other. | 1 | 2 | 3 | 4 | 5 |
| 5. | Selection of materials | Instructional materials and resources used specific, current, and clearly related to the objectives of the course. | 1 | 2 | 3 | 4 | 5 |
| 6. | Clarity of presentation | Content of lessons was presented so that it was understandable to the students. | 1 | 2 | 3 | 4 | 5 |
| 7. | Clarity of presentation | Different point of view and/or methods with specific illustrations were used when appropriate. | 1 | 2 | 3 | 4 | 5 |

OVER

**LAKE LAND COLLEGE
INSTRUCTOR AND COURSE EVALUATION
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		<u>WEAK</u>				<u>SUPERIOR</u>	
<u>PERSONAL CHARACTERISTICS AND STUDENT RAPPORT:</u>							
8.	Vocabulary	Instructor's vocabulary level was appropriate for the class.	1	2	3	4	5
9.	Pupil participation and interest	Instructor encouraged students to ask questions and actively participate in class.	1	2	3	4	5
10.	Personal attributes	Instructor indicated an interest and enthusiasm for teaching the subject matter.	1	2	3	4	5
11.	Personal attributes	Instructor was familiar with current industry practices.	1	2	3	4	5
12.	Personal attributes	Instructor's mannerisms were pleasing.	1	2	3	4	5
13.	Instructor-student rapport	Instructor indicated a willingness to help you in times of difficulty.	1	2	3	4	5
14.	Instructor-student rapport	Instructor was fair and impartial in dealings with you.	1	2	3	4	5
<u>EXAMINATION:</u>							
15.	Exam material	The exam correlated to the materials being covered in class.	1	2	3	4	5
<u>SUMMARY:</u>							
16.	Considering everything, how would you rate this instructor?		1	2	3	4	5
17.	Considering everything, how would you rate this course?		1	2	3	4	5

COMMENTS: (Please use the area below to add any additional comments regarding the class and exam.)

COURSE REQUIREMENTS FOR SUCCESSFUL COMPLETION

Student must attend all class sessions.

- **PREREQUISITE COURSES** — Either the Mixture Aggregate Technician Course (3-day) or the Aggregate Technician Course (5-day), and the Portland Cement Concrete Level I Technician Course are required. However, these courses are not required before you enroll in the Portland Cement Concrete Level II Technician Course.
- **WRITTEN TEST** — The test is open book. The time limit is 2 hours. A minimum grade of 70 is required.

Note: The Department has no out-of-state reciprocity.

- **WRITTEN RETEST** — If the student fails the written test, a retest can be performed. The test is open book. The time limit is 2 hours. A minimum grade of 70 is required. A retest will not be given on the same day as the initial test. A retest must be taken by the end of the academic year that the initial test was taken. The academic year runs from September 1st to August 31st. **(For example, if the test was taken January 18, 2013, the last date to retest is August 31, 2013.)** Failure of the written retest, or failure to comply with the academic year retest time limit, shall require the student to retake the class and the test. The student shall be required to pay the appropriate fee for the additional class.
- **NOTIFICATION** — The student will be notified by letter of their test score. A certificate of completion will be issued if the student passes the course, and 12 professional development hours earned will be indicated on the certificate. Once trained, the Department will not require the individual to take the class again for recertification purposes.

PREFACE

This manual has been prepared to train the student to become a Level II PCC Technician. The manual discusses the various aspects to proportion portland cement concrete, for Illinois Department of Transportation (herein referred to as "IDOT" or the "Department"), Quality Control/Quality Assurance (QC/QA) projects. The manual discusses various test methods, but any question regarding the correct test method shall be resolved by the Manual of Test Procedures for Materials, which has precedence over this manual. The manual provides basic information, and is intended to be a useful reference tool. This manual is applicable for the January 1, 2012, Standard Specifications for Road and Bridge Construction, the Portland Cement Concrete (BDE) Special Provision, Revised: January 1, 2013 and the Placing and Consolidating Concrete (BDE) Special Provision, Effective: January 1, 2013. It shall be noted that Section 1020 in the Portland Cement Concrete (BDE) Special Provision completely replaces Section 1020 in the Standard Specifications. Therefore, any reference to an Article in Section 1020 in this manual is referring to the Portland Cement Concrete (BDE) Special Provision.

Revision History and Document Control

The Portland Cement Concrete Level II Technician Course Manual will be reviewed by the Engineer of Concrete and Soils for adequacy annually and updated as necessary to reflect the current policies and technology changes. Updates are made to the electronic file as needed and hard copies are uncontrolled. Archive versions are available to examine in the Bureau of Material and Physical Research.

<u>Revision Date</u>	<u>Description</u>	<u>Approval</u>
December 1, 2012	Revised information in Preface regarding the updated Portland Cement Concrete (BDE) Special Provision, and added a reference to the Placing and Consolidating Concrete (BDE) Special Provision.	Doug Dirks
December 1, 2012	Updated page numbers in Table of Contents.	Doug Dirks
December 1, 2012	Revised section titles for 5.4.3.2, 5.4.3.3, 5.4.3.4, and 5.4.3.5 in Table of Contents.	Doug Dirks
December 1, 2012	Added definitions for "Cold Joint" and "Supplementary Cementitious Material" to Definitions.	Doug Dirks
December 1, 2012	Revised designations for Illinois Modified AASHTO test procedures for aggregates to Illinois Test Procedure designations in Summary of Test Methods.	Doug Dirks
December 1, 2012	Added Class PC "Precast Concrete" and Class PS "Precast Prestressed" to Class of Concrete.	Doug Dirks
December 1, 2012	Revised Section 3.2 "Calibration of Plant Scales" with respect to increment of loading, conducting sensitivity checks.	Doug Dirks
December 1, 2012	Revised Section 3.3 "Calibration of Plant Water Meter" to clarify the process and provide example calculations.	Doug Dirks
December 1, 2012	Added Table 3.3.1 "Density of Water at Different Temperatures" for calibrating plant water meters.	Doug Dirks
December 1, 2012	Revised Section 4.2.3 "Admixtures and Dispensers" to recommend the admixture company calibrate dispensers annually, and be contacted when problems arise with dispensers.	Doug Dirks
December 1, 2012	Revised Section 4.2.4 "Moisture Sensor" with updated Illinois Test Procedure designations.	Doug Dirks
December 1, 2012	Updated Section 4.2.7 "Condition of Trucks" to include requirements for minimum revolutions for self-consolidating concrete.	Doug Dirks
December 1, 2012	Added Section 4.3.3 "Mobile Mixer and Quality Control" to include recommendations for when to conduct quality control testing.	Doug Dirks
December 1, 2012	Updated Section 4.4 "Sampling and Testing Frequency at the Plant" to include self-consolidating concrete test methods.	Doug Dirks

<u>Revision Date</u>	<u>Description</u>	<u>Approval</u>
December 1, 2012	Updated reference to Article 1020.11 in Section 4.5.1 "Production and Delivery" to read Article 1020.11(a)(8).	Doug Dirks
December 1, 2012	Revised volumetric proportioning example calculations in Section 5.3 "Volumetric Proportioning Diagram".	Doug Dirks
December 1, 2012	Revised sections 5.4.2 "Total Moisture and Absorption" and 5.4.3.2 "Illinois Test Procedure 255" with updated Illinois Test Procedure designations.	Doug Dirks
December 1, 2012	Revised titles to sections 5.4.3.3, 5.4.3.4, and 5.4.3.5 to put the Illinois Test Procedure designation first.	Doug Dirks
December 1, 2012	Revised water adjustment example calculations in Section 5.5.1 "Adjusting Batch Weights for Moisture".	Doug Dirks
December 1, 2012	Revised Section 5.6 "Water-Cement Control" to reference Class PC (dry cast) concrete, and to include water in admixture for consideration.	Doug Dirks
December 1, 2012	Revised example calculations in Section 5.6 "Water-Cement Control" to reference Article 1020.05(b).	Doug Dirks
December 1, 2012	Revised Section 5.7.3 "Water/Cement Ratio" to simplify the options to increase slump once the maximum w/c ratio has been reached.	Doug Dirks
December 1, 2012	Revised Section 6.1.1 "Fine Aggregate Grading" to include recommendations for fineness modulus when slipforming.	Doug Dirks
December 1, 2012	Revised Section 6.1.2 "Coarse Aggregate Grading" to include recommendations for larger size aggregate in mass concrete.	Doug Dirks
December 1, 2012	Revised Section 6.1.5 "Aggregate Particle Shape" with updated Illinois Test Procedure designation.	Doug Dirks
December 1, 2012	Revised Section 6.1.6 "Aggregate Moisture Uniformity" to add wording regarding crushed concrete moisture.	Doug Dirks
December 1, 2012	Revised second paragraph of Section 6.1.7 "Aggregate Uniformity".	Doug Dirks
December 1, 2012	Added second paragraph to Section 6.1.8 "Aggregate Absorption and Specific Gravity" to note the effects of batching high absorption aggregate on the dry side.	Doug Dirks
December 1, 2012	Added to bullet points to Section 6.2.2 "Influence" regarding cement loss on ignition (LOI) and anhydrite.	Doug Dirks
December 1, 2012	Revised first bullet point of Section 6.3.1.5 "Influence" to account for carbon content in fly ash.	Doug Dirks
December 1, 2012	Corrected reference to GGBF slag in Section 6.3.2.2 "Use - General", and made reference to Article 1020.04 in the eighth paragraph.	Doug Dirks
<u>Revision Date</u>	<u>Description</u>	<u>Approval</u>

December 1, 2012	Updated reference to Article 1020.05(c)(3) in Section 6.3.3.1 "Use".	Doug Dirks
December 1, 2012	Updated reference to Article 1020.05(c)(4) in Section 6.3.4.1 "Use".	Doug Dirks
December 1, 2012	Revised Section 6.4.1, "General" to note admixtures should not be put directly on dry aggregate.	Doug Dirks
December 1, 2012	Revised the first bullet point in Section 6.4.4.1 "Types".	Doug Dirks
December 1, 2012	Revised Section 6.4.5 "Retarding Admixture" to allow for haul time, and to specify how long Class DS concrete should remain fluid.	Doug Dirks
December 1, 2012	Revised last paragraph of Section 6.4.5.2 "Quality Control" to note the effects of over-retarded concrete.	Doug Dirks
December 1, 2012	Added a second paragraph to Section 6.8 "Synthetic Fibers" to note their use in slipformed curb and gutter. Also added a final bullet point regarding large amounts of finely divided minerals.	Doug Dirks
December 1, 2012	Added a recommendation to the second bullet point of Section 7.1 "Pumping Concrete" regarding presoaking aggregate and added another bullet point at the end.	Doug Dirks
December 1, 2012	Added a note to Section 7.2 "Hot Weather" regarding mass concrete.	Doug Dirks
December 1, 2012	Revised the fourth bullet point of Section 7.2.1 "Temperature Effects" regarding cold joints.	Doug Dirks
December 1, 2012	Revised temperature ranges in the fourth and fifth bullet points of Section 7.2.2 "Taking Precautions at the Plant".	Doug Dirks
December 1, 2012	Added a paragraph to the first bullet point of Section 8.1.2 "Troubleshooting" regarding aggregate absorption. Also, added note to the fifth bullet point regarding entraining air in slipformed concrete.	Doug Dirks
December 1, 2012	Added recommendation to the first bullet point of Section 8.2.2 "Troubleshooting" regarding aggregate absorption.	Doug Dirks
December 1, 2012	Updated figure in Section 11.6 "Voids in Coarse Aggregate".	Doug Dirks
December 1, 2012	Revised figure wording in Section 11.7 "Mortar Factor".	Doug Dirks
December 1, 2012	Updated website address for the American Concrete Institute in Section 12.0 "Various Publications".	Doug Dirks
December 1, 2012	Added references to self-consolidating concrete (SCC) to No. 8 of Section 16.0 "Proportioning Inspection (For IDOT Personnel)".	Doug Dirks

<u>Revision Date</u>	<u>Description</u>	<u>Approval</u>
December 1, 2012	Updated the "Quality Control/Quality Assurance of	Doug Dirks

	Concrete Mixtures (BDE)” Special Provision (Revised: January 1, 2013) in Appendix A.	
December 1, 2012	Updated “Qualifications and Duties of Concrete Quality Control Personnel” (Revised: June 1, 2012) in Appendix B.	Doug Dirks
December 1, 2012	Updated Policy Memorandum 16-08.1 “Approval of Concrete Plants and Delivery Truck,” and inserted updated forms (BMPR PCC001, PCC002, and PCC003) in Appendix C.	Doug Dirks
December 1, 2012	Updated Policy Memorandum 11-08.2 “Aggregate Gradation Control System (AGCS)” and Policy Memorandum 10-08.1 “Use of Non-Certified Aggregate Stockpiles Under the Aggregate Gradation Control System (AGCS)” in Appendix D.	Doug Dirks
December 1, 2012	Updated “Development of Gradation Bands on Incoming Aggregate at Mix Plants” (Revised: June 1, 2012) in Appendix E.	Doug Dirks
December 1, 2012	Updated “Required Sampling and Testing Equipment for Concrete” (Revised: June 1, 2012) in Appendix F.	Doug Dirks
December 1, 2012	Updated “Model Quality Control Plan for Concrete Production” (Revised: June 1, 2012) in Appendix H.	Doug Dirks
December 1, 2012	Replaced Illinois Modified Test Procedure AASHTO T 255 with “Illinois Test Procedure 255” (Effective June 1, 2012) in Appendix I.	Doug Dirks
December 1, 2012	Updated forms BMPR MI504, MI654, MI655, and their respective instructions in Appendix K.	Doug Dirks
December 1, 2012	Updated “Plant or Jobsite Documentation Example Format” in Appendix L.	Doug Dirks
December 1, 2012	Updated “PCC Mix Design Computer Printout and Instructions” in Appendix N.	Doug Dirks
December 1, 2012	Updated forms BMPR PCCQ01, PCCQ02, PCCQ03, PCCQ04, and PCCQ05 (Revised: September 1, 2012) in Appendix O.	Doug Dirks
December 1, 2012	Updated Policy Memorandum 20-08.1 “Field Test Procedures for Mixer Performance and Concrete Uniformity Tests” in Appendix P.	Doug Dirks

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DEFINITIONS

Abrasion — A wearing away of aggregate by friction.

Absolute Volume — The solid volume, excluding the voids between the particles. It is expressed as the ratio of the loose materials weight (mass), to the solid weight (mass) per volume, of the same material.

Absorbed Moisture — The absorbed water in the pores of the individual aggregate particles.

Absorption — The moisture content at which the saturated surface-dry condition occurs.

Air Dry Condition — There is no free moisture on the surface of the individual aggregate particles. There is some absorbed moisture in the pores of the individual aggregate particles.

Alkali — A cement or finely divided mineral which has sodium oxide (Na_2O) or potassium oxide (K_2O).

Attrition — A rubbing away or wearing down of aggregate by friction.

Bleed Water — The migration of water to the surface of the freshly placed concrete, due to the settlement of cement, finely divided minerals, and aggregates.

Blended Cement — A hydraulic cement which meets the requirements of AASHTO M 240 (ASTM C 595). The hydraulic cement consists of portland cement and one or more inorganic constituents.

Cement Aggregate Mixture (CAM) II — A lean (low cement and finely divided mineral) concrete mixture for stabilized subbase.

Cement Factor — The number of kilograms of cement per cubic meter (Metric). The number of pounds of cement per cubic yard (English). Cement factor is the same as cement content.

Cementitious Material — A general term used to indicate fly ash, ground granulated blast-furnace slag, microsilica, or high-reactivity metakaolin. However, the term is misleading because fly ash, microsilica, and high-reactivity metakaolin do not have cementitious characteristics. The term may be used interchangeably with Finely Divided Mineral.

Chips — The aggregate particle size range between the No. 4 (4.75 mm) and 1/2 in. (12.5 mm) sieves.

Clay — A soil material having a grain size of < 0.002 mm to 0.001 mm.

Cold Joint — A distinct and separate layer in hardened concrete.

Concrete — A mixture consisting of cement, water, and aggregates as a minimum. Admixtures and finely divided minerals may be added.

Consistency — The ability of freshly mixed concrete to flow. Consistency is measured by the slump test.

Control Chart — A visual representation of test results, in an orderly sequence, in respect to time.

Controlled Low-Strength Material (CLSM) — A self-consolidating mortar mixture, which is typically used as a backfill.

Cumulative Weigh Hopper — A container suitable for weighing more than one ingredient of concrete, such as cement and fly ash. The term “batcher” is sometimes used in place of “weigh hopper.”

Degradation — The breakdown of the individual aggregate particles, due to abrasion and attrition during stockpiling and handling.

Drying Shrinkage — The slight contraction of concrete when it dries.

False Set — Early stiffness of the concrete without much heat. The stiffness can be dispelled by further mixing with no additional water.

Final Set — The point of time where the concrete is no longer plastic and finishing no longer can take place. This will typically occur 5 to 8 hours after batching the concrete.

Finely Divided Mineral — A general term to indicate fly ash, ground granulated blast-furnace slag, microsilica, or high-reactivity metakaolin. The term may be used interchangeably with Cementitious Material.

Fineness Modulus — The Fineness Modulus (FM) is an index of the fineness of an aggregate. The higher the FM, the coarser the aggregate. The Fineness Modulus is used to estimate proportions of fine and coarse aggregate in concrete mixtures.

Flash Set — Early stiffness of the concrete, usually with much heat. The stiffness cannot be dispelled by further mixing with no additional water.

Fly Ash — The finely divided residue that results from the combustion of ground or powdered coal.

Free Moisture — Water on the surface of the individual aggregate particles.

Ground Granulated Blast-Furnace (GGBF) Slag — The glassy granular material formed when molten blast-furnace slag is rapidly chilled, and then finely ground.

High-Reactivity Metakaolin (HRM) — A manufactured product formed by calcining purified kaolinite, at a specific temperature range.

Hundredweight (cwt) — A unit of measurement equal to 100 lbs.

Independent Sample — A field sample obtained and tested by only one party.

Individual Weigh Hopper — A container suitable for weighing a single ingredient of concrete, such as cement. The term “batcher” is sometimes used in place of “weigh hopper.”

Initial Set — The point of time where the concrete begins to become firm. This will typically occur 2 to 4 hours after batching the concrete.

Loss on Ignition (LOI) — A percentage in weight (mass), determined when a sample of material is ignited in a muffle furnace.

Maximum Size — The smallest sieve which 100 percent of the aggregate sample particles pass.

Microsilica — The extremely fine by-product that results from the manufacture of silicon or silicon alloys.

Mortar — The fine aggregate, cement, finely divided minerals, water, and air in a concrete mixture.

Mortar Factor — The volume of mortar per volume of dry rodded coarse aggregate.

Nominal Maximum Size — The largest sieve which retains any of the aggregate sample particles.

Oven Dry Condition — The aggregates have been heated until completely dry. There is no free moisture on the surface of the individual aggregate particles. There is no absorbed moisture in the pores of the individual aggregate particles.

Paste — The cement, finely divided minerals, water, and air in a concrete mixture.

Plasticity — The ease of molding the concrete. A plastic concrete mixture will maintain suspension of the aggregates.

Plastic Shrinkage Cracking — Cracks as a result of rapid evaporation of moisture from the concrete surface. The cracks occur when water evaporates from the surface faster than bleed water can appear at the surface.

Pervious Concrete — A permeable concrete that allows water to infiltrate the concrete and drain into the soil beneath it. The zero slump concrete mixture has little or no fine aggregate.

Portland Cement — A hydraulic cement which meets the requirements of AASHTO M 85 (ASTM C 150).

Saturated Surface-Dry Condition — There is no free moisture on the surface of the individual aggregate particles. All possible moisture which can be absorbed into the pores of the individual aggregate particles has occurred.

Saturated Surface-Dry Specific Gravity — The ratio of the weight (mass) of a volume of saturated surface-dry material, to the weight (mass) of an equal volume of water.

Scale Accuracy — The maximum tolerance for weighing a material.

Scale Calibration — The weighing device is checked for accuracy and sensitivity.

Scale Sensitivity — The determination of whether the scale will respond to small load changes, when attempting to weigh the material within the allowable tolerance.

Scaling — The deterioration of the upper concrete surface, which normally extends to a maximum depth of 0.5 in. (13 mm).

Segregation — For concrete, the coarse aggregate has separated from the mortar. For aggregate, the separation of a well graded production aggregate into individual sizes, due to handling.

Self-Consolidating Concrete (SCC) — A flowable concrete mixture that does not require mechanical vibration for consolidation.

Shale — Essentially a compacted and hardened clay. Normally, shale is identified by its visible laminations, and occurs in layers of variable thickness.

Silt — A soil material having a grain size of < 0.075 mm to 0.002 mm.

Specific Gravity — The ratio of the weight (mass) of a material, to the weight (mass) of an equal volume of water.

Split Sample — One of two equal portions of a field sample, where two parties each receive one portion for testing.

Standard Specifications — The Standard Specifications for Road and Bridge Construction.

Supplementary Cementitious Material — See definition for Cementitious Material.

Thermal Cracking — Cracks resulting from a significant drop in concrete temperature.

Thermal Shrinkage — The slight contraction of concrete as the temperature decreases.

Total Moisture — The sum of the free moisture and absorbed moisture.

Wash Water — Residual rinse water in the drum of a truck mixer or truck agitator.

Water/Cement Ratio — The weight (mass) of water, divided by the weight (mass) of cement. The water shall include mixing water, water in admixtures, free moisture on the aggregates, and water added at the jobsite.

When fly ash, ground granulated blast-furnace slag, microsilica, or high-reactivity metakaolin are used in a concrete mix, the water/cement ratio will be based on the total cement and finely divided minerals material contained in the mixture.

Wet Condition — There is free moisture on the surface of the individual aggregate particles. All possible moisture which can be absorbed into the pores of the individual aggregate particles has occurred.

Workability — A measure of how easy or difficult it is to place, consolidate, and finish concrete.

Yield — The volume of freshly mixed concrete from a known quantity of materials.

SUMMARY OF TEST METHODS

Aggregate Absorption:

Illinois Test Procedure 84 and 85

Aggregate Angularity:

Illinois Method for Fine Aggregate Classification *

Aggregate Moisture:

Illinois Test Procedure 255, 301, 302, and 303

Aggregate Gradation:

Illinois Test Procedure 11 and 27

Aggregate Particle Shape:

ASTM C 295 *

Illinois Test Procedure 4791

Aggregate Specific Gravity:

Illinois Test Procedure 84, 85, and 302

Aggregate Voids Test:

Illinois Test Procedure 306

Air Content:

Illinois Modified AASHTO T 152 and T 196

Controlled Low-Strength Material (CLSM):

Illinois Test Procedure 307

Self-Consolidating Concrete (SCC):

Illinois Test Procedure SCC-1, SCC-2, SCC-3, SCC-4, SCC-6, and SCC 10

Slump:

Illinois Modified AASHTO T 119

Strength:

Illinois Modified AASHTO T 22 and T 177

Temperature:

Illinois Modified AASHTO T 309

Unit Weight/Yield:

Illinois Modified AASHTO T 121

Water Content:

Illinois Modified AASHTO T 318

All test methods are published in the Manual of Test Procedures for Materials, except those indicated with an asterisk.

CLASS OF CONCRETE

Class Designation	Description
PV	Pavement
PP	PCC Patching
RR	Railroad Crossing
BS	Bridge Superstructure
PC	Precast Concrete
PS	Precast Prestressed
DS	Drilled Shaft
SC	Seal Coat
SI	Structures (except superstructure)

Refer to Article 1020.04 for additional information.

1.0 QC/QA PERSONNEL

1.1 PERSONNEL REQUIREMENTS

The Special Provisions for Quality Control of Concrete Mixtures at the Plant and Quality Control/Quality Assurance of Concrete Mixtures will indicate when the presence of the Level II PCC Technician is required at the plant. To review the Special Provisions, refer to Appendix A.

The Special Provisions allow flexibility for the presence of the Level II at the plant. However, a plant start-up as described in 4.4 "Sampling and Testing Frequency at the Plant" warrants the presence of the Level II PCC Technician. Also, any large or critical pour warrants the presence of the Level II PCC Technician at the plant.

1.2 QUALIFICATIONS AND DUTIES OF CONCRETE QUALITY CONTROL PERSONNEL

The responsibilities of the Level II PCC Technician are listed in Appendix B.

2.0 CONCRETE PLANT, DELIVERY TRUCK, AND LAB APPROVAL

2.1 APPROVAL PROCESS

The Level II PCC Technician shall verify the concrete plant and delivery trucks have been approved by the Department before production begins. The approval shall be according to the Department's Policy Memorandum, Approval of Concrete Plants and Delivery Trucks. Refer to Appendix C. Any questions concerning the approval of the concrete plant, or a delivery truck, are to be directed to the Department's District office.

The Level II PCC Technician shall verify the plant lab has been approved by the Department before production begins. The approval shall be according to the Department's Policy Memorandum, Minimum Private Laboratory Requirements for Construction Materials Testing or Mix Design. Refer to Appendix C. Any questions concerning the approval of the plant lab are to be directed to the Department's District office.

3.0 CONCRETE PLANT PREPARATION

3.1 PLANT SETUP

The plant shall be setup to provide continuous production. This is especially important for a plant located on the jobsite, which is the typical case for a large paving contract. Continuous production is essential for a smooth pavement, since paving equipment must operate continuously and at a uniform speed. The plant setup shall consider the following:

- A site sufficient in size to store materials.
- A layout which provides easy entry and exit from the plant.
- A road network which provides adequate support for traffic. Mud is a typical problem at jobsite plants. Mud can cause trucks to get stuck, and can contaminate aggregate stockpiles by dropping from hauling and loading equipment.

For non-permanent plants, Article 1103.02(a) requires the fine aggregate bin to have a tilted screening device. The device shall reject all material coarser than 1 in. (25 mm). The specification is required because of the occurrence of mud, and other foreign material at a jobsite plant.

3.2 CALIBRATION OF PLANT SCALES

Article 1103.02(c) requires the scales at the plant to be calibrated at the beginning of each construction season or each 12 month period, and each time the scales are moved, or when scale components are repaired or replaced.

A scale calibration consists of checking the weighing device for accuracy and sensitivity, to the full weight (mass) of the anticipated batch that will be used, or the capacity of the scale. A scale calibration will be observed by Department personnel.

To check the accuracy of the scale, Article 1103.02(c) requires an independent scale company to perform the work and the weights shall meet the requirements of the National Institute of Standards and Technology (NIST).

Before the start of the scale calibration, clean the scales and check for wear. After this has been completed, the scales may be checked. Article 1103.02(c) requires the scale accuracy to have a maximum tolerance of 0.4 percent of the net load, in the weigh hopper. Any drag due to the weighing device shall be included in the 0.4 percent tolerance. If greater accuracy is desired, especially for large paving contracts, the Department recommends a maximum tolerance of 0.2 percent.

Begin the scale calibration by balancing the scale with the weigh hopper empty (no load). When multiple beams are used, all beams shall be balanced. Then one or more standard weights are placed on the scale, in a manner which applies the load in the same position as when the materials are weighed. The scale reading is recorded for each increment of load.

The increment of loading normally used to calibrate a plant scale is the minimum graduation of the scale multiplied by 100, but may be modified by Department personnel. The modification may be based on existing plant equipment or other factors.

When all of the standard weights have been applied and the scale reading recorded, the weights shall be removed. Material is then placed in the weigh hopper, to produce the same scale reading. Using the partially loaded weigh hopper, the standard weights shall again be applied. The scale reading is recorded for each increment, and when all of the standard weights have been applied. The process shall be repeated until the full weight (mass) of the anticipated batch is reached, or until the capacity of the scale is reached.

In the case of multiple scale beams, the beams shall be checked in the order in which they are used. Each beam shall be left in balance, upon changing to the next beam. This will assure any error, which may exist in one beam, will not be transferred to the next. To ensure the correct distribution of load on the scale during calibration, the materials placed in the weigh hopper should be of the same material, and should have the same weight (mass) as the anticipated batch. The order of material shall be the same as for actual weighing.

Scale sensitivity is the determination of whether the scale will respond to small load changes, when attempting to weigh material within the required tolerance. When a scale is being checked for accuracy, a sensitivity check shall be performed at full load. Additional checks may be required by Department personnel, if more than one material is weighed by the weigh hopper. In this situation, a sensitivity check may be required at anticipated accumulative loads.

To check the sensitivity of the scale, apply by hand, a downward pressure of 15 to 20 lbs (7 to 9 kg) to the weigh hopper or scale linkage. Then slowly release this pressure, and record the scale reading. The same procedure shall be repeated by applying an upward lift to the weigh hopper or scale linkage, with subsequent slow release. The new scale reading shall return to the initial reading or within plus/minus one graduation interval of the scale.

Another method to check scale sensitivity consists of placing a small weight on the scale. The small weight shall correspond to the graduation interval on the scale. The scale shall be able to detect the additional weight. After the scale sensitivity is checked, the small weight is removed and the scale accuracy check may continue.

Once a scale is calibrated, the settings shall not be altered. The Contractor or Commercial Concrete Producer shall submit for approval by the Engineer, a method to verify the settings have not been altered. If at any time the Engineer determines the settings have been altered, a new calibration will be required. This is according to Article 1103.02(c).

3.3 CALIBRATION OF PLANT WATER METER

If the plant's water is measured by volume instead of weight, the water meter should be checked. The Department recommends the volume of water be checked at 50 gal (200 L) increments. However, Department personnel have the option to use higher increments. The maximum volume of water checked shall be the maximum batch size that will be produced by the plant.

For a water meter, Article 1103.01(a) requires an accuracy of one percent, or 1 qt (1 L); whichever is greater. The two common methods for checking a water meter are as follows:

- Method 1 - Use a cement or finely divided mineral weigh hopper, which has been calibrated according to 3.2 "Calibration of Plant Scales." Suspend a holding tank from the weigh hopper, and weigh it (weight A). Then fill the tank with water and

weigh again (weight B). Determine the weight and volume of water in the tank as follows:

$$\text{Weight of Water, } C = A - B$$

$$\text{Actual Volume of Water} = \frac{C}{\rho_{\text{water}}}$$

Because the density of water (ρ_{water}) changes depending on its temperature, refer to Table 3.3.1, which provides the density of water at different temperatures.

The accuracy is then calculated as follows:

$$\text{Accuracy (\%)} = \frac{\text{Actual Volume} - \text{Theoretical Metered Volume}}{\text{Theoretical Metered Volume}} \times 100$$

- Method 2 - A calibrated scale is used, instead of a weigh hopper. The holding tank is weighed on the calibrated scale, and the procedure thereafter is the same as Method 1.

The following is an example calculation in English units:

Given: Theoretical Metered Volume (Desired Volume) = 50.0 gal
 Weight of Water in Tank = 415.0 lbs
 Temperature of Water = 65 °F

Based on the water's temperature, the density is 8.3332 lbs/gal

Actual Volume of Water = 415.0 lbs ÷ 8.3332 lbs/gal = 49.8 gal

$$\text{Accuracy (\%)} = \frac{49.8 - 50.0}{50.0} \times 100 = -0.4\% \text{ (OK)}$$

The following is an example calculation in Metric units:

Given: Theoretical Metered Volume (Desired Volume) = 200.0 L
 Weight of Water in Tank = 201.0 kg
 Temperature of Water = 25 °C

Based on the water's temperature, the density is 0.99705 kg/L

Actual Volume of Water = 201.0 kg ÷ 0.99705 kg/L = 201.6 L

$$\text{Accuracy (\%)} = \frac{201.6 - 200.0}{200.0} \times 100 = +0.8\% \text{ (OK)}$$

Table 3.3.1. Density of Water at Different Temperatures.

Temperature		Density				
°C	°F	lbs/yd ³	lbs/ft ³	lbs/gal	kg/m ³	g/ml*
0	32	1685.29	62.418	8.3441	999.84	0.99984
1	33.8	1685.44	62.422	8.3448	999.90	0.99990
1.7	35	1685.44	62.424	8.3448	999.93	0.99993
4	39.2	1685.52	62.427	8.3452	999.98	0.99998
4.4	40	1685.50	62.426	8.3452	999.97	0.99997
5	41	1685.50	62.426	8.3452	999.97	0.99997
7.2	45	1685.37	62.421	8.3445	999.89	0.99989
10	50	1685.05	62.409	8.3429	999.70	0.99970
12.8	55	1684.56	62.391	8.3405	999.41	0.99941
15.6	59	1684.04	62.372	8.3379	999.10	0.99910
18.3	65	1683.09	62.337	8.3332	998.54	0.99854
20	68	1682.54	62.316	8.3305	998.21	0.99821
21.1	70	1682.13	62.301	8.3285	997.97	0.99797
23.9	75	1681.06	62.261	8.3231	997.33	0.99733
25	77	1680.58	62.244	8.3208	997.05	0.99705
26.7	80	1679.84	62.216	8.3171	996.61	0.99661
29.4	85	1678.51	62.167	8.3105	995.82	0.99582
30	86	1678.22	62.156	8.3091	995.65	0.99565
32.2	90	1677.06	62.113	8.3033	994.96	0.99496
35	95	1675.49	62.055	8.2956	994.03	0.99403
37.8	100	1673.84	61.994	8.2874	993.05	0.99305

* 1 g/ml = 1 g/cm³ = 1 kg/L

Source: Senese, F. 2010. "General Chemistry Online: FAQ." Frostburg State University.

Link: <http://antoine.frostburg.edu/chem/senese/101/measurement/faq/water-density.shtml>

4.0 CONCRETE PLANT OPERATIONS

4.1 CHECKING SHIPMENTS OF MATERIAL

All aggregates (except finely divided minerals) shall be produced in accordance with the Department's Policy Memorandum, Aggregate Gradation Control System. Refer to Appendix D. The Department's Policy Memorandum, Use of Non-Certified Aggregate Stockpiles Under the Aggregate Gradation Control System (AGCS), is also included in Appendix D. The Aggregate Producer is responsible for providing certified aggregate gradation bands (including master band, if required). These bands may supersede Sections 1003 and 1004 according to the Aggregate Gradation Control System Policy Memorandum. The Level II PCC Technician shall check the aggregate gradation for compliance with the bands provided by the Aggregate Producer.

The Aggregate Producer's certified aggregate gradations bands may be modified by the Contractor, as per the Development of Gradation Bands on Incoming Aggregate at Mix Plants document. Refer to Appendix E. In this case, the Level II PCC Technician shall check the aggregate gradation for compliance with the bands developed by the Contractor.

For additional information regarding various aggregate requirements, refer to Sections 1003 and 1004.

The Level II PCC Technician shall verify that cement, fly ash, ground granulated blast-furnace slag, microsilica, high-reactivity metakaolin, and admixtures are approved. Refer to the Approved List of Qualified Cement Plants, Approved List of Suppliers for Finely Divided Minerals, and the Approved List of Concrete Admixtures. To view or download any approved list, go to <http://www.dot.il.gov/>. The lists are found under Doing Business; Materials; Approved Lists for Materials. There is also an Index which includes the contact person for questions about each list. For your convenience, a link has also been provided on the web page for an e-mail subscription to receive notice of changes to any list. If the material is not on the approved list, the Level II PCC Technician shall notify Department personnel. The Department will sample and test the material.

For the water supply used at the plant, the District office may obtain a sample for testing. This would typically occur for a non-potable source. Water shall meet Section 1002.

If steel fiber reinforcement is to be incorporated in the concrete, check with the District office to determine if the material is approved. For synthetic fiber reinforcement, refer to the Approved List of Synthetic Fibers.

4.1.1 Compliance of Aggregate Gradation

The Level II PCC Technician shall sample and test the aggregate for gradation in accordance with the Special Provision for Quality Control of Concrete Mixtures at the Plant (Appendix A), the Special Provision for Quality Control/Quality Assurance of Concrete Mixtures (Appendix A) and the Aggregate Technician Course Workbook. A Mixture Aggregate Technician (3-day course) or Aggregate Technician (5-day course) may assist with sampling and testing for aggregate gradation. A Gradation Technician may only assist with aggregate gradation testing, and shall be monitored on a daily basis.

The minimum equipment required to perform aggregate gradation tests shall be according to the Required Sampling and Testing Equipment for Concrete document. Refer to Appendix F.

The minimum field sample size per Illinois Specification 201, "Aggregate Gradation Sample Size Table & Quality Control Sieves", is as follows:

Aggregate Gradation Number	Minimum Field Sample Size (English)	Minimum Field Sample Size (Metric)	Minimum Test Sample Size
CA 3	110 lbs	50 kg	10,000 grams
CA 5	110 lbs	50 kg	10,000 grams
CA 7	55 lbs	25 kg	5,000 grams
CA 11	55 lbs	25 kg	5,000 grams
CA 13	35 lbs	16 kg	2,000 grams
CA 14	35 lbs	16 kg	2,000 grams
CA 16	25 lbs	11 kg	1,500 grams
FA 1	25 lbs	11 kg	500 grams
FA 2	25 lbs	11 kg	500 grams
FA 20	25 lbs	11 kg	500 grams

Illinois Specification 201 is found in the Manual of Test Procedures for Materials, and information for additional gradation numbers is provided in this document.

The Level II PCC Technician shall immediately notify the Quality Control Manager and Department personnel, if an aggregate gradation test failure occurs.

4.1.2 Aggregate Acceptance

For aggregate gradation sampling and testing, one important aspect is sampling and testing aggregate upon arrival at the plant vs. immediately prior to batching. For Department acceptance of the aggregate, compliance is determined by sampling and testing the aggregate immediately prior to batching. However, the Contractor or Commercial Concrete Producer must determine whether to accept the delivered aggregate from the aggregate producer.

Sampling and testing aggregate arriving at the plant, also known as incoming aggregate, is important because the delivered aggregate may not meet specification requirements. In addition, the Contractor or Commercial Concrete Producer must allow for and minimize segregation and degradation. Segregation and degradation, as a result of stockpiling and handling at the plant, will alter the aggregate gradation. If a borderline passing aggregate material is delivered to the plant, the segregation and degradation can cause the aggregate material to fail, when sampled and tested immediately prior to batching.

The Contractor or Commercial Concrete Producer must indicate their needs to the Aggregate Producer. The Contractor or Commercial Concrete Producer should discuss the sampling location, sampling method, acceptable gradation, and resampling for a failure, with the Aggregate Producer. This will avoid a dispute over the acceptability of the incoming aggregate material.

4.2 CONCRETE PLANT AND DELIVERY TRUCK INSPECTION

The Level II PCC Technician is responsible for inspecting the concrete plant and delivery trucks, on a daily basis. However, some discretion may be used when only one or two truck loads will be delivered to the project for that day. Deficiencies shall require immediate correction. Department personnel shall be notified of these deficiencies.

The following discussion indicates the minimum inspection required.

4.2.1 Aggregates

The Level II PCC Technician shall check aggregate stockpiles for the following:

- Segregation - Check the stockpile for the separation of a well graded production aggregate into individual sizes. Refer to the Aggregate Technician Course Workbook for additional information.
- Degradation - Check the stockpile for breakdown of the individual aggregate particles. Refer to the Aggregate Technician Course Workbook for additional information.
- Cleanliness - Check the stockpile for clumps of soil or other foreign material.
- Separation - Ensure that various stockpiles do not intermingle.
- Moisture - Determine the moisture content of the aggregate according to 5.4.3 "Aggregate Moisture Test Methods."

Aggregate bins should be kept full as possible at all times, aggregate should be loaded into the center of the bin, and aggregate should not become intermixed.

4.2.2 Scales

4.2.2.1 Accuracy

The Level II PCC Technician shall check the scales for accuracy by performing a unit weight/yield test or weighing a loaded delivery truck. When weighing a loaded delivery truck, a separate scale (platform type) is used to check the net weight of material batched.

4.2.2.2 Sensitivity

The Level II PCC Technician shall check the scales for sensitivity. The sensitivity of a scale shall be checked at the load to be weighed or at successive accumulative loads when more than one material is weighed into the hopper.

The method to perform a sensitivity check is discussed in 3.2 "Calibration of Plant Scales." If the plant setup does not permit the sensitivity check to be performed easily, a unit weight/yield test or weighing of a loaded delivery truck may be performed as a reasonable substitute. When weighing a loaded delivery truck, a separate scale (platform type) is used to check the net weight of material batched.

4.2.2.3 Scale Zero

The Level II PCC Technician shall check the scales for scale zero. When a dial or digital readout scale is used, the Level II PCC Technician shall make frequent observations of whether the indicator returns to the zero reading, upon discharge of the weigh hopper. When a beam scale is used, the Level II PCC Technician shall make frequent observations of whether the tare beam is in balance, upon discharge of the weigh hopper.

If the scale reading is not zero after discharge of each batch, there are several possible reasons. They include build-up of material in the weigh hopper, friction in the scale mechanism, and binding in the scale mechanism. If material remains in the weigh hopper, a vibrator of sufficient frequency and power shall be installed to assure complete discharge.

4.2.2.4 Measurement

The Level II PCC Technician shall check the batched weights for accuracy. The following formula shall be used:

$$\text{Actual Accuracy (\%)} = \frac{AB - (D \times B)}{(D \times B)} \times 100$$

Where: AB = Actual Batched weight (mass)
 D = Design weight (mass) per yd³ (m³)
 B = Batch size

Aggregates measured individually or cumulatively shall have a tolerance within $\pm 1 \frac{1}{2}$ percent of the required quantity. Cement and cementitious materials measured individually or cumulatively shall have a tolerance within ± 1 percent of the required quantity. Water shall be measured to a tolerance within ± 1 percent of the required quantity. However, for water, a limit of accuracy closer than 1 qt. (1 L) will not be required. This is according to Articles 1103.01 and 1103.03(a)(1).

The following is an example calculation for checking the allowable tolerance for cement, in English units:

Given: AB = 3,650 lbs of cement, as indicated by the batch weight scale
 D = 605 lbs/yd³ of cement
 B = 6 cubic yards

$$\text{Actual Accuracy (\%)} = \frac{3,650 - (605 \times 6)}{(605 \times 6)} \times 100 = +0.6\% \text{ (O.K.)}$$

The following is an example calculation for checking the allowable tolerance for fine aggregate, in Metric units:

Given: AB = 2,840 kg of fine agg., as indicated by the batch weight scale
 D = 575 kg/m³ of fine aggregate
 B = 5 cubic meters

$$\text{Actual Accuracy (\%)} = \frac{2,840 - (575 \times 5)}{(575 \times 5)} \times 100 = -1.2\% \text{ (O.K.)}$$

For manual plants, the allowable tolerance is easily met by careful weighing. For automatic or semi-automatic plants, repetitive or substantial deviations from the allowable tolerance shall require the interlock to be reset.

When an underweight condition occurs, the problem is easily corrected by adding more material.

When an overweight condition occurs, the problem may be corrected as follows:

- Physically remove the excess material. This is rarely done for any material except water, which can be wasted.
- If the material has been weighed in an individual weigh hopper, discharge only the required amount. The remaining material in the weigh hopper may be used for the next batch.
- Determine the percent of overweighted material, and increase all other materials by the same percent. This will increase the batch size, but will result in the correct proportions to be batched. This method may be used for individual and cumulative weigh hoppers.
- If the material is cement, determine if the amount is reasonable and will not harm the mix.

4.2.3 Admixtures and Dispensers

The admixture company should calibrate the admixture dispensers at the concrete plant at least once a year.

The Level II PCC Technician shall check the functioning of the dispenser, for accurate measurement of admixtures. All lines are to be clean and leak free. Periodic flushing with clean water may be required. Admixtures shall be measured to a tolerance within ± 3 percent of the required quantity according to Article 1103.03(a)(1). The dispenser may be checked for accuracy by any of the following methods:

- Visual inspection is the most common method. The dispenser shall fill to the proper level and then go back to the zero mark.
- If the admixture dispenser has a drainage petcock, the filled dispenser is drained into a measuring container.

The above methods may not provide an accurate method for checking the allowable tolerance, but the Level II PCC Technician should not become overly concerned. The Level II PCC Technician should remember that field results are more important. The allowable tolerance is primarily intended for setting the interlock control on automatic and semi-automatic plants. However, if the problem is believed to be serious, then the admixture company should be contacted.

The Level II PCC Technician shall check the dispensers for addition of each admixture separately, and in the proper sequence. The sequence shall be according to specifications or manufacturer's instructions.

The Level II PCC Technician shall check liquid admixtures for protection from freezing and contamination. Agitation shall be provided for liquid admixtures which are not stable solutions. This is according to Article 1103.03(a)(4).

4.2.4 Moisture Sensor

The Level II PCC Technician shall compare moisture test results with the moisture sensor, to ensure proper operation. The material tested must represent the material measured by the moisture sensor. If the moisture test and moisture sensor disagree by more than 0.5 percent, retest. If the difference remains, adjust the moisture meter to the average of the moisture tests, using Illinois Test Procedure 255, Illinois Test Procedure 301 (Flask Method), Illinois Test Procedure 302 (Dunagan Method), or Illinois Test Procedure 303 (Pycnometer Jar Method). Refer to 5.4.3 "Aggregate Moisture Test Methods" for additional information.

NOTE: As a minimum, the moisture sensor may be checked weekly. However, the Department encourages this to be done daily.

4.2.5 Water Measuring Device

The Level II PCC Technician shall check the water measuring device for accuracy, by performing a unit weight/yield test, or by performing a water content test, or by weighing a loaded delivery truck. When weighing a loaded delivery truck, a separate scale (platform type) is used. The three methods to check accuracy are applicable for water which is weighed or measured.

If wet or dry loads are received in the field, and aggregate moisture is accurately known, this may be an indication to check the water measuring device. If the Level II PCC Technician determines or suspects the water measuring device is not accurate, the device shall be calibrated according to 3.2 "Calibration of Plant Scales" or 3.3 "Calibration of Plant Water Meter."

4.2.6 General Condition of Plant

The Level II PCC Technician shall check the volume of mixed concrete, to ensure it does not exceed the capacity of the stationary mixer.

The Level II PCC Technician shall check a stationary mixer for compliance with minimum mixing time, which is normally 75 seconds. The stationary mixer shall operate at the speed recommended by the manufacturer, and mixing time shall begin when all solid materials are in the mixer. Refer to Articles 1020.11(a)(1) and 1020.11(c) for additional information.

The Level II PCC Technician shall check the stationary mixer for worn blades. Blades which are worn down 3/4 in. (20 mm) or more in depth shall be replaced with new blades. This is according to Article 1103.01(a). The stationary mixer shall also be watertight.

If wide variations in slump or air tests occur, or if uncoated aggregates are observed, this may be an indication to check concrete build-up or blade wear within the stationary mixer; or to check mixing time. If spillage occurs during or after charging the stationary mixer, this may be an indication to check concrete build-up within the stationary mixer.

The Level II PCC Technician shall check the time clock for accuracy and operation to stamp delivery tickets. The delivery ticket is to be stamped no later than five minutes after the addition of the mixing water to the cement, or after the addition of the cement to the aggregate when the combined aggregates contain

free moisture in excess of 2 percent by weight (mass). If more than one batch is required for charging a truck using a stationary mixer, the time of haul shall start with mixing of the first batch. This is according to Article 1020.01(a)(7).

For semi-automatic and automatic plants, the Level II PCC Technician shall check that “over” and “under” interlock controls are set at the correct tolerance, and operating properly.

Cement and finely divided mineral silos should be emptied periodically, and inspected for buildup. Remove any buildup before refilling. In addition, check split silos for holes, which would allow mixing of cement and a finely divided mineral.

The Level II PCC Technician shall check the cement for lumps. This may occur when cement has been in storage for a length of time, especially from one construction season to another. Cement with lumps may be used if easily crushed between the thumb and forefinger. If harder lumps exist, they shall be removed by screening; or the cement shall be removed and replaced. If cement contains lumps, it is to be sampled and tested by the Department before use.

4.2.7 Condition of Trucks

The Level II PCC Technician shall verify the delivery equipment is adequate for field placement. For example, some truck mixers may not be suited for quick discharge operations, such as for paving. Truck mixers, truck agitators, and nonagitator trucks shall be watertight according to Article 1103.01.

The Level II PCC Technician shall check the volume of mixed concrete. The volume of mixed concrete in truck mixers or truck agitators shall in no case be greater than the rated capacity determined according to the Truck Mixer, Agitator, and Front Discharge Concrete Carrier Standards of the Truck Mixer Manufacturer's Bureau, as shown by the rating plate attached to the truck. If the truck mixer does not have a rating plate, the volume of mixed concrete shall not exceed 63 percent of the gross volume of the drum or container, disregarding the blades. For truck agitators, the value is 80 percent. This is according to Article 1020.11(a)(6).

The Level II PCC Technician shall check the truck mixer or agitator for satisfactory mixing or agitating of the concrete batched. For a truck mixer or agitator, wide variations in slump or air tests, or uncoated aggregates, or discharge problems may indicate concrete build-up or worn blades within the drum or container.

Concrete build-up may be checked by visual inspection, or by weighing the truck. For weighing, approximately 500 lbs (225 kg) or more of hardened concrete build-up is considered excessive.

Worn blades may be checked by visual inspection, or by measurement. For measurement of truck mixers, the mixer blades at the point of maximum drum diameter, nearest the drum head, shall not be worn more than 10 percent of the original radial height.

The Level II PCC Technician shall check the truck mixer's revolution counter, and water sight gauge for proper operation.

The Level II PCC Technician shall check truck mixers for the required number of revolutions. For truck mixers charged with fine and coarse aggregates

simultaneously, not less than 60 nor more than 100 revolutions of the drum or blades at mixing speed shall be required, after all of the ingredients including water are in the drum. When fine and coarse aggregates are charged separately, not less than 70 revolutions will be required. For self-consolidating concrete, a minimum of 100 revolutions is required in all cases. The mixing operation shall begin immediately after the cement and water, or the cement and wet aggregates come in contact. This is according to Article 1020.11(a)(2).

For shrink-mixed concrete, the concrete shall be mixed for a minimum of 30 seconds in a stationary mixer, before transfer to the truck mixer. Thereafter, the concrete in the truck mixer shall be mixed not less than 50 nor more than 100 revolutions of the drum or blades at mixing speed. For self-consolidating concrete, a minimum of 100 revolutions is required in the truck mixer. This is according to Article 1020.11(a)(3).

For microsilica or high-reactivity metakaolin concrete bridge deck overlays, refer to the Special Provision for mixing instructions.

For a truck mixer, wide variations in slump or air tests, or uncoated aggregates, or discharge problems may indicate an insufficient number of revolutions.

The Level II PCC Technician shall check truck mixers for mixing speed. The mixing speed, according to Article 1020.11(a)(5), shall be per the manufacturer's rating plate.

The Level II PCC Technician shall check for agitating speed. The agitating speed, according to Article 1020.11(a)(5), shall be per the manufacturer's rating plate. If the Level I PCC Technician indicates that the overall total revolutions is exceeding 300 in the field, this is an indication that a slower agitating speed is warranted. However, the concrete in the field is still acceptable to place.

4.3 MOBILE PORTLAND CEMENT CONCRETE PLANTS

Mobile plant mixers are truck mounted. All mixture ingredients are carried by the truck, are batched by volume, and are continuously mixed by a screw auger. The Level II PCC Technician shall be familiar with Articles 1020.12 and 1103.04.

The Level II PCC Technician should be aware that procedures for aggregate gradation, aggregate moisture, slump, air content, unit weight/yield, and temperature testing may vary from those used in a plant at a fixed location. In addition, the Engineer reserves the right to observe the calibration of the mobile portland cement concrete plant, and should be notified when one is to occur.

4.3.1 Mobile Mixer Mix Design Calibration

Refer to Appendix G for the mobile mixer calibration worksheet.

1. Determine the percent moisture of the fine and coarse aggregate according to Illinois Modified AASHTO T 255 or Illinois Test Procedure 301, 302, or 303.
2. From the mix design, determine number of bags of cement per cubic yard:

$$\text{Number of Cement Bags per yd}^3 = \text{Total Cement in lbs/yd}^3 \div 94 \text{ lbs/bag}$$

Determine "Adjusted Weight" for the fine and coarse aggregate:

$$\text{Adjusted Weight in lbs/yd}^3 = \text{SSD Weight in lbs/yd}^3 \times \left(1 + \frac{\% \text{Moisture}}{100}\right)$$

Note: SSD, Saturated Surface-Dry

3. Calibrate Cement

Use an electronic platform scale that has a minimum capacity of 150 lbs, and has been calibrated with weights that meet the requirements of the National Institute of Standards and Technology.

Zero the scale with a container large enough to catch 1 bag (94 lbs) of cement.

Prime the belt with cement, and then reset the cement meter counter.

Only cement must be run off the belt into the container.

Target approximately 94 pounds (1 bag).

Run test 5 times. Each time record the following:

- Weight of cement in container to nearest 0.1 pound,
- Final reading of cement meter counter, and
- Time in seconds.

Disregard any weight which is unusually high or low from target.

Calculate “New Meter Count” as follows:

$$\text{New Meter Count} = \left(\frac{\text{Sum of Counter Readings}}{\text{Sum of Weights}}\right) \times 94$$

Calculate “New Time” as follows:

$$\text{New Time} = \frac{\text{Sum of Time Readings}}{\text{Sum of Weights}}$$

Calculate “1/4 Yard Count” as follows:

$$1/4 \text{ Yard Count} = (\text{New Meter Count} \times \text{Number of Cement Bags per yd}^3) \div 4$$

“1/4 Yard Count” will be used for running yield checks.

4. Calibrate Fine Aggregate

Determine “Target Weight” as follows:

$$\text{Target Weight, lbs} = \frac{\text{Adjusted Weight}}{2 \times \text{Number of Cement Bags}}$$

Zero the scale with the empty container.

Prime the belt with fine aggregate, and then reset the cement meter counter.

Run fine aggregate down the belt into the container until the count meter reads half the “New Meter Count.”

The weight of the material collected should be within 1.5 percent of the target. If too much material is collected, lower the gate setting. If too little material is collected, raise the gate setting.

Once the proper gate setting is determined, run 2 additional tests to ensure repeatability. This gate setting now becomes the "Final FA Setting".

5. **Calibrate Coarse Aggregate** (Refer to Step 4 using coarse aggregate.)

6. **Calibrate Latex**

Determine number of gallons of latex per cubic yard using either of the following methods:

- a. If you know the specific gravity or the density (lbs/ft³) of the latex, weigh up the latex for that amount of time established in Step 3 (New Time). Calculate the gallons of latex based on the weight of material in the container. This volume must be within 1.5 percent of the design requirement.
- b. Meter out the latex into a calibrated flask with the time established in Step 3 (New Time).

7. **Calibrate Water**

Refer to Step 6. The density of water is 62.4 lbs/ft³. Calibration can be waived per the Engineer.

8. **Calibrate Admixtures**

Target Admixture, oz =

$$\left[\text{Dosage oz/cwt} \times \left(\frac{\text{Total Cement in lbs/yd}^3}{100} \right) \right] \div (2 \times \text{Number of Cement Bags})$$

Run admixture for half the time established in Step 3 (New Time).

Determine flow settings and record.

9. **Yield Check**

At placement of the mobile mixed concrete, a yield test is taken by running the mix into a 1/4 yard container for a number of counts equal to the "1/4 Yard Count."

The yield test may be misleading directly after startup. It is recommended that a cubic yard of concrete be produced before using the yield test to determine proportioning accuracy.

4.3.2 Mobile Mixer Mix Design Calibration Frequency

Each mix design should be calibrated when first used in the construction season.

A new mix design calibration should be done when you have considerable changes in aggregate moisture, or adjustments to the mix design.

Yield checks should be performed at the beginning of every pour. If the yield check is good then the calibration is most likely still valid.

4.3.3 Mobile Mixer and Quality Control

Per Article 1020.12 for mobile portland cement concrete plants, it states: "Slump and air tests made immediately after discharge of the mix may be misleading, since the aggregate may absorb a significant amount of water for four or five minutes after mixing." Therefore, it is recommended to wait a minimum of 4 minutes before the start of slump and air tests. Refer to Article 1020.12 for additional information on quality control.

The angle of the auger will influence the amount of air entrained in latex concrete mixtures. A steep angle will entrain more air than a shallow angle.

4.4 SAMPLING AND TESTING FREQUENCY AT THE PLANT

The frequency of sampling and testing is indicated in the Special Provisions for Quality Control of Concrete Mixtures at the Plant (Appendix A) and Quality Control/Quality Assurance of Concrete Mixtures (Appendix A). The sampling and testing frequency indicated in the two Special Provisions is a minimum. Additional sampling and testing may be necessary to control concrete production. The PCC Level II Technician should also check the Quality Control Plan for sampling and testing frequencies.

The sampling and testing frequency for a plant start-up is always higher than for continuous production thereafter. The following conditions are considered a plant start-up situation. The Contractor or Commercial Concrete Producer may propose different conditions in the Quality Control Plan.

- The plant is beginning production after a winter shut down.
- The plant has not produced any material for 7 days.
- The plant has been shut down for repairs, or acquired new equipment.
- The plant batching operation is changed.
- The first day of a critical pour, such as for a bridge deck.
- The source of material is changed.
- The mixing time or revolutions is changed.

The following tests are performed at the plant. This is according to the Special Provisions for Quality Control of Concrete Mixtures at the Plant and Quality Control/Quality Assurance of Concrete Mixtures.

- Coarse and Fine Aggregate Gradation
- Coarse and Fine Aggregate Moisture
- Slump
- Air Content
- Unit Weight/Yield
- Slump Flow (SCC*)
- Visual Stability Index (SCC*)
- J-Ring (SCC*)

- L-Box (SCC*)
- Temperature

* Self-Consolidating Concrete

The following tests, at the Contractor's or Commercial Concrete Producer's option, may be performed at the plant. This is according to the Special Provisions for Quality Control of Concrete Mixtures at the Plant and Quality Control/Quality Assurance of Concrete Mixtures.

- Strength
- Water Content
- Other Available SCC Tests

The frequency of sampling and testing for coarse aggregate gradation, fine aggregate gradation, and fine aggregate moisture is specified in the Special Provisions for Quality Control of Concrete Mixtures at the Plant and Quality Control/Quality Assurance of Concrete Mixtures. For all remaining tests at the plant, the sampling and testing frequency is indicated by the Contractor or Commercial Concrete Producer in the Quality Control Plan. Refer to Appendix H.

The frequency of sampling and testing needed for quality control, at the plant, will depend on the type of plant (i.e. manual, semi-automatic, or automatic), condition of equipment, material handling, weather, and other factors. The following is an example for sampling and testing at the plant. The example is not intended to be applicable to all plants.

Example for Plant Start-Up on 1st Day

- Coarse and fine aggregate washed gradation. (Stored at plant in stockpiles or bins.) Before start of day, then every 2,500 yd³ (1,900 m³).
- Coarse and fine aggregate moisture. Before start of day, then as needed to control production.
- Slump. First two trucks, then as needed to control production.
- Air content. First two trucks, then as needed to control production.
- Unit weight/yield. First two trucks, then as needed to control production.
- Temperature. First two trucks, then as needed to control production.

Example for Plant Production on 2nd Day and Thereafter

- Coarse and fine aggregate washed gradation. (Stored at plant in stockpiles or bins.) Every 2,500 yd³ (1,900 m³), except minimum one per day when pouring a bridge deck unless the stockpile has not received additional aggregate material since the previous test.
- Coarse aggregate moisture. As needed to control production.
- Fine aggregate moisture. Before start of day, then as needed to control production.
- Slump. First truck, then as needed to control production.
- Air content. First truck, then as needed to control production.
- Unit weight/yield. First truck, then as needed to control production.
- Temperature. First truck, then as needed to control production.

4.5 CONCRETE DELIVERY OPERATIONS

4.5.1 Production and Delivery

The Standard Specifications have requirements for production and delivery of concrete. Article 503.07 states for concrete structures that “separate batches shall follow each other closely and in no case shall the interval of time between the placing of successive batches be greater than 20 minutes”. Article 1020.11(a)(8) states for production and delivery that “The production of ready-mixed concrete shall be such that the operations of placing and finishing will be continuous insofar as the job operations require.”

4.5.2 Haul Time

Haul time shall end when the truck is emptied for incorporation of the concrete into the work according to Article 1020.11(a)(7).

4.5.2.1 Nonagitator Trucks

The maximum haul time for nonagitating trucks is 30 minutes according to Article 1020.11(a)(7).

4.5.2.2 Mixer and Agitator Trucks

The maximum haul time for truck mixers and truck agitators according to Article 1020.11(a)(7) is as follows:

Concrete Temperature at Point of Discharge, °F (°C)	Haul Time		
	Hours	Minutes	
50 - 64 (10 - 17.5)	1	30	
> 64 (> 17.5)	1	0	(without retarder)
> 64 (> 17.5)	1	30	(with retarder)

When installing chain link or woven wire fence, the time limit for unloading may be extended to 120 minutes when approved by the Engineer according to Article 664.02 Note 2. The concrete shall be mixed in truck mixers or transported in agitating trucks.

4.5.2.3 Plant Testing

To encourage start-up testing for mix adjustments at the plant, the first two trucks are allowed an additional 15 minutes haul time whenever such testing is performed. This is according to Article 1020.11(a)(7).

5.0 PROPORTIONING

Concrete is batched by weight, but sold by the volume. The volume is commonly 1 cubic yard (1 cubic meter). Therefore, the Level II PCC Technician must understand the concept for converting a weight to a volume.

5.1 SPECIFIC GRAVITY OF MATERIALS

Specific gravity is the ratio of the weight (mass) of a material, to the weight (mass) of an equal volume of water.

Specific Gravity = Weight (mass) of Material ÷ Weight (mass) of Equal Volume of Water

Therefore, specific gravity tells us if the object is heavier or lighter than water. Knowing the specific gravity of water is 1.00, materials with a specific gravity less than 1.00 will float on water. Materials with a specific gravity greater than 1.00 will sink to the bottom. Specific gravity is illustrated as follows:

<u>Specific Gravity of</u>	=	<u>Weight of One Voidless ft³ ÷ Weight of 1 ft³ Water</u>	<u>Mass of One Voidless m³ ÷ Mass of 1 m³ Water</u>
Water 1.00	=	62.37 lbs/62.37 lbs	1,000 kg/1,000 kg
Sand 2.66	=	166 lbs/62.37 lbs	2,660 kg/1,000 kg
Stone 2.68	=	167 lbs/62.37 lbs	2,680 kg/1,000 kg
Cement 3.15	=	196.5 lbs/62.37 lbs	3,150 kg/1,000 kg
Fly Ash 2.50	=	156 lbs/62.37 lbs	2,500 kg/1,000 kg

Typical specific gravities of basic materials:

Water	= 1.00
Liquid Admixtures*	= 1.00 (Assumed Value)
Cement **	= 3.15 (Assumed Value)
Aggregates	= 2.60 to 2.75
Fly Ash	= 2.30 to 2.80
GGBF Slag***	= 2.80 to 2.90
Microsilica	= 2.15 to 2.25
HRM****	= 2.50 to 2.60

* The specific gravity for admixtures will vary from 0.90 to 1.40.

**Blended cement may have a specific gravity which is significantly less than 3.15. Refer to 6.2.1 "Types" for additional information on blended cement.

***GGBF Slag = Ground Granulated Blast-Furnace Slag.

****HRM = High-Reactivity Metakaolin.

The specific gravity for aggregate is obtained from the Department's District office. For finely divided minerals, the specific gravity may be obtained from the Approved List of Suppliers for Finely Divided Minerals.

5.2 SPECIFIC GRAVITY (SATURATED SURFACE-DRY)

When a mix design is developed, aggregates are assumed to be in a saturated surface-dry (SSD) condition. Refer to 5.4.1 "Aggregate Moisture Condition" for additional information. Therefore, a saturated surface-dry specific gravity is used.

Saturated surface-dry specific gravity is the ratio of the weight (mass) of a volume of saturated surface dry material, to the weight (mass) of an equal volume of water.

The saturated surface-dry specific gravity for an aggregate is obtained from the Department's District office.

5.3 VOLUMETRIC PROPORTIONING DIAGRAM

A volumetric proportioning diagram is an illustration, which compares absolute volume to weight. Absolute volume is defined as the solid volume, excluding the voids between the particles. It is expressed as the ratio of the loose materials weight (mass), to the solid weight (mass) per volume, of the same material. The formula is as follows:

$$\text{Absolute Volume} = \frac{\text{Weight(Mass) of Material}}{(\text{Specific Gravity of Material} \times \text{Unit Weight of Water})}$$

As an example, one sack of cement weighs 94 pounds and occupies 1 cubic foot. The absolute volume of the solid cement particles is as follows:

$$\text{Absolute Volume} = \frac{94 \text{ lbs}}{(3.15 \times 62.37 \text{ lbs/ft}^3)} = 0.478 \text{ ft}^3$$

Where: 3.15 is the specific gravity of cement.
62.37 is the unit weight of water.

The following is an example calculation in English units for a batch of concrete, assuming 0.44 water/cement ratio, 0.40 Voids in Coarse Aggregate (refer to Section 11.6 "Voids in Coarse Aggregate"), and 0.85 Mortar Factor (refer to Section 11.7 "Mortar Factor"):

<u>ABSOLUTE VOLUME</u>				<u>BATCH WEIGHT</u>
<u>Cu. Ft.</u>	<u>Cu. Yd.</u>	<u>Materials</u>	<u>Specific Gravity</u>	<u>Pounds Per Cu. Yd.</u>
1.76	0.065	Air	0.0	0.0
3.99	0.148	Water	1.00	249***
2.89	0.107	Cement	3.15*	565
7.18	0.266	Fine Aggregate	2.66**	1,192
11.18	0.414	Coarse Aggregate	2.68**	1,868
<u>27.00****</u>	<u>1.000****</u>			<u>3,874</u>

* For cement and finely divided minerals, there are no pores for the material to absorb water. Therefore, a saturated surface-dry condition cannot exist as it can for aggregates. Thus, the term "apparent specific gravity" is used to describe this type of specific gravity.

** Saturated Surface-Dry (SSD) specific gravity.

*** 1 gallon of water = 8.33 lbs
 1 cubic foot of water = 62.37 lbs
 1 cubic yard of water = 1,683.99 lbs

**** 27.00 cubic foot = 1 cubic yard

To determine the absolute volume, given the batch weights, the calculations are as follows:

- Air has no weight, but does occupy 6.5 percent of the volume. Therefore, the calculation is as follows:

$$\text{Air Volume (yd}^3\text{)} = 1.000 \text{ yd}^3 \times (6.5\% \div 100) = 0.065 \text{ Air Volume (yd}^3\text{)}$$

$$\text{Air Volume (ft}^3\text{)} = 27.00 \text{ ft}^3 \times (6.5\% \div 100) = 1.76 \text{ Air Volume (ft}^3\text{)}$$

- The volume of water, cement, finely divided minerals, fine aggregate, and coarse aggregate is calculated as follows:

$$\text{Volume (yd}^3\text{)} = \frac{\text{Weight of Material in lbs}}{(\text{Specific Gravity of Material} \times 1,683.99 \text{ lbs/yd}^3)}$$

$$\text{Volume (ft}^3\text{)} = \frac{\text{Weight of Material in lbs}}{(\text{Specific Gravity of Material} \times 62.37 \text{ lbs/ft}^3)}$$

The following is an example calculation in metric units for a batch of concrete, assuming 0.44 water/cement ratio, 0.40 Voids in Coarse Aggregate (refer to Section 11.6), and 0.85 Mortar Factor (refer to Section 11.7):

<u>ABSOLUTE VOLUME</u>			<u>BATCH WEIGHT</u>
<u>Cubic Meter</u>	<u>Materials</u>	<u>Specific Gravity</u>	<u>Kilograms Per Cubic Meter</u>
0.065	Air	0.0	0.0
0.148	Water	1.00	148***
0.107	Cement	3.15*	335
0.266	Fine Aggregate	2.66**	707
0.414	Coarse Aggregate	2.68**	1,109
<hr/> 1.000			<hr/> 2,299

* For cement and finely divided minerals, there are no pores for the material to absorb water. Therefore, a saturated surface-dry condition cannot exist. The term "apparent specific gravity" is used to describe this type of specific gravity.

** Saturated Surface-Dry (SSD) specific gravity.

*** 1 cubic meter of water = 1,000.0 kg

To determine the absolute volume, given the batch weights, the calculations are as follows:

- Air has no weight, but does occupy 6.5 percent of the volume. Therefore, the calculation is as follows:

$$\text{Air Volume (m}^3\text{)} = 1.000 \text{ m}^3 \times (6.5\% \div 100) = 0.065 \text{ Air Volume (m}^3\text{)}$$

- The volume of water, cement, finely divided minerals, fine aggregate, and coarse aggregate is calculated as follows:

$$\text{Volume (m}^3\text{)} = \frac{\text{Weight of Material in kg}}{(\text{Specific Gravity of Material} \times 1,000.0 \text{ kg/m}^3)}$$

The volumetric proportioning diagram illustrates that the volume change of any material will affect the volume of concrete produced. The diagram also illustrates that an increase in weight (mass) will increase volume, assuming the specific gravity of the material is the same. Finally, while air does not have weight (mass), if the air content were increased from 6.5 percent to 7.0 percent, the volume of concrete would be increased 0.5 percent.

5.4 AGGREGATE MOISTURE

5.4.1 Aggregate Moisture Condition

There are four conditions for the moisture content (water content) of aggregates. They are as follows:

- Oven Dry Condition - The aggregates have been heated until completely dry. There is no free moisture (water) on the surface of the individual aggregate particles. There is no absorbed moisture (water) in the pores of the individual aggregate particles.
- Air Dry Condition - There is no free moisture on the surface of the individual aggregate particles. There is some absorbed moisture in the pores of the individual aggregate particles.
- Saturated Surface-Dry (SSD) Condition - There is no free moisture on the surface of the individual aggregate particles. All possible moisture which can be absorbed into the pores of the individual aggregate particles has occurred.

Aggregate in this condition will look damp.

- Wet Condition - There is free moisture on the surface of the individual aggregate particles. All possible moisture which can be absorbed into the pores of the individual aggregate particles has occurred.

Aggregate in this condition will have water which is visible.

5.4.2 Total Moisture and Absorption

Free moisture and absorbed moisture are discussed in 5.4.1 "Aggregate Moisture Condition." Total moisture is defined by the following formula:

Total Moisture = Free Moisture + Absorbed Moisture

Therefore, total moisture is simply the sum of free moisture and absorbed moisture.

Absorption is the moisture content at which the saturated surface-dry condition occurs. The percent of absorption for a fine aggregate is determined according to Illinois Test Procedure 84. The percent of absorption for a coarse aggregate is determined according to Illinois Test Procedure 85. These test methods are in the Manual of Test Procedures for Materials.

The formula to determine absorption is as follows:

$$\text{Absorption (\%)} = \frac{\text{SSD Weight (Mass)} - \text{Oven Dry Weight (Mass)}}{\text{Oven Dry Weight (Mass)}} \times 100$$

The absorption for an aggregate is obtained from the Department's District office.

5.4.3 Aggregate Moisture Test Methods

Aggregates encountered at the plant are normally in a wet condition. Refer to 5.4.1 "Aggregate Moisture Condition" for additional information. Fine aggregate typically has 2.5 to 4 percent moisture, and normally does not exceed 10 percent. Coarse aggregate typically has 0.5 to 1.5 percent moisture, and normally does not exceed 2 percent. A variety of test methods are available to determine aggregate moisture.

5.4.3.1 Sampling for Aggregate Moisture

The field sample size shall be according to 4.1.1 "Compliance of Aggregate Gradation." The test sample size shall be according to the test method used.

5.4.3.2 Illinois Test Procedure 255

Illinois Test Procedure 255 is an accurate method for determining the total moisture of a coarse or fine aggregate, by drying the sample. The test method is in the Manual of Test Procedures for Materials, and a copy is provided in Appendix I. The formula to calculate total moisture content is as follows:

$$\text{Total Moisture Content (\%)} = \frac{M - OD}{OD} \times 100$$

Where: M = Moist weight (mass).
OD = Oven Dry weight (mass)

Note: M - OD = Weight (mass) Moisture Loss.

The following are example calculations:

Scale Without Tare – Fine Aggregate (FA 1)

(Measure to nearest 0.1 gram for fine aggregate.)

Absorption of Fine Aggregate in Percent	= 1.8% (Note 1)
Weight (mass) of Pan	= 225.0 grams
Moist Sample + Pan weight (mass)	= 787.1 grams
Oven Dry Sample + Pan weight (mass)	= 759.1 grams
Oven Dry Sample weight (mass)	= 759.1 - 225.0 = 534.1 grams
Weight (mass) Moisture Loss	= 787.1 - 759.1 = 28.0 grams
Total Moisture in Percent	= $(28.0 \div 534.1) \times 100 = 5.2\%$
Moisture Deviation from SSD in Percent	= 5.2 - 1.8 = +3.4% (Note 2)

Scale With Tare – Course Aggregate (CA 11)

(Measure to nearest 1 gram for coarse aggregate.)

Absorption of Coarse Aggregate in Percent	= 1.8% (Note 1)
Moist Sample weight (mass)	= 3040 grams
Oven Dry Sample weight (mass)	= 3004 grams
Weight (mass) Moisture Loss	= 3040 - 3004 = 36 grams
Total Moisture in Percent	= $(36 \div 3004) \times 100 = 1.2\%$
Moisture Deviation from SSD in Percent	= 1.2 - 1.8 = -0.6% (Note 3)

Notes for scale without tare and scale with tare:

Note 1: The absorption for an aggregate is obtained from the Department's District office.

Note 2: The plus sign indicates moisture in excess of SSD. The aggregate in this condition would contribute water to the mix water.

Note 3: The negative sign indicates moisture is less than SSD. The aggregate in this condition would absorb some of the mix water.

5.4.3.3 Illinois Test Procedure 301 – Flask Method

The Chapman Flask Method is a rapid test for determining fine aggregate moisture only. The test method is valid only for fine aggregate in a wet condition, since the test determines free moisture.

The test is not to be used for determining absorption, because of the rapid nature of the test. In other words, aggregate in an air dry condition does not have sufficient time to adequately absorb the water, to the extent possible.

The test method is in the Manual of Test Procedures for Materials, and a copy is provided in Appendix I.

5.4.3.4 Illinois Test Procedure 302 – Dunagan Method

The Dunagan Method can be used to determine the moisture of a coarse or fine aggregate. The Dunagan method determines free moisture or absorption. The Dunagan Method can also check the specific gravity of a coarse or fine aggregate. The test method is in the Manual of Test Procedures for Materials, and a copy is provided in Appendix I.

5.4.3.5 Illinois Test Procedure 303 – Pycnometer Jar Method

The Pycnometer Jar Method is a rapid test for determining fine or coarse aggregate moisture. The test method is valid only for fine or coarse aggregate in a wet condition, since the test determines free moisture.

The test is not to be used for determining absorption, because of the rapid nature of the test. In other words, aggregate in an air dry condition does not have sufficient time to adequately absorb the water, to the extent possible.

The test method is in the Manual of Test Procedures for Materials, and a copy is provided in Appendix I.

5.4.3.6 Other Methods

Other test methods are available for determining aggregate moisture. If the Contractor desires to use one of these methods, it shall be indicated in the Quality Control Plan. Refer to Appendix H.

5.4.4 Aggregate Moisture Quality Control

The Level II PCC Technician is advised to monitor aggregate moisture closely if using high absorption aggregate, if recent wet weather has occurred, if stockpiles are partially frozen, and when water is sprinkled on stockpiles during hot weather.

5.5 ADJUSTING BATCH WEIGHTS

The mix design batch weights are based on fine and coarse aggregates being in the saturated surface-dry condition. Refer to 5.4.1 “Aggregate Moisture Condition” for additional information. In reality, these are ideal conditions rarely found in the field. Therefore, accurate determination of aggregate moisture is important for the following reasons.

- To adjust aggregate batch weights. Otherwise, the volume of batched concrete will change. This will result in an over yield or under yield condition.
- To determine the correct amount of mix water to batch. Otherwise, the water/cement ratio and slump will change, producing inconsistent concrete batches. A variable water will also affect the strength and the durability of the concrete, and the smoothness of a pavement or bridge deck.

5.5.1 Adjusting Batch Weights for Moisture

The Level II PCC Technician shall test aggregates for moisture, to adjust the aggregate batch weights and mix water accordingly. The following rules of thumb will help with adjusting the aggregate batch weight.

- For a positive moisture deviation (free moisture), **increase** the aggregate and **decrease** the mix water batched.
- For a negative moisture deviation (water which will be absorbed), **decrease** the aggregate and **increase** the mix water batched.

The following is an example calculation in English units:

Given: Mix Design for 1 yd³ and Aggregate Moisture Test Results

	Batch Weight (lbs/yd³)	Moisture Deviation from SSD (%)	Aggregate Moisture Condition
Fine Aggregate	1,192	+ 3.0	Wet
Coarse Aggregate	1,868	- 1.0	Air Dry
Mix Water	249	n/a	n/a

Water Correction:

Fine Aggregate $1,192 \times (+ 3.0 \div 100) = + 36 \text{ lbs/yd}^3$ (excess water)
 Coarse Aggregate $1,868 \times (- 1.0 \div 100) = - 19 \text{ lbs/yd}^3$ (short of water)

Batch Weight Adjustments:

Fine Aggregate $1,192 + 36 = 1,228 \text{ lbs/yd}^3$
 Coarse Aggregate $1,868 - 19 = 1,849 \text{ lbs/yd}^3$
 Mix Water $249 - 36 + 19 = 232 \text{ lbs/yd}^3$ (* 27.9 gal/yd³)

* 1 gallon of water = 8.33 lbs

The following is an example calculation in Metric units:

Given: Mix Design for 1 m³ and Aggregate Moisture Test Results

	Batch Weight (kg/m³)	Moisture Deviation from SSD (%)	Aggregate Moisture Condition
Fine Aggregate	707	+ 3.0	Wet
Coarse Aggregate	1,109	- 1.0	Air Dry
Mix Water	148	n/a	n/a

Water Correction:

Fine Aggregate $707 \times (+ 3.0 \div 100) = + 21 \text{ kg/m}^3$ (excess water)
 Coarse Aggregate $1,109 \times (- 1.0 \div 100) = - 11 \text{ kg/m}^3$ (short of water)

Batch Weight Adjustments:

Fine Aggregate $707 + 21 = 728 \text{ kg/m}^3$
 Coarse Aggregate $1,109 - 11 = 1,098 \text{ kg/m}^3$
 Mix Water $148 - 21 + 11 = 138 \text{ kg/m}^3$ (* 138 liters/m³)

* 1 liter of water = 1 kilogram

5.6 WATER-CEMENT CONTROL

The water/cement ratio is defined as the weight (mass) of water, divided by the weight (mass) of cement. The water shall include mixing water, water in admixtures, free moisture on the aggregates (i.e. water on the surface of the individual aggregate particles), and water added at the jobsite.

When fly ash, ground granulated blast-furnace slag, microsilica, or high-reactivity metakaolin are used as part of the cement in a concrete mix, the water/cement ratio will be based on the total cement and finely divided minerals contained in the mixture.

A maximum water/cement ratio will limit the quantity of water which can be added at the jobsite. A water/cement ratio range is specified for the following:

- The minimum water/cement ratio for all classes of concrete is 0.32, except Class PC (dry cast) which may be 0.25. The water/cement ratio should never be below 0.32 because cement hydration could be restricted.
- To ensure durability of concrete, the maximum water/cement ratio should never exceed 0.45 for a concrete mixture except as allowed for Class PP-4 concrete.
- The maximum water/cement ratio for Class PV concrete is 0.42. The maximum water/cement ratio for Class RR, BS, PC (wet cast), PS, DS, SC, and SI concrete is 0.44. The maximum water/cement ratio for Class PC (dry cast) concrete is 0.40. The maximum water/cement ratio for Class PP-1 concrete is 0.44, for Class PP-2 concrete it is 0.38, for Class PP-3 concrete it is 0.35, for Class PP-4 concrete it is 0.50, and for Class PP-5 concrete it is 0.40.

- The water/cement ratio for a bridge deck overlay varies with the type of overlay. For a bridge deck fly ash or ground granulated blast-furnace slag overlay, the water/cement ratio range is 0.32 to 0.44. For bridge deck microsilica and high-reactivity metakaolin overlays, the water/cement ratio range is 0.37 to 0.41. For latex concrete bridge deck overlays, the range is 0.30 to 0.40. For a concrete wearing surface, the range is 0.32 to 0.44.

The Level II PCC Technician is responsible for determining the allowable quantity of water which can be added at the jobsite, and communicating this information to the Level I PCC Technician on-site. The Level I PCC Technician is responsible for notifying the Level II PCC Technician the quantity of water added at the jobsite.

To determine the allowable quantity of water which can be added at the jobsite, the Level II PCC Technician shall use the Department's "Water/Cement Ratio Worksheet" document. Refer to Appendix J.

When calculating water/cement ratio, wash water remaining in a truck mixer is very difficult to estimate. Therefore, Article 1020.11(a)(4) requires a truck mixer to discharge all wash water prior to batching the concrete materials. It shall also be noted that wash water remaining in a truck agitator will increase the water/cement ratio, and therefore shall be removed before introducing the batch of concrete. Refer to 6.7 "Water" for additional information regarding wash water.

When calculating water/cement ratio, it is recommended the Level II PCC Technician consider any water used by the truck driver after batching. This will occur for a truck mixer, which requires the discharge opening to be rinsed. Normally, 3 gal (11 L) is adequate to rinse material into the truck mixer. The water added by the plant may be reduced by the amount of rinse water used. Thus, the correct amount of mix water required by the mix design is used. The other option is to include the rinse water with the water added at the jobsite.

The Level II PCC Technician should also consider water in admixtures when significant. This will most often occur when using a high range water-reducing admixture (superplasticizer), calcium chloride accelerator, or latex admixture.

The following are example calculations for determining water/cement ratio. The calculations are numbered, to correspond with the Water/Cement Ratio Worksheet. The worksheet explains the calculation method.

The following is an example calculation in English units:

Given: Bridge Deck Mix Design and Aggregate Moisture Test Results

	Design Weight (lbs/yd³)	Moisture Deviation from SSD* (%)	Aggregate Moisture Condition
Cement	605		
Fine Aggregate	1,000	+ 2.0	Wet
Coarse Aggregate	2,000	- 0.5	Dry
Mix Water	250 (** 30 gal/yd ³)		

* SSD, Saturated Surface-Dry

** 1 gallon of water = 8.33 lbs. Therefore, divide 250 by 8.33 to calculate the gallons of water per cubic yard. This is the Design Water Requirement.

Water in Admixtures

Maximum Water/Cement Ratio = 0.44 (Bridge Deck Pour)

Batch Size = 7 cubic yards

Admixtures:

- Air Entrainment Admixture

Admixture Dosage = 1 oz/cwt of cement***

- Type G High Range Water-Reducing and Retarding Admixture

Admixture Dosage = 10 oz/cwt of cement***

*** cwt = hundredweight = 100 lbs of cement

$$\text{Admixture Water Content} = \left\{ \left[0.7 \times (d_1 + d_2 + d_3 + \dots) \times \frac{\text{Cement, lbs}}{100} \right] \div 128 \right\} \times \text{Batch Size, yd}^3$$

Where: 0.7 = Admixture water content factor****

d_n = Admixture dosage, oz/cwt

128 oz = 1 gallon of water

**** For most admixtures, approximately 70 percent of each ounce is water. Use a water content factor of 0.5 for latex admixtures. Refer to Article 1020.05(b).

$$\text{Admixture Water Content} = \left\{ \left[0.7 \times (1 + 10) \times \frac{605}{100} \right] \div 128 \right\} \times 7 = 2.5 \text{ gal/batch}$$

Calculations (Refer to Appendix J for worksheet)

1.	Total Cement plus Finely Divided Minerals*, lb/yd ³ * Fly Ash, Ground Granulated Blast-Furnace Slag, Microsilica, High Reactivity Metakaolin	<u>605</u>	lb/yd ³
2.	Maximum water/cement ratio	<u>0.44</u>	
3.	Maximum Allowable Water, gal/yd ³ English: (Line 1 × Line 2) ÷ 8.33	(605 × 0.44) ÷ 8.33 = <u>32.0</u>	gal/yd ³
4.	Batch Size, yd ³	<u>7</u>	yd ³
5.	Water in Fine Aggregate per Batch, gal English: {[(%FA Moisture ÷ 100) × FA lb/yd ³] × Line 4} ÷ 8.33 Moisture can be positive (+, excess water) or negative (-, short water)	{[(+2.0 ÷ 100) × 1000] × 7} ÷ 8.33 = <u>+16.8</u>	gal
6.	Water in Coarse Aggregate per Batch, gal English: {[(%CA Moisture ÷ 100) × CA lb/yd ³] × Line 4} ÷ 8.33 Moisture can be positive (+, excess water) or negative (-, short water)	{[(-0.5 ÷ 100) × 2000] × 7} ÷ 8.33 = <u>-8.4</u>	gal
7.	Water in Admixtures per Batch, gal English: {[0.7(d ₁ + d ₂ + d ₃ + ...) × (Line 1 ÷ 100)] ÷ 128} × Line 4 Where d ₁ , d ₂ , d ₃ , etc. is the dosage rate, oz/cwt, of each admixture. Note: 0.7 is estimated value for admixture water content. Use 0.5 for latex admixtures.	{[0.7(1 + 10) × (605 ÷ 100)] ÷ 128} × 7 = <u>2.5</u>	gal
8.	Plant Water per Batch, gal (Design Water Requirement, gal × Line 4) - (Line 5 + Line 6 + Line 7)	(30.0 × 7) - (16.8 - 8.4 + 2.5) = <u>199.1</u>	gal
9.	Wash Water in Truck per Batch, gal Truck mixer shall discharge all wash water.	<u>0.0</u>	gal
10.	Total Water in Batch, gal Line 5 + Line 6 + Line 7 + Line 8 + Line 9	16.8 - 8.4 + 2.5 + 199.1 + 0.0 = <u>210.0</u>	gal
11.	Maximum Water Allowed per Batch, gal Line 3 × Line 4	32.0 × 7 = <u>224.0</u>	gal
12.	Maximum Additional Water Allowed per Batch, gal Line 11 - Line 10	224.0 - 210.0 = <u>14.0</u>	gal

To clarify Calculation 8, 16.8 gallons is subtracted from the Design Water Requirement because the fine aggregate is wet (excess moisture is a contribution to mix water content), and 8.4 gallons is added to the Design Water Requirement because the coarse aggregate is dry (mix water will be absorbed to achieve saturated surface-dry condition). Refer to 5.5 "Adjusting Batch Weights" for additional information. The 2.5 gallons is subtracted because the admixture water is a contribution to the Design Water Requirement.

NOTE: This example is for a stationary mixer, which is discharging into a nonagitator truck. If a truck mixer is used, and 3 gallons of water are needed to rinse the discharge opening, then the plant water may be adjusted to 196.1 gal (199.1 - 3.0). Refer to 5.6 "Water-Cement Control" for additional information.

The following is an example calculation in Metric units:

Given: Bridge Deck Mix Design and Aggregate Moisture Test Results

	Batch Weight (kg/m³)	Moisture Deviation from SSD* (%)	Aggregate Moisture Condition
Cement	360		
Fine Aggregate	593	+ 2.0	Wet
Coarse Aggregate	1,187	- 0.5	Dry
Mix Water	148 (** 148 L/m ³)		

* SSD, Saturated Surface-Dry

** 1 liter of water = 1 kilogram. Therefore, divide 148 by 1 to calculate the liters of water per cubic meter. This is the Design Water Requirement.

Water in Admixtures

Maximum Water/Cement Ratio = 0.44 (Bridge Deck Pour)

Batch Size = 5 cubic meters

Admixtures:

- Air Entrainment Admixture

Admixture Dosage = 65 ml/100 kg of cement

- Type G High Range Water-Reducing and Retarding Admixture

Admixture Dosage = 652 ml/100 kg of cement

$$\text{Admixture Water Content} = \left\{ \left[0.7 \times (d_1 + d_2 + d_3 + \dots) \times \frac{\text{Cement, kg}}{100} \right] \div 1000 \right\} \times \text{Batch Size, m}^3$$

Where: 0.7 = Admixture water content factor***

d_n = Admixture dosage, ml/100 kg

1000 ml = 1 liter of water

*** For most admixtures, approximately 70 percent of each milliliter is water. Use a water content factor of 0.5 for latex admixtures. Refer to Article 1020.05(b).

$$\text{Admixture Water Content} = \left\{ \left[0.7 \times (65 + 652) \times \frac{360}{100} \right] \div 1000 \right\} \times 5 = 9.0 \text{ L/batch}$$

Calculations (Refer to Appendix J for worksheet)

1.	Total Cement plus Finely Divided Minerals*, kg/m ³ * Fly Ash, Ground Granulated Blast-Furnace Slag, Microsilica, High Reactivity Metakaolin		<u>360</u>	kg/m ³
2.	Maximum water/cement ratio		<u>0.44</u>	
3.	Maximum Allowable Water, L/m ³ Metric: Line 1 × Line 2	360 × 0.44 =	<u>158.4</u>	L/m ³
4.	Batch Size, m ³		<u>5</u>	m ³
5.	Water in Fine Aggregate per Batch, L Metric: [(%FA Moisture ÷ 100) × FA kg/m ³] × Line 4 Moisture can be positive (+, excess water) or negative (-, short water)	[(+2.0 ÷ 100) × 593] × 5 =	<u>+59.3</u>	L
6.	Water in Coarse Aggregate per Batch, L Metric: [(%CA Moisture ÷ 100) × CA lb/yd ³] × Line 4 Moisture can be positive (+, excess water) or negative (-, short water)	[(-0.5 ÷ 100) × 1187] × 5 =	<u>-29.7</u>	L
7.	Water in Admixtures per Batch, L Metric: {[0.7(d ₁ + d ₂ + d ₃ + ...) × (Line 1 ÷ 100)] ÷ 1000} × Line 4 Where d ₁ , d ₂ , d ₃ , etc. is the dosage rate, ml/100 kg, of each admixture. Note: 0.7 is estimated value for admixture water content. Use 0.5 for latex admixtures.	{[0.7(65 + 652) × (360 ÷ 100)] ÷ 1000} × 5 =	<u>9.0</u>	L
8.	Plant Water per Batch, L (Design Water Requirement, L × Line 4) - (Line 5 + Line 6 + Line 7)	(148 × 5) - (59.3 - 29.7 + 9.0) =	<u>701.4</u>	L
9.	Wash Water in Truck per Batch, L Truck mixer shall discharge all wash water.		<u>0.0</u>	L
10.	Total Water in Batch, L Line 5 + Line 6 + Line 7 + Line 8 + Line 9	59.3 - 29.7 + 9.0 + 701.4 + 0.0 =	<u>740.0</u>	L
11.	Maximum Water Allowed per Batch, L Line 3 × Line 4	158.4 × 5 =	<u>792.0</u>	L
12.	Maximum Additional Water Allowed per Batch, L Line 11 - Line 10	792.0 - 740.0 =	<u>52.0</u>	L

Remember that 1 kilogram of water equals 1 liter of water.

To clarify Calculation 8, 59.3 liters is subtracted from the Design Water Requirement because the fine aggregate is wet (excess moisture is a contribution to mix water content), and 29.7 liters is added to the Design Water Requirement because the coarse aggregate is dry (mix water will be absorbed to achieve saturated surface-dry condition). Refer to 5.5 "Adjusting Batch Weights" for additional information. The 9.0 liters is subtracted because the admixture water is a contribution to the Design Water Requirement.

NOTE: This example is for a stationary mixer, which is discharging into a nonagitator truck. If a truck mixer is used, and 11 liters of water are needed to rinse the discharge opening, then the plant water may be adjusted to 690.4 liters (701.4 - 11.0). Refer to 5.6 "Water-Cement Control" for additional information.

5.7 FIELD PROPORTIONING ADJUSTMENTS

The Level II PCC Technician is responsible for minor mix design adjustments. Mix design adjustments are necessary to satisfy jobsite requirements. These jobsite requirements include the following:

- Slump within the specification range.
- Air content within the specification range.
- Water/cement ratio which does not exceed the range allowed by the specification.
- Mixture which contains no more water than is necessary to produce workable and plastic concrete. In addition, a uniform consistency (slump) should be maintained continuously. Good quality control of water and air content are two aspects needed to produce uniform consistency.
- Mixture which yields one cubic meter (cubic yard).

5.7.1 Slump

If the slump is low and more mix water is necessary, the Level II PCC Technician is advised the additional water will increase air content. Air content will normally increase 0.5 to 1 percent, with each additional 1 gal/yd³ (5 L/m³) of added water. Therefore, perform an air content test after the addition of water.

Normally, 1 gal/yd³ (5 L/m³) of concrete, will raise the slump 1 in. (25 mm). When the mix water is increased, the aggregate is decreased to maintain the same yield. After the mix design is adjusted, the aggregate batch weights are then adjusted for aggregate moisture.

If the slump is high, and it has been determined less mix water is necessary, the Level II PCC Technician shall follow the procedure discussed in the previous paragraph.

The slump will be affected if significant quantities of admixtures are used, because of water in the admixtures. This is resolved by reducing the mix water by the amount of water contained in the admixtures. Refer to 5.6 "Water-Cement Control" for additional information regarding water in admixtures.

5.7.2 Air Content

If the air content is high or low, and it has been determined the admixture dosage is the problem, the Level II PCC Technician shall adjust the dosage accordingly.

5.7.3 Water/Cement Ratio

If the maximum additional water allowed per batch has been added at the jobsite, and the concrete requires additional slump, the Level II PCC Technician has the option to use a water-reducing admixture, or to increase the dosage if the admixture is already being used.

The water/cement ratio will be affected if significant quantities of admixtures are used, because of water in the admixtures. This is resolved by reducing the mix water by the amount of water contained in the admixtures. Refer to 5.6 "Water-Cement Control" for additional information regarding water in admixtures.

5.7.4 Workability

In some cases to increase air content, improve pumpability, and improve finishability, it is necessary to increase the fine aggregate and decrease the coarse aggregate. After the mix design is adjusted, the aggregate batch weights are then adjusted for aggregate moisture.

If the fine aggregate is increased, the maximum permitted is governed by the mortar factor. Refer to 11.8 "Mortar Factor" and 11.9 "Design Mortar Factors" for additional information. If the mortar factor increases 0.05 or more from the original value, a new mix design is required. A 0.05 increase in mortar factor is approximately equal to a fine aggregate increase of 65 lbs (30 kg).

5.7.5 Yield

The measured yield shall be within ± 1 percent of the theoretical yield. Any under yield is costly to the Contractor. Any over yield will impact strength, because the cement factor is reduced. Cement factor is the number of pounds (kilograms) of cement contained in a cubic yard (cubic meter).

As an example, assume the cement batch weight is 605 lbs/yd³ (360 kg/m³), and the yield is 1.01 yd³ (1.01 m³). The cement factor is calculated as follows:

English:

$$\text{Cement Factor} = \frac{605}{1.01} = 599 \text{ lbs/yd}^3$$

Metric:

$$\text{Cement Factor} = \frac{360}{1.01} = 356 \text{ kg/m}^3$$

As illustrated by this example, the over yield reduced the cement factor.

When an admixture is used for water reduction, the actual amount of reduction shall be determined. This is necessary to maintain a yield of one cubic yard (cubic meter). After performing a unit weight/yield test, adjust the fine aggregate and mix water accordingly. After the mix design is adjusted, the aggregate batch weights are then adjusted for aggregate moisture.

The yield will be affected if significant quantities of admixtures are used, because of water in the admixtures. This is resolved by reducing the mix water by the amount of water contained in the admixtures. Refer to 5.6 "Water-Cement Control" for additional information regarding water in admixtures.

5.7.6 Synthetic Fibers

When synthetic fibers are added, normally no proportioning adjustments are performed.

5.7.7 Mortar Content

To improve the finish against formed surfaces, increasing the mortar content will help. To do so, increase the mortar factor. Adjusting the mortar factor adjusts the coarse aggregate-to-fine aggregate ratio. Increasing the mortar factor will increase the fine aggregate and decrease the coarse aggregate. After the mix design is adjusted, the aggregate batch weights are then adjusted for aggregate moisture.

6.0 MATERIALS AND THEIR INFLUENCE

6.1 AGGREGATES

The grading or particle size distribution of an aggregate can have a significant influence on a concrete mixture. The two types of grading are as follows:

- Uniformly Graded - Aggregates which do not have a large deficiency or excess of any particle size.
- Gap Graded - Aggregates which have specific particle sizes omitted, or the specific particle sizes are minimal.

To measure the uniformity of grading for an aggregate, fineness modulus is used. This is applicable for fine or coarse aggregate. As per ASTM C 125, fineness modulus is “a factor obtained by adding the percentages of material in the sample that is coarser than each of the following sieves (cumulative percentages retained), and dividing the sum by 100: No. 100 (0.15 mm), No. 50 (0.3 mm), No. 30 (0.6 mm), No. 16 (1.18 mm), No. 8 (2.36 mm), No. 4 (4.75 mm), 3/8 in. (9.5 mm), 3/4 in. (19.0 mm), 1 1/2 in. (37.5 mm), 3 in. (75 mm), 6 in. (150 mm).” The factor determined is an indication of aggregate fineness. The higher the factor (fineness modulus), the coarser the aggregate.

The following is an example calculation for fineness modulus:

<u>Sieve Size</u>	<u>Cumulative Percent Retained *</u>
3/8 in. (9.5 mm)	0
No. 4 (4.75 mm)	5
No. 8 (2.36 mm) **	20
No. 16 (1.18 mm)	30
No. 30 (0.6 mm) **	55
No. 50 (0.3 mm)	80
No. 100 (0.15 mm)	<u>95</u>
	285

$$\text{Fineness Modulus} = 285 \div 100 = 2.85$$

* Obtained from Form Bmpr MI504, for an FA 1.

** The sieve is not required, according to the Required Sampling and Testing Equipment for Concrete. The Contractor or Commercial Concrete Producer would have to acquire this sieve.

6.1.1 Fine Aggregate Grading

The grading of a fine aggregate has a significant influence on the air content, workability, and pumpability of a concrete mixture. Therefore, the following items are important to know.

- Material from the No. 30 (0.6 mm) to No. 100 (0.15 mm) sieve is the most effective for entraining air.
- Increasing the amount of minus No. 100 (minus 0.15 mm) or minus No. 200 (minus 0.075 mm) sieve material will decrease air content and increase water demand. An increase in this material may occur during stockpiling and handling, or during mixing. If the fine aggregate minerals degrade into clay fines, the affect on air content and water demand may be significant.

It is also important to know that clays, in some fine aggregates, may disperse slowly in water. Therefore, the decrease in air content can be delayed, with significant differences between the plant and jobsite.

- Increasing the amount of material passing the No. 30 (0.6 mm) sieve, but retained on the No. 50 (0.3 mm) sieve will increase air content. The sand voids within this grading range are very good for holding entrained air bubbles. The voids prevent the entrained air bubbles from escaping; or from coalescing to form larger bubbles, which are more likely to break. For the Department's mix design method, a higher mortar factor may be needed to have sufficient sand to entrain air. Refer to 11.7 "Mortar Factor" for additional information.
- Increased bleed water typically occurs for aggregate gradations with missing or minimal material on the No. 30 (0.6 mm) and the No. 50 (0.3 mm) sieves.
- For pumping, it is recommended to have 15 to 30 percent passing the No. 50 (0.3 mm) sieve, and 5 to 10 percent passing the No. 100 (0.15 mm) sieve. In addition, a fineness modulus between 2.40 and 3.00 is recommended. These recommendations are per ACI Committee 304.

According to Article 1003.01(c), the only difference between a FA 1 and FA 2 occurs on the No. 50 (0.3 mm) sieve. For FA 1, the No. 50 (0.3 mm) sieve will range from 3 to 29 percent passing. For FA 2, the No. 50 (0.3 mm) sieve will range from 10 to 30 percent. Therefore, FA 1 may be less advantageous for pumping, because the percent passing the No. 50 (0.3 mm) sieve may be as low as 3.

- For slipform construction which requires a stiff mix, an FA 20 may be desirable to use because of high No. 100 (0.15 mm) and No. 200 (0.3 mm) material. In addition, a fineness modulus between 2.7 and 3.5 is recommended for slipform paving. A very coarse sand with a fineness modulus between 3.5 and 3.8 may also work, but a test batch is recommended.
- If the fineness modulus changes more than 0.2, changes in the mix proportions are probably needed to provide the same workability.
- A low fineness modulus will require a higher paste (i.e. cement, finely divided minerals, water, and air) or the use of an admixture, for good workability.

The information provided on fine aggregate grading is not intended for the Level II PCC Technician to control, but to provide possible reasons for problems encountered.

6.1.2 Coarse Aggregate Grading

The grading of a coarse aggregate has an influence on the air content, workability, and pumpability of a concrete mixture. Therefore, the following items are important to know.

- Increasing the amount of minus No. 200 mm (minus 0.075) sieve material will decrease air content and increase water demand, especially if the material consists of clay, shale, or silt.

If the minus No. 200 mm (minus 0.075) sieve material consists primarily of stone fines, and is essentially free from clay, shale, or silt, this material will have less of an affect on air content and water demand. Stone fines are a result of: (1) dust of fracture from the crushing operation (2) degradation from abrasion and attrition during stockpiling and handling (3) degradation during mixing of the concrete mixture.

Gravel aggregate deposits frequently contain clay, shale, or silt. Stone deposits (i.e. limestone or dolomite) may contain clay or shale. For stone deposits, clay or shale will occur as thin partings between the beds of stone, and clay will occur as small particles scattered throughout the stone's crystalline structure. Shale is essentially compacted and hardened clay. Normally, shale is identified by its visible laminations, and will occur in layers of variable thickness.

Knowledge of an aggregate's minus No. 200 mm (minus 0.075) sieve material (i. e. clay fines vs. stone fines) can be very important.

- The grading of a coarse aggregate can vary moderately, without appreciable effect on workability.
- A gap graded coarse aggregate is more suitable for placement by chute or bucket, than for pumping.

A CA 7 or CA 11 will typically have minimal particle size between the No. 4 (4.75 mm) and 1/2 in. (12.5 mm) sieves. This particle size range is commonly referred to as chips. The chips are used for hot mix asphalt mixtures. Therefore, consideration should be given for using a uniformly graded CA 7 or CA 11 when pumping concrete. Another option is to blend a second coarse aggregate with the gap graded coarse aggregate, to produce a uniform gradation.

When Class BS concrete is to be pumped, the coarse aggregate gradation shall have a minimum of 45 percent passing the 1/2 in. (12.5 mm) sieve. Two or more coarse aggregate sizes may be combined, consisting of CA 7, CA 11, CA 13, CA 14, and CA 16, provided a CA 7 or CA 11 is included in the blend.

- Using larger size aggregate will require less cement and finely divided minerals for workability because of less surface area. However, the biggest use of large aggregate is for mass concrete pours. A reduction in the total amount of cement and finely divided minerals will reduce the heat of hydration. This will prevent excessive temperatures from occurring.

The information provided on coarse aggregate grading is not intended for the Level II PCC Technician to control, but to provide possible reasons for problems encountered.

6.1.3 Aggregate Blend

As discussed in 6.1.1 “Fine Aggregate Grading” and 6.1.2 “Coarse Aggregate Grading”, the aggregate gradation can have an effect on the concrete mixture. Therefore, it is useful to know how to determine the aggregate blend, when the coarse aggregate and fine aggregate are combined. The formula for determining the total blend, for a particular sieve, is as follows:

$$TB = \left(\frac{a}{100} \times A\right) + \left(\frac{b}{100} \times B\right) + \left(\frac{c}{100} \times C\right) + \dots$$

Where: TB = Total Blend of Aggregate Passing the Sieve.

a, b, c... = Percent of Total Aggregate.

A, B, C... = Percent of Aggregate Passing the Sieve.

The following is an example calculation in English Units:

Given: Material A is a FA 1, which is batched at the rate of 1,000 lbs/yd³.
The percent passing the # 200 sieve is 1.1%.

Material B is a CA 11, which is batched at the rate of 2,000 lbs/yd³. The percent passing the # 200 sieve is 0.6%.

$$a = \frac{1,000}{1,000 + 2,000} \times 100 = 33\% \quad b = \frac{2,000}{1,000 + 2,000} \times 100 = 67\%$$

$$TB_{200} = TB = \left(\frac{33}{100} \times 1.1\right) + \left(\frac{67}{100} \times 0.6\right) = 0.8\%$$

The following is an example calculation in Metric Units:

Given: Material A is a FA 1, which is batched at the rate of 600 kg/m³.
The percent passing the 0.075 mm sieve is 1.3%.

Material B is a CA 11, which is batched at the rate of 1,185 kg/m³.
The percent passing the 0.075 mm sieve is 0.8%.

$$a = \frac{600}{600 + 1,185} \times 100 = 34\% \quad b = \frac{1,185}{600 + 1,185} \times 100 = 66\%$$

$$TB_{200} = TB = \left(\frac{34}{100} \times 1.3\right) + \left(\frac{66}{100} \times 0.8\right) = 1.0\%$$

The advantage for understanding aggregate blend can be illustrated. Assume there is one coarse aggregate source available, and several fine aggregate sources available. A Contractor or Commercial Concrete Producer will obviously consider the price of the fine aggregate, but may also want to consider the coarse and fine aggregate blend, when selecting the fine aggregate source.

6.1.4 Aggregate Angularity

As the angularity of a coarse or fine aggregate increases, the air-entraining admixture dosage is increased to maintain the same air content, and water demand is increased to maintain the same workability. For coarse aggregate, angularity can be readily seen. The difference between a rounded gravel, crushed gravel, and crushed stone is obvious. For fine aggregate angularity, the Department will classify it as a Type A, B, or C, according to the Illinois Method for Fine Aggregate Classification.

A Type A fine aggregate is composed completely of rounded particles. A Type C fine aggregate is composed completely of angular particles. A Type B fine aggregate is composed of a mixture of rounded and angular particles. Therefore, a Type A fine aggregate has the least water demand, and a Type C fine aggregate has the highest water demand. A Type A fine aggregate will require less air-entraining admixture dosage than a Type C fine aggregate, assuming the gradations are the same.

For fine aggregate, very angular aggregate may cause problems and slow down production because of clumping in the aggregate bins. Stone sand and lightweight fine aggregate are susceptible to this problem, but it is normally resolved by attaching vibrators to the bins for discharge of material.

6.1.5 Aggregate Particle Shape

Aggregate particles which are flat and elongated will increase water demand, because of the greater surface area than a cubical particle. This is applicable to crushed coarse aggregate and crushed fine aggregate. Differences in fine aggregate particle shape cannot be seen without the aid of a microscope or a magnifying glass. For coarse aggregate particle shape, differences are readily seen. If necessary, tests are available for determining the percentage of flat and elongated particles. Refer to ASTM C 295 and Illinois Test Procedure 4791.

6.1.6 Aggregate Moisture Uniformity

According to Article 1020.10, aggregates shall have a uniform moisture content before placement in the plant bins. This may require aggregates to be stockpiled for 12 hours or more to allow drainage, or water added to the stockpile, or other methods approved by the Engineer. For crushed concrete, crushed slag, or lightweight aggregate, the coarse aggregate shall be stockpiled in a moist condition (saturated surface-dry or greater). Refer to Article 1004.01(e)(5). The moisture content shall be maintained uniformly throughout the stockpile by periodic sprinkling. As a guide, aggregate moisture which does not vary more than 0.5 percent is considered uniform.

If the plant has an automatic moisture sensor and can automatically adjust aggregate batch weights, the Department still recommends a uniform aggregate moisture before placement in plant bins. This will alleviate any problems if an equipment failure occurs.

6.1.7 Aggregate Uniformity

Aggregates shall be handled in a manner which produces a uniform gradation, before placement in the plant bins. Aggregates delivered to the plant in a non-uniform gradation shall be stockpiled. The stockpiled aggregate shall be mixed uniformly, before placement in the plant bins.

The Department recommends the aggregates be delivered in a uniform condition. Otherwise, the Contractor or Commercial Concrete Producer has no method to check aggregates arriving at the plant. Refer to 4.1.2 "Aggregate Acceptance." Another reason is that stockpile remixing methods for fine aggregate have not proven to significantly alter the gradation. Fine aggregate is usually in a wet condition, which makes remixing difficult.

6.1.8 Aggregate Absorption and Specific Gravity

The Level II PCC Technician is advised that aggregate absorption or specific gravity has been known to change, but this is infrequent. A change in aggregate absorption will change aggregate moisture, and batch weight adjustments. Refer to 5.4 "Aggregate Moisture" and 5.5 "Adjusting Batch Weights" for additional information. A change in aggregate absorption or specific gravity will also change saturated surface-dry specific gravity, which ultimately changes yield. Refer to 5.2 "Specific Gravity (Saturated Surface-Dry)" and 5.3 "Volumetric Proportioning Diagram" for additional information.

The Level II PCC Technician is also advised that high absorption aggregate batched on the dry side will absorb mix water. This will decrease slump and air content.

6.1.9 Aggregate Sampling

The aggregate sampling method must represent the information desired. For example, a truck-dump sample is more appropriate for checking the gradation of aggregate arriving at the plant. Whereas, a bin-discharge sample is more appropriate for checking aggregate gradation immediately prior to batching. The bin-discharge sample is taken from aggregate entering the weigh hopper.

As another example, the bin-discharge sample may not be a good method to check aggregate moisture content. This may occur when the bin-discharge sample is obtained from the first batches discharged, after the plant has been shut down overnight or longer. During the shut down, water may have drained to the bottom of the bin.

As a final example for checking aggregate moisture content, a conveyor belt sample may be better than a stockpile sample. Additional water may be drained from the aggregate while on the conveyor belt.

6.2 CEMENT

6.2.1 Types

There are eight types of portland cement allowed by the Department according to AASHTO M 85 (ASTM C 150). They are as follows:

- Type I * - General purpose.
- Type IA - General purpose and air-entraining.
- Type II * - Moderate sulfate resistance.
- Type IIA - Moderate sulfate resistance and air-entraining.
- Type II(MH) - Moderate heat of hydration and moderate sulfate resistance.
- Type II(MH)A - Moderate heat of hydration, moderate sulfate resistance, and air-entraining.
- Type III * - High early strength. **
- Type IIIA - High early strength ** and air-entraining.
- Type IV - Low heat of hydration.
- Type V - High sulfate resistance.

* The cement is commonly used in Illinois.

** The cement is finely ground.

There are two types of blended cement allowed by the Department according to AASHTO M 240 (ASTM C 595). They are as follows:

Type IP - Portland-pozzolan cement for general use. The pozzolan constituent shall not exceed 25 percent of the weight (mass) of the portland-pozzolan cement when using Class F fly ash, 30 percent when using Class C fly ash, and 10 percent when using microsilica or high-reactivity metakaolin.

Type IS *- Portland blast-furnace slag cement for general use. The slag constituent shall not exceed 35 percent of the weight (mass) of the portland blast-furnace slag cement.

* The cement is commonly used in Illinois.

There are three types of inorganic processing additions allowed for cement. They are granulated blast-furnace slag, fly ash and cement kiln dust. Up to 5.0 percent may be incorporated in portland or blended cement. In addition, up to 5.0 percent limestone by weight (mass) is permitted in portland cement. Therefore, the PCC Level II Technician should determine if the cement contains inorganic processing additions or limestone. These materials may influence the admixtures being used.

6.2.2 Influence

Cement characteristics will influence a concrete mixture. Therefore, the following items are important to know.

- Cement Factor - An increase in cement factor will decrease air content. A high cement factor will result in less bleed water.
- Cement Fineness - An increase in cement fineness will decrease air content and increase water demand. Higher early strengths should result in the field. A fine cement will result in less bleed water.
- Cement Air Content - This can vary, and will have a direct effect on air content.
- Low-Alkali Cement (≤ 0.60) - This will decrease air content when compared to a high-alkali cement (> 0.60). However, a high-alkali cement may produce a less stable air-void system. For high-alkali cements, a thinner or more soluble air-entraining admixture film may surround the bubbles. Therefore, the bubbles are more susceptible to breakage during mixing. Refer to 6.4.4 "Air-Entraining Admixture" for additional information.
- Cement Loss on Ignition (LOI) - An increase in loss on ignition will decrease air content.
- Cement with Anhydrite - A cement containing anhydrite that is used with a calcium-lignosulfonate water-reducing admixture may have rapid slump loss and difficulty controlling air content. Consider a longer mix time to correct the problem. Refer to 6.2.3 "Flash Set and False Set" for additional information.

6.2.3 Flash Set and False Set

Flash set is the early stiffness of the concrete, usually with much heat. The stiffness cannot be dispelled by further mixing with no additional water.

Flash set may occur for the following reasons:

- The cement does not have sufficient gypsum to control the tricalcium aluminate (C_3A) reaction.
- Heated aggregates or water are being used. Refer to 7.3.2 "Taking Precautions at the Plant" for additional information.
- The cement has been recently manufactured, and is still very hot.
- A high dosage of accelerator is being used.
- A calcium - lignosulfonate water-reducing admixture is added to a cement which contains marginally inadequate gypsum, or the cement contains natural anhydrite. Typically a delay flash set occurs in this situation.
- A water reducing admixture which tends to accelerate the tricalcium aluminate (C_3A) reaction in cement.
- Fly ash with a high tricalcium aluminate (C_3A) or calcium oxide (CaO) content.

False set is the early stiffness of the concrete without much heat. The stiffness can be dispelled by further mixing with no additional water. False set may occur when concrete is mixed in a stationary mixer for a short period of time, and subsequently transported in nonagitating trucks. Paving jobs are an example.

False set may also occur when there is an incompatibility between a cement and an admixture.

6.2.4 Initial Set and Final Set

Two other terms to know are initial and final set of concrete, which is influenced by the cement, finely divided minerals, admixtures, and concrete temperature. Initial set is the point of time where the concrete begins to become firm. This will typically occur 2 to 4 hours after batching the concrete. Final set is the point of time where the concrete is no longer plastic and finishing no longer can take place. This will typically occur 5 to 8 hours after batching the concrete.

6.3 FINELY DIVIDED MINERALS

Finely divided minerals include fly ash, ground granulated blast-furnace slag, microsilica, and high-reactivity metakaolin. A discussion of each material follows:

6.3.1 Fly Ash

6.3.1.1 Types

There are two classes of fly ash used in Illinois. They are Class C and Class F, and they are defined according to AASHTO M 295. The Class F fly ash usually has low-calcium oxide (< 10 percent CaO), and carbon contents less than 5 percent. The Class C fly ash usually has high-calcium oxide (10 – 30 percent CaO), and carbon contents less than 2 percent. In Illinois, most fly ash used in concrete is Class C.

6.3.1.2 Use - General

The following information is according to Article 1020.05(c)(1).

Fly ash may partially replace portland cement in cement aggregate mixture II, Class PV, PP-1, PP-2, RR, BS, PC, PS, DS, SC, and SI concrete.

Fly ash is also used because it increases workability, lowers heat of hydration, delays the set of concrete, and reduces permeability.

When Class F fly ash is used in cement aggregate mixture II, Class PV, BS, PC, PS, DS, SC, and SI concrete, the amount of cement replaced shall not exceed 25 percent by weight (mass).

When Class C fly ash is used in cement aggregate mixture II, Class PV, PP-1, PP-2, RR, BS, PC, PS, DS, SC, and SI concrete, the amount of cement replaced shall not exceed 30 percent by weight (mass).

Measurements of fly ash and cement shall be rounded up to the nearest 5 lbs (2.5 kg).

Fly ash may be used in concrete mixtures when the air temperature is below 40 °F (4 °C), but the Engineer may request a trial batch of the concrete mixture to show the mix design strength requirement will be met.

The following information is according to the applicable Guide Bridge Special Provisions (GBSP).

For bridge deck microsilica and high-reactivity metakaolin concrete overlays, only Class C fly ash may be used to replace portland cement. The amount of cement replaced shall not exceed 30 percent by weight (mass). For bridge deck fly ash or ground granulated blast-furnace slag concrete overlay, the portland cement content selected for the Class BS concrete shall be replaced with 25 percent Class F fly ash or 25 – 30 percent Class C fly ash.

6.3.1.3 Use - Pavement Patching and Railroad Crossings

According to Article 1020.05(b)(3), for Class PP-1 and RR concrete, a water-reducing admixture or high range water-reducing admixture shall be used when using Class C fly ash.

The Department has obtained improved strength test results for fly ash patching mixtures used in hot weather, when compared to cement only mixtures. The improved strength test results are more noticeable for mixtures using a gravel coarse aggregate.

6.3.1.4 Use - Multiple Finely Divided Minerals

For Class PV, PP-1, PP-2, RR, BS, PC, PS, DS, SC and SI concrete, the Contractor has the option to use a Class F fly ash and Class C fly ash combination. A Class F and Class C 30.0 percent combination is allowed with a maximum 25.0 percent Class F fly ash according to Article 1020.05(c)(5).

6.3.1.5 Influence

Fly ash characteristics will influence a concrete mixture. Therefore, the following items are important to know.

- Air content will decrease. This is applicable to fly ash which is added separately, or interground with the cement. The decrease in air content is less for high calcium oxide (CaO) fly ashes (Class C) when compared to low calcium oxide (CaO) fly ashes (Class F). In addition, greater amounts of fly ash will cause a larger decrease in air content.

When using fly ash, an increase in fineness will decrease air content. An increase in carbon content will also decrease air content. (Note: The loss on ignition is used as an indication of the amount of carbon. If the loss on ignition reaches 4 percent or more, it may become difficult to entrain air.) An increase in alkali content will increase air content.

It should be noted that some fly ashes with a high loss on ignition may not significantly decrease air content because the carbon phase is encapsulated or the portion of the loss on ignition is due to carbonate. In addition, a carbon blocker technology exists where an additive is added to the fly ash to mitigate the influence of loss on ignition when entraining air. At this time, one fly ash source uses this technology.

- An increase in fineness will increase water demand.
- Workability will improve (i.e. pumping and finishing).

- Segregation will be reduced.
- Bleed water will be reduced.
- Heat of hydration will be reduced.
- Set time will be delayed. However, a fly ash with high tricalcium aluminate (C_3A) or calcium oxide (CaO) may cause a faster set time.

Hardened concrete containing fly ash will normally have lower early strengths and higher long term strengths, than comparable “cement only” concrete mixtures.

6.3.2 Ground Granulated Blast-Furnace (GGBF) Slag

6.3.2.1 Types

There are two grades of GGBF slag used in Illinois. They are Grade 100 and Grade 120, and they are defined according to AASHTO M 302. The Grade 120 will normally have a greater strength gain than a Grade 100. This assumes an equal amount of each is used to replace a portion of the portland cement, in a concrete mixture.

6.3.2.2 Use - General

The following information is according to Article 1020.05(c)(2).

GGBF slag may partially replace portland cement in concrete mixtures, for Class PV, PP-1, PP-2, RR, BS, PC, PS, DS, SC, and SI concrete. For Class PP-3 concrete, GGBF slag shall be used according to Article 1020.04.

GGBF slag is also used because it increases workability, lowers heat of hydration, delays the set of concrete, and reduces permeability.

When GGBF slag is used in Class PV, PP-1, PP-2, RR, BS, PC, PS, DS, SC, and SI concrete, the amount of cement replaced shall not exceed 35 percent by weight (mass).

Measurements of GGBF slag and cement shall be rounded up to the nearest 5 lbs (2.5 kg).

GGBF slag may be used in concrete mixtures when the air temperature is below 40 °F (4 °C), but the Engineer may request a trial batch of the concrete mixture to show the mix design strength requirement will be met.

The following information is according to the applicable Guide Bridge Special Provisions (GBSP).

For bridge deck microsilica and high reactivity metakaolin concrete overlays, the portland cement may be replaced with GGBF slag. The replacement shall not result in a mixture with cement content below the minimum specified in Article 1020.04. For bridge deck fly ash or ground granulated blast-furnace slag concrete overlay, the portland cement content selected for the Class BS concrete shall be replaced with 25 – 35 percent GGBF slag.

6.3.2.3 Use – Pavement Patching and Railroad Crossings

According to Article 1020.05(b)(3), for Class PP-1 and RR concrete, a water-reducing or high range water-reducing admixture shall be used when using GGBF Slag.

6.3.2.4 Influence

GGBF slag characteristics will influence a concrete mixture. Therefore, the following items are important to know.

- Air content may increase or decrease.
If the fineness of the GGBF slag is higher than the portland cement, a small decrease in air content may occur.
- An increase in fineness will increase water demand.
- Workability will improve (i.e. pumping and finishing).
- Segregation is not adversely affected.
- Bleed water may increase or decrease slightly.
- Heat of hydration will be reduced.
- Set time will be delayed.

Hardened concrete containing GGBF slag will normally have lower early strengths and higher long term strengths, than comparable “cement only” concrete mixtures.

6.3.3 Microsilica

6.3.3.1 Use

Microsilica is currently used for bridge deck overlays to reduce permeability. According to Article 1020.05(c)(3), at the Contractor’s option, microsilica may be added at a maximum 5.0 percent by weight (mass) of the cement and finely divided minerals summed together.

6.3.3.2 Influence

Microsilica characteristics will influence a concrete mixture. Therefore, the following items are important to know.

- Air content will decrease.
- An increase in fineness will increase water demand.
- Workability will be reduced. Thus, high range water-reducing admixtures (superplasticizers) are used.
- Segregation will be reduced.
- Bleed water will be reduced.
- Heat of hydration is not affected. (Note: A superplasticizer allows more complete hydration of the individual cement grains. Thus, more heat will be released.)
- Set time is not affected.

Hardened concrete containing microsilica will have higher early and long term strengths, than comparable “cement only” concrete mixtures.

6.3.3.3 Field Problems

Microsilica is sensitive to balling or microballs. Refer to 8.4 “Troubleshooting Problems with a Concrete Mixture” for additional information.

6.3.4 High-Reactivity Metakaolin (HRM)

6.3.4.1 Use

High-reactivity metakaolin is currently used for bridge deck overlays to reduce permeability. According to Article 1020.05(c)(4), at the Contractor’s option, HRM may be added at a maximum 5.0 percent by weight (mass) of the cement and finely divided minerals summed together.

6.3.4.2 Influence

High-reactivity metakaolin characteristics will influence a concrete mixture. Therefore, the following items are important to know.

- Air content will decrease.
- Workability will be reduced. Thus, high range water-reducing admixtures (superplasticizers) are used. When compared to microsilica, HRM will require slightly less superplasticizer.
- Segregation will be reduced.
- Bleed water will be reduced.
- Heat of hydration is reduced.
- Set time is not affected.

Hardened concrete containing HRM will have higher early and long term strengths, than comparable “cement only” concrete mixtures.

6.4 ADMIXTURES

6.4.1 General

According to Article 1020.05(b), the Contractor shall be responsible for using admixtures and determining dosages for all Classes of concrete, cement aggregate mixture II, and controlled low-strength material that will produce a mixture with suitable workability, consistency, and plasticity. The Contractor shall obtain approval from the Engineer to use an accelerator when the concrete temperature is greater than 60 °F (16 °C). However, this accelerator approval will not be required for Class PP, RR, PC, and PS concrete. Information on the use of admixtures is provided in Article 1020.05 (b). Admixtures are used to modify the properties of a concrete mixture, and are added as a water based solution. Solids, except for controlled low-strength material, are not permitted because they provide less uniformity in a mixture.

The Level II PCC Technician shall consider the quantity of water in admixtures. Failure to consider the water will affect the slump, water/cement ratio, and unit weight/yield of the concrete. Therefore, the mix water is reduced by the amount of water contained in the admixtures. Refer to 5.6 "Water-Cement Control" for additional information regarding water in admixtures.

The sequence for dispensing admixtures must also be considered. For example, direct contact of the retarding or water-reducing admixture with the air-entraining admixture, may nullify the effect of one or both. Therefore, admixtures shall enter the batch separately. In addition, admixtures should not be put directly on dry aggregate since they could be absorbed and thus would not be mixed with the concrete.

When using more than one admixture, they shall be compatible. The Level II PCC Technician shall check the manufacturer's instructions or contact the admixture technical representative.

Admixture effectiveness is highly dependent on cement or finely divided mineral chemistry. Therefore, admixture dosage will vary with each material source.

To determine an admixture dosage, air temperature, concrete temperature, cement source and quantity, finely divided mineral sources and quantity, influence of other admixtures, haul time, placement conditions, and other factors as appropriate shall be considered.

Admixture dosage rates are measured in oz./hundredweight (ml/100 kg) of cement. A hundredweight (cwt) is the same as 100 lbs. For more detailed information on determining admixture dosages, refer to Article 1020.05(b).

6.4.2 Admixtures and Their Designations

In addition to an air-entraining admixture, other chemical admixtures are typed as follows:

- Type A — Water-reducing admixture
- Type B — Retarding admixture
- Type C — Accelerating admixture
- Type D — Water-reducing and retarding admixture
- Type E — Water-reducing and accelerating admixture
- Type F — Water-reducing, high range admixture
- Type G — Water-reducing, high range, and retarding admixture
- Type S — Specific performance admixtures

This is according to AASHTO M 194 (ASTM C494).

6.4.3 Air Temperature vs. Concrete Temperature for Admixtures

In some instances, a significant difference may occur between the air temperature and the concrete temperature. If this occurs, use the concrete temperature when determining admixture dosage.

6.4.4 Air-Entraining Admixture

Except for Class SC concrete (air entrainment optional) and bridge deck latex concrete overlay (latex entrains air), all concrete and cement aggregate mixture II mixtures shall contain entrained air. This may be accomplished through the use of air-entraining cement, but is most commonly done through the use of air-entraining admixtures. Air-entraining admixtures are commonly used because they allow more flexibility to make alterations, for various conditions which influence air content.

For air-entrained concrete, an air-entraining admixture does not create air bubbles. Air bubbles are created by the mixing process. The shearing action of the mixer blades breaks up large bubbles. An air-entraining admixture retains air in a mixture, by producing a film around the air bubbles. During mixing, these stable air bubbles are less likely to break and escape.

If the Level II PCC Technician is interested in obtaining more information on air-entrained concrete, the “Manual on Control of Air Content in Concrete,” by David A. Whiting and Mohammad A. Nagi is very good. The publication is available from the Portland Cement Association. Refer to 12.0 “Various Publications” for additional information.

6.4.4.1 Types

The types of air-entraining admixtures are as follows:

- Salts of wood resins. One type, vinsol resin, is increasingly limited because of material availability. Wood resins are known for quick air generation, minor air gain with mixing, air loss with prolonged mixing, and are compatible with most admixtures.
- Synthetic detergents. One type, alkyl olefin sulfonates are known for quick air generation, minor air loss with mixing, and a good application for concrete mixtures with less than 3 in. (75 mm) slump.
- Salts of sulfonated lignin
- Salts of petroleum acids
- Salts of proteinaceous material
- Fatty and resinous acids and their salts. Fatty acids are known for slower air generation, a possible increase in air with prolonged mixing, excellent use in fly ash concrete mixtures, good performance in hot weather, and are compatible with most admixtures.
- Alkylbenzene sulfonates
- Salts of sulfonated hydrocarbons

In general, slumps less than or equal to 7.5 in. (190 mm) will require less air-entraining admixture than high slumps over 7.5 in. (190 mm). The high slump mixtures normally have more water which tend to lose air.

When batching concrete, air-entraining admixtures are incorporated on the fine aggregate or with the water, but not on the coarse aggregate for the most effectiveness.

6.4.4.2 Other Admixtures

When using an air-entraining admixture, the effects of other admixtures shall be considered. The effects are as follows:

- Retarding Admixture - Increases air content. Lignin retarding admixtures may provide significant increases in air content.
- Water-Reducing Admixture or Mid-Range Water-Reducing Admixture - Lignosulfonate water-reducing admixtures will increase air content because they entrain air. The lignosulfonate may cause a 50 percent or more reduction in the required air-entraining admixture dosage. Hydroxylated carboxylic acid and salt water-reducing admixtures will increase air content, but they do not entrain air. Hydroxylated carboxylic acid and salt water-reducing admixtures will improve the efficiency of an air-entraining admixture. Carbohydrate water-reducing admixtures have no effect on air content.
- High Range Water-Reducing Admixture - Highly fluid mixtures may lose air content. Sulfonated melamine formaldehyde condensate (melamine-based) superplasticizers may decrease air content or have little effect. Sulfonated naphthalene formaldehyde condensates (naphthalene-based) superplasticizers will decrease air content. Lignosulfate superplasticizers and polycarboxylate superplasticizers will increase air content. A polycarboxylate superplasticizer is especially prone to increasing air content when the drum mixing speed is too fast.
- Accelerating Admixture - Calcium chloride accelerators increase air content. The other types of accelerators have little effect or will increase air content.

6.4.4.3 Pigments

Pigments such as carbon black, black iron oxide, and integral coloring agents for colored concrete may reduce air content.

6.4.4.4 Retempering (Water)

The practice to withhold some of the mix water at the plant and retempering at the jobsite will make the air-entraining admixture less effective. In addition, retempering with water at the jobsite can cause air void clustering around aggregate particles. This may cause above normal decreases in strength.

6.4.5 Retarding Admixture

When the atmospheric or concrete temperature is 65 °F (18 °C) or higher, a retarding admixture shall be used for Class BS concrete and concrete bridge deck overlays. The retarding admixture is required at such a low temperature to allow ample time to add the required superplasticizer at the jobsite, and to consider the deflections that occur during the bridge deck pour. Deflections may cause cracking if the concrete becomes stiff as a result of the hydration process. Refer to 11.5 "High-Range Water-Reducing Admixture" for additional information. For Class PP-4 concrete, a retarding admixture shall be used to allow for haul time. For Class DS concrete, a retarding admixture shall be used. In addition, for Class DS concrete, the concrete mixture shall be designed to remain fluid throughout the anticipated duration of the pour plus one hour.

The main reason the Department requires the use of a retarder is to counter the rapid setting caused by high temperatures. If the correct dosage is used, the initial set of concrete is not affected by the high temperatures. In other words, the time period for workability remains unchanged.

Another reason to use a retarder is to extend the haul time allowed; or extend the time to place, consolidate, and finish the mixture, if the haul distance is short. In other words, the retarder is used to extend the time period for mixture workability.

The dosage of a retarder must be done with great care. Excessive retardation may occur if a retarder is used in combination with other admixtures, or the mixture contains fly ash and/or ground granulated blast-furnace slag. In addition, most retarders do not provide a linear increase in set time with an increase in dosage. However, a special group of retarders known as hydration stabilizers will provide a linear increase in set time with an increase in dosage.

6.4.5.1 Types

The types of retarding admixtures are as follows:

- Lignin
- Borax
- Sugars
- Tartaric acid and salts

6.4.5.2 Quality Control

Refer to 6.4.4.2 “Other Admixtures” for effect on air content. In some cases, a retarding admixture is not needed despite high temperatures. For example, a short haul with rapid placement, consolidation, and finishing. Another example is a bridge deck pour, with a short span and haul that uses concrete with a temperature of 68 °F (20 °C), but the atmospheric temperature is only 55 °F (13 °C). If these situations occur, the Level II PCC Technician shall obtain permission from the Engineer to omit the retarding admixture.

If a water-reducing or mid-range water-reducing admixture is used in combination with a retarder, also known as “stacking,” the total admixture dosage for the combination is frequently lower than the recommended dosage for the individual admixtures added together. Refer also to 6.4.6.2 “Quality Control” for information on water-reducing admixtures and delay in the initial set of concrete. It is a recommended practice to use the full dosage of the water-reducing or mid-range water-reducing admixture, and a reduced dosage of retarder. However, a reduced dosage of the water-reducing or mid-range water-reducing admixture in combination with a reduced dosage of retarder is also acceptable. The benefit of stacking is that the required water reduction is obtained with a moderate 30 to 60 minute increase in delaying initial concrete set. A standard dose of a water-reducing retarder admixture may provide the required water reduction, but the concrete mix retardation may be longer than desired. Another benefit of stacking is that lignosulfonate water-reducing admixtures are maintained at a dosage rate which aids air development. Refer to 6.4.4.2 “Other Admixtures”. It should also be mentioned that stacking can be defined as a water-reducing or mid-range water-reducing admixture used in combination with a water-reducing retarder admixture.

The Level II PCC Technician is cautioned that an over retarded concrete mixture will significantly increase the risk for plastic shrinkage cracking if curing is delayed (refer to 7.2.1 “Temperature Effects” for additional information) and will slow down subsequent strength gain. An over retarded concrete mixture may also experience rapid stiffening and slump loss for some cements. Therefore, the Level II PCC Technician is encouraged to closely work with the admixture technical representative to determine the correct dosage.

6.4.6 Water-Reducing Admixture

A water-reducing admixture may be used to increase slump, while maintaining the same water/cement ratio; or to maintain the same slump, while decreasing the water/cement ratio; or to maintain the same slump and water/cement ratio, while decreasing the cement factor. The third use is permitted according to Article 1020.05(b)(8), and is primarily used for reducing heat generated by hydration, and for reducing material costs. A water-reducing admixture shall be used for cement aggregate mixture II according to Article 312.26. If Class C fly ash or ground granulated blast-furnace slag is used in Class PP-1 or RR concrete, a water-reducing or high range water-reducing admixture shall be used according to Article 1020.05(b)(3). For Class DS concrete involving dry excavations 10 ft (3 m) or less, a high range water-reducing admixture may be replaced with a water-reducing admixture if the concrete is vibrated. This is according to Article 1020.05(b)(7). Refer to 7.2.1 “Temperature Effects” for additional information regarding the use of a water-reducing admixture in hot weather.

A water-reducing admixture reduces the amount of water needed for a workable mixture. The typical water content reduction is between 5 and 10 percent.

A water-reducing admixture functions by dispersing cement, allowing water trapped within the cement grain clusters to become free. In addition, by dispersing the cement, more cement surface area is exposed to mix water. This allows more complete hydration of the individual cement grains, resulting in higher strength.

6.4.6.1 Types

The types of water-reducing admixtures are as follows:

- Lignosulfonates
- Hydroxylated carboxylic acids and salts
- Carbohydrates, which include natural sugars (i.e. corn syrup or molasses) and hydroxylated polymers

6.4.6.2 Quality Control

Refer to 6.2.3 “Flash Set and False Set”, 6.4.4.2 “Other Admixtures” for effect on air content, and to 6.4.5.2 “Quality Control” for interaction with a retarding admixture. Lignosulfates reduce bleed water; hydroxylated carboxylic acids and salts increase bleed water; and carbohydrates have no effect on bleed water. A Type D admixture with hydroxylated carboxylic acid is known for extended bleed water.

If the water-reducing admixture is used to maintain the same slump, while decreasing the water/cement ratio; strength will increase.

If the water-reducing admixture is used to maintain the same slump and water/cement ratio, while decreasing the cement factor; increased bleed water, poor pumpability, and finishing difficulties may occur. These three characteristics may occur because of insufficient fines, since cement has been removed. Therefore, a cement reduction may require the addition of fly ash or ground granulated blast-furnace slag.

All water-reducing admixtures will delay the initial set of concrete, if not modified. Therefore, various amounts of an accelerator are used to produce three types of chemical admixtures. They are a normal set admixture (Type A - Water-Reducing Admixture), a retarded set (Type D - Water-Reducing and Retarding Admixture), and an accelerated set (Type E - Water-Reducing and Accelerating Admixture). Sometimes a Type A water-reducing admixture dosage is increased beyond the standard rate to obtain a moderate increase in delaying initial concrete set.

6.4.7 Mid-Range Water-Reducing Admixture

Mid-range water-reducing admixtures do not have their own type designation per 6.4.2 "Admixtures and their Designations," but the term is more descriptive of what the admixture can do. However, the Approved List of Concrete Admixtures does provide a list of admixtures that are capable of functioning as a mid-range water reducing admixture.

A mid-range water-reducing admixture may be used to increase slump, while maintaining the same water/cement ratio; or to maintain the same slump, while decreasing the water/cement ratio.

A mid-range water-reducing admixture will typically reduce the water content between 8 and 15 percent. A mid-range water-reducing admixture functions the same way as a water-reducing admixture, by dispersing cement.

6.4.7.1 Types

The typical mid-range water-reducing admixture consists of an additive, which is combined with a lignosulfate. Some more recently introduced mid-range water-reducing admixtures are based on a polycarboxylate formulation.

6.4.7.2 Quality Control

A mid-range water-reducing admixture has the following advantages:

- At 50 °F (10 °C) or cooler temperatures, a mid-range water-reducing admixture has less of a tendency to delay the initial set of concrete, when compared to a Type A - Water-Reducing Admixture.
- A mid-range water-reducing admixture may provide improved workability (i.e. easier pumping, placement, and finishing), when compared to a water-reducing admixture or superplasticizer. Many mid-range water-reducing admixtures contain a surfactant, or slickening agent, which helps the concrete particles move over and around each other more freely.

6.4.8 High Range Water-Reducing Admixture (Superplasticizer)

A superplasticizer may be used to produce a very high slump or slump flow for self-consolidating concrete, while maintaining the same water/cement ratio. The highly fluid and workable concrete will not bleed water excessively; and will not segregate readily, if handled and consolidated properly. Superplasticizers are ideal for pumping concrete, since the superplasticizer will reduce pump pressure, and thus, increase the lift and distance capacity. A superplasticizer may also be used to maintain the same slump, while decreasing the water/cement ratio significantly.

A superplasticizer shall be used for Class PP-2, PP-3, PP-4, PP-5 concrete, Class DS concrete, formed concrete repair, a bridge deck, a concrete wearing surface, a bridge deck fly ash or ground granulated blast-furnace slag overlay, a bridge deck microsilica overlay, or a bridge deck high-reactivity metakaolin overlay. If Class C fly ash or ground granulated blast-furnace slag is used in Class PP-1 or RR concrete, a water-reducing or superplasticizer admixture shall be used.

For a superplasticizer, the maximum slump according to Article 1020.04 is 7 in. (175 mm), except for Class PV, SC, and PP concrete. For Class SC, the maximum slump may be increased to 8 in. (200 mm). For Class PP-1, the maximum slump may be increased to 6 in. (150 mm). For Class PS, the 7 in. (175 mm) slump may be increased to 8 1/2 in. (215 mm) if the high range water-reducing admixture is the polycarboxylate type. For Class DS concrete that is placed to displace drilling fluid, or against temporary casing, the slump shall be 8 – 10 in. (200 – 250 mm) at the point of placement. A superplasticizer will typically reduce the water content between 12 and 30 percent. A polycarboxylate superplasticizer may reduce the water content up to 40 percent. Care shall be taken to ensure the water/cement ratio is not reduced below 0.32, which will restrict cement hydration. A superplasticizer functions the same way as a water-reducing admixture, by dispersing cement.

6.4.8.1 Types

The types of superplasticizers are as follows:

- Sulfonated melamine formaldehyde condensates
- Sulfonated naphthalene formaldehyde condensates
- Lignosulfonates
- Polycarboxylates

6.4.8.2 Quality Control

The effectiveness of the superplasticizer is increased with concrete containing more cement and fines. Therefore, a higher mortar factor is desired. The higher mortar factor will also help prevent segregation. Refer to 11.7 “Mortar Factor” for additional information. The initial slump of the concrete will affect the final slump produced by a superplasticizer.

Type F superplasticizers are frequently added at the jobsite, because of their 30 to 60 minute life, which is followed by a rapid slump loss. The polycarboxylate superplasticizer is known for its longer slump life, provided the mixture is agitated until discharge. Extended life superplasticizers are available for addition at the concrete plant, and a Type G superplasticizer will

typically fall in this category. If a superplasticizer will be added at the plant, the admixture technical representative should be consulted.

If slump loss occurs after a period of time, retempering the concrete shall be per the manufacturer's recommendations. Remember that retempering may unduly affect set times, especially when using a Type G.

Compatible admixtures can be used with the superplasticizer, but are added after the air-entraining admixture, and before the superplasticizer.

For effects on initial set time and bleed water, consult with the manufacturer. However, naphthalene-based and melamine-based superplasticizers will cause retardation at high doses. Naphthalene-based superplasticizers have a greater tendency to retard initial set time than melamine-based superplasticizers. Polycarboxylate superplasticizers have less tendency to retard initial set time. Refer to 6.4.4.2 "Other Admixtures" for effect on air content.

6.4.9 Viscosity Modifying Admixture

A viscosity modifying admixture is used to increase the cohesiveness of a concrete mixture and reduce or eliminate bleed water. The two applications for a viscosity modifying admixture are as follows:

- To provide resistance to washout of cement, finely divided minerals, and aggregate fines when placing concrete underwater. The term anti-washout admixture is more commonly used for this application.
- To supplement the resistance to segregation in self-consolidating concrete mixtures. Normally, the superplasticizer will be sufficient to prevent segregation. However, a mixture with a little too much water can be corrected by adding a viscosity modifying admixture to the concrete mixture. Some types of superplasticizers used to make self-consolidating concrete require a separate viscosity modifying admixture to be added to the concrete mixture.

6.4.9.1 Types

Viscosity modifying admixtures are often composed of natural, semisynthetic, welan gum, or synthetic polymers.

6.4.9.2 Quality Control

Consult with an admixture technical representative when using this type of admixture.

6.4.10 Accelerating Admixture

An accelerating admixture is used to accelerate strength development at an early age, by reducing the initial set time of concrete. Accelerators are recommended in cold weather to help concrete gain high early strength. An accelerator will make the concrete resistant to damage from freezing, and reduces the time period for cold weather protection measures. However, accelerators shall not be used to replace proper curing and cold weather protection. Accelerators are sometimes used to begin finishing operations earlier. An accelerator is frequently used for patching mixtures, and is

required for Class PP-2, PP-3, and PP-5 concrete. For Class PP-3 concrete, the accelerator is required to be calcium nitrite. Refer to 6.4.1 "General" for additional information on accelerators.

Accelerators should not be used for mass concrete pours, because the heat from hydration may increase the possibility for thermal cracking. Thermal cracking occurs when there is a significant drop in concrete temperature. A cool night can cause this significant drop in temperature.

6.4.10.1 Types

The types of accelerators are as follows:

- Calcium chloride
- Triethanolamine
- Sodium thiocyanate
- Calcium formate
- Calcium nitrite
- Calcium nitrate

6.4.10.2 Quality Control

The accelerating admixture should be used cautiously when added at the plant or jobsite. High atmospheric temperatures will cause the concrete mixture to stiffen rapidly.

Calcium chloride is the most commonly used accelerating admixture, but may increase drying shrinkage (the slight contraction of concrete when it dries). Calcium chloride will increase the possibility of reinforcement corrosion, and makes the concrete darker in color. Calcium chloride will also reduce the freeze/thaw durability of the concrete mixture. The standard solution for calcium chloride and water is discussed in the Portland Cement Concrete Level I Technician Course.

Non-chloride accelerators are available if corrosion is a concern, but they usually are not as effective as calcium chloride.

The calcium nitrite accelerator is sometimes specified for its corrosion inhibiting properties, even when no acceleration is desired.

Refer to 6.4.4.2 "Other Admixtures" for accelerator effects on air content.

6.5 RHEOLOGY-CONTROLLING ADMIXTURE

A rheology-controlling admixture is a specialty admixture available for use. A rheology-controlling admixture lowers the yield stress, or force required to initiate flow, of the bulk concrete mixture without necessarily changing its viscosity. A rheology-controlling admixture is ideal for slipform applications. The admixture increases extrusion rate/productivity, improves surface appearance/minimizes bugholes, and reduces vibration intensity for consolidation.

Consult with a technical representative when using a rheology-controlling admixture.

6.6 CORROSION INHIBITOR

A corrosion inhibitor is used in concrete to inhibit the corrosion of steel reinforcement that is exposed to high concentrations of chlorides from deicing agents. Corrosion inhibitors are normally used in precast prestressed concrete members, but may be used in other applications. Corrosion inhibitors approved by the Department are calcium nitrite and those listed on the Department's Approved List of Corrosion Inhibitors. Refer to Article 1020.05(b)(10) for the dosage rate to be used for corrosion inhibitors.

6.7 WATER

Water has an influence on a concrete mixture as follows:

- An extreme water hardness may decrease air content.
- Algae contaminated water will increase air content. Algae contaminated water will reduce strength because the algae interferes with cement hydration.
- Wash water from the truck mixer will decrease air content. Refer to 5.6 "Water-Cement Control" for additional information regarding wash water.
- A decrease in water content will decrease air content. Typically, slipform concrete will require a higher admixture dosage for air entrainment. In the case of slipform concrete barrier, a very high dosage may be required for air entrainment.
- A low water content will result in less bleed water.
- An air-entraining admixture works better with a concrete mixture that has a higher water content than a lower water content.

6.8 SYNTHETIC FIBERS

The Department may require synthetic fibers for thin concrete overlays. The fibers are used as a reinforcement, which will improve the concrete's resistance to cracking. When using synthetic fibers, the amount of bleed water is decreased.

Contractors also have the option to use synthetic fibers in slipformed concrete for gutter, curb, median, and paved ditch. The synthetic fibers reduce concrete tearing, which is a labor savings for finishing operations.

7.0 FIELD OPERATIONS

7.1 PUMPING CONCRETE

The key to successful pumping is to minimize the pressure required to move the concrete through the pump line. Minimizing pump pressure will also help to minimize air content loss during pumping. Therefore, the following items are to be considered.

- Consider the capability of the pumping equipment. (i.e. Maximum volume output of the equipment, and maximum pressure which can be applied to the concrete.)
- Ensure uniform materials are used, such as a uniform aggregate moisture content and consistent aggregate gradation. Aggregate that has been soaked to achieve SSD is preferable because it will not absorb mix water, thus avoiding problems with pumping. Ensure uniformity of mixing for each batch. The pumping operation will improve with minimal variation between concrete batches.
- Consider the adequacy of the inside diameter of the pump or pump line. The maximum size, for angular coarse aggregate, is limited to one-third the smallest inside diameter. The maximum size, for well-rounded coarse aggregate, should be limited to two-fifths the smallest inside diameter. These recommendations are per ACI Committee 304.
- Optimize the use of aggregates to produce a uniform gradation. This will reduce pump pressure. Refer to 6.1.1 “Fine Aggregate Grading” and 6.1.2 “Coarse Aggregate Grading” for additional information.
- Consider coarse aggregate angularity. Crushed products will require more mortar (i.e. fine aggregate, cement, finely divided minerals, water, and air) to pump.
- Consider coarse aggregate particle shape. Flat and elongated particles will require more mortar to pump.
- Consider coarse aggregate porosity. A significant amount of mix water absorbed by the coarse aggregate will decrease pumpability.
- Adding sand will not always improve pumpability. The sand could be coarse, whereas the mix may need fines; or the sand could have too many fines. For excess fines, the increased surface area will increase the friction between the concrete and the pump line. Adding sand may also increase shrinkage cracks and lower concrete strength.
- Reduce the amount of water required to maintain workability, by using a water-reducing, or a mid-range water-reducing, or a high range water-reducing (superplasticizer) admixture. The admixture will also help ensure the optimum slump is obtained for pumpability. Refer to 6.4.6.2 “Quality Control”, 6.4.7.2 “Quality Control”, 6.4.8 “High Range Water-Reducing Admixture (Superplasticizer)”, and 6.4.8.2 “Quality Control” for additional information.
- Ensure adequate air entrainment. Too much entrained air lowers pump efficiency because the air compresses, and absorbs some of the pump stroke energy. Too little entrained air may not provide the cohesiveness needed to pump the concrete.

- Consider the use of fly ash or ground granulated blast-furnace slag. These materials will help improve pumpability for mixtures deficient in fines. Fly ash will also improve pumpability because most of the particles are spherical in shape. Be aware the concrete mixtures using CA 3 or CA 5 may be deficient in fines. In addition, be aware that a low mortar factor may be deficient in fines.
- Adding large amounts of finely divided minerals will not always improve pumpability. Mixes with higher cement and finely divided minerals content will pump easier, but very high cement and finely divided minerals content may result in sticky mixes that are difficult to pump. Microsilica will make a mix sticky and potentially difficult to pump. A very high fly ash content may also make the mix sticky and difficult to pump.

Even after all these items have been considered, the Department recommends a full-scale pumping test under field conditions. The test may show the mixture pumps poorly, or does not pump at all. Thus, the occurrence of costly idle time can be prevented.

7.2 HOT WEATHER

The concrete temperature shall not be more than 90 °F (32 °C). However, a maximum concrete temperature shall not apply to Class PP concrete. For insulated forms in cold weather, the concrete temperature shall not exceed 80 °F (25 °C). (Note: Insulated forms are frequently used in mass concrete applications, but the 80 °F (25 °C) maximum temperature requirement does not apply. This is because the Contractor is required to submit a thermal control plan for mass concrete.) Refer to Article 1020.14 for additional information regarding concrete temperature.

7.2.1 Temperature Effects

As the concrete temperature increases, the following will occur:

- Increased slump loss, which will make concrete more difficult to place. As a rule of thumb, a 10 °F (6 °C) increase in concrete temperature will reduce slump 1 in. (25 mm). To compensate for this, more water may be added. However, more water will increase drying shrinkage and lower strength. Drying shrinkage is the slight contraction of concrete when it dries. Therefore, the use of a water-reducing admixture is recommended in hot weather. A water-reducing admixture may also reduce the cement factor, which reduces the heat of hydration.
- Increased water demand, as a result of moisture loss through evaporation. As stated in the previous paragraph, the use of a water-reducing admixture is preferred to adding water.
- Decreased air content, unless the air-entraining admixture dosage is increased.
- Acceleration of the initial set time. The time to set will decrease approximately one-third for every 10 °F (6 °C) increase in temperature. Thus, there is greater potential for a cold joint. (Note: A cold joint is visible as a distinct and separate layer in hardened concrete. It occurs when there has been a delay in placing a subsequent lift of concrete. The lift may have been vibrated, but not sufficiently to combine it with the previous lift.) Use a retarding admixture when required. Refer to 6.4.5 "Retarding Admixture" for additional information.
- Increased potential for plastic shrinkage cracking. Plastic shrinkage cracking is the result of rapid evaporation of moisture from the concrete surface. The

cracks occur when water evaporates from the surface faster than bleed water can appear at the surface. The cracks can occur soon after freshly mixed concrete has been placed, and while it is being finished.

If hot weather occurs when there is low humidity and high winds, the possibility of plastic shrinkage cracking is significantly increased. **In the Portland Cement Association's publication entitled, "Design and Control of Concrete Mixtures," there is a very helpful evaporation rate figure. Refer to the Section on "Plastic Shrinkage Cracking." It is very important to know when the evaporation rate is dangerously high. In addition, the Contractor is responsible for providing temperature, relative humidity, and wind speed measuring equipment to determine the evaporation rate for bridge deck and bridge deck overlay pours.**

The use of fine cement, fly ash, microsilica, high-reactivity metakaolin, synthetic fibers, and some admixtures (Refer to 6.4 "Admixtures") will result in less bleed water. Also, a low water content mixture or high entrained air mixture will have less bleed water. A concrete mixture which lacks bleed water will be more susceptible to plastic shrinkage cracking.

The bridge deck microsilica or high-reactivity metakaolin overlay mixture is especially susceptible to plastic shrinkage cracking, because of little bleed water. The lack of bleed water is due to the ultra-fineness of the microsilica or high-reactivity metakaolin and the thinness of the overlay. Therefore, take precautions with either mixture.

- The possibility for thermal cracking. Thermal cracking occurs when there is a significant drop in concrete temperature. As an example, the cracking can occur when a hot day is followed by a cool night.
- Higher early strengths but lower long term strengths.

7.2.2 Taking Precautions at the Plant

The following methods can be used to reduce the temperature of concrete during hot weather conditions.

- Shade aggregate stockpiles or aggregate bins.
- Sprinkle aggregate stockpiles with water, to take advantage of evaporative cooling. Sprinkling the aggregate with water while being conveyed (before batching) is another option. Since aggregate is approximately 70 to 80 percent of the concrete weight, cooling it will have a significant effect on reducing the concrete temperature.
- Blow cool air through bins or silos.
- Use cool mix water. Cool water may reduce the concrete temperature up to 10° F (6° C), but 3° F (2° C) is more typical. A 5 °F (3 °C) decrease in water temperature will decrease concrete temperature approximately 1 °F (0.6 °C).
- Use ice as part of the mixing water. Up to 75 percent of the mix water may be replaced with ice. Ice may reduce the concrete temperature up to 30° F (17° C), but 20° F (11° C) is more typical. As a rule of thumb, the concrete temperature can be reduced 1 °F (0.6 °C) for each 2 percent of total water replaced by ice. Therefore, approximately 5 lbs of ice per cubic yard of concrete (3 kg of ice per cubic meter) will lower the concrete temperature 1 °F (0.6 °C).
- Inject liquid nitrogen into the mixed concrete.

- Use fly ash or ground granulated blast-furnace slag to lower the heat of hydration. Refer to 7.2.1 “Temperature Effects” for additional information regarding plastic shrinkage cracking.
- Spray the drums of truck mixers and agitators with water, to take advantage of evaporative cooling.
- Ensure truck mixers carry cool water, if water has to be added at the jobsite.
- Ensure truck drivers have directions for the jobsite which will minimize travel time.
- For other precautions, use admixtures as discussed in 7.2.1 “Temperature Effects.”

7.2.3 Taking Precautions in the Field

The following methods can be used to reduce the concrete temperature gain, during hot weather conditions.

- Provide adequate labor to quickly place, consolidate, finish, and cure the concrete. **The sooner curing is started, the better! If finishing is delayed, then cover the concrete with wet burlap or cotton mats until finishing can be completed.**
- Pour during the cool part of the day or at night.
- Spray the subgrade, forms, and reinforcement with water, to take advantage of evaporative cooling.
- Erect sunscreens to reduce the concrete surface temperature.

For other precautions, consider the following:

- Reschedule the pour.
- Consider the use of windbreaks to reduce wind. This will decrease moisture loss from the concrete surface, which can prevent plastic shrinkage cracking. Refer to 7.2.1 “Temperature Effects” for additional information regarding plastic shrinkage cracking.
- Consider the use of fog spraying equipment. For bridge deck overlays, fog spraying with a triple head nozzle or an equivalent nozzle is required. Fog spraying increases the relative humidity above the concrete, which decreases moisture loss from the concrete surface. This will help prevent plastic shrinkage cracking. Refer to 7.2.1 “Temperature Effects” for additional information regarding plastic shrinkage cracking.

For fog spraying, do not use garden-type spray nozzles because they are not effective. Fog spray nozzles can be purchased from finish-tool suppliers. Pressure washers can be used for fog spraying, if they provide 2 to 3 gallons (8 to 11 liters) per minute at 2,000 to 2,500 psi (14,000 to 17,000 kPa).

A 40 to 50 degree wide angle is used for calm days. On a windy day, use a 10 to 15 degree wide angle. The information concerning pressure washers was obtained from Concrete Construction (June 1997). The article was called “Curing During the Pour.”

- Do not apply an evaporation retardant to the concrete. Testing by the Department has not shown any conclusive data that the products will reduce the evaporation of moisture. There is also concern for scaling (i.e.

deterioration of the upper concrete slab surface), if the evaporation retardant is finished into the concrete surface.

7.3 COLD WEATHER

The concrete temperature shall not be less than 50 °F (10 °C). Refer to Article 1020.14 for additional information regarding concrete temperature.

7.3.1 Temperature Effects

As the concrete temperature decreases, the following will occur:

- The initial set time will be delayed.
- The bleed water will decrease.
- The strength gain will slow down.

If mix water for concrete freezes, a 30 to 50 percent reduction in concrete strength can occur. The danger from freezing is eliminated when the hydration process has consumed sufficient mix water. This occurs when the concrete compressive strength reaches 500 psi (3,450 kPa); provided no water is available from outside the concrete, such as curing water.

7.3.2 Taking Precautions at the Plant

The following methods can be used to increase the temperature and strength gain of concrete, during cold weather conditions.

- Increase the cement factor.
- Use a Type III cement.
- Decrease the water/cement ratio.
- Use an accelerating admixture.
- Use heated water as mixing water.

Water above 100 °F (38 °C) shall not come in direct contact with the cement, without having first been mixed with the aggregates. This will prevent a flash or quick set of the concrete. This will also allow water up to the boiling point. A 5 °F (3 °C) increase in water temperature will increase concrete temperature approximately 1 °F (0.6 °C).

At air temperatures above freezing, usually only the water is heated. The exceptions are when fine or coarse aggregates contain frozen lumps. Then the aggregates should be heated. This will prevent thawing during mixing, which can produce a mixture with excessive water content.

- Use heated aggregates.

This can be accomplished by enclosing and heating the space around the aggregate bins, by circulating hot water through coils in the bin, or by injecting steam. The disadvantage of injecting steam is the increase in aggregate moisture, which can cause slump control problems. Sometimes additional heating is required, and the aggregates are heated before placement in the bins. Aggregates above 100 °F (38 °C) shall not come in

direct contact with the cement, without having first been mixed with the water. This will prevent a flash or quick set of the concrete.

At air temperatures below freezing, usually the fine aggregate is heated. The exception is when the coarse aggregate contains frozen lumps. Then the coarse aggregate should be heated. This will prevent thawing during mixing, which can produce a mixture with excessive water content.

Except for Class PP concrete, a concrete temperature above 70 °F (21 °C) is rarely needed for the following reasons:

- A higher temperature does not provide longer protection from freezing, because the heat loss is greater.
- A higher temperature will increase thermal shrinkage after hardening. Thermal shrinkage is the slight contraction of concrete as the temperature decreases.
- A higher temperature will require more mix water for the same slump.
- A higher temperature could cause plastic shrinkage cracking. Typically, cold air has low humidity, which can cause rapid moisture loss through evaporation. Refer to 7.2.1 “Temperature Effects” for additional information regarding plastic shrinkage cracking.

7.3.3 Taking Precautions in the Field

The following methods can be used to reduce concrete temperature loss, during cold weather conditions.

- Provide adequate labor to quickly place, consolidate, finish, and cure the concrete; and to begin cold weather protection.
- Provide a heated enclosure.
- Preheat the subgrade, forms, and reinforcement.

7.4 RETEMPERING CONCRETE WITH WATER

Article 1020.05(b) allows a cement factor reduction for some classes of concrete. If the mix design has less than 565 lbs/cu. yd. (335 kg/cu. m.) of cement and finely divided minerals summed together, no water may be added at the jobsite for central-mixed concrete according to Article 1020.11(a)(4). The Level II PCC Technician shall inform the Level I PCC Technician when additional water is not permitted.

For slump control, the practice to batch on the dry side is not appropriate. Refer to 6.4.4.4 “Retempering” for negative consequences. Constant retempering at the jobsite will also slow down production. If the Level II PCC Technician is practicing good quality control at the plant and communicating with the Level I PCC Technician at the jobsite, there is no reason to withhold mix water.

Refer to 6.4.8.2 “Quality Control” which explains what to do when a superplasticizer is no longer effective.

7.5 COMMUNICATION

The ability for the Level II PCC Technician to communicate with the Level I PCC Technician at the jobsite cannot be overemphasized. The most effective methods for communication are cellular phones or two-way portable radios.

Effective quality control at the plant requires the Level I PCC Technician to provide immediate notification of field test results. The weather conditions will change as the progresses, and will affect the concrete mixture. Field observations are also to be reported by the Level I PCC Technician. These field observations should include mixture characteristics, slump loss rate, workability, finishing characteristics, and bleed water rate. This field information will allow the Level II PCC Technician to diagnose problems at the plant, and to adjust the mixture before several delivery trucks leave for the jobsite.

By maintaining good communication between the plant and jobsite, concrete production can meet actual field production. As an example, pumping difficulties in the field are not unusual. There have been many instances for rejecting the entire load of concrete delivered, because the haul time had expired.

8.0 TROUBLESHOOTING

Troubleshooting is the ability to locate and eliminate a problem. Troubleshooting can also be an investigation of variations, for material within specification.

When problems occur and adjustments are needed to the mixture, it is important to test after an adjustment. For example, assume a low slump test at the plant is adjusted by adding mix water. By testing for slump and air content after the adjustment, two questions can be answered. First, did the additional water correct the low slump? Second, did the additional water increase the air content, and was the new air content within the acceptable range?

Another important aspect is to do one adjustment at a time, if possible. For example, assume the slump and air content test results are low at the plant. By only increasing the water to adjust the slump, an individual may then determine if an air-entraining admixture dosage increase is warranted. The addition of water may be sufficient to correct the air content.

8.1 AIR CONTENT

8.1.1 Quality Control Testing at the Plant

The following are guidelines for air content testing at the plant:

- Increased tests are recommended at the beginning of a project, until test results remain fairly constant. Refer to 4.4 “Sampling and Testing Frequency at the Plant” for additional information.
- A test should be performed when there is a sudden loss in slump, development of finishing difficulties, increased bleed water, increased segregation, or a loss in yield. These are indications of a low air content. A test should also be conducted when there is a sticky mixture. This is an indication of high air content.
- A test should be performed anytime there is a change in materials, equipment, or operations.
- Testing is advisable when any new shipment of material is used, especially a new shipment of air-entraining admixture.

8.1.2 Troubleshooting

The following are guidelines for diagnosing the cause of an air content variation:

- **Aggregates**

Check maximum size aggregate since air content will decrease if the maximum size aggregate increases.

Check amount of minus No. 100 (minus 0.15 mm), or minus No. 200 (minus 0.075 mm) material. An increase in this material will decrease air content.

Check aggregate for degradation during stockpiling and handling, or during mixing.

Check amount of material passing the No. 30 (0.6 mm) sieve, but retained on the No. 50 (0.3 mm) sieve. An increase in this material will increase air content.

Check aggregate angularity. Crushed stone aggregate will entrain less air than gravel aggregate.

Check aggregate absorption. The Level II PCC Technician is also advised that aggregate batched on the dry side will absorb mix water. This is especially true for high absorption aggregate. The reduction in water makes it harder to entrain air.

Check batch weights.

- Cement

Check characteristics of cement. For example, a grinding aid used in the manufacture of cement can also act as an air-entraining admixture. Cement chemistry such as alkali content can result in variances. Finally, the effectiveness of air-entraining admixtures can vary with cement chemistry.

Check batch weight.

- Finely Divided Mineral

Check characteristics of finely divided mineral.

Check influence for each type of finely divided mineral used.

Check batch weight.

- Admixtures

Check accuracy of measurement.

Remember to consider the quantity of water within an admixture.

Check influence by other admixtures. Altering the dosage of an admixture may influence the air-entraining admixture

Be advised that a change in the type, source, or concentration of the air-entraining admixture can affect air content.

Adjust the air-entraining admixture dosage as temperature changes during the day.

- Water

Check characteristics of water.

Check moisture sensor.

Check amount measured, and remember to verify all wash water in a truck mixer or truck agitator has been discharged.

Check accuracy of the aggregate moisture tests, which includes the absorption values used.

Check aggregate stockpile for moisture uniformity. A wet spot can occur in the aggregate stockpile because of recently delivered material.

Note: It is more difficult to entrain air with slipformed concrete because of the minimal water content.

- Batching Sequence

The air content will increase if the air-entraining admixture dosage is added after all materials have been batched.

The air content will decrease if the air-entraining admixture is batched directly on dry cement.

- **Mixing Equipment Condition**
Check concrete build-up and blade wear.
- **Mixer Capacity vs. Amount of Concrete**
Air content decreases when the amount of concrete is small, when compared to the capacity load of the mixer.
Air content increases when the amount of concrete is less than the capacity load of the mixer. In other words, air content increases as the capacity is approached.
Air content decreases when the amount of concrete is greater than the capacity load of the mixer.
- **Mixing Speed**
Air content will increase for truck mixing speeds up to 20 revolutions per minute.
Check uniformity of mixing for each batch.
- **Mixing Time or Revolutions**
For the stationary mixer, air content will increase for the first 1.5 to 2 minutes. For the truck mixer, air content will increase for the first 10 to 15 minutes. After this optimum time, air content will decrease. The air content decrease may range from 10 to 50 percent after 90 minutes of mixing.
Check uniformity of mixing for each batch.
Check mixing time since variations in air content are much higher for a concrete produced with a very short mixing time.
- **Concrete Temperature**
Air content will decrease with an increase in temperature.
- **Haul Time**
Air content will decrease for long haul times.
- **Transportation/Handling Method**
Air content will normally decrease when concrete is pumped or conveyed.
- **Retempering with Water**
Check for unnecessary withholding of mix water.
Air content will normally increase 0.5 to 1 percent, with each additional 1 gal/yd³ (5 L/m³) of added water.

8.2 SLUMP

8.2.1 Quality Control Testing at the Plant

The following are guidelines for slump testing at the plant:

- Increased tests are recommended at the beginning of a project, until test results remain fairly constant. Refer to 4.4 “Sampling and Testing Frequency at the Plant” for additional information.

- A test should be performed anytime there is a change in materials, equipment, or operations.
- Testing is advisable when any new shipment of material is used.

8.2.2 Troubleshooting

The following are guidelines for diagnosing the cause of a slump variation:

- **Aggregates**
Check amount of minus No. 100 (minus 0.15 mm), or minus No. 200 (minus 0.075 mm) material.
Check aggregate for degradation during stockpiling and handling, or during mixing.
Check aggregate for segregation in stockpile.
Check fineness modulus.
Check aggregate angularity.
Check aggregate particle shape.
Check aggregate absorption. The Level II PCC Technician is also advised that aggregate batched on the dry side will absorb mix water. This is especially true for high absorption aggregate.
Check batch weights.
- **Cement**
Check characteristics of cement.
Check type of cement used. For example, a Type III cement will have an earlier set time than a Type I cement, which will effect the rate of slump loss.
Check batch weight.
- **Finely Divided Mineral**
Check characteristics of finely divided mineral.
Check influence for each type of finely divided mineral used.
Check batch weight.
- **Admixtures**
Check accuracy of measurement.
Remember to consider the quantity of water within an admixture.
Any change in air content will change slump. If air content decreases 1 percent, slump will decrease approximately 1/2 in. (13 mm).

- Water
 - Check the moisture sensor.
 - Check amount measured, and remember to verify all wash water in a truck mixer or truck agitator has been discharged.
 - Check accuracy of the aggregate moisture tests, which includes the absorption values used.
 - Check aggregate stockpile for moisture uniformity. In addition, a wet spot can occur in the aggregate stockpile because of recently delivered material. The Level II PCC Technician should be aware that a 0.5 percent change in moisture content will result in a 1 in. (25 mm) change in slump.
 - Any increase in water demand will decrease slump.
- Mixing Equipment Condition
 - Check concrete build-up and blade wear.
- Mixing Speed
 - Check uniformity of mixing for each batch.
- Mixing Time or Revolutions
 - Check uniformity of mixing for each batch.
- Concrete Temperature
 - Slump will decrease with an increase in temperature.
- Haul Time
 - Slump will decrease for long haul times.
- Transportation/Handling Method
 - Slump will normally decrease when concrete is pumped or conveyored.
- Retempering with Water
 - Slump will normally increase 1 in. (25 mm), with each additional 1 gal/yd³ (5 L/m³) of added water.

8.3 UNIT WEIGHT/YIELD

8.3.1 Quality Control Testing at the Plant

The following are guidelines for unit weight/yield testing at the plant:

- Perform the test to check scale accuracy, scale sensitivity, and water measurement. Refer to 4.4 “Sampling and Testing Frequency at the Plant”, 4.2.2 “Scales”, and 4.2.5 “Water Measuring Device” for additional information.
- Perform the test as needed to check aggregate uniformity. For aggregate uniformity, a change in the test may indicate a change in aggregate particle shape or specific gravity.
- A test should be performed after initial adjustment of the mix water.
- A test should be performed after adjustment of the batch weights.

- A test should be performed any time there is a discrepancy in the yield. (i.e. A shortage or overrun of concrete.)

8.3.2 Troubleshooting

The following are guidelines for diagnosing the cause of a unit weight/yield variation. (Note: Refer to the Portland Cement Concrete Level I Technician Course for a discussion on required yield accuracy.) A lower unit weight/higher yield indicates any of the following have changed:

- The aggregates may have a lower specific gravity. Perform a specific gravity test.
- The air content may be higher. Perform an air content test. Refer to 8.1.2 “Troubleshooting” for causes of an air content change.
- The water content may be higher.
Perform a water content test.
Check moisture sensor.
Check amount of water measured, and remember to verify all wash water in a truck mixer or truck agitator has been discharged.
Check accuracy of the aggregate moisture tests, which includes the absorption values used.
Check aggregate stockpile for moisture uniformity. A wet spot can occur in the aggregate stockpile because of recently delivered material.
Remember to consider the quantity of water within an admixture.
- The cement factor may be lower. Check the amount of cement measured.
- The proportion of ingredients may have changed. Check the amount of aggregate or finely divided mineral measured.
- The weighing devices may not be operating properly. Check the scale accuracy and sensitivity.

A higher unit weight/lower yield would indicate opposite trends, and is costly to the Contractor, because there is a deficiency of concrete volume.

8.4 TROUBLESHOOTING PROBLEMS WITH A CONCRETE MIXTURE

The following are guidelines for diagnosing the cause of the problem, when these situations are observed at the plant or jobsite.

- Uncoated Aggregates — Uncoated aggregates may indicate concrete build-up or worn blades within the mixer. Mixing speed, and mixing time or revolutions should also be checked. Concrete containing uncoated aggregates is to be discarded by the Contractor.
- Segregation — Segregation occurs when the coarse aggregate separates from the mortar. Mortar consists of fine aggregate, cement, finely divided minerals, water, and air.

If segregation occurs, check for lower air content and the transport/handling method used.

- **Microball** — A microball is a clump of material containing cement on the outside and microsilica on the inside. A microball is normally 2 in. (50 mm) or less in diameter, and very hard to detect in a batch of concrete. The Level II PCC Technician shall reject the entire batch of concrete if a microball is observed. The Department has experienced numerous popouts on microsilica bridge deck overlays, because of microballs. These popouts will appear after the overlay experiences one or more freeze/thaw cycles.

If a microball occurs, check the mixer for concrete build-up and blade wear; and verify the mixing sequence is according to the bridge deck microsilica overlay special provision.

- **Cement Ball** — A cement ball is a clump of material containing cement, fine aggregate, and coarse aggregate. The dry materials may pack into the truck mixer and are not mixed. During discharge, the lumps will break loose. Occasional cement balls can be removed by the Contractor during placement.

Cement balls may occur for the following reasons:

- Any loading (charging) method which wets the cement before mixing with the aggregates. Do not charge cement with water, or cement with wet aggregates; into the head of the truck mixer.
 - Insufficient mixing due to rapid charging of cement or water, excessive charging speed, worn mixer blades, overloading the mixer, insufficient truck mixer revolutions, or insufficient mixing time in a stationary mixer.
 - Use of heated aggregates or water.
 - Use of recently manufactured cement, which is still very hot.
 - A clay film on fine or coarse aggregate, due to poor washing.
- **Sand Streaks** — Sand streaks consist of fine aggregate, or fine aggregate and cement which have become packed in the head of the truck mixer, and are not mixed. Occasionally, dry fine aggregate material will also pack around or behind the blades, in the discharge end of the drum. Concrete containing sandy material is to be discarded by the Contractor.

If sand streaks occur, review the loading (charging) method used. Do not charge fine aggregate, or cement with wet fine aggregate; into the head of the truck mixer.

- **Change In Color** — A change in concrete color may be an indication of a change in materials, incomplete mixing, or too little cement.
- **Change in Appearance** — A change in appearance, such as a sticky mixture, may indicate too many fine materials. These fine materials may be cement or finely divided minerals. A sticky mixer may also indicate high air content.
- **Mudballs** — Mudballs can be introduced into concrete as a result of contaminated aggregate stockpiles. Aggregate stockpiles can be contaminated by mud which drops from hauling and loading equipment. Occasional mudballs can be removed by the Contractor during placement.

If mudballs occur, inspect the road network at the plant for pumping of the soil subgrade. Otherwise, the source of mud is probably from the aggregate source.

- Mix Foaming — Mix foaming or other detrimental material may be observed during placement or at the completion of a self-consolidating concrete pour. In this case, the material may be removed by the Contractor while the concrete is still plastic.

Mix foaming is an indication that the self-consolidating concrete is not cohesive (or stable) and may have excess water.

8.5 CONCRETE CRACKING

Many times concrete will experience undesirable cracking due to late sawing, or improper location of joints. However, cracking may still appear despite early sawing and proper location of the joints.

The following changes to the concrete mix design may help reduce concrete cracking:

- Use a low heat-of-hydration cement.
- Use the largest aggregate possible to reduce thermal and shrinkage cracking.
- Use a well graded aggregate to reduce shrinkage.
- Use a water reducer to reduce the quantity of water needed.
- Use a retarder to reduce temperature gain during hydration. NOTE: A retarder can increase the susceptibility of the concrete to plastic shrinkage cracking if curing is delayed. Refer to 7.2.1 “Temperature Effects” for additional information.
- Use finely divided minerals in hot weather.
- Reduce or eliminate finely divided minerals in cool weather.
- Reduce total cement and finely divided minerals to minimize shrinkage.
- Reduce the temperature of the concrete mixture.

9.0 DOCUMENTATION

For process control at the plant, the Level II PCC Technician shall complete the following documentation:

- Aggregate Gradations — Complete MISTIC form Bmpr MI504. Refer to Appendix K for instructions to complete the form.
- Aggregate Moisture, Air Content, Slump, Unit Weight, Yield, Strength, Water Content, and Other Tests — A bound, hardback field book or diary is acceptable for calculating and recording test results, and retest results. A plant or jobsite documentation example format is provided in Appendix L. For strength test results using the hand pump beam breaker, Form Bmpr PCCW04 “Modulus of Rupture Test Worksheet for Concrete Beams” is available.

If required by the Quality Control Manager, complete MISTIC forms Bmpr MI654 and Bmpr MI655. To view or download the forms on the internet go to <http://www.dot.il.gov/>; Doing Business; Construction Guides; Materials; Materials Forms. Refer to Appendix K for instructions to complete the forms. Only field test results shall be recorded on MISTIC forms Bmpr MI654 and Bmpr MI655.

- Bridge Deck Pour or When Water-Cement Control is Required — Complete the “Water/Cement Ratio Worksheet” document. Refer to 5.5 “Water-Cement Control” for additional information, and Appendix J to view the document.
- Miscellaneous — A bound, hardback field book or diary is acceptable for recording all observations, inspections, adjustments to the mix design, and corrective actions.
- Delivery Truck Ticket — Refer to the Special Provision for Quality Control/Quality Assurance of Concrete Mixtures, in Appendix A and Article 1020.11(a)(7). It is important to check the Department mix design number and the delivery ticket to ensure the correct mix is being delivered.

Forms Bmpr MI504, Bmpr MI654, and Bmpr MI655 shall be submitted to the Engineer weekly or as required by the Engineer. The three forms, correctly completed, are also required to authorize payment by the Engineer.

In some cases, a District may have modified form Bmpr MI504, Bmpr MI654, or Bmpr MI655. Therefore, the Level II PCC Technician shall check with the District office.

Information entered in a hardback field book or diary is never to be erased, whited-out, or eradicated in any manner. To correct information already entered, cross-out the information to be changed. When a change is made, the individual shall indicate their initials and the date of the change.

10.0 CONTROL CHARTS

Control charts are not required according to the Special Provisions for Quality Control of Concrete Mixtures at the Plant (Appendix A) and Quality Control/Quality Assurance of Concrete Mixtures (Appendix A). However, a control chart can be beneficial for quality control. A control chart provides a visual representation of test results, in an orderly sequence, in respect to time. A control chart provides the means to measure the state of process control, the means to detect lack of control, and the course of action needed to restore control. A control chart can be used for aggregate gradation, air content, slump, unit weight, yield, strength, and water content. An example control chart is illustrated in Appendix M. The procedure for developing a control chart is as follows:

- Scope — All required Contractor test results, Contractor biased resample tests, and Engineer assurance tests should be plotted on a control chart. No other biased tests shall be plotted on the control chart. The minimum frequency of such tests shall be as stated in the Special Provisions for Quality Control of Concrete Mixtures at the Plant, Quality Control/Quality Assurance of Concrete Mixtures, or the Quality Control Plan.
- General Procedures — Control charts should be plotted in ink, on standard cross section paper, ten divisions per 1 in. (25 mm). The vertical scale should conform to the following requirements:
 - Coarse or Fine Aggregate - For the No. 200 (0.075 mm) sieve, use 0.1% per division. For all remaining sieves, use 1% per division.
 - Air Content - Use 0.1% per division.
 - Slump - Use 0.1 in. (2.5 mm) per division.
 - Unit Weight - Use 0.1 lb./ft.³ (1 kg/m³) per division.
 - Yield - Use 0.1 ft.³ (0.01 m³) per division.
 - Flexural Strength - Use 50 kPa (5 psi) per division.
 - Compressive Strength - Use 10 psi (100 kPa) per division.
 - Water Content - Use 1 lb./yd.³ (1 kg/m³) per division.
 - Slump Flow - Use 0.1 in. (2.5 mm) per division.
 - J-Ring - Use 0.1 in. (2.5 mm) per division.
 - L-Box - Use 0.5% per division.

For the horizontal scale, each test value should be plotted at 1/2 in. (12.5 mm) intervals.

- Symbols and Control Limits — Individual Contractor test values, including resamples, should be represented by open circles, which are centered on the correct test value. Moving average values should be represented by open squares, which are centered on the correct value. State assurance test values should be represented by solid triangles, which are centered on the correct test value. All symbols should have a maximum 0.1 in. (2.5 mm) dimension, when placed on the control chart.

Individual Contractor test values, including resamples, should be connected by dashed lines. Department assurance test values should not be connected with any other point. Moving average data points should be connected by solid lines.

A solid horizontal line should be placed on the control chart, to indicate the upper and lower specification limits.

- Individual Test Values and Moving Average — The moving average value is the average of four consecutive Contractor test values. Individual Contractor test values and Contractor resample test values should be used as individual points, for determining a moving average value. A moving average value is determined by starting with the fourth test value, and averaging it with the three preceding test values. Thereafter, additional moving average values are determined in the same manner. Rounding procedures for the moving average value are the same as for individual test values.
- Underneath the horizontal axis, the following information should be listed:
 - Date and specific time (include a.m. or p.m.) of sample or resample.
 - Series number and letter for strength tests.
 - Quantity of material represented (produced since previous test).
 - Initials of person performing the test.
 - Use “rs” to denote resample.
- In the upper right hand corner of the chart, the following information should be listed:
 - The concrete mix design number.
 - The type of test [i.e. aggregate gradation (indicate sieve), slump, unit weight, yield, flexural strength, compressive strength, water content, slump flow, J-Ring, or L-Box.
 - The test day of record for strength (i.e. 14 day or other).
- Resample Test Values — The Contractor resample test value should be the only biased process control test placed on the control chart. An elongated circle should be drawn around the resample test value, and the individual Contractor test value for which the resample represents.

- Rounding — Test results are rounded as follows:

Test Method	Rounding
Aggregate Gradation All sieves except No. 200 (0.075 mm)	Nearest 1 %
Aggregate Gradation No. 200 (0.075 mm) sieve	Nearest 0.1%
Air Content	Nearest 0.1%
Slump	Nearest 1/4 in. (5 mm)
Unit Weight	Nearest 0.1 lb./ft. ³ (1 kg/m ³)
Yield	Nearest 0.1 ft ³ (0.01 m ³)
Flexural Strength	Nearest 5 psi (50 kPa)
Compressive Strength	Nearest 10 psi (100 kPa)
Water Content	Nearest 1 lb/yd ³ (1 kg/m ³)
Slump Flow	Nearest 0.25 in. (5 mm)
J-Ring	Nearest 0.25 in. (5 mm)
L-Box	Nearest 1 %

11.0 IDOT MIX DESIGN

11.1 VOLUMETRIC MIX DESIGN

Volumetric mix design is a proportioning method that produces an exact volume of concrete, commonly 1 yd³ (1 m³). Several methods are in use for volumetric mix design. Among these are methods published by the American Concrete Institute, Portland Cement Association, and the Department. The Department's mix design method is explained in the PCC Level III Technician Course – "Manual of Instructions for Design of Concrete Mixtures." The various mix design methods are based upon previously established properties of the materials and the intended use of the concrete.

The requirements for providing a mix design are specified in the Special Provision for Quality Control/Quality Assurance of Concrete Mixtures. Refer to Appendix A to review the Special Provision. This manual will not go into the details of developing a concrete mix design. The following mix design information is the most essential information that the PCC Level II Technician needs to know.

11.2 FINE AGGREGATE WATER REQUIREMENT

For fine aggregate, the Department mix design method determines the water requirement and resulting water/cement ratio, by the classification (type) assigned to the fine aggregate. Refer to 6.1.4 "Aggregate Angularity" for additional information. This information is summarized in the following table.

FA Type	Water Requirement for Cement
A	5.1 gal/cwt (0.42 L/kg)
B	5.3 gal/cwt (0.44 L/kg)
C	5.5 gal/cwt (0.46 L/kg)

The fine aggregate classification as a Type A, B, or C is available from the Department's District office.

11.3 COARSE AGGREGATE WATER REQUIREMENT

For coarse aggregate, the Department mix design method determines the water requirement and resulting water/cement ratio, by the angularity of the coarse aggregate. Refer to 6.1.4 "Aggregate Angularity" for additional information. The Department allows an additional 0.1 to 0.4 gal/cwt (0.008 to 0.033 liter/kg) for the coarse aggregate. The value is determined from experience, but 0 gal/cwt (0 liter/kg) is commonly used for gravel, and 0.2 gal/cwt (0.017 liter/kg) is commonly used for crushed stone. Contact the Department's District office if you have any questions.

11.4 BASIC WATER REQUIREMENT

For the Department's mix design method, the basic water requirement is the summation of the water required for the fine and coarse aggregate. An example calculation for determining basic water requirement is as follows:

Given: Fine Aggregate (FA), Type B	Refer to 11.2 "Fine Aggregate Water Requirement"
Coarse Aggregate (CA), Crushed Stone	Refer to 11.3 "Coarse Aggregate Water Requirement"

Basic Water Requirement (English) = $5.3_{FA} + 0.2_{CA} = 5.5$ gal/cwt cement

Basic Water Requirement (Metric) = $0.44_{FA} + 0.017_{CA} = 0.46$ liter/kg cement

If a water-reducing admixture is used, and the water content reduction is assumed to be 10 percent, the previously determined values are adjusted as follows:

Adjusted Basic Water Requirement (English) = $5.5 - (5.5 \times 0.1) = 5.0$ gal/cwt cement

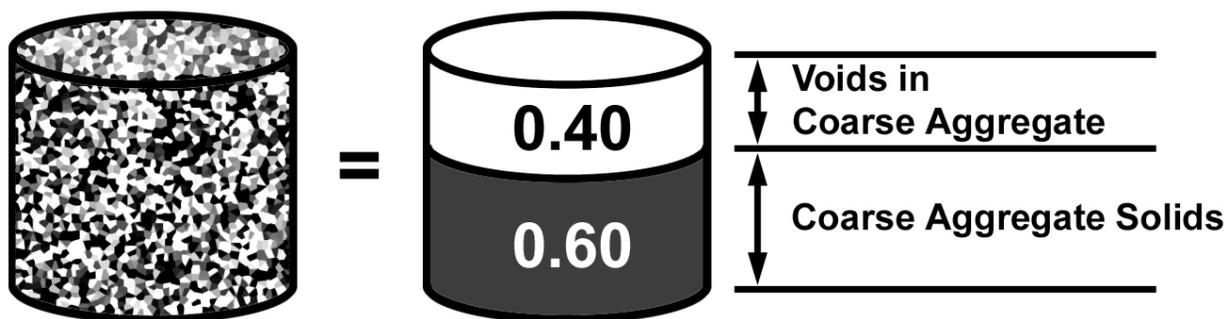
Adjusted Basic Water Requirement (Metric) = $0.46 - (0.46 \times 0.1) = 0.41$ L/kg cement

11.5 MIX DESIGN WATER/CEMENT RATIO

The water/cement ratio for various concrete mixtures is discussed in 5.6 "Water-Cement Control." If the basic water requirement exceeds the maximum water/cement ratio permitted, then a water-reducing admixture will be required, or the cement will have to be increased. Refer to 11.4 "Basic Water Requirement" for additional information.

11.6 VOIDS IN COARSE AGGREGATE

For the Department mix design method, the amount of voids in the coarse aggregate shall be determined. The voids test determines the amount of voids in a unit of coarse aggregate material.



$$1.00_{(\text{Aggregate Volume})} = 0.40_{(\text{Voids Volume})} + 0.60_{(\text{Solids Volume})}$$

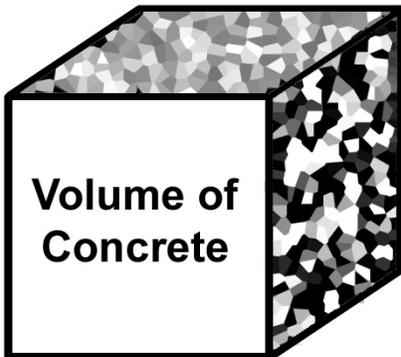
The coarse aggregate voids are determined according to Illinois Test Procedure 306. To understand how this information is used in the development of a mix design, refer to 11.7 "Mortar Factor."

A change in coarse aggregate particle shape will change the voids. Refer to 6.1.5 "Aggregate Particle Shape" for additional information.

The coarse aggregate voids are determined by the Contractor unless provided by the Department's District office. The coarse aggregate voids will normally range from 0.30 to 0.50.

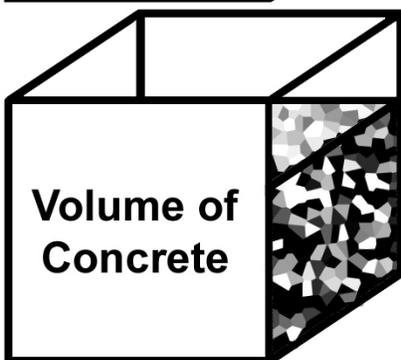
11.7 MORTAR FACTOR

Mortar is the total amount of fine aggregate, cement, finely divided minerals, water, and air (i.e. everything but the coarse aggregate) in a concrete mixture. The volume of mortar per volume of dry rodded coarse aggregate in a unit volume of concrete is called the Mortar Factor. In other words, mortar factor is the ratio of total volume of fine aggregate, cement, finely divided minerals, water and air per total volume of coarse aggregate solids and voids.



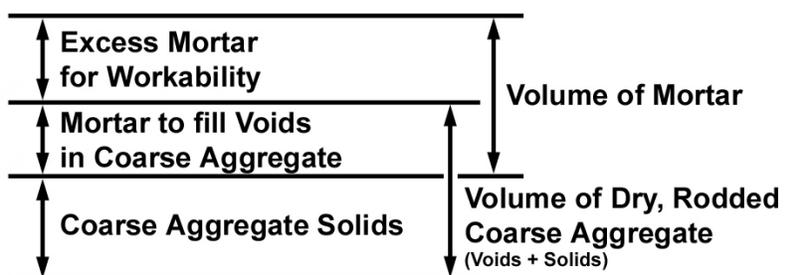
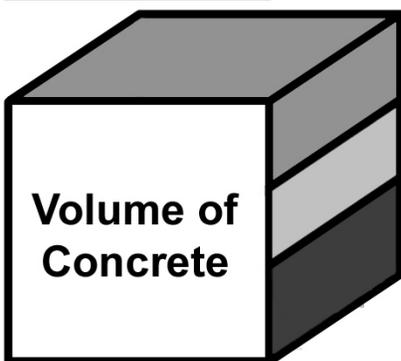
Imagine a unit of concrete consisting entirely of coarse aggregate. Everything else in the concrete mixture (i.e., mortar) would be limited to filling the spaces (voids) between coarse aggregate particles.

A concrete mixture consisting entirely of coarse aggregate and only enough mortar to fill the voids between coarse aggregate particles would have poor workability.



To increase workability, the coarse aggregate particles need to be dispersed. Thus, in order to maintain the same unit of concrete, some of the coarse aggregate needs to be removed.

If we add mortar to replace what was removed (i.e., coarse aggregate), we will have a more workable concrete mixture because the mortar will disperse and lubricate the remaining coarse aggregate particles.



$$\text{MORTAR FACTOR} = \frac{\text{Volume of Mortar}}{\text{Volume of Dry, Rodded Coarse Aggregate}}$$

To understand how the voids in coarse aggregate value was obtained, refer to 11.6 "Voids in Coarse Aggregate."

11.8 PCC MIX DESIGN COMPUTER PRINTOUT

All mix design information is entered in the Department's Materials Integrated System for Test Information and Communication (MISTIC) database. The Contractor will be provided a printout of the mix design from MISTIC, which will include the Department's mix design number. Refer to Appendix N for a copy of the printout and input instructions.

12.0 VARIOUS PUBLICATIONS

If the Level II PCC Technician desires to obtain more information regarding concrete, various publications are available at the following:

American Concrete Institute (ACI)
www.concrete.org/general/home.asp

American Concrete Pavement Association (ACPA)
www.pavement.com

National Ready Mixed Concrete Association (NRMCA)
www.nrmca.org

Portland Cement Association (PCA)
www.cement.org

13.0 APPLICABLE SPECIFICATIONS

The Level II PCC Technician shall be familiar with the following Sections or Articles.

Section 106 Control of Materials

Article 285.05. Fabric Formed Concrete Revetment Mat

Article 312.26. Proportioning (Cement Aggregate Mixture II)

Section 1001 Cement

Section 1002 Water

Section 1003 Fine Aggregates

Section 1004 Coarse Aggregate

Section 1010 Finely Divided Minerals

Section 1019 Controlled Low-Strength Material (CLSM)

Section 1020 Portland Cement Concrete

Section 1021 Concrete Admixtures

Article 1103.01 Concrete Mixers

Article 1103.02 Batching and Weighing Equipment

Article 1103.03 Automatic and Semi-Automatic Batching Equipment

Article 1103.04 Mobile Portland Cement Concrete Plants

To view or download the Standard Specifications for Road and Bridge Construction on the Internet go to <http://www.dot.il.gov/> Doing Business; Construction Guides; BDE Specifications/Special Provisions/Highway Standards. In addition to the Standard Specifications, it is important for the Level II PCC Technician to be familiar with the Supplemental Specifications and Recurring Special Provisions document and the Bureau of Design and Environment (BDE) Special Provisions. They are also found under BDE Specifications/Special Provisions/Highway Standards and may be downloaded. The Supplemental Specifications are a supplement to the Standard Specifications. The Recurring Special Provisions are frequently included by reference, in selected contracts. The BDE Special Provisions are frequently included by insertion, in selected contracts.

The PCC Level II Technician should also be familiar with Guide Bridge Special Provisions (GBSP). To view or download them go to <http://www.dot.il.gov/>; Doing Business; Construction Guides; Guide Bridge Special Provisions (GBSP). The GBSP are frequently included by insertion in selected contracts. As an example, the bridge deck fly ash or ground granulated blast-furnace slag overlay, microsilica overlay, high-reactivity metakaolin overlay, and latex concrete overlay Special Provisions are found in this area.

14.0 ADDITIONAL QC/QA DOCUMENTS

The following documents are contained in Appendix O of this manual.

- Calibration of Concrete Testing Equipment
- Method for Obtaining Random Samples for Concrete

15.0 CONCRETE PLANT MIXER PERFORMANCE TEST

The Level II PCC Technician may sometime be involved with a concrete plant mixer performance test. The purpose of the test is to determine if the mixing time can be reduced for a concrete plant that produces stationary-mixed (central-mixed) concrete. Refer to Article 1020.11(c) and Appendix P for additional information.

16.0 PROPORTIONING INSPECTION (For IDOT Personnel)

The duties of the IDOT Inspector at a concrete plant for method specification or quality control/quality assurance concrete projects are as follows:

1. Cooperate with the Resident Engineer and assist as necessary.
2. Verify the concrete plant and delivery trucks have been approved according to the Department's Policy Memorandum, "Approval of Concrete Plants and Delivery Trucks" and the plant lab (if applicable) is approved according to the Department's Policy Memorandum, "Minimum Private Laboratory Requirements for Construction Materials Testing or Mix Design."
3. Check the mix design to determine if the correct one is being used, and has been approved (method specification project) or verified (quality control / quality assurance project).
4. Inspect materials for approval and storage, and obtain required material samples. Submit admixture samples to the Bureau of Materials and Physical Research for testing.
5. Inspect all weighing and measuring devices.
 - Verify weighing and measuring devices have been calibrated.
 - Perform sensitivity checks.
 - Check scale zero.
 - Observe weighing of materials and check for correct weights.
 - Check interlock controls for semi-automatic and automatic plants.
6. Inspect for proper functioning of admixture dispensers.
7. Perform aggregate moisture tests to adjust batch weights and check moisture sensor.
8. Perform slump, air content, unit weight/yield, slump flow (self-consolidating concrete (SCC)), J-Ring (SCC), L-Box (SCC), flow (controlled low-strength material (CLSM)), and aggregate gradation tests as required.
9. Check if proper batch sequence is being followed.
10. Check mixer for worn blades and concrete build-up. For stationary-mixed (central-mixed) concrete, check that the stationary mixer is watertight. In addition, check that the volume of batch does not exceed the capacity of the mixer.
11. Check mixing time for stationary-mixed (central-mixed) concrete. Mixing time shall begin when all materials are in the mixing compartment and shall end when the discharge of any part of the batch is started.
12. For truck mixers, check that the revolution counter and water sight gauge are operating properly. Check that the revolution counter is set at zero at the end of charging for which the start of mixing follows. Check the required number of revolutions for mixing and the mixing speed.
13. Check the time clock for accuracy and operation. In addition, check that the delivery ticket is stamped no later than five minutes after the addition of the mixing water to the cement, or after the addition of the cement to the aggregate when the mixer drum contains residual water or the combined aggregates contain free moisture in excess of two percent by weight (mass). If more than one batch is required for charging a truck using a stationary mixer, the time of haul shall start with mixing of the first batch.
14. Require the adjustment of admixture dosages as necessary.
15. Determine the allowable water that can be added at the jobsite.
16. For concrete being agitated during transport, check agitating speed.
17. Prepare required reports and distribute to the appropriate personnel.



Illinois Department of Transportation

PORTLAND CEMENT
CONCRETE
LEVEL II
TECHNICIAN COURSE

APPENDICES

Effective: November 1, 1994

Revised: December 1, 2012

Appendix A

State of Illinois
Department of Transportation

SPECIAL PROVISION
FOR
QUALITY CONTROL OF CONCRETE MIXTURES AT THE PLANT

Effective: August 1, 2000
Revised: January 1, 2011

Description. This Special Provision specifies the quality control responsibilities of the Contractor at the plant, for portland cement concrete mixtures, cement aggregate mixture II, and controlled low-strength material incorporated in the project, and defines the quality assurance and acceptance responsibilities of the Engineer.

A list of quality control/quality assurance (QC/QA) documents is provided in Schedule C.

Equipment/Laboratory. The Contractor shall provide a laboratory and test equipment to perform their quality control testing, as required in Schedule A.

The laboratory shall be of sufficient size and be furnished with the necessary equipment, supplies, and current published test methods for adequately and safely performing all required tests. The laboratory will be approved by the Engineer at the beginning of each construction season or each 12 month period. Production of a mixture shall not begin until the Engineer provides written approval of the laboratory. The Contractor shall refer to the Department's "Required Sampling and Testing Equipment for Concrete" for equipment requirements.

Test equipment shall be maintained and calibrated as required by the appropriate test method, and when required by the Engineer. This information shall be documented on the Department's "Calibration of Concrete Testing Equipment" form.

The Engineer shall have unrestricted access to the plant and laboratory at any time to inspect measuring and testing equipment, and will notify the Contractor of any deficiencies. Defective equipment shall be immediately repaired or replaced by the Contractor.

Plant/Delivery Trucks. The concrete plant and delivery trucks shall be approved according to the Department's Policy Memorandum "Approval of Concrete Plants and Delivery Trucks".

Quality Control Plan. The Contractor shall submit, in writing, a proposed Quality Control (QC) Plan, Part 2, to the Engineer. The QC Plan shall be submitted a minimum of 45 calendar days prior to the production of a mixture. The QC Plan shall address the quality control of the concrete, cement aggregate mixture II, and controlled low-strength material at the plant. The Contractor shall refer to the Department's "Model Quality Control Plan for Concrete Production" to prepare a QC Plan. The Engineer will respond in writing to the Contractor's proposed QC Plan within 15 calendar days of receipt.

Production of a mixture shall not begin until the Engineer provides written approval of the QC Plan. The approved QC Plan shall become a part of the contract between the Department and the Contractor, but shall not be construed as acceptance of any mixture produced.

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The QC Plan may be amended during the progress of the work, by either party, subject to mutual agreement. The Engineer will respond in writing to a Contractor's proposed QC Plan amendment within 15 calendar days of receipt. The response will indicate the approval or denial of the Contractor's proposed QC Plan amendment.

Plant Quality Control by Contractor. At the plant, the Contractor shall perform quality control inspection, sampling, testing, and documentation to meet contract requirements. Quality control includes the recognition of obvious defects and their immediate correction. Quality control also includes appropriate action when passing test results are near specification limits. Quality control may require increased testing, communication of test results to the plant or the jobsite, modification of operations, suspension of mixture production, rejection of material, or other actions as appropriate. The Engineer shall be immediately notified of any failing tests and subsequent remedial action. Passing tests shall be reported no later than the start of the next work day.

When a mixture does not comply with specifications, the Contractor shall reject the material; unless the Engineer accepts the material for incorporation in the work, according to Article 105.03 of the Standard Specifications.

- (a) Personnel Requirements. The Contractor shall provide personnel to perform the required inspections, sampling, testing, and documentation in a timely manner. A Quality Control (QC) Manager will not be required. The Contractor shall refer to the Department's "Qualifications and Duties of Concrete Quality Control Personnel" document.

A Level II PCC Technician shall be provided at the plant, or shall be available, during mixture production and placement. A Level II PCC Technician may supervise a maximum of three plants. Whenever the Level II PCC Technician is not at the plant during mixture production and placement, a Concrete Tester or Level I PCC Technician shall be present at the plant to perform any necessary concrete tests. The Concrete Tester, Level I PCC Technician, or other individual shall also be trained to perform any necessary aggregate moisture tests, if the Level II PCC Technician is not at the plant during mixture production and placement. The Concrete Tester, Level I PCC Technician, plant personnel, and jobsite personnel shall have the ability to contact the Level II PCC Technician by cellular phone, two-way radio, or other methods approved by the Engineer.

A Concrete Tester may provide assistance with sampling and testing, and shall be supervised by a Level I or Level II PCC Technician.

- (b) Required Plant Tests. Sampling and testing shall be performed at the plant, or at a location approved by the Engineer, to control the production of a mixture. The required minimum Contractor plant sampling and testing is indicated in Schedule A.

Plant Quality Assurance by Engineer. The Engineer will perform quality assurance tests on independent samples and split samples at the plant. An independent sample is a field sample obtained and tested by only one party. A split sample is one of two equal portions of a field sample, where two parties each receive one portion for testing. The Engineer may request the Contractor to obtain a split sample. Aggregate split samples and any failing strength specimen shall be retained until permission is given by the Engineer for disposal. The results of all quality assurance tests by the Engineer will be made available to the Contractor. However, Contractor split sample test results shall be provided to the Engineer before Department test results are revealed. The Engineer's quality assurance independent sample and split sample testing is indicated in Schedule B.

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- (a) Comparing Test Results. Differences between the Engineer's and the Contractor's split sample test results will not be considered extreme if within the following limits:

Test Parameter	Acceptable Limits of Precision
Slump	0.75 in. (20 mm)
Air Content	0.9%
Aggregate Gradation	See "Guideline for Sample Comparison" in Appendix "A" of the Manual of Test Procedures for Materials.

When acceptable limits of precision have been met, but only one party is within specification limits, the failing test shall be resolved before the material may be considered for acceptance.

- (b) Test Results and Specification Limits. Split sample and independent sample testing shall be as follows.

- (1) Split Sample Testing. If either the Engineer's or the Contractor's split sample test result is not within specification limits, and the other party is within specifications limits; immediate retests on a split sample shall be performed for slump, air content, or aggregate gradation. A passing retest result by each party will require no further action. If either the Engineer's or Contractor's slump, air content, or aggregate gradation split sample retest result is a failure; or if either the Engineer's or Contractor's strength test result is a failure, and the other party is within specification limits; the following actions shall be initiated to investigate the test failure:
- a. The Engineer and the Contractor shall investigate the sampling method, test procedure, equipment condition, equipment calibration, and other factors.
 - b. The Engineer or the Contractor shall replace test equipment, as determined by the Engineer.
 - c. The Engineer and the Contractor shall perform additional testing on split samples, as determined by the Engineer.

For aggregate gradation, plant slump, and plant air content: if the failing split sample test result is not resolved according to a., b., or c., and the mixture has not been placed, the Contractor shall reject the material; unless the Engineer accepts the material for incorporation in the work according to Article 105.03 of the Standard Specifications. If the mixture has already been placed, the material will be considered unacceptable.

If a continued trend of difference exists between the Engineer's and the Contractor's split sample test results, or if split sample test results exceed the acceptable limits of precision, the Engineer and the Contractor shall investigate according to a., b., or c.

- (2) Independent Sample Testing. For aggregate gradation, plant slump, and plant air content; if the result of a quality assurance test on a sample independently obtained by the Engineer is not within specification limits, and the mixture has not been placed, the Contractor shall reject the material, unless the Engineer accepts the material for incorporation in the work according to Article 105.03 of the Standard Specifications. If the mixture has already been placed, the material will be considered unacceptable.

CHECK SHEET #30

Jobsite Acceptance Testing by the Engineer. The Engineer will perform acceptance testing at the jobsite for slump, air content, and strength.

Acceptance by the Engineer. Final acceptance will be based on the Standard Specifications and the following:

- (a) The Contractor's compliance with all contract documents for quality control.
- (b) Comparison of the Engineer's jobsite acceptance test results with specification limits, using samples independently obtained by the Engineer.
- (c) Validation of Contractor plant quality control test results by comparison with the Engineer's quality assurance test results using split samples. Any quality control or quality assurance test determined to be flawed may be declared invalid only when reviewed and approved by the Engineer. The Engineer will declare a test result invalid only if it is proven that improper sampling or testing occurred. The test result is to be recorded and the reason for declaring the test invalid will be provided by the Engineer.
- (d) Comparison of the Engineer's plant quality assurance test results with specification limits using samples independently obtained by the Engineer.

The Engineer may suspend mixture production, reject materials, or take other appropriate action if the Contractor does not control the quality of concrete, cement aggregate mixture II, or controlled low-strength material for acceptance. The decision will be determined according to (a), (b), (c), and (d).

Documentation. The Contractor shall be responsible for documenting all observations, inspections, adjustments to the mix design, test results, retest results, and corrective actions in a bound hardback field book, bound hardback diary, or appropriate Department form, which shall become the property of the Department. The documentation shall include a method to compare the Engineer's test results with the Contractor's results. The Contractor shall be responsible for the maintenance of all permanent records whether obtained by the Contractor, the consultants, subcontractors, or the producer of the mixture. The Contractor shall provide the Engineer full access to all documentation throughout the progress of the work.

The Department's form MI 504M shall be completed by the Contractor, and shall be submitted to the Engineer weekly or as required by the Engineer. A correctly completed Form MI 504M is required to authorize payment by the Engineer, for applicable pay items.

The Engineer will be responsible for completing form MI 654 and form MI 655.

Basis of Payment. Quality Control of Concrete Mixtures at the Plant will not be paid for separately, but shall be considered as included in the cost of the various types of concrete mixtures required to construct the work items included in the contract.

CHECK SHEET #30

SCHEDULE A

CONTRACTOR PLANT SAMPLING AND TESTING - DOUBLE A			
Item	Test	Frequency	IL Modified AASHTO, IL Modified ASTM, or Department Test Method ^{1/}
Aggregates (Arriving at Plant)	Gradation ^{2/}	As needed to check source for each gradation number	T 2, T 11, T 27, and T 248
Aggregates (Stored at Plant in Stockpiles or Bins)	Gradation ^{2/}	2,500 cu yd (1,900 cu m) for each gradation number ^{3/}	T 2, T 11, T 27, and T 248
Aggregates (Stored at Plant in Stockpiles or Bins)	Moisture: ^{4/} Fine Aggregate	Once per week for moisture sensor, otherwise daily for each gradation number	Flask, Dunagan, Pycnometer Jar, or T 255
	Moisture: ^{4/} Coarse Aggregate	As needed to control production for each gradation number	Dunagan, Pycnometer Jar, or T 255
Mixture ^{5/}	Slump, Air Content, Unit Weight / Yield, and Temperature	As needed to control production	T 141 and T 119 T 141 and T 152 or T 196 T 141 and T 121 T 141 and ASTM C 1064

- 1/ Refer to the Department's "Manual of Test Procedures for Materials".
- 2/ All gradation tests shall be washed. Testing shall be completed no later than 24 hours after the aggregate has been sampled.
- 3/ One per week (Sunday through Saturday) minimum unless the stockpile has not received additional aggregate material since the previous test.

One per day minimum for a bridge deck pour unless the stockpile has not received additional aggregate material since the previous test. The sample shall be taken and testing completed prior to the pour. The bridge deck aggregate sample may be taken the day before the pour or as approved by the Engineer.

- 4/ If the moisture test and moisture sensor disagree by more than 0.5 percent, retest. If the difference remains, adjust the moisture sensor to an average of two or more moisture tests, using the Dunagan or Illinois Modified AASHTO T 255 test method. The Department's "Water/Cement Ratio Worksheet" form shall be completed when applicable.
- 5/ The Contractor may also perform strength testing according to Illinois Modified AASHTO T 141, T 23, and T 22 or T 177; or water content testing according to Illinois Modified AASHTO T 318; or other tests at the plant to control mixture production.

CHECK SHEET #30

SCHEDULE B

ENGINEER QUALITY ASSURANCE INDEPENDENT SAMPLE TESTING		
Location	Measured Property	Testing Frequency ^{1/}
Plant	Gradation of aggregates stored in stockpiles or bins, Slump and Air Content	As determined by the Engineer.

ENGINEER QUALITY ASSURANCE SPLIT SAMPLE TESTING		
Location	Measured Property	Testing Frequency ^{1/}
Plant	Gradation of aggregates stored in stockpiles or bins ^{2/}	At the beginning of the project, the first test performed by the Contractor. Thereafter, a minimum of 10% of total tests required of the Contractor will be performed per aggregate gradation number and per plant.
	Slump and Air Content ^{2/}	As determined by the Engineer.

- 1/ The Engineer will perform the testing throughout the period of quality control testing by the Contractor.
- 2/ The Engineer will witness and take immediate possession of or otherwise secure the Department's split sample obtained by the Contractor.

SCHEDULE C

IDOT CONCRETE QUALITY CONTROL AND QUALITY ASSURANCE DOCUMENTS

- (a) Model Quality Control Plan for Concrete Production (*)
- (b) Qualifications and Duties of Concrete Quality Control Personnel (*)
- (c) Development of Gradation Bands on Incoming Aggregate at Mix Plants (*)
- (d) Required Sampling and Testing Equipment for Concrete (*)
- (e) Calibration of Concrete Testing Equipment (*)
- (f) Water/Cement Ratio Worksheet (BMPR PCCW01) (*)
- (g) Field/Lab Gradations (MI 504 M) (*)
- (h) Aggregate Technician Course or Mixture Aggregate Technician Course (*)
- (i) Portland Cement Concrete Tester Course (*)
- (j) Portland Cement Concrete Level I Technician Course – Manual of Instructions for Concrete Testing (*)
- (k) Portland Cement Concrete Level II Technician Course – Manual of Instructions for Concrete Proportioning (*)
- (l) Portland Cement Concrete Level III Technician Course – Manual of Instructions for Design of Concrete Mixtures (*)
- (m) Manual of Test Procedures for Materials

* Refer to the Manual of Test Procedures for Materials for more information.

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QUALITY CONTROL/QUALITY ASSURANCE OF CONCRETE MIXTURES (BDE)

Effective: January 1, 2012

Revised: January 1, 2013

Add the following to Section 1020 of the Standard Specifications:

“1020.16 Quality Control/Quality Assurance of Concrete Mixtures. This Article specifies the quality control responsibilities of the Contractor for concrete mixtures (except Class PC and PS concrete), cement aggregate mixture II, and controlled low-strength material incorporated in the project, and defines the quality assurance and acceptance responsibilities of the Engineer.

A list of quality control/quality assurance (QC/QA) documents is provided in Article 1020.16(g), Schedule D.

A Level I Portland Cement Concrete (PCC) Technician shall be defined as an individual who has successfully completed the Department’s training for concrete testing.

A Level II Portland Cement Concrete (PCC) Technician shall be defined as an individual who has successfully completed the Department’s training for concrete proportioning.

A Level III Portland Cement Concrete (PCC) Technician shall be defined as an individual who has successfully completed the Department’s training for concrete mix design.

A Concrete Tester shall be defined as an individual who has successfully completed the Department’s training to assist with concrete testing and is monitored on a daily basis.

Aggregate Technician shall be defined as an individual who has successfully completed the Department’s training for gradation testing involving aggregate production and mixtures.

Mixture Aggregate Technician shall be defined as an individual who has successfully completed the Department’s training for gradation testing involving mixtures.

Gradation Technician shall be defined as an individual who has successfully completed the Department’s training to assist with gradation testing and is monitored on a daily basis.

- (a) Equipment/Laboratory. The Contractor shall provide a laboratory and test equipment to perform their quality control testing.

The laboratory shall be of sufficient size and be furnished with the necessary equipment, supplies, and current published test methods for adequately and safely performing all required tests. The laboratory will be approved by the Engineer according to the current Bureau of Materials and Physical Research Policy Memorandum “Minimum Private Laboratory Requirements for Construction Materials Testing or Mix Design”. Production of a mixture shall not begin until the Engineer provides written approval of the laboratory. The Contractor shall refer to the Department’s “Required Sampling and Testing Equipment for Concrete” for equipment requirements.

Test equipment shall be maintained and calibrated as required by the appropriate test method, and when required by the Engineer. This information shall be documented on the Department’s “Calibration of Concrete Testing Equipment” form.

Test equipment used to determine compressive or flexural strength shall be calibrated each 12 month period by an independent agency, using calibration equipment traceable

to the National Institute of Standards and Technology (NIST). The Contractor shall have the calibration documentation available at the test equipment location.

The Engineer will have unrestricted access to the plant and laboratory at any time to inspect measuring and testing equipment, and will notify the Contractor of any deficiencies. Defective equipment shall be immediately repaired or replaced by the Contractor.

- (b) Quality Control Plan. The Contractor shall submit, in writing, a proposed Quality Control (QC) Plan to the Engineer. The QC Plan shall be submitted a minimum of 45 calendar days prior to the production of a mixture. The QC Plan shall address the quality control of the concrete, cement aggregate mixture II, and controlled low-strength material incorporated in the project. The Contractor shall refer to the Department's "Model Quality Control Plan for Concrete Production" to prepare a QC Plan. The Engineer will respond in writing to the Contractor's proposed QC Plan within 15 calendar days of receipt.

Production of a mixture shall not begin until the Engineer provides written approval of the QC Plan. The approved QC Plan shall become a part of the contract between the Department and the Contractor, but shall not be construed as acceptance of any mixture produced.

The QC Plan may be amended during the progress of the work, by either party, subject to mutual agreement. The Engineer will respond in writing to a Contractor's proposed QC Plan amendment within 15 calendar days of receipt. The response will indicate the approval or denial of the Contractor's proposed QC Plan amendment.

- (c) Quality Control by Contractor. The Contractor shall perform quality control inspection, sampling, testing, and documentation to meet contract requirements. Quality control includes the recognition of obvious defects and their immediate correction. Quality control also includes appropriate action when passing test results are near specification limits, or to resolve test result differences with the Engineer. Quality control may require increased testing, communication of test results to the plant or the jobsite, modification of operations, suspension of mixture production, rejection of material, or other actions as appropriate. The Engineer shall be immediately notified of any failing tests and subsequent remedial action. Passing tests shall be reported no later than the start of the next work day.

When a mixture does not comply with specifications, the Contractor shall reject the material; unless the Engineer accepts the material for incorporation in the work, according to Article 105.03.

- (1) Personnel Requirements. The Contractor shall provide a Quality Control (QC) Manager who will have overall responsibility and authority for quality control. The jobsite and plant personnel shall be able to contact the QC Manager by cellular phone, two-way radio or other methods approved by the Engineer.

The QC Manager shall visit the jobsite a minimum of once a week. A visit shall be performed the day of a bridge deck pour, the day a non-routine mixture is placed as determined by the Engineer, or the day a plant is anticipated to produce more than 1000 cu yd (765 cu m). Any of the three required visits may be used to meet the once per week minimum requirement.

The Contractor shall provide personnel to perform the required inspections, sampling, testing and documentation in a timely manner. The Contractor shall refer

to the Department's "Qualifications and Duties of Concrete Quality Control Personnel" document.

A Level I PCC Technician shall be provided at the jobsite during mixture production and placement, and may supervise concurrent pours on the project. For concurrent pours, a minimum of one Concrete Tester shall be required at each pour location. If the Level I PCC Technician is at one of the pour locations, a Concrete Tester is still required at the same location. Each Concrete Tester shall be able to contact the Level I PCC Technician by cellular phone, two-way radio or other methods approved by the Engineer. A single Level I PCC Technician shall not supervise concurrent pours for multiple contracts.

A Level II PCC Technician shall be provided at the plant, or shall be available, during mixture production and placement. A Level II PCC Technician may supervise a maximum of three plants. Whenever the Level II PCC Technician is not at the plant during mixture production and placement, a Concrete Tester or Level I PCC Technician shall be present at the plant to perform any necessary concrete tests. The Concrete Tester, Level I PCC Technician, or other individual shall also be trained to perform any necessary aggregate moisture tests, if the Level II PCC Technician is not at the plant during mixture production and placement. The Concrete Tester, Level I PCC Technician, plant personnel, and jobsite personnel shall have the ability to contact the Level II PCC Technician by cellular phone, two-way radio, or other methods approved by the Engineer.

For a mixture which is produced and placed with a mobile portland cement concrete plant as defined in Article 1103.04, a Level II PCC Technician shall be provided. The Level II PCC Technician shall be present at all times during mixture production and placement. However, the Level II PCC Technician may request to be available if operations are satisfactory. Approval shall be obtained from the Engineer, and jobsite personnel shall have the ability to contact the Level II PCC Technician by cellular phone, two-way radio, or other methods approved by the Engineer.

A Concrete Tester, Mixture Aggregate Technician, and Aggregate Technician may provide assistance with sampling and testing. A Gradation Technician may provide assistance with testing. A Concrete Tester shall be supervised by a Level I or Level II PCC Technician. A Gradation Technician shall be supervised by a Level II PCC Technician, Mixture Aggregate Technician, or Aggregate Technician.

- (2) Required Plant Tests. Sampling and testing shall be performed at the plant, or at a location approved by the Engineer, to control the production of a mixture. The required minimum Contractor plant sampling and testing is indicated in Article 1020.16(g) Schedule A.
- (3) Required Field Tests. Sampling and testing shall be performed at the jobsite to control the production of a mixture, and to comply with specifications for placement. For standard curing, after initial curing, and for strength testing; the location shall be approved by the Engineer. The required minimum Contractor jobsite sampling and testing is indicated in Article 1020.16(g), Schedule B.
- (d) Quality Assurance by Engineer. The Engineer will perform quality assurance tests on independent samples and split samples. An independent sample is a field sample obtained and tested by only one party. A split sample is one of two equal portions of a field sample, where two parties each receive one portion for testing. The Engineer may request the Contractor to obtain a split sample. Aggregate split samples and any failing strength specimen shall be retained until permission is given by the Engineer for disposal. The results of all quality assurance tests by the Engineer will be made

available to the Contractor. However, Contractor split sample test results shall be provided to the Engineer before Department test results are revealed. The Engineer's quality assurance independent sample and split sample testing is indicated in Article 1020.16(g), Schedule C.

- (1) Strength Testing. For strength testing, Article 1020.09 shall apply, except the Contractor and Engineer strength specimens may be placed in the same field curing box for initial curing and may be cured in the same water storage tank for final curing.
- (2) Comparing Test Results. Differences between the Engineer's and the Contractor's split sample test results will be considered reasonable if within the following limits:

Test Parameter	Acceptable Limits of Precision
Slump	0.75 in. (20 mm)
Air Content	0.9%
Compressive Strength	900 psi (6200 kPa)
Flexural Strength	90 psi (620 kPa)
Slump Flow (Self-Consolidating Concrete (SCC))	1.5 in. (40 mm)
Visual Stability Index (SCC)	Not Applicable
J-Ring (SCC)	1.5 in. (40 mm)
L-Box (SCC)	10 %
Hardened Visual Stability Index (SCC)	Not Applicable
Dynamic Segregation Index (SCC)	1.0 %
Flow (Controlled Low-Strength Material (CLSM))	1.5 in. (40 mm)
Strength (Controlled Low-Strength Material (CLSM))	40 psi (275 kPa)
Aggregate Gradation	See "Guideline for Sample Comparison" in Appendix "A" of the Manual of Test Procedures for Materials.

When acceptable limits of precision have been met, but only one party is within specification limits, the failing test shall be resolved before the material may be considered for acceptance.

- (3) Test Results and Specification Limits.
 - a. Split Sample Testing. If either the Engineer's or the Contractor's split sample test result is not within specification limits, and the other party is within specification limits; immediate retests on a split sample shall be performed for slump, air content, slump flow, visual stability index, J-Ring, L-Box, dynamic segregation index, flow (CLSM), or aggregate gradation. A passing retest result by each party will require no further action. If either the Engineer's or Contractor's slump, air content, slump flow, visual stability index, J-Ring, L-Box, dynamic segregation index, flow (CLSM), or aggregate gradation split sample retest result is a failure; or if either the Engineer's or Contractor's strength or hardened visual stability index test result is a failure, and the other party is within specification limits; the following actions shall be initiated to investigate the test failure:
 1. The Engineer and the Contractor shall investigate the sampling method, test procedure, equipment condition, equipment calibration, and other factors.
 2. The Engineer or the Contractor shall replace test equipment, as determined by the Engineer.

3. The Engineer and the Contractor shall perform additional testing on split samples, as determined by the Engineer.

For aggregate gradation, jobsite slump, jobsite air content, jobsite slump flow, jobsite visual stability index, jobsite J-Ring, jobsite L-Box, jobsite dynamic segregation index, and jobsite flow (CLSM); if the failing split sample test result is not resolved according to 1., 2., or 3., and the mixture has not been placed, the Contractor shall reject the material; unless the Engineer accepts the material for incorporation in the work according to Article 105.03. If the mixture has already been placed, or if a failing strength or hardened visual stability index test result is not resolved according to 1., 2., or 3., the material will be considered unacceptable.

If a continued trend of difference exists between the Engineer's and the Contractor's split sample test results, or if split sample test results exceed the acceptable limits of precision, the Engineer and the Contractor shall investigate according to items 1., 2., and 3.

- b. Independent Sample Testing. For aggregate gradation, jobsite slump, jobsite air content jobsite slump flow, jobsite visual stability index, jobsite J-Ring, jobsite L-Box, jobsite dynamic segregation index, and jobsite flow (CLSM); if the result of a quality assurance test on a sample independently obtained by the Engineer is not within specification limits, and the mixture has not been placed, the Contractor shall reject the material, unless the Engineer accepts the material for incorporation in the work according to Article 105.03. If the mixture has already been placed or the Engineer obtains a failing strength or hardened visual stability index test result, the material will be considered unacceptable.
- (e) Acceptance by the Engineer. Final acceptance will be based on the Standard Specifications and the following:
- (1) The Contractor's compliance with all contract documents for quality control.
 - (2) Validation of Contractor quality control test results by comparison with the Engineer's quality assurance test results using split samples. Any quality control or quality assurance test determined to be flawed may be declared invalid only when reviewed and approved by the Engineer. The Engineer will declare a test result invalid only if it is proven that improper sampling or testing occurred. The test result is to be recorded and the reason for declaring the test invalid will be provided by the Engineer.
 - (3) Comparison of the Engineer's quality assurance test results with specification limits using samples independently obtained by the Engineer.

The Engineer may suspend mixture production, reject materials, or take other appropriate action if the Contractor does not control the quality of concrete, cement aggregate mixture II, or controlled low-strength material for acceptance. The decision will be determined according to (1), (2), or (3).

- (f) Documentation.

- (1) Records. The Contractor shall be responsible for documenting all observations, inspections, adjustments to the mix design, test results, retest results, and corrective actions in a bound hardback field book, bound hardback diary, or appropriate Department form, which shall become the property of the Department. The documentation shall include a method to compare the Engineer's test results with the

Contractor's results. The Contractor shall be responsible for the maintenance of all permanent records whether obtained by the Contractor, the consultants, the subcontractors, or the producer of the mixture. The Contractor shall provide the Engineer full access to all documentation throughout the progress of the work.

The Department's form MI 504M, form BMPR MI654, and form BMPR MI655 shall be completed by the Contractor, and shall be submitted to the Engineer weekly or as required by the Engineer. A correctly completed form MI 504M, form BMPR MI654, and form BMPR MI655 are required to authorize payment by the Engineer, for applicable pay items.

- (2) Delivery Truck Ticket. The following information shall be recorded on each delivery ticket or in a bound hardback field book: initial revolution counter reading (final reading optional) at the jobsite, if the mixture is truck-mixed; time discharged at the jobsite; total amount of each admixture added at the jobsite; and total amount of water added at the jobsite.
- (g) Basis of Payment and Schedules. Quality Control/Quality Assurance of portland cement concrete mixtures will not be paid for separately, but shall be considered as included in the cost of the various concrete contract items.

SCHEDULE A

CONTRACTOR PLANT SAMPLING AND TESTING			
Item	Test	Frequency	IL Modified AASHTO or Department Test Method ^{1/}
Aggregates (Arriving at Plant)	Gradation ^{2/}	As needed to check source for each gradation number	2, 11, 27, and 248
Aggregates (Stored at Plant in Stockpiles or Bins)	Gradation ^{2/}	2,500 cu yd (1,900 cu m) for each gradation number ^{3/}	2, 11, 27, and 248
Aggregates (Stored at Plant in Stockpiles or Bins)	Moisture ^{4/} : Fine Aggregate	Once per week for moisture sensor, otherwise daily for each gradation number	Flask, Dunagan, Pycnometer Jar, or 255
	Moisture ^{4/} : Coarse Aggregate	As needed to control production for each gradation number	Dunagan, Pycnometer Jar, or 255
Mixture ^{5/}	Slump, Air Content, Unit Weight / Yield, Slump Flow (SCC) Visual Stability Index (SCC) J-Ring (SCC) L-Box (SCC) Temperature	As needed to control production	T 141 and T 119 T 141 and T 152 or T 196 T 141 and T 121 SCC-1 and SCC-2 SCC-1 and SCC-2 SCC-1 and SCC-3 SCC-1 and SCC-4 T 141 and T 309
Mixture (CLSM) ^{7/}	Flow Air Content Temperature	As needed to control production	Illinois Test Procedure 307

1/ Refer to the Department's "Manual of Test Procedures for Materials".

2/ All gradation tests shall be washed. Testing shall be completed no later than 24 hours after the aggregate has been sampled.

3/ One per week (Sunday through Saturday) minimum unless the stockpile has not received additional aggregate material since the previous test.

One per day minimum for a bridge deck pour unless the stockpile has not received additional aggregate material since the previous test. The sample shall be taken and testing completed prior to the pour. The bridge deck aggregate sample may be taken the day before the pour or as approved by the Engineer.

4/ If the moisture test and moisture sensor disagree by more than 0.5 percent, retest. If the difference remains, adjust the moisture sensor to an average of two or more moisture tests. The Department's "Water/Cement Ratio Worksheet" form shall be completed when applicable.

5/ The Contractor may also perform strength testing according to Illinois Modified AASHTO T 141, T 23, and T 22 or T 177; or water content testing according to Illinois Modified AASHTO T 318; or other tests at the plant to control mixture production.

The Contractor may also perform other available self-consolidating concrete (SCC) tests at the plant to control mixture production.

6/ The Contractor shall select the J-Ring or L-Box test for plant sampling and testing.

7/ The Contractor may also perform strength testing according to Illinois Test Procedure 307.

SCHEDULE B

CONTRACTOR JOBSITE SAMPLING & TESTING ^{1/}			
Item	Measured Property	Random Sample Testing Frequency per Mix Design and per Plant ^{2/}	IL Modified AASHTO Test Method
Pavement, Shoulder, Base Course, Base Course Widening, Driveway Pavement, Railroad Crossing, Cement Aggregate Mixture II	Slump ^{3/ 4/}	1 per 500 cu yd (400 cu m) or minimum 1/day	T 141 and T 119
	Air Content ^{3/ 5/ 6/}	1 per 100 cu yd (80 cu m) or minimum 1/day	T 141 And T 152 or T 196
	Compressive Strength ^{7/ 8/} or Flexural Strength ^{7/ 8/}	1 per 1250 cu yd (1000 cu m) or minimum 1/day	T 141, T 22 and T 23 Or T 141, T 177 and T 23
Bridge Approach Slab ^{9/} , Bridge Deck ^{9/} , Bridge Deck Overlay ^{9/} , Superstructure ^{9/} , Substructure, Culvert, Miscellaneous Drainage Structures, Retaining Wall, Building Wall, Drilled Shaft Pile & Encasement Footing, Foundation, Pavement Patching, Structural Repairs	Slump ^{3/ 4/}	1 per 50 cu yd (40 cu m) or minimum 1/day	T 141 and T 119
	Air Content ^{3/ 5/ 6/}	1 per 50 cu yd (40 cu m) or minimum 1/day	T 141 And T 152 or T 196
	Compressive Strength ^{7/ 8/} or Flexural Strength ^{7/ 8/}	1 per 250 cu yd (200 cu m) or minimum 1/day	T 141, T 22 and T 23 Or T 141, T 177 and T 23
Seal Coat	Slump ^{3/}	1 per 250 cu yd (200 cu m) or minimum 1/day	T 141 and T 119
	Air Content ^{3/ 6/}	1 per 250 u yd (200 cu m) or minimum 1/day when air is entrained	T 141 And T 152 or T 196
	Compressive Strength ^{7/ 8/} or Flexural Strength ^{7/ 8/}	1 per 250 cu yd (200 cu m) or minimum 1/day	T 141, T 22 and T 23 Or T 141, T 177 and T 23

CONTRACTOR JOBSITE SAMPLING & TESTING ^{1/}			
Curb, Gutter, Median, Barrier, Sidewalk, Slope Wall, Paved Ditch, Fabric Formed Concrete Revetment Mat ^{10/} , Miscellaneous Items, Incidental Items	Slump ^{3/ 4/}	1 per 100 cu yd (80 cu m) or minimum 1/day	T 141 and T 119
	Air Content ^{3/ 5/ 6/}	1 per 50 cu yd (40 cu m) or minimum 1/day	T 141 And T 152 or T 196
	Compressive Strength ^{7/ 8/} or Flexural Strength ^{7/ 8/}	1 per 400 cu yd (300 cu m) or minimum 1/day	T 141, T 22 and T 23 Or T 141, T 177 and T 23
The Item will use a Self-Consolidating Concrete Mixture	Slump Flow ^{3/} VSI ^{3/} J-Ring ^{3/ 11/} L-Box ^{3/ 11/}	Perform at same frequency that is specified for the Item's slump	SCC-1 & SCC-2 SCC-1 & SCC-2 SCC-1 & SCC-3 SCC-1 & SCC-4
The Item will use a Self-Consolidating Concrete Mixture	HVSI ^{12/}	Minimum 1/day at start of production for that day	SCC-1 and SCC-6
The Item will use a Self-Consolidating Concrete Mixture	Dynamic Segregation Index (DSI)	Minimum 1/week at start of production for that week	SCC-1 and SCC-8 (Option C)
The Item will use a Self-Consolidating Concrete Mixture	Air Content ^{3/ 5/ 6/}	Perform at same frequency that is specified for the Item's air content	SCC-1 and T 152 or T 196
The Item will use a Self-Consolidating Concrete Mixture	Compressive Strength ^{7/ 8/} or Flexural Strength ^{7/ 8/}	Perform at same frequency that is specified for the Item's strength	SCC-1, T22 and T 23 or SCC-1, T 177 and T 23
All	Temperature ^{3/}	As needed to control production	T 141 and T 309
Controlled Low-Strength Material (CLSM)	Flow, Air Content Compressive Strength (28-day) ^{13/} , and Temperature	First truck load delivered and as needed to control production thereafter	Illinois Test Procedure 307

- 1/ Sampling and testing of small quantities of curb, gutter, median, barrier, sidewalk, slope wall, paved ditch, miscellaneous items, and incidental items may be waived by the Engineer if requested by the Contractor. However, quality control personnel are still required according to Article 1020.16(c)(1) The Contractor shall also provide recent evidence that similar material has been found to be satisfactory under normal sampling and testing procedures. The total quantity that may be waived for testing shall not exceed 100 cu yd (76 cu m) per contract.

If the Contractor's or Engineer's test result for any jobsite mixture test is not within the specification limits, all subsequent truck loads delivered shall be tested by the Contractor until the problem is corrected.

- 2/ If one mix design is being used for several construction items during a day's production, one testing frequency may be selected to include all items. The construction items shall have the same slump, air content, and water/cement ratio specifications. For self-consolidating concrete, the construction items shall have the same slump flow, visual stability index, J-Ring, L-Box, air content, and water/cement ratio specifications. The frequency selected shall equal or exceed the testing required for the construction item.

One sufficiently sized sample shall be taken to perform the required test(s). Random numbers shall be determined according to the Department's "Method for Obtaining Random Samples for Concrete". The Engineer will provide random sample locations.

- 3/ The temperature, slump, and air content tests shall be performed on the first truck load delivered, for each pour. For self-consolidating concrete, the temperature, slump flow, visual stability, index, J-Ring or L-Box, and air content tests shall be performed on the first truck load delivered, for each pour. Unless a random sample is required for the first truck load, testing the first truck load does not satisfy random sampling requirements.
- 4/ The slump random sample testing frequency shall be a minimum 1/day for a construction item which is slipformed.
- 5/ If a pump or conveyor is used for placement, a correction factor shall be established to allow for a loss of air content during transport. The first three truck loads delivered shall be tested, before and after transport by the pump or conveyor, to establish the correction factor. Once the correction is determined, it shall be re-checked after an additional 50 cu yd (40 cu m) is pumped, or an additional 100 cu yd (80 cu m) is conveyed. This shall continue throughout the pour. If the re-check indicates the correction factor has changed, a minimum of two truckloads is required to re-establish the correction factor. The correction factor shall also be re-established when significant changes in temperature, distance, pump or conveyor arrangement, and other factors have occurred. If the correction factor is >3.0 percent, the Contractor shall take corrective action to reduce the loss of air content during transport by the pump or conveyor. The Contractor shall record all air content test results, correction factors and corrected air contents. The corrected air content shall be reported on form Bmpr MI654.
- 6/ If the Contractor's or Engineer's air content test result is within the specification limits, and 0.2 percent or closer to either limit, the next truck load delivered shall be tested by the Contractor. For example, if the specified air content range is 5.0 to 8.0 percent and the test result is 5.0, 5.1, 5.2, 7.8, 7.9 or 8.0 percent, the next truck shall be tested by the Contractor.
- 7/ The test of record for strength shall be the day indicated in Article 1020.04. For cement aggregate mixture II, a strength requirement is not specified and testing is not required. Additional strength testing to determine early falsework and form removal, early pavement or bridge opening to traffic, or to monitor strengths is at the discretion of the Contractor. Strength shall be defined as the average of at least two cylinder or two beam breaks for field tests.
- 8/ In addition to the strength test, a slump test, air content test, slump test, and temperature test shall be performed on the same sample. For self-consolidating concrete, a slump flow test, visual stability index test, J-Ring or L-Box test, air content test, and temperature test shall be performed on the same sample as the strength test. For mixtures pumped or conveyed, the Contractor shall sample according to Illinois Modified AASHTO T 141.
- 9/ The air content test will be required for each delivered truck load.
- 10/ For fabric formed concrete revetment mat, the slump test is not required and the flexural strength test is not applicable.
- 11/ The Contractor shall select the J-Ring or L-Box test for jobsite sampling and testing.
- 12/ In addition to the hardened visual stability index (HVSI) test, a slump flow test, visual stability index (VSI) test, J-Ring or L-Box test, air content test, and temperature test shall be performed on the same sample. The Contractor shall retain all hardened visual stability index cut cylinder specimens until the Engineer notifies the Contractor that the specimens may be discarded.

13/ The test of record for strength shall be the day indicated in Article 1019.04. In addition to the strength test, a flow test, air content test, and temperature test shall be performed on the same sample. The strength test may be waived by the Engineer if future removal of the material is not a concern.

SCHEDULE C

ENGINEER QUALITY ASSURANCE INDEPENDENT SAMPLE TESTING		
Location	Measured Property	Testing Frequency ^{1/}
Plant	Gradation of aggregates stored in stockpiles or bins, Slump and Air Content	As determined by the Engineer.
Jobsite	Slump, Air Content, Slump Flow, Visual Stability Index, J-Ring, L-Box, Hardened Visual Stability Index, Dynamic Segregation Index and Strength	As determined by the Engineer.
	Flow, Air Content, Strength (28-day), and Dynamic Cone Penetration for Controlled Low-Strength Material (CLSM)	As determined by the Engineer

ENGINEER QUALITY ASSURANCE SPLIT SAMPLE TESTING		
Location	Measured Property	Testing Frequency ^{1/}
Plant	Gradation of aggregates stored in stockpiles or bins ^{2/}	At the beginning of the project, the first test performed by the Contractor. Thereafter, a minimum of 10% of total tests required of the Contractor will be performed per aggregate gradation number and per plant.
	Slump and Air Content	As determined by the Engineer.
Jobsite	Slump ^{2/} , Air Content ^{2/ 3/} , Slump Flow ^{2/} , Visual Stability Index ^{2/} , J-Ring ^{2/} and L-Box ^{2/}	At the beginning of the project, the first three tests performed by the Contractor. Thereafter, a minimum of 20% of total tests required of the Contractor will be performed per plant, which will include a minimum of one test per mix design.
	Hardened Visual Stability Index ^{2/}	As determined by the Engineer.
	Dynamic Segregation Index ^{2/}	As determined by the Engineer.
	Strength ^{2/}	At the beginning of the project, the first test performed by the Contractor. Thereafter, a minimum of 20% of total tests required of the Contractor will be performed per plant, which will include a minimum of one test per mix design.
	Flow, Air Content, and Strength (28-day) for Controlled Low-Strength Material (CLSM)	As determined by the Engineer.

- 1/ The Engineer will perform the testing throughout the period of quality control testing by the Contractor.
- 2/ The Engineer will witness and take immediate possession of or otherwise secure the Department's split sample obtained by the Contractor.
- 3/ Before transport by pump or conveyor, a minimum of 20 percent of total tests required of the Contractor will be performed per mix design and per plant. After transport by pump

or conveyor, a minimum of 20 percent of total tests required of the Contractor will be performed per mix design and per plant.

SCHEDULE D

CONCRETE QUALITY CONTROL AND QUALITY ASSURANCE DOCUMENTS

- (a) Model Quality Control Plan for Concrete Production (*)
- (b) Qualifications and Duties of Concrete Quality Control Personnel (*)
- (c) Development of Gradation Bands on Incoming Aggregate at Mix Plants (*)
- (d) Required Sampling and Testing Equipment for Concrete (*)
- (e) Method for Obtaining Random Samples for Concrete (*)
- (f) Calibration of Concrete Testing Equipment (BMPR PCCQ01 through BMPR PCCQ09) (*)
- (g) Water/Cement Ratio Worksheet (BMPR PCCW01) (*)
- (h) Field/Lab Gradations (MI 504M) (*)
- (i) Concrete Air, Slump and Quantity (BMPR MI654) (*)
- (j) P.C. Concrete Strengths (BMPR MI655) (*)
- (k) Aggregate Technician Course or Mixture Aggregate Technician Course (*)
- (l) Portland Cement Concrete Tester Course (*)
- (m) Portland Cement Concrete Level I Technician Course - Manual of Instructions for Concrete Testing (*)
- (n) Portland Cement Concrete Level II Technician Course - Manual of Instructions for Concrete Proportioning (*)
- (o) Portland Cement Concrete Level III Technician Course - Manual of Instructions for Design of Concrete Mixtures (*)
- (p) Manual of Test Procedures for Materials

* Refer to Appendix C of the Manual of Test Procedures for Materials for more information."

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Appendix B

ILLINOIS DEPARTMENT OF TRANSPORTATION

QUALIFICATIONS AND DUTIES OF CONCRETE QUALITY CONTROL PERSONNEL

Effective: December 1, 1993

Revised: June 1, 2012

This document summarizes the qualifications and duties of quality control personnel for Portland Cement Concrete (PCC) mixtures, Cement Aggregate Mixture II (CAM II), and Controlled Low-Strength Material (CLSM). Duties shall be performed daily, or as required, according to the QC/QA specifications and related documents.

QUALITY CONTROL MANAGER: An individual who has the experience, responsibility, and authority to make decisions regarding quality control of Portland Cement Concrete, Cement Aggregate Mixture II, and Controlled Low-Strength Material. This individual is required to have successfully completed the Department's Portland Cement Concrete Level I Technician Course, the Portland Cement Concrete Level II Technician Course, and either the 3-day Mixture Aggregate Technician Course or 5-day Aggregate Technician Course.

- Duties:**
1. Understand the specifications and related documents regarding QC/QA. Read the Quality Control Plan and any amendments to the Plan.
 2. Manage overall project quality control.
 3. Ensure the laboratory, concrete plant, and delivery trucks are approved by the Engineer.
 4. Ensure the test equipment is maintained and calibrated as required by the appropriate test procedure.
 5. Ensure the mixture meets the requirements of the specifications.
 6. Ensure good communication between the plant and jobsite to quickly resolve quality control problems. Failure to resolve quality control problems shall result in mixture production suspension.
 7. Ensure the Engineer is notified of any material supply problems.
 8. Ensure the Engineer is immediately notified of any failing tests and subsequent remedial action. Ensure passing tests are reported no later than the start of the next work day. Consult with the Engineer when questions arise concerning acceptance or rejection of materials.
 9. Ensure all observations, inspections, adjustments to the mix design, test results, retest results, and corrective actions are documented promptly, and in the specified format. Ensure form MI 504M, form MI 654, and form MI 655 are submitted to the Engineer weekly, or as required by the Engineer.
 10. Supervise the Level III PCC Technician, Level II PCC Technician, Level I PCC Technician, Concrete Tester, Gradation Technician, Mixture Aggregate Technician, and Aggregate Technician.

11. Ensure sufficient personnel are provided to perform the required inspections, sampling, testing, and documentation. Ensure work is accurate and done in a timely manner.

LEVEL III PCC TECHNICIAN: An individual who has successfully completed the Department's Portland Cement Concrete Level I Technician Course, the Portland Cement Concrete Level II Technician Course, the Portland Cement Concrete Level III Technician Course, and either the 3-day Mixture Aggregate Technician Course or 5-day Aggregate Technician Course.

- Duties:
1. Understand the specifications and related documents regarding QC/QA. Read the Quality Control Plan and any amendments to the Plan.
 2. Read contract special provision(s) for project specific mix design information.
 3. Obtain component materials' specific gravities and absorptions (aggregates).
 4. Ensure coarse aggregate voids tests are performed when necessary to calculate mix design batch weights (mass). NOTE: The Level III PCC Technician may train anyone to sample and test coarse aggregate voids, provided the individual is monitored on a daily basis by the Level III PCC Technician. This is not applicable to aggregate sampling and testing for gradation, or to any other type of test.
 5. Determine the correct proportions of aggregates, cement, finely divided minerals, water, admixtures, and fiber reinforcement per cubic yard (meter).
 6. Evaluate results when a trial mixture is performed.
 7. Supervise a trial batch when requested by the Engineer.
 8. Ensure the mix design is verified by the Engineer.
 9. Ensure the mix design meets specification requirements during construction. If not, take appropriate action and re-submit to the Engineer.

LEVEL II PCC TECHNICIAN: An individual who has successfully completed the Department's Portland Cement Concrete Level I Technician Course, the Portland Cement Concrete Level II Technician Course, and either the 3-day Mixture Aggregate Technician Course or 5-day Aggregate Technician Course.

- Duties:
1. See Level I PCC Technician duties.
 2. Check the operation of the concrete plant and condition of the delivery trucks.
 3. Ensure only materials approved by the Department are used.
 4. Obtain and split aggregate samples.

5. Perform gradation test for coarse and fine aggregates. If test results are near specification limits or unsatisfactory, take appropriate action and retest when applicable.
6. Perform aggregate moisture tests to adjust mix design aggregate batch weights (mass). NOTE: The Level II PCC Technician may train anyone to sample and test aggregate for moisture, provided the individual is monitored on a daily basis by the Level II PCC Technician. This is not applicable to aggregate sampling and testing for gradation, or to any other type of test.
7. Verify the specified mix design is used, and the correct proportions of aggregates, cement, finely divided minerals, water, admixtures, and fiber reinforcement are batched.
8. Control water/cement ratio by determining the allowable quantity of water which can be added at the jobsite.
9. Maintain communications with jobsite personnel to control the mixture, for compliance with the specifications.
10. Supervise the Gradation Technician, or assign the task to the Mixture Aggregate Technician or Aggregate Technician.

LEVEL I PCC TECHNICIAN: An individual who has successfully completed the Department's Portland Cement Concrete Level I Technician Course.

- Duties:**
1. Understand the specifications and related documents regarding QC/QA. Read the Quality Control Plan and any amendments to the Plan.
 2. Maintain and calibrate test equipment as required by the appropriate test procedure.
 3. Sample the mixture.
 4. Perform temperature, slump, slump flow (self-consolidating concrete (SCC)), flow (CLSM), J-Ring (SCC), L-Box (SCC), hardened visual stability index (SCC), measured stability index (SCC), dynamic segregation index (SCC), and air content tests and compare with specifications. If test results are unsatisfactory or near specification limits, take appropriate action and retest when applicable.
 5. Perform unit weight test and determine yield.
 6. Make strength and static segregation (SCC) specimens. Transport strength specimens properly and ensure correct curing. Break strength specimens. NOTE: If an individual has the responsibility of breaking strength specimens only, such as at a consultant's laboratory, this individual is required to have the Level I PCC Technician training or the Concrete Strength Testing Technician certification by the American Concrete Institute (ACI).
 7. Monitor truck revolutions and haul time.

8. Determine the required quantity of water and admixtures for adjusting the mixture, to meet specifications and field conditions.
9. Observe the discharge of a mixture by the delivery truck, and take appropriate action if a problem is identified.
10. For a mixture which is not mixed on the jobsite, ensure the required information is recorded on the delivery truck ticket.
11. Document all observations, inspections, adjustments to the mix design, test results, retest results, and corrective actions promptly, and in the specified format.
12. Maintain communications with plant personnel to control the mixture, for compliance with the specifications.
13. Notify the Engineer of test results.
14. Report test results to the Quality Control Manager.
15. Supervise the Concrete Tester.

CONCRETE TESTER: An individual who has successfully completed the Department's Portland Cement Concrete Tester Course. The Concrete Tester shall be monitored on a daily basis by the Level I or the Level II PCC Technician when performing tests.

- Duties:**
1. Sample the mixture.
 2. Perform temperature, slump, slump flow (self-consolidating concrete (SCC)), flow (CLSM), J-Ring (SCC), L-Box (SCC), hardened visual stability index (SCC), measured stability index (SCC), dynamic segregation index (SCC), air content and unit weight tests.
 3. Make strength and static segregation (SCC) specimens.
 4. Monitor truck revolutions and haul time.
 5. Observe the mixture and notify the Level I or Level II PCC Technician of any problems.
 6. Assist the Level I or Level II PCC Technician with adjustments to a mixture, by adding water or an admixture.
 7. For a mixture which is not mixed on the jobsite, ensure the required information is recorded on the delivery ticket.
 8. Document all observations, inspections, adjustments to the mix design, test results, retest results, and corrective actions promptly, and in the specified format.

9. Report truck revolutions, haul time, and test results to the Level I or Level II PCC Technician. Immediate notification is required if truck revolutions, haul time, or test results are near specification limits or unsatisfactory.

GRADATION TECHNICIAN: An individual who has successfully completed the Department's Aggregate Gradation Testing Course and has demonstrated satisfactory field performance. The Gradation Technician shall be monitored on a daily basis by the Level II PCC Technician when performing tests. The Level II PCC Technician may have the Mixture Aggregate Technician, or Aggregate Technician responsible for supervising the Gradation Technician on a daily basis.

- Duties:**
1. Split aggregate samples provided by others.
 2. Perform gradation test for coarse and fine aggregates.
 3. Document test results.
 4. Report test results to Level II PCC Technician. Immediate notification is required if test results are near specification limits or unsatisfactory.

MIXTURE AGGREGATE TECHNICIAN: An individual who has successfully completed the Department's 3-day Aggregate Training Course.

- Duties:**
1. Obtain and split aggregate samples.
 2. Perform gradation test for coarse and fine aggregates.
 3. Document test results.
 4. Report test results to Level II PCC Technician. Immediate notification is required if test results are near specification limits or unsatisfactory.
 5. Supervise the Gradation Technician, when required by the Level II PCC Technician.

NOTE: The duties listed are for assisting the Level II PCC Technician, and are not to be confused with the "Aggregate Gradation Control System" program.

AGGREGATE TECHNICIAN: An individual who has successfully completed the Department's 5-day Aggregate Training Course.

- Duties:
1. Obtain and split aggregate samples.
 2. Perform gradation test for coarse and fine aggregates.
 3. Document test results.
 4. Report test results to Level II PCC Technician. Immediate notification is required if test results are near specification limits or unsatisfactory.
 5. Supervise the Gradation Technician, when required by the Level II PCC Technician.

NOTE: The duties listed are for assisting the Level II PCC Technician, and are not to be confused with the "Aggregate Gradation Control System" program.

Appendix C

State of Illinois
Department of Transportation
Bureau of Materials and Physical Research
Springfield

POLICY MEMORANDUM

Revised: January 1, 2012

16-08.1

This Policy Memorandum supersedes number 16-08.0 dated January 1, 2008

TO: REGIONAL ENGINEERS AND HIGHWAY BUREAU CHIEFS

SUBJECT: APPROVAL OF CONCRETE PLANTS AND DELIVERY TRUCKS

DEFINITIONS

Bureau - Bureau of Materials and Physical Research, 126 E. Ash Street, Springfield, IL 62704-4766.

Commercial Concrete Producer - A company engaged in the production of concrete.

Contractor - The individual, firm, partnership, joint venture, or corporation contracting with Department for performance of prescribed work.

Department - Illinois Department of Transportation

District - One of nine Illinois Department of Transportation highway districts located throughout the State of Illinois.

1.0 PURPOSE

1.1 To establish a uniform procedure, for all Districts, to approve a concrete plant [Article 1103.02 of the *Standard Specifications for Road and Bridge Construction* (January 1, 2012)] and delivery trucks before production begins.

To ensure the concrete plant and delivery trucks are maintained according to Department specifications, with minimal District inspection.

To establish a concrete plant equipment database.

2.0 APPLICATION FOR APPROVAL

2.1 To obtain approval for a concrete plant the Contractor or Commercial Concrete Producer shall provide the following:

- A completed "Concrete Plant Survey" on form BMPR PCC001 (<http://www.dot.il.gov/materials/materialforms.html>). The form is submitted once every five years, unless the plant equipment is changed, or equipment is added to the plant.

- A completed "Inspection Certification for Concrete Plant" on form BMPR PCC002 (<http://www.dot.il.gov/materials/materialsforms.html>). The form is submitted annually, for the period which begins April 1st, and which expires the following year on March 31st.
- 2.2 To obtain approval for concrete delivery trucks, the Contractor or Commercial Concrete Producer shall provide the following:
- A completed "Inspection Certification for Concrete Delivery Trucks" on form BMPR PCC003 [http://www.dot.il.gov/materialforms.html](http://www.dot.il.gov/materials/materialforms.html)). The form is submitted annually, for the period which begins April 1st, and which expires the following year on March 31st.
- 2.3 The Contractor or Commercial Concrete Producer shall submit the forms to the District in which the concrete plant or delivery trucks are located, or the nearest District if the concrete plants or trucks are located out of state. If the Contractor or Commercial Concrete Producer is supplying material only to a precast producer under the inspection of the Bureau, the forms shall be submitted to the Bureau.

3.0 DEPARTMENT APPROVAL

Prior to approval, the District will review the completed forms, observe the calibration of the plant scales, inspect the concrete plant, and inspect the delivery trucks. The extent of the plant and truck equipment inspection will be determined by the District.

Upon approval, the Contractor or Commercial Concrete Producer will be notified in writing by the District.

4.0 RENEWAL OF APPROVAL

- 4.1 The Contractor or Commercial Concrete Producer shall resubmit the forms as indicated in **Section 2.0**. Re-approval will be according to **Section 3.0**.



David L. Lippert, P.E.
Engineer of Materials
and Physical Research

Attachments

DAD/dkt



Illinois Department of Transportation

Concrete Plant Survey

Instructions: **Please type or print neatly.** Fill in the blanks or mark the item with an "X". The "Concrete Plant Survey" is submitted once every five years, unless the plant equipment is changed, or equipment is added to the plant.

Producer No: _____ Plant Name: _____ Permanent Portable
 Company Address: _____ Phone No.: _____
 Plant Address: _____ Phone No.: _____
 (Indicate "Various" if Portable Plant or "same" if plant shares company address.)

Plant Manufacturer: _____ Model # _____ Serial # _____
 Indicate Plant Type Below:
 Wet Batch Plant (Stationary / Central-Mixed):
 Mixer Capacity: (Cubic Meters) _____ (Cubic Yards) _____ * Type _____
 Mixer Capacity: (Cubic Meters) _____ (Cubic Yards) _____ * Type _____
 * Indicate: Non-Tilting; Tilting; Vertical Shaft; or Horizontal Shaft
 Dry Batch Plant: (Truck / Transit-Mixed):
 Capacity as Determined by the Weigh Hopper: (Cubic Meters) _____ (Cubic Yards) _____
 Capacity as Determined by the Weigh Hopper: (Cubic Meters) _____ (Cubic Yards) _____

Slurry Mixer Type: Vortex Paddle None

Batching System Manufacturer: _____
 Batching System Type:
 Automatic** Semi-Automatic** Manual**
 ** Reference: Article 1103.03 of Standard Specifications for Road and Bridge Construction (January 1, 2012)
 Automatic Actuation: Computer Punch Card Step Switch

*** Material(s)	Scale Capacity For Weighing (Do not consider Weigh Hopper) (kg / lbs)	Scale Graduation Interval (kg / lbs)	Scale Graduation Interval (Percent of Scale Capacity)	**** Scale Type
_____	_____ / _____	_____ / _____	_____	_____
_____	_____ / _____	_____ / _____	_____	_____
_____	_____ / _____	_____ / _____	_____	_____
_____	_____ / _____	_____ / _____	_____	_____
_____	_____ / _____	_____ / _____	_____	_____

*** Indicate the materials(s) weighed by each scale. This should include Fine Aggregate, Coarse Aggregate, Cement, Finely Divided Minerals, Water, and Admixtures.
 **** Indicate: Beam; Dial; or Load Cell
 Weighing of Aggregates in Weigh Hopper: Individually Cumulatively
 Weighing of Cement and Cementitious Materials in Weight Hopper: Individually Cumulatively

Number of Silos: Cement: _____ Fly Ash: _____ GGBF Slag: _____ Microsilica: _____
 Number of Aggregate Bins: Outside: _____ Inside or Partially Enclosed: _____



Annual Inspection Certification for Concrete Plant

Instructions: **Please type or print neatly.** Fill in the blanks or mark the item with an "X". The "Annual Inspection Certification for Concrete Plant" is submitted for the period which begins April 1st, and which expires the following year on March 31st.

Specifications:

The specifications for a concrete plant, as per the Standard Specifications for Road and Bridge Construction (January 1, 2012) and the Portland Cement Concrete (BDE) Special Provision are as follows:

Article 106.04

Article 106.06

Article 106.07

Article 1020.10

Article 1020.11

Section 1103

Applicant:

Company Name: _____

Company Address: _____

Company Phone Number: _____

Name & Title of Officer/Director of Company: _____

Plant Name: _____

Plant Location: _____

Inspection:

Name of Individual: _____

Company Name: _____

Company Address: _____

Company Phone Number: _____

NOTE: The inspection is normally performed by an employee of the applicant. However, an applicant may also desire plant certification by the National Ready Mixed Concrete Association (NRMCA). In this situation, the registered professional engineer hired by the applicant to do the NRMCA plant certification, may also perform the inspection required by IDOT.

If an individual from a scale company calibrates the plant scales only, it is not appropriate to indicate that this individual inspected the plant.

Certification:

I _____ , certify the concrete plant indicated has been
(Signature of Individual – Inspection)
inspected on _____ , and is according to specifications.
(Date)

I _____ , certify on _____ , the concrete plant
(Signature of Officer/Director – Applicant) (Date)
will be maintained according to specifications, and designate _____
(Print Name of Designee)
to be contacted at _____ if a problem occurs.
(Phone Number)

Additional Information:

A “Concrete Plant Survey” form is required and attached: Yes No

The plant scales were calibrated on _____ .
(Date)

_____ (Print Name)	of District _____ (Number)	inspected the concrete plant on _____ . (Date)
Approved By: _____ of District _____ on _____ . (Print Name) (Number) (Date)		
_____ (Signature)		
The time period is from _____ to _____ . (Month/Day/Year) (Month/Day/Year)		
(FOR DEPARTMENT USE ONLY)		



Annual Inspection Certification for Concrete Delivery Trucks

Instructions: Please type or print neatly. Fill in the blanks or mark the item with an "X". The "Annual Inspection Certification for Concrete Delivery Trucks" is submitted for the period which begins April 1st, and which expires the following year on March 31st.

Specifications:

The specifications for a concrete plant, as per the Standard Specifications for Road and Bridge Construction (January 1, 2012) and the Portland Cement Concrete (BDE) Special Provision are as follows:

- Truck Mixers:
Article 1020.11(a)(1)
Article 1020.11(a)(2)
Article 1020.11(a)(3)
Article 1020.11(a)(5)
Article 1020.11(a)(6)
Article 1103.01(b)

- Truck Agitators
Article 1020.11(a)(1)
Article 1020.11(a)(5)
Article 1020.11(a)(6)
Article 1103.01(c)

- Nonagitator Truck
Article 1103.01(d)

Applicant:

Company Name:
Company Address:
Company Phone Number:
Name & Title of Officer/Director of Company:

Inspection:

Name of Individual:
Company Name:
Company Address:
Company Phone Number:

NOTE: The inspection is normally performed by an employee of the applicant. However, an applicant may also desire plant certification by the National Ready Mixed Concrete Association (NRMCA). In this situation, the registered professional engineer hired by the applicant to do the NRMCA plant certification, may also perform the inspection required by IDOT.

Certification:

I _____ , certify the following concrete delivery trucks
(Signature of Individual – Inspection)
have been inspected on _____ , and are according to specifications.
(Date)

I _____ , certify on _____ .
(Signature of Officer/Director – Applicant) (Date)
the following concrete delivery trucks will be maintained according to specifications, and designate
_____ to be contacted at _____ if a problems occurs.
(Print Name of Designee) (Phone Number)

List of Concrete Delivery Trucks:

Truck No. or Designation of Acceptable Truck Mixers:

Truck No. or Designation of Acceptable Truck Agitators:

Truck No. or Designation of Acceptable Nonagitator Trucks:

(Print Name) of District _____ (Number) inspected the concrete delivery trucks listed above
on _____ (Date)
Approved By: _____ of District _____ on _____ .
(Print Name) (Number) (Date)

(Signature)
The time period is from _____ to _____ .
(Month/Day/Year) (Month/Day/Year)
(FOR DEPARTMENT USE ONLY)

State of Illinois
Department of Transportation
Bureau of Materials and Physical Research

POLICY MEMORANDUM

Revised: January 1, 2008

6-08.0

This Policy Memorandum supersedes number 07-19 dated January 1, 2007

TO: REGIONAL ENGINEERS AND HIGHWAY BUREAU CHIEFS
AGGREGATE, HOT-MIX ASPHALT (HMA), AND
PORTLAND CEMENT CONCRETE (PCC) PRODUCERS

SUBJECT: MINIMUM PRIVATE LABORATORY REQUIREMENTS FOR
CONSTRUCTION MATERIALS TESTING OR MIX DESIGN

1.0 DEFINITIONS

AASHTO R 18 - The American Association of State Highway and Transportation Officials (AASHTO) Standard for "Establishing and Implementing a Quality System for Construction Materials Laboratories." The principles of AASHTO R 18 are used by the Bureau of Materials and Physical Research (BMPR) to administer the qualified laboratory program for **District** and **Private Laboratories**.

ACCREDITED LAB – A laboratory that is currently accredited by the AASHTO Accreditation Program (AAP) or other accrediting body recognized by FHWA.

BMPR LABORATORY - The Department's central laboratory maintained and operated by the Bureau of Materials and Physical Research (BMPR). The BMPR Laboratory administers the qualified laboratory program for **District** and **Private Laboratories**.

CONSULTANT - A Private firm which performs construction materials testing for the **Department**, **Producer**, or **Contractor**. **Department** prequalification and AASHTO accreditation requirements apply where **Department** construction testing is performed directly for the **Department** under a **Department** contract or subcontract.

CONTRACTOR - The individual, firm, partnership, joint venture, or corporation contracting with the **Department** for performance of prescribed work.

DEPARTMENT – Illinois Department of Transportation (IDOT), including its Districts and Central Bureau offices.

DISTRICT LABORATORY - A **Department** laboratory that is operated by a District.

FIELD TESTS – Tests that may be performed outside of a laboratory, for example, a portland cement concrete (PCC) or hot-mix asphalt (HMA) test performed at the jobsite.

HMA MIX DESIGN LABORATORY – Any **Private Laboratory** that has a **Department** approved HMA mix design lab. Consultants that are prequalified with the **Department** for HMA Mix Design must be capable of performing the tests listed in Table 1 under HMA Design.

PRIVATE LABORATORY - Any construction materials testing or design laboratory not operated by the **Department**. This includes **Contractor, Producer, or Consultant** laboratories performing Quality Control (QC), Quality Assurance (QA), acceptance, independent assurance, or any other required or contracted testing on a **Department** project.

PRODUCER - An individual or business entity providing materials for performance of prescribed work.

QUALIFIED LABORATORIES – Laboratories that are inspected and approved by the **Department**. FHWA's Construction regulations (23 CFR 637.203) define these as *Laboratories that are capable as defined by appropriate programs established by each state transportation department. As a minimum, the qualification program shall include provisions for checking test equipment, and the laboratory shall keep records of calibration checks.*

QUALIFIED PERSONNEL - Personnel with demonstrated and documented capability to perform the applicable inspection and testing. The minimum requirement for aggregate, hot-mix asphalt (HMA), or Portland cement concrete (PCC) testing is successful completion of the prescribed **Department** Quality Control/Quality Assurance (QC/QA) Trained Technician classes. (Note: Additional personnel or experience requirements may apply to labs performing professional service work for the **Department**, e.g. Professional Engineer (P.E.) registrations, resumes, documented experience. When required, such notice will be provided in the prequalification process or solicitation notice.)

QUALITY ASSURANCE TESTING CONSULTANT – A Professional Engineering firm that is prequalified by the **Department** to perform field and/or laboratory tests for the **Department**. Required tests for quality assurance testing consultants are listed in Table 2.

QUALITY ASSURANCE LABORATORY - Any laboratory used for Quality Assurance (QA) testing (**Department** tests) required by the **Department**. Required tests for quality assurance laboratories are listed in Table 2.

QUALITY CONTROL LABORATORY - Any laboratory used for Quality Control (QC) testing (**Contractor** or **Producer** tests) required by the **Department**. Required tests for quality control laboratories are listed in Table 1.

QUALITY CONTROL (QC) MANAGER – An employee (or **Consultant**) of a **Contractor** or **Producer** who is responsible for compliance with the QC/QA requirements in a **Department** contract or policy.

TECHNICAL MANAGER - The individual with responsibility for the overall operations, condition, and maintenance of the **Private Laboratory**. The Technical Manager shall be identified in writing. The Technical Manager is not required to be the **QC Manager** defined in the contract. However, the Technical Manager shall be familiar with the Quality Control (QC) testing requirements and the specified equipment.

2.0 SCOPE

This policy governs the minimum qualifications for materials **Quality Control** and **Quality Assurance Laboratories** operated by **Contractors**, **Producers** and **Consultants**. It applies to aggregate, hot-mix asphalt (HMA) and Portland cement concrete (PCC) testing laboratories.

3.0 PURPOSE

- To ensure that **Private Laboratories** are equipped and maintained at a uniform and high level of quality.
- To establish a uniform procedure for evaluating and approving **Private Laboratories**.
- To maintain a uniform standard for inspecting test equipment and test procedures.

4.0 AUTHORITY

Federal regulations (23 CFR Part 637) require the **Department** to establish a program for "qualifying" construction laboratories involved in tests which are used for acceptance. Under the **Department's** QC/QA specifications, **Contractor/Producer** test results are used in the acceptance process

5.0 REFERENCE DOCUMENTS

- IDOT *Standard Specifications for Road and Bridge Construction*.
- IDOT *Manual of Test Procedures for Materials*.
- IDOT QC/QA Specifications for Hot-Mix Asphalt and Portland Cement Concrete.
- AASHTO, ASTM, and IDOT Test Procedures.
- Code of Federal Regulations (23 CFR Part 637).
- **Department** Policy MAT-15, "Quality Assurance Procedures for Construction."

6.0 PRIVATE LABORATORY REQUIREMENTS

6.1 Personnel Qualifications/Responsibilities

6.1.1 All testing for **Department** contracts shall be performed by **Qualified Personnel** as specified in the contract.

6.1.2 The **Department** will maintain a computer database of **Qualified Personnel** who have successfully passed the appropriate QC/QA classes.

6.2 **Facilities and Equipment**

6.2.1 The **Department** shall approve all **Private Laboratories** used on **Department** projects.

6.2.2 Each **Private Laboratory** shall maintain the equipment and facilities necessary to perform the tests as appropriate for the product to be tested. A list of required **Private Laboratory** tests is provided in Tables 1 and 2.

6.2.3 Each **Private Laboratory** shall have adequate floor space to efficiently conduct required tests. Suggested minimum floor space is provided under "Model Quality Control Plans" in the Manual of Test Procedures for Materials.

6.2.4 Each **Private Laboratory** shall have HVAC equipment capable of maintaining a room temperature of 20 to 30° C (68-86° F). A **Private Laboratory** that performs only aggregate gradation and/or aggregate moisture testing is exempt from this requirement.

6.2.5 All equipment shall be as specified in the current Manual of Test Procedures for Materials.

7.0 **QUALITY SYSTEM CRITERIA**

7.1 **AASHTO R 18**

Each **Private Laboratory** shall establish and implement a quality system which meets the criteria from **AASHTO R 18**. Accredited Laboratories shall comply with all of **AASHTO R 18** for AMRL, and ASTM C 1077 for CCRL.

7.2 **Technical Manager**

Each **Private Laboratory** shall have a **Technical Manager** (however titled) who has overall responsibility for the technical operations of the **Private Laboratory**. The **Technical Manager** shall be responsible for equipment maintenance and calibration, maintaining records, and ensuring that current test procedures are utilized. If the **Private Laboratory** is prequalified in a Professional **Consultant** service category, a licensed Illinois Professional Engineer shall have direct supervision of the laboratory.

7.3 **Equipment Calibration and Verification**

The **Private Laboratory** shall calibrate or verify all testing equipment associated with tests performed by the **Private Laboratory**. Table 3 includes a maximum interval for calibrating most laboratory equipment. Heavy use or specific test requirements may justify more frequent checks.

7.4 **Proficiency Testing**

Private Laboratory qualifications may include round-robin proficiency testing conducted by the **Department**. Results of proficiency testing may be considered in the overall evaluation of the **Private Laboratory** to conduct specific tests.

7.5 Records

7.5.1 Test Records – Each **Private Laboratory** shall maintain test records which contain sufficient information to permit verification of any test report.

7.5.2 Records Retention - Each **Private Laboratory** shall maintain documentation of the internal quality controls. At a minimum, the records shall include:

- Documentation of assignment of personnel responsible for internal quality controls.
- Documentation of equipment calibration.
- Logs of sample pick-up shall be maintained for a minimum period of three years.
- All documentation shall be maintained and available to **Department** inspection for a period of three years.

7.5.3 Equipment Calibration and Verification Records - Calibration records shall include the minimum information listed below. **AASHTO R 18** and ASTM Standard C 1077 provide additional guidance for calibration of most testing equipment.

1. Description
2. Model & Serial Number
3. Name of person calibrating
4. Calibration equipment used
(e.g., standard weights, proving rings, thermometers)
5. Date calibrated & next due date
6. Reference procedure used
7. Results of calibration / verification

7.5.4 Proficiency Sample Records – Each **Private Laboratory** shall retain results of participation in any proficiency sample program, including the documentation of steps taken to determine the cause of poor results and corrective action taken.

7.6 Publications

Each **Approved Private Laboratory** shall maintain current copies of all test procedures performed. This requirement shall include a current copy of the Manual of Test Procedures for Materials.

8.0 LABORATORY INSPECTIONS

8.1 General

The **Department** will approve **Private Laboratories** by inspection.

- **AGGREGATE LABORATORIES** - Initial inspections and re-inspections will be performed by the District.
- **OTHER LABORATORIES** - Initial inspections are performed by the **Bureau of Materials and Physical Research**. Re-inspections are performed by the District.

8.2 AASHTO Accredited Private Laboratories

8.2.1 Current AASHTO accreditation of the **private** laboratory is a prerequisite for **Consultant** prequalification as a **Quality Assurance Testing Consultant**. Conditions for prequalification may be found in the prequalification instructions and forms.

AASHTO accreditation does not waive the right of the **Department** to conduct inspections and/or re-inspections.

8.3 Initial Inspection

- Facilities - Physical and environmental conditions.
- Equipment - Test apparatus for specification compliance.
- Documentation - Calibration and verification records.
- Personnel - A review of qualified personnel credentials.
- Observation - The **Private Laboratory** may be required to demonstrate **Required Tests**. Some test procedures, such as field tests, may be evaluated through discussion with laboratory personnel.
- Report - The **Private Laboratory** will be provided with a report listing those tests for which it is approved. The report will note deficiencies.

8.4 Initial HMA and PCC Laboratory Inspections

8.4.1 The **Private Laboratory** shall submit a written request for an inspection to the District. The request shall indicate the following:

- The location of the **Private Laboratory**.
- The type of **Private Laboratory**, i.e., aggregate, HMA, or PCC.
- The name of the **Technical Manager**, who will be present for the inspection.
- The date the **Private Laboratory** will be ready for inspection.

8.4.2 The District will notify the **BMPR Laboratory** of the inspection request. **BMPR** personnel will establish a tentative date to perform the inspection.

8.4.3 The District will perform a brief visual inspection approximately seven calendar days before the **BMPR** inspection. The District will verify that the **Private Laboratory** is ready for inspection and notify the **BMPR Laboratory**.

8.4.4 **BMPR** personnel will perform the inspection and prepare a preliminary report. Standard inspection forms and a preliminary report, developed and maintained by the **BMPR Laboratory**, will be used.

8.4.5 **BMPR** personnel will assign identification numbers to all test equipment. Unless a District has an established numbering system, the following sequences will be used.

Sieves

e.g., IL07 -1418-01

where: IL = State

07 = inspection year

1418-01 = Producer/Supplier Number

Sieves are engraved on the inside of the bottom lip directly beneath the label.

HMA Equipment

e.g., IL07B1 - 123

where: IL = State

07 = inspection year

B = hot mix asphalt (bituminous)

1 = district number

123 = sequential numbers

PCC Equipment

e.g., IL07C1 - 123

where: IL = State

07 = inspection year

C = concrete

1 = district number

123 = sequential numbers

*The numbering system prior to 2007 was IL07-123 for HMA and IL07CND1-123 for PCC. The change was made to make the numbering system more uniform.

- 8.4.6** **BMPR** personnel will perform a close-out with the **Technical Manager** and the District representative. The **Technical Manager** and the District will be given a copy of the preliminary report.
- 8.4.7** If a review of the preliminary report indicates there are no deficiencies, **BMPR** will provide written notification to the **Private Laboratory** indicating the **Private Laboratory** is now an approved private laboratory. The notification will include an equipment list. A copy of the notification will be provided to the District.
- 8.4.8** If the preliminary report indicates there are deficiencies, **BMPR** will provide written notification to the **Private Laboratory**, indicating the deficiencies and that corrective action is required. A copy of the written notification will be provided to the District.
- 8.4.9** After correction of all cited deficiencies, the **Private Laboratory** shall notify the District. The District will inspect the **Private Laboratory** to verify the deficiencies have been corrected and will notify **BMPR** in writing.
- 8.4.10** **BMPR** will provide written notification to the **Private Laboratory**, indicating the private laboratory is now an approved private laboratory. The notification will include an equipment list. A copy of the written notification will be provided to the District.
- 8.4.11** Uncorrected deficiencies will not be waived. Equivalent equipment specifications may be approved only with the written approval of **BMPR's** Engineer of Tests.

8.5 Initial Aggregate Laboratory Inspection

For an aggregate **Private Laboratory**, the procedures outlined in 8.4 shall be followed, except District personnel will perform the inspection instead of personnel from **BMPR**.

8.6 Re-Approval of Approved Private Laboratories

8.6.1 The re-inspection of **Private Laboratories** shall be conducted at intervals deemed appropriate by the District. The interval between inspections shall not exceed two calendar years. The District's evaluation may include the following:

- Physical inspection of the laboratory facility and equipment.
- Review of the **Private Laboratory's** internal quality plan and documentation in accordance with this policy and those parts of **AASHTO R 18** incorporated by this policy.
- Observations of tests performed by qualified personnel.
- Results of split sample testing between the **Private Laboratory** and the District.
- Results of proficiency sample testing programs conducted by the **Department**.
- Overall past performance and experience.

8.6.2 The District may not waive any requirements for **Private Laboratories** or test equipment for **Required Tests**.

8.6.3 The District shall issue a letter of re-approval to the **Private Laboratory**, or provide a written and itemized deficiency list. The **Private Laboratory** shall notify the District when deficiencies are corrected and ready for re-inspection.

8.6.4 At any time, if the District identifies deficiencies in the facility, equipment, or test procedures that could affect the results of any QC or QA tests, the District will require the **Private Laboratory** to take immediate action to correct the deficiency.

9.0 Exemptions – AMRL

If a **Private Laboratory** maintains current accreditation from AMRL for the appropriate test procedures, the District may waive the re-inspection requirements of this policy. To enact the waiver, the **Private Laboratory** must provide copies of inspection reports and proficiency sample results to the District. This waiver does not apply to the initial inspection requirements, including the required equipment list.

10.0 LABORATORY DATABASE

The **Department** will maintain a computer database to monitor the approval status of **Private Laboratories**. The database will include the following information:

- Laboratory Codes (Department, Producer, etc.)
- Responsible District
- Type Laboratory (Aggregate, HMA, PCC, Other)
- Demographics (Address, etc.)
- Date Inspected
- Approval Status



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Engineer of Materials
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Attachments

DAD/rm

AGGREGATE TESTS	PROCEDURE		PRIVATE LAB TYPE				DESCRIPTION
	AASHTO (Illinois Modified)	ASTM	AGG	HMA QC	HMA DESIGN	PCC QC	
	T 2 (IL)		√	√	√	√	Sampling of Aggregates
	T 11 (IL)		√	√	√	√	Materials Finer Than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing
	T 19 (IL)		√ ¹			√	Unit Weight and Voids in Aggregate
	T 27 (IL)		√	√	√	√	Sieve Analysis of Fine and Coarse Aggregates
	T 84 (IL)		√ ²				Specific Gravity and Absorption of Fine Aggregate
	T 85 (IL)		√ ²				Specific Gravity and Absorption of Coarse Aggregate
T 248 (IL)		√	√	√	√	Reducing Field Samples of Aggregate to Testing Size	
T 255 (IL)		√	√	√	√	Total Moisture Content of Aggregate by Drying	

Note 1: Required for laboratories that test Air Cooled Blast Furnace Slag.

Note 2: Required for laboratories that run the Department's Slag Producers' Self-Testing Program.

HOT-MIX ASPHALT TESTS

PROCEDURE		PRIVATE LAB TYPE				DESCRIPTION
AASHTO (Illinois Modified)	ASTM	AGG	HMA QC	HMA DESIGN	PCC QC	
T 30 (IL)				√		Mechanical Analysis of Extracted Aggregate
T 164 (IL)			√ ¹ Or T287 or T308 ²	√ ¹		Quantitative Extraction of Bitumen from Bituminous Paving Mixtures
T 166 (IL)			√	√		Bulk Specific Gravity of Compacted Bituminous Mixtures Using Saturated Surface-Dry Specimens
T 209 (IL)			√	√		Maximum Specific Gravity of Bituminous Paving Mixtures
T 245 (IL)						Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus
T 283 (IL)				√		Resistance of Compacted Bituminous Mixture to Moisture Induced Damage
T 287 (IL)			√ Or T164 or T 308 ²			Asphalt Content of Bituminous Concrete Mixtures by the Nuclear Method
T 312 (IL)			√	√		Superpave Gyrotory Compaction
T 308 (IL)			√ or T164 or T 287 ²	√		Asphalt Binder Content of Hot-Mix Asphalt by the Ignition Method
_____	D 2950 (IL)		√			Determination of Density of Bituminous Concrete In-Place by Nuclear Method – Field Test; not observed during Lab Inspection

Note 1: Method B shall be used for quantitative extraction. Method A or E shall be used to recover binder for qualitative analysis.

Note 2: Determined by which piece of equipment is more appropriate for the lab to determine asphalt content.

PORTLAND CEMENT CONCRETE TESTS

PROCEDURE		PRIVATE LAB TYPE				DESCRIPTION
AASHTO (Illinois Modified)	ASTM	AGG	HMA QC	HMA DESIGN	PCC QC	
T 22 (IL)					√ ¹ Either T22 or T177.	Compressive Strength of Cylindrical Concrete Specimens
T 23 (IL)					√	Making and Curing Concrete Test Specimens in the Field
T 119 (IL)					√	Slump of Portland Cement Concrete
T 121 (IL)					√	Weight per Cubic Foot, Yield, and Air Content
T 126 (IL)					Required If developing mix designs.	Making and Curing Concrete Test Specimens in the Laboratory
T 141 (IL)					√	Sampling Fresh Concrete
T 152 (IL)					√	Air Content of Freshly Mixed Concrete by the Pressure Method - Type A or B Air Meter
T 177 (IL)					√ ¹ Either T22 or T177.	Flexural Strength of Concrete - Hand Pump or Mechanical Breaker
T 196 (IL)						Air Content of Freshly Mixed Concrete by the Volumetric Method
T 231						Capping Cylindrical Concrete Specimens
T 309 (IL)					√	Temperature of Freshly Mixed PCC
IL Test Procedure 301	—					Fine Aggregate Moisture Content by Flask Method
IL Test Procedure 302	—					Fine or Coarse Aggregate Specific Gravity and Moisture Content by Dunagan Method
IL Test Procedure 303	—					Fine or Coarse Aggregate Moisture Content by Pycnometer Jar Method
IL Test Procedure 306					Required If developing mix designs.	Voids Test of Coarse Aggregate for Concrete Mixtures

Note 1: For an exception to the strength testing requirement of performing compressive or flexural testing (example: labs at Concrete Producer Plants), refer to the Department's "Required Sampling and Testing Equipment for Concrete" document and check with district for approval of exception.

**TABLE 2
REQUIRED TESTS – QUALITY ASSURANCE TESTING CONSULTANTS¹**

	PROCEDURE		REQUIRED FOR PREQUALIFICATION			DESCRIPTION
	AASHTO (Illinois Mod)	ASTM	IDOT QA	AAP On-Site Assessment	AAP Proficiency Assessment	
AGGREGATE	T 2 (IL)		√			Sampling of Aggregates
	T 11 (IL)		√	√	√	75-µm (No. 200) by Washing
	T 19 (IL)		√	√		Unit Weight and Voids in Aggregate
	T 27 (IL)		√	√	√	Sieve Analysis of Fine and Coarse Aggregates
	T 84 (IL) ²		√	√	√	SG and Absorption of Fine Aggregate
	T 85 (IL) ²		√	√	√	SG and Absorption of Coarse Aggregate
	T 248 (IL)		√	√		Reducing Field Samples Size
	T 255 (IL)		√	√		Total Moisture Content
HOT-MIX ASPHALT	T 30 (IL)		√			Mechanical Analysis of Extracted Aggregate
	T 164 (IL)		√	√		Quantitative Extraction
	T 166 (IL)		√	√	√	Bulk Specific Gravity
	T 209 (IL)		√	√	√	Maximum Specific Gravity
	T 245 (IL)					Marshall Stability & Flow
	T 283 (IL)		√	√		Resistance to Moisture Induced Damage
	T 287 (IL)			√ ³		Asphalt Content by the Nuclear Method
	T 312(IL)		√	√	√	Superpave Gyrotory Compaction
	T 308(IL)		√	√	√	Asphalt Binder Content by Ignition
	D 2950 (IL)		√		Nuclear Density– Field Test	

Note 1: QA labs have the option to be HMA/AGG, PCC/AGG, or HMA/PCC/AGG approved

Note 2: Required for laboratories that run the Department's Slag Producers' Self-Testing Program.

Note 3: Requirement determined on case to case basis by district in which lab is located.

TABLE 2 (CON'T)
REQUIRED TESTS – QUALITY ASSURANCE TESTING CONSULTANTS¹

	PROCEDURE		REQUIRED FOR PREQUALIFICATION			DESCRIPTION
	AASHTO (Illinois Mod)	ASTM	IDOT QA	AAP On-Site Assessment	AAP Proficiency Assessment	
CONCRETE	R39 (IL)				√	Making and Curing Test Specimens in the Laboratory
	T 22 (IL)		√	√	√	Compressive Strength of Cylinders
	T 23 (IL)		√	√	√	Making and Curing Test Specimens in the Field
	T 119 (IL)		√	√	√	Slump
	T 121 (IL)		√	√	√	Weight, Yield, and Air Content
	T 141 (IL)		√	√		Sampling Fresh Concrete
	T 152 (IL)		√	√	√	Air Content-Type A or B Pressure Method
	T 177 (IL)		√	√ ²		Flexural Strength of Concrete - Hand Pump or Mechanical Breaker
	T 196 (IL)		3	3	5	Air Content by Volumetric Method
	T 231 (IL)		3	3		Capping Cylinders
	T309 (IL)		√	√		Temperature of Freshly Mixed PCC
	IL Test 301		3			FA Moisture by Flask Method
	IL Test 302		3			FA or CA Aggregate SG and Moisture - Dunagan
	IL Test 303		3			FA or CA Moisture Content by Pycnometer Jar Method
	IL Test 306		4			Void Test of CA for Concrete Mixtures

Note 1: QA labs have the option to be HMA/AGG, PCC/AGG, or HMA/PCC/AGG approved.

Note 2: The AAP on-site assessment is not required for Illinois type portable beam breakers but is required for all other types of beam breakers. Additional Information regarding use of portable PCC labs and their approval is provided In Department Policy MAT-15, "Quality Assurance Procedures for Construction".

Note 3 Test equipment must be presented during an inspection if the consultant lab has the ability to perform the test.

Note 4 Test equipment must be presented during an inspection if consultant lab has the ability to verify PCC mix designs.

Note 5 Test must be performed if consultant lab has the ability to perform the test.

TABLE 3¹
EQUIPMENT CALIBRATION SCHEDULE

EQUIPMENT	REQUIREMENT	MAXIMUM INTERVAL (MONTHS)
Aggregate & General		
Unit Weight Measures	Standardize	12
General Purpose Balances, Scales, Weights	Standardize	12
Mechanical Shakers	Check Sieve Thoroughness	12
Ovens	Standardize Thermometric Device	12
Sieves	Check Physical Condition	6
Thermometers	Calibrate	6
PCC		
Air Meters (Pressure Type)	Standardize During Use	3 (Type B)
	Standardize	12 (Type A)
Air Meters (Volumetric Type)	Standardize	12
Compression & Flexural Testing Machine	Standardize	12
Capping Material	Check Strength	3 or New Shipment
Slump Cones	Check Critical Dimensions	12
Reusable Molds	Check Critical Dimensions	12
Single Use Molds	Check Dimensions	Each Shipment
Moist Room/Storage Tanks Recording Thermometer or Max/Min Thermometer	Standardize	6 Months
HMA		
Gyratory Compactor	Calib. Angle, Pressure, Ht.	1 During use
Base Plates, Ram Face, Molds	Check Critical Dimensions	12
Marshall Hammer	Check Physical Condition	12
	Standardize	36
Ignition Furnace	Standardize	Each mix
Vacuum Pump	Check Pressure	12
Tensile Strength Machine	Standardize	12
Timers	Check Accuracy	6
Molds, Breaking Heads	Check Critical Dimensions	12
Pycnometers	Check Critical Dimensions & Physical Condition	12
Mixers, Bituminous	Check Physical Condition	12
Water Baths	Standardize	8
Extraction Equipment	Check Physical Condition	12

Note 1: See AASHTO R18 for equipment calibration terminology definitions

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Appendix D

State of Illinois
Department of Transportation
Bureau of Materials and Physical Research

POLICY MEMORANDUM

Revised: June 1, 2012

11-08.2

This Policy Memorandum supersedes number 11-08.1 dated January 1, 2011

TO: REGIONAL ENGINEERS AND HIGHWAY BUREAU CHIEFS

SUBJECT: AGGREGATE GRADATION CONTROL SYSTEM (AGCS)

1.0 SCOPE

1.1 This program shall apply to all Sources that supply certified aggregate for uses identified in this program to projects let under the jurisdiction of the Illinois Department of Transportation (includes local agency projects). All aggregate shipped for program-designated uses on these projects shall be from a Certified Source.

2.0 PURPOSE

2.1 To establish a procedure of certification whereby Sources shall supply aggregate for designated use meeting test properties cited by the Bureau.

2.2 To set forth the conditions for Source certification and revocation of certification.

3.0 DEFINITIONS

3.1 **AGCS Technician** - A technician at the Source who has successfully completed the Department's AGCS Technician Course. This individual may perform all duties of the Aggregate Technician under the Gradation Control Program except gradation testing. Gradation testing (including splitting) must be performed by an Aggregate Technician or a Mixture Aggregate Technician. This training course is no longer available.

3.2 **Aggregate Inspector** - District materials inspector who has successfully completed the Department's Aggregate Technician Course and is responsible for inspection at an aggregate Source. A Consultant, hired by the Department to perform the duties of an Aggregate Inspector, shall not be allowed to take any quality or Freeze-Thaw samples at an aggregate source.

3.3 **Aggregate Technician** - Sampling and testing technician at the Source who has successfully completed the Department's Aggregate Technician Course and is responsible for the Gradation Control Program at the Source.

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- 3.4 **Approved Aggregate Source List** - A list maintained by the Department identifying aggregate sources certified to supply aggregate to Department/Local Agency projects.
- 3.5 **Bureau** - The Bureau of Materials and Physical Research, of the Illinois Department of Transportation, located in Springfield, Illinois.
- 3.6 **Department** - Illinois Department of Transportation.
- 3.7 **District** - Materials Office located at each Illinois Department of Transportation highway district office.
- 3.8 **Failing Gradation Sample** - A gradation sample which, when tested, exceeds the established Master Band on the critical sieve and/or exceeds the specification ranges on the other sieves for that gradation.
- 3.9 **Gradation Technician** - A technician who has successfully completed the Department's Gradation Technician Course and is responsible only for testing gradation samples. The Gradation Technician shall be monitored on a daily basis by the Aggregate Technician.
- 3.10 **Manual** - Illinois Department of Transportation *Manual for Aggregate Inspection*.
- 3.11 **Mixture Aggregate Technician** - A technician who has successfully completed the Department's 3-day Aggregate for Mixtures course and is responsible only for sampling and testing gradation.
- 3.12 **Monitor Sample** - Gradation sample taken from the Source, Terminal, Supplier Yard, or mix plant and tested by the Department to monitor the gradation being produced by the Source under its Gradation Control Program. This sample shall also be used to evaluate the adequacy of procedures and equipment used by the Source in its Gradation Control Program.
- 3.13 **Outlying (OS) Source** – A certified aggregate source located out-of-state which is specifically designated by the inspecting District and the Bureau and required to run the requirements listed in Section 8.0 herein.
- 3.14 **Quality Control (QC) Manager** - The Aggregate Technician or the AGCS Technician designated by the Source who shall be responsible for compliance with the requirements of the Aggregate Gradation Control System. The QC Manager shall have successfully completed the Department's Aggregate Technician Course or the AGCS Technician Course.
- 3.15 **Source** - Individual aggregate source, i.e., a specific quarry or pit location supplying a specific product or products.
- 3.16 **Source Classification** - Under this program, a Source will be classified as Certified, De-Certified, or Non-Certified.

- 3.16.1 **Certified Source** - A Source that has met the requirements for certification and is allowed to supply aggregate for Department/Local Agency projects.
- 3.16.2 **De-Certified Source** - A Source that has had its Certified Source status revoked because requirements warranting certification have not been maintained. A De-Certified Source shall not be allowed to supply aggregate to Department/Local Agency projects.
- 3.16.3 **Non-Certified Source** - A Source that does not initially meet certification requirements or has not applied for certification.
- 3.17 **Source QC Plan** - A QC Plan detailing how a source designated as Outlying will comply with the AGCS.
- 3.18 **Standard Specifications** - Current edition of the Illinois Department of Transportation *Standard Specifications for Road and Bridge Construction*.
- 3.19 **Supplier Yard** – A Yard which buys aggregate from an AGCS or IDOT-inspected source and resells the aggregate from the yard for use on IDOT contracts (including local agency).
- 3.20 **Terminal** – A location owned by, leased to, or provided to an AGCS or IDOT-inspected source from which the source ships aggregate for use on IDOT contracts (including local agency).

4.0 GENERAL RESPONSIBILITIES

- 4.1 The Bureau shall maintain an Approved Aggregate Source List identifying certified sources. Only Certified Sources shall supply material to Department/Local Agency projects. Each Certified Source shall maintain its own Gradation Control Program unless producing Category IV aggregate only. Aggregate shipped from a Certified Source shall be certified to meeting the quality and gradation requirements in the Standard Specifications. However, if approved by the District, the Source may choose to certify and supply other than standard Department gradations as established by the criteria in Article 6.2 herein.
- 4.2 A Supplier Yard shall meet the requirements of the AGCS on all aggregates which will be used on IDOT contracts (including local agency). Start-of-Production (6.3.1) and Normal-Production (6.3.2) sampling/testing shall be waived. Incoming aggregate sampling/testing shall be run. The sampling/testing shall be according to the current Department QC/QA document, Model Annual Quality Control (QC) Plan for Hot-Mix Asphalt (HMA) Production, Section B. Materials, 1. Aggregates, b. Incoming Aggregate Gradation Samples.
- 4.3 A Terminal shall meet all the requirements of the AGCS on all aggregates which will be used on IDOT contracts (including Local Agency). Start-of-Production (6.3.1) and Normal-Production (6.3.2) sampling/testing shall be waived.

5.0 REQUIREMENTS FOR SOURCE CERTIFICATION

5.1 A Certified Source shall have been checked using the procedures set forth in Section 9.0 herein and found to meet the requirements for Source certification. Any Source subsequently found not meeting these or any other requirements of this program shall be removed from the Approved Aggregate Source List based on the procedure detailed in Section 11.0. The requirements for Source certification are as follows:

5.1.1 Gradation Control Program - Gradation samples shall be taken and tested as per Section 6.0 herein.

Gradations and their ranges established per Article 6.2 herein which do not meet the Standard Specifications shall be submitted to the District for approval prior to production.

5.1.2 Stockpiling and Handling - Stockpiling and handling procedures of material for Department use shall be as noted in QC/QA Procedure, "Stockpiling and Handling of Aggregate," located in the current "Manual of Test Procedures for Materials".

Materials certified under this program shall be stockpiled separately and identified by signs. Signs shall have a minimum of 3" lettering. Each individual sign shall be free-standing and moveable. Any changes made to signing must be pre-approved by the district.

5.1.3 Approved Laboratory - Laboratory facilities and equipment must conform to Section 7.0 herein. Laboratories shall be checked by District personnel and reapproved on an annual basis. One (1) laboratory may be used as an approved laboratory for more than one (1) Source as long as no problems occur in maintaining each Source's Gradation Control Program.

5.1.4 Aggregate Technicians - Sampling and testing personnel (including consultants and contractors) at the Source shall be Aggregate Technicians.

The Source may use an AGCS Technician to perform all duties of an Aggregate Technician except splitting and gradation testing. When an AGCS Technician is used, splitting and gradation testing must be performed by an Aggregate Technician or a Mixture Aggregate Technician.

The Source may use Gradation Technicians for gradation testing only. The Gradation Technician shall be under the direct supervision of the Aggregate Technician when testing gradation samples. The source may also use Mixture Aggregate Technicians for sampling and gradation testing only. The Mixture Aggregate Technician shall be under the supervision of the Aggregate Technician or the AGCS Technician. The Aggregate Technician, when supervising a Gradation Technician or Mixture Aggregate Technician, shall demonstrate gradation testing proficiency to the Aggregate Inspector on a quarterly basis.

A mixture QC/QA Technician shall not be allowed to concurrently perform the duties of an Aggregate Technician, an AGCS Technician, or a Mixture Aggregate Technician in the AGCS.

6.0 GRADATION CONTROL PROGRAM

- 6.1 The Gradation Control Program shall be run by an Aggregate Technician or an AGCS Technician as defined in Section 3.0 herein. The QC Manager shall assume responsibility for compliance with the Aggregate Gradation Control System and specifically shall ensure that the Aggregate Technician, AGCS Technician, or Mixture Aggregate Technician is performing all the required duties under the Aggregate Gradation Control System.

All communication concerning the Aggregate Gradation Control System shall be directed to the QC Manager.

Primary duties of the Aggregate Technician shall include frequent visual inspection, gradation sampling and testing, documentation, etc., as detailed herein and in QC/QA Procedure, "Quality Control (QC) Manager / Aggregate Technician / AGCS Technician / IDOT Inspector / Gradation Technician Responsibilities", located in the current "Manual of Test Procedures for Materials." The AGCS Technician may perform the same duties as the Aggregate Technician except gradation testing. Gradation testing shall be performed by an Aggregate Technician or a Mixture Aggregate Technician.

- 6.2 **Gradation Specifications** - Sieve limits for each sieve/each product under the Aggregate Gradation Control System shall be as specified in the Department's Standard Specifications and/or as amended herein. The special critical sieve criteria for certain designated products as described in QC/QA Procedure, "Aggregate Producer Control Chart Procedure" located in the current "Manual of Test Procedures for Materials" are also required.

The midpoint/tolerance range of a designated critical sieve shall be developed from an average as shown in QC/QA Procedure, "Aggregate Producer Control Chart Procedure," noted above. The average shall be a historical average or a production average derived from start-of-production samples that is agreed to by the Department. Critical sieve limits shall take precedence over Standard Specification limits. Requests for critical sieve limits shall be submitted in writing to the District Materials Engineer for approval.

For sieves other than the top and bottom specification sieves, sieve limits may be developed based on historical or average production values. These sieve limits may be different from those in the Standard Specifications. These modifications are also allowed for fine aggregate. Changes in the top sieve or any No. 200 sieve ranges will not be permitted. In cases where the bottom sieve is other than the No. 200 sieve, a variance in limits may be granted if the Bureau determines the minus No. 200 material to be within acceptable limits. The Source shall request in writing to the District Materials Engineer approval of limits other than those in the

Standard Specifications, but the range of the limits shall remain the same as the Standard Specifications.

Although the Department reserves the right to reject unacceptable material at any point prior to incorporation into the final product, the agreed upon gradation limits shall apply at the final point of shipping within the Source's control.

- 6.3 **Sampling and Testing** - Gradation samples shall be reduced to testing size by Illinois Test Procedure 248. Minimum Field Sample Size and Minimum Test Sample Size shall be as noted in the Sample Size table, Illinois Specification 201. All sampling and gradation testing shall conform to Illinois Test Procedure 2, Illinois Test Procedure 11, and Illinois Test Procedure 27. The Illinois Test Procedures noted above are located in the current "Manual of Test Procedures for Materials."

Sampling and testing frequencies (including washed tests) by category/use shall be as noted in Table 1. Definitions of each frequency are as follows:

- 6.3.1 **Start-of-Production Frequency** - After a seasonal shutdown of production or when first producing a new product, the sampling and testing of start-up production or of the new product at each production point shall be at start-of-production frequencies/requirements noted in Table 1.
- 6.3.2 **Normal-Production Frequency** - During normal production, the minimum production sampling and testing frequency/requirements as noted in Table 1 shall be maintained at each production point.
- 6.3.3 **Stockpile Frequency** - During loadout of stockpiles, the minimum stockpile sampling and testing frequency/requirements as noted in Table 1 shall be maintained for each stockpile.
- 6.3.4 **Production Changes (Short-Term Shutdown, Screen Change, Crusher Modification, Different Feed Rate, New Products, etc.)** - If a production change is made, a washed gradation sample shall immediately be run on all affected products. The start-of-production sampling frequency shall be implemented if the result on any critical sieve in that sample exceeds the warning bands on the critical sieve or if any results fail any specified sieve limits.
- 6.4 **Documentation** - Gradation results shall be charted on control charts, if required in Table 1, according to QC/QA Procedure, "Aggregate Producer Control Chart Procedure", located in the current "Manual of Test Procedures for Materials". Within one (1) working day of sampling, all gradation results shall be charted, posted, or entered into a source computer, each of which shall be located at the source and/or approved laboratory, at the District's option. Computer-maintained charting must be approved by the Department and accessible in a timely manner during any Department inspection. Computer-maintained charts shall be printed and displayed once per week or at the request of the Department. Control charts are the property of the Department and shall not be removed or altered in any manner. The Aggregate Inspector shall check the control

charts on a regular basis. Source gradation computation sheets shall be maintained by the Department for a minimum of three (3) years after the date run.

A Source diary shall be maintained by the Aggregate Technician or the AGCS Technician. The Aggregate Technician or the AGCS Technician will log all actions taken during the production day, such as new product production, sampling, resampling, screen changes, separate stockpiling, visual inspections, etc., as noted in QC/QA Procedure, "Quality Control (QC) Manager / Aggregate Technician / AGCS Technician / IDOT Inspector / Gradation Technician Responsibilities." in the current "Manual of Test Procedures for Materials."

The Source shall immediately notify the District whenever new products are being produced at the Source under its Gradation Control Program.

6.5 **Failing Gradation Samples** - Any Failing Gradation Sample (start-of-production, normal-production, or stockpile) shall be evaluated according to the following procedure and, if necessary, immediate action taken to correct the failing gradation.

If a gradation sample fails, one (1) resample from the same sampling location shall immediately be taken and tested. If the resample passes, the testing frequency being run prior to the failure shall be resumed. If the resample fails, a second resample shall immediately be taken.

If the second resample passes, the start-of-production sampling frequency shall be initiated. All samples in the series must pass before the normal production or stockpile sampling frequency for that location can be restarted.

If the second production resample fails, production of that specified aggregate shall not be incorporated in the approved stock, or, in the case of the second stockpile resample failing, shipment from that stockpile shall cease. Corrective action shall be initiated by the Source. No material shall be placed on or, in the case of stockpile problems, shipped from the certified stock until a passing gradation sample is taken and tested. The start-of-production frequency shall then be run at that location. All samples in the series must pass before the normal-production or stockpile sampling frequency for that location can be restarted.

All resamples shall be washed gradation tests except as stated under Note 2 in Table 1.

Any action taken, such as resampling, screen changes, separate stockpiling, etc., shall be noted on the bottom of the failing test computation sheet and in the Source diary.

The Aggregate Inspector or the AGCS Technician shall monitor the corrective action. Failure to comply with Article 6.5 herein shall cause the Source to be removed from the Approved Aggregate Source list as per Section 11.0 herein.

- 6.6 **Failing Monitor Gradation Samples** - Any Source's failing Monitor gradation sample taken and tested by the Department and determined to be a source problem per Section 9.6 shall be considered a Failing Gradation Sample under the Source's Gradation Control Program and shall cause the Source to enact Article 6.5 herein.

7.0 APPROVED LABORATORY

- 7.1 An approved Source laboratory shall have the following equipment or alternatives approved by the Bureau (see "Aggregate Laboratory Equipment" in the current *Manual of Test Procedures for Materials*):
- 7.1.1 Current Manual of Test Procedures for Materials.
- 7.1.2 **Balance** - meeting the current AASHTO M 231, "General Purpose Balances and Scales".
- 7.1.3 **Rainhart Shaker (305-mm [12"] Sieves)** - for coarse aggregate testing.
- 7.1.4 **Rainhart Shaker (305-mm [12"] Sieves)** - for fine aggregate testing.
- 7.1.5 **Sieves or Screens** - meeting ASTM 11, "Sieves for Testing Purposes".
- 7.1.6 **Drying Oven** - of appropriate size, built specifically for drying, and capable of maintaining a uniform temperature of $110 \pm 5^\circ \text{C}$ ($230 \pm 9^\circ \text{F}$). An electric hot plate, gas burner, or comparable heat source (microwaves are not allowed) may be substituted provided that no indication of variation in the test results occurs due to overheating of the material. Hot plates, gas burners, or comparable heat sources shall be **continually attended** by the Aggregate Technician or the Mixture Aggregate Technician during drying.
- 7.1.7 **Sample Splitters** - meeting Illinois Test Procedure 248.
- 7.2 If a mixture QC laboratory is used for AGCS testing, the following additional equipment is required for use only on AGCS aggregate samples:
- One set of nested sieves for coarse and/or fine aggregate.
 - One set of wash sieves.
 - One coarse and/or fine aggregate splitter.

All equipment listed above shall be as specified "Aggregate Laboratory Equipment" in the current *Manual of Test Procedures for Materials*.

8.0 OUTLYING (OS) SOURCE REQUIREMENTS

- 8.1 Each district may designate in writing to the Bureau a certified aggregate source located **out-of-state** which shall follow specific requirements in running the AGCS, listed herein. The District shall detail the criteria used to select the source for the Outlying designation. The Source QC plan tentatively approved by the District shall accompany the District request.

The Bureau shall notify the District Materials Engineer in writing as to whether the aggregate source has met the Outlying criteria, the Source QC Plan is acceptable, and the Source will be designated as an Outlying (OS) Source.

- 8.2 The OS Source shall follow all requirements of the AGCS program unless otherwise noted within this section. A Source QC plan shall be submitted for department approval to the inspecting District. Other states' QC/QA programs or parts thereof may be substituted for the Illinois AGCS program, if approved by the Bureau. All substitutions/changes shall be noted in the Source QC Plan. The minimum sampling frequencies noted in the Illinois AGCS program shall be met regardless of frequencies listed in the other state programs.
- 8.3 The District will, at least annually, visit each Source to obtain quality/gradation samples, observe program procedures, and inspect the AGCS laboratory. Laboratory inspections conducted under other states' programs may be used if the OS Source has been approved to use the other states' QC/QA program.
- These inspections may be unannounced.
- 8.4 The District will inspect, sample, and test incoming aggregate at the specified AGCS monitor frequency at Illinois sites (job sites, mix plants, terminals, or supplier yards). Split sample, load-out, and comparison requirements noted in Section 9 herein shall be waived.
- The District shall communicate the test results to the QC Manager at the aggregate Source for appropriate action, including any corrective action. In addition, the District shall communicate the test results to any QC Manager or Resident Engineer at the jobsite, mix plant, terminal, or supplier yard, for appropriate action, including corrective action.
- 8.5 Outlying Sources shall notify their inspecting District of all scheduled AGCS shipments/production (including shipments to mix plants, terminals, and supplier yards) prior to the shipment/production.
- 8.6 Once designated as an Outlying Source, all aggregate, including Category I, II, III, and IV, shipped to Illinois Department of Transportation projects (including all Local Agency projects) shall be produced under the AGCS program. Category IV shall be run at the Category III frequency.

9.0 DEPARTMENT RESPONSIBILITIES

- 9.1 Sampling and testing for quality shall remain the responsibility of the Department. A Consultant, hired by the Department to perform the duties of an Aggregate Inspector, shall not be allowed to take any quality or Freeze-Thaw samples at an aggregate source.
- 9.2 Monitor gradation samples at the Source shall be taken, by or in the presence of an Aggregate Inspector, from each aggregate being produced for designated use at each Certified Source. All Monitor samples shall be

split samples of a Source's gradation sample taken as per the Source's Gradation Control Program. Additionally, the Department does reserve the right to sample Monitor samples at any time. At least two (2) out of every five (5) Monitor samples shall be taken from the stockpile's loadout face once loadout procedures have started. The Monitor samples shall be tested by District personnel on Department testing equipment according to the first paragraph of Section 6.3 herein. All Monitor samples shall be washed gradation tests unless Note 2 in Table 1 is applicable. Each Monitor sample shall be identified as to sampling location and gradation test procedure used.

- 9.3 Sampling and testing frequency for the Monitor gradation samples shall be a minimum of one (1) sample per every twenty (20) production days for each gradation being produced for designated use.
- 9.4 All Monitor gradations run shall be reported in the MISTIC system. Computation sheets shall be retained for a minimum of three (3) years in the Department's Source file.
- 9.5 The Inspector shall compare both the Monitor sample and the Source's split sample for validity as defined by the Department's "Guideline for Sample Comparison" (see Appendix A of the current "Manual of Test Procedures for Materials"). The reason for any significant difference between the two (2) samples shall be determined and corrected.
- 9.6 All Monitor gradations shall be communicated to the QC Manager. All failing monitor gradations shall be investigated by the Department. Any failing gradations, which are determined to be a Source problem not already corrected by the Producer, shall cause Article 6.6 herein to be enacted by the Source. The Aggregate Inspector shall compare the failing gradation to the Source's control charts and/or split sample computation sheet. If the control chart indicates that the Source is aware of the problem and is taking corrective action, normal Monitor sampling shall resume. The Aggregate Inspector shall continue to visually monitor the problem and the Source's corrective action. If the control chart indicates the Source is not aware of the problem, a split sample of the Source's next sample as specified in Article 6.5 shall be tested. Failure of the Source to follow Article 6.6 shall result in the Source being removed from the Approved Aggregate Source list per Section 11.0 herein.
- 9.7 A copy of all correspondence between the District and the Certified Source shall be sent to the Bureau for inclusion in the aggregate Source file.

10.0 SOURCE CERTIFICATION PROCEDURE

- 10.1 The certification procedure shall follow the Department's "Producer Start-Up for the Aggregate Gradation Control System". An aggregate Source wishing to become certified shall verbally contact the District. A preliminary meeting may be held to discuss requirements of the program. After the initial contact or the preliminary meeting, a written request for certification shall be submitted to the District Materials Engineer.

- 10.2 An evaluation team composed of two (2) District personnel and one (1) Bureau representative (if possible) shall conduct an inspection of the Source for compliance to the certification checklist for all sources producing Category I, II, and III aggregate. A formal meeting with the Source's management, QC Manager, and quality control personnel shall be held to discuss the Source's Gradation Control Program requirements, if applicable, and any problems noted in the certification checklist. The Source shall submit a certification letter as designated by the Department. Each Source shall provide and maintain a listing of current certified gradations being produced under the Aggregate Gradation Control System. The certification letter, a copy of the checklist, and the evaluation team's recommendations, shall be forwarded to the Bureau along with a memorandum from the District requesting certification.
- 10.3 The Bureau shall notify the District Materials Engineer in writing whether or not the aggregate Source has met the certification criteria and has been added to the Approved Aggregate Source list.
- 10.4 Each Certified Source shall be reevaluated on an annual basis by District personnel. The reevaluation shall be a complete evaluation of the Source's laboratory and technician(s). A copy of the reevaluation checklist and comments shall be forwarded to the Bureau. Failure to comply with the certification criteria shall result in the Source's certification being revoked as per the procedure detailed in Section 11.0 and the Source will be classified as De-Certified and removed from the Approved Aggregate Source list.
- 10.5 Only during the initial certification procedure and at the request of the aggregate Source, existing IDOT-approved stockpiles at the Source may be approved as certified AGCS aggregate for Category II and Category III use only under the AGCS. This request, including identification and location of the stockpiles, shall be included in the written letter requesting certification submitted to the District Materials Engineer. The Engineer shall review the gradations representing the stockpiles for compliance to the specifications. If acceptable, the stockpiles shall be considered AGCS aggregate at such time as the aggregate source is certified. Any Category I aggregate may be grandfathered into the AGCS using the Department's current Policy Memorandum, "Use of Non-certified Aggregate Stockpiles Under the Aggregate Gradation Control System (AGCS)", located in the current "Manual of Test Procedures for Materials."
- 10.6 If at any time a Certified Source does not maintain the proper QC personnel, the source will be given thirty (30) days to comply by either hiring a new QC person, training existing personnel or by contracting with a qualified consultant. If after thirty (30) days the source does not have the proper QC personnel; the source's Certification will be revoked by the BMPR. Section 11.0 will not apply to this type of Revocation. The source will be reinstated as an Approved Aggregate Source once the proper QC personnel are acquired.

11.0 REVOCATION OF A SOURCE'S CERTIFICATION

- 11.1 The Department may revoke a Source's Certification for any of the following reasons:
- Failing to follow the procedures and requirements of the Aggregate Gradation Control System (AGCS) Policy Memorandum.
 - Misrepresentation of materials or products.
 - Failing to follow the approved Quality Control Plan, if applicable.
- 11.2 Before removal, the District Materials Engineer shall detail, in a non-conformance letter to the Source's QC Manager, why the Department is seeking to revoke the Source's Certification. The Source has within two weeks to reply. The Source shall not place materials in question on certified stockpiles during the two-week period. If the Department's reasons warrant, the Source may be required to stop shipment of any and all products to Department and/or Local Agency projects.
- 11.3 Within this two-week period, the Source's QC Manager shall reply, in writing, outlining the steps the Source is taking to address the issues outlined within the Department's non-conformance letter.
- 11.4 After receipt of the Source's letter, the District will schedule a meeting with the Source to discuss the proposed revocation and the Source's response. After such meeting, the District Materials Engineer will either (1) conclude the steps taken by the Source's QC Manager are adequate and terminate the revocation process, or (2) conclude the Source's response does not address the issues outlined in the Department's non-conformance letter and recommend in writing to the Bureau of Materials and Physical Research the Source be taken off the Approved Aggregate Source List. The recommendations shall include details and District/Source comments concerning the proposed revocation. Copies of all correspondence, including meeting minutes, shall be sent to the Bureau and the Source.
- 11.5 If requested by the Source within seven days of the District's recommendation to revoke the Certification, the Bureau will schedule a meeting with the Source's QC Manager and the District. After such meeting, the Bureau will either terminate the revocation process or proceed with removing the Source from the Approved Aggregate Source List.
- The Bureau's decision to revoke the Source's Certification is a final agency decision of the Illinois Department of Transportation.
- 11.6 The Bureau shall notify the District Materials Engineer and Source in writing when a Source's Certification has been revoked and the Source has been removed from the Approved Aggregate Source List as a De-Certified Source. The Source may not provide aggregate materials or products for Department and/or Local Agency projects until such time as the Source's Certification has been reinstated.

- 11.7 The QC Manager, at any time, may inform the District in writing that the Source is no longer producing or shipping a specific certified gradation. This action shall terminate any revocation process against the source concerning that certified gradation. Production of that gradation for the AGCS shall not be restarted unless the District concurs that corrective action has been completed by the Source. If the revocation process is based on misrepresentation of materials or products, and/or failure to follow the overall general requirements of this policy, 11.7 does not pertain.

12.0 REINSTATEMENT OF A SOURCE'S CERTIFICATION

- 12.1 The Source may re-apply for reinstatement of its certification at the end of the revocation period. Re-application shall be in writing to the Bureau of Materials and Physical Research and include the specific steps to be taken to correct the cause for loss of certification.



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GENERAL	CATEGORY I (See Notes 1 and 5)	CATEGORY II (See Notes 1 and 5)	CATEGORY III (See Notes 1 and 5)	CATEGORY IV (See Note 4)
Critical Aspects				
Gradation	High	High/Medium	Medium	Low
P200	High	High	Medium	Low
Use	Coarse Aggregate and Manufactured Sand Used in HMA and PCC Coarse Aggregate for Pavement Drainage			Ag Lime Kiln Dust Lime Products Mineral Filler Sealant Aggregate (Resinous) Sealant Aggregate (Prime) Rock Fill Erosion and Sediment Control Riprap Bedding Sand Bedding
	Coarse Aggregate for All PCC and High / Low ESAL HMA Projects Manufactured Sand for All PCC and Class I / Superpave HMA Projects		Natural Sand for All PCC and HMA Projects	Porous Granular Embankment and Bedding Sand Backfill for Underdrains French Drains Membrane Waterproofing Fine Blend Sand Mortar Sand Ice Control Abrasives Blotter
		Coarse Aggregate and Manufactured Sand for All Other HMA Projects	Aggregate Surface Course Granular Shoulders Granular Subbase Granular Base Granular Embankment Special Cover/Seal Coat MSE Wall Materials	Stone Screenings Non-porous Granular Embankment Trench Backfill

GENERAL	CATEGORY I (See Notes 1 and 5)	CATEGORY II (See Notes 1 and 5)	CATEGORY III (See Notes 1 and 5)	CATEGORY IV (See Note 4)
Program				
Start of Production	5 @ 1,000 T (all wash)	3 @ 1,000 T (all wash) (See Note 2)	2 @ 2,000 T (all wash) (See Note 2)	Department testing
Normal Production	2,000 T max. 2/day (wash 1/3 coarse aggregate) (wash all manufactured sand)	5,000 T max. 2/day, min. 1/week (all wash) (See Note 2)	10,000 T max. 2/day, min. 1/week (all wash) (See Notes 2 and 6)	
Stockpile Loadout Control Charts Masterband	2/week (all wash) (See Note 3) Yes Yes (See Note 8)	1/week (all wash) (See Notes 2 and 7) Yes Yes (See Note 8)	1/week (all wash) (See Notes 2 and 7) No No	

Note 1: A producer may adjust gradation bands for any product in accordance with Article 6.2 of the AGCS.

Note 2: Wash only products used for HMA, PCC, Seal/cover coat and products with #200 sieve requirements.

Note 3: No loadout tests for quantities under 500 tons or less shipped weekly. When loadout occurs but no weekly loadout test is run, the tonnage shipped shall be accumulated from the start of that week. When the accumulated tonnage exceeds 500 tons, a loadout sample shall be run.

Note 4: Testing to be performed by IDOT personnel.

Note 5: Testing frequency may be reduced based on conformance to QC requirements, consistency in meeting sieves' midpoints, statistical consistency, etc.

Note 6: Minimum of 1 per week after the first 10,000 tons of production per week for aggregate surface course, granular shoulders, granular subbase, granular base, and granular embankment special; minimum of 1 every 2 weeks if producing less than 10,000 tons per 2-week period.

Note 7: No loadout tests for quantities under 1,000 tons or less shipped weekly. When loadout occurs but no weekly loadout test is run, the tonnage shipped shall be accumulated from the start of that week. When the accumulated tonnage exceeds 1,000 tons, a loadout sample shall be run.

Note 8: Refer to current QC/QA Procedure, "Aggregate Producer Control Chart Procedure" for required gradations.

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State of Illinois
Department of Transportation
Bureau of Materials and Physical Research
Springfield

POLICY MEMORANDUM

Revised: June 1, 2012

10-08.1

This Policy Memorandum supersedes number 10-08.0 dated January 1, 2008

TO: REGIONAL ENGINEERS AND HIGHWAY BUREAU CHIEFS

SUBJECT: USE OF NON-CERTIFIED AGGREGATE STOCKPILES UNDER THE
AGGREGATE GRADATION CONTROL SYSTEM (AGCS)

1.0 SCOPE

1.1 The AGCS requires the aggregate source to control the gradation of its certified aggregate during production. Non-certified aggregate stockpiles are those that were not produced under the requirements of the AGCS.

2.0 PURPOSE

2.1 To establish a procedure to accept specific non-certified aggregate for use under the AGCS.

3.0 ELIGIBILITY

3.1 Only certified aggregate Sources currently running the AGCS are eligible to participate in this program.

4.0 AGGREGATE QUALITY

4.1 Non-certified stockpiles shall have current acceptable quality test data (no more than three [3] years old) before processing. Any stockpile not conforming to this requirement shall be sampled as required by the District and tested for quality at the Bureau of Materials and Physical Research.

5.0 GENERAL PROCEDURE

5.1 The aggregate Source shall submit a letter through the District to the Bureau of Materials and Physical Research (BMPR) requesting to certify a non-certified stockpile for AGCS use using this policy memorandum. The letter shall detail the aggregate code number (Example: 032CM16), stockpile location, and the method to be used to certify the stockpile.

Upon BMPR approval, the District and aggregate Source shall meet to review the method to be used for certification.

- 5.2 One of the following two methods shall be used to certify non-certified stockpiles for use under the current AGCS.

Method #1:

The designated non-certified stockpile shall be sampled and tested for gradation to establish the critical sieve Master Band prior to shipping the material to a certified project. A minimum of one (1) gradation sample per 500 metric tons for at least 2,500 metric tons of stockpiled aggregate shall be taken and tested during loadout to work not requiring certified aggregate. The average of these results shall be used by the aggregate Source to establish the Master Band on the critical sieve. The aggregate Source may set the specification limits on the other sieves as allowed in Section 6.2 of the current Illinois Department of Transportation (IDOT) policy memorandum, "Aggregate Gradation Control System". After IDOT approval of the Master Band and other sieve limits, the material may be shipped to projects requiring certified aggregate and shall be tested at a minimum rate of one (1) gradation sample for each 1,000 metric tons of loadout.

Method #2

The aggregate Source may submit a plan to the Bureau of Materials and Physical Research proposing a satisfactory method of sampling and testing the entire pile either in-situ or by restocking (or any combination thereof). If approved, the aggregate Source shall average all the tests taken to establish a Master Band on the critical sieve. The aggregate Source may set the specification limits on the other sieves as allowed in Section 6.2 of the current AGCS policy memorandum. After IDOT approval of the Master Band and other sieve limits, the material may be shipped to projects requiring certified aggregate. When shipping activity begins, loadout sampling and testing shall be performed in accordance with Section 6.3.3 of the current AGCS policy memorandum.

- 5.3 All requirements of the AGCS shall apply except those referring to production samples. In addition, all samples shall be washed gradations run in accordance with Illinois Test Procedure 11/Illinois Test Procedure 27. Failing gradation samples shall be handled in accordance with Section 6.5 of the current AGCS policy memorandum, except that references to production samples shall apply to the samples obtained to meet the requirements of this policy memorandum. All test data shall be plotted on control charts as specified in Section 6.4 in the current AGCS memorandum.



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APPENDIX E

Illinois Department of Transportation

Development of Gradation Bands on Incoming Aggregate at Mix Plants

Effective: January 1, 1994

Revised: June 1, 2012

A. Scope

Quality Control Plans for QC/QA Contracts normally require incoming aggregate to be checked for gradation compliance before use in mix plants. Aggregate is produced to tight gradation bands at the source but will degrade during handling and shipment.

B. Purpose

Establish a procedure to modify aggregate source gradation bands to develop mix plant gradation bands for use in checking gradation compliance on incoming aggregate at mix plants. The mix plant gradation bands will also be used in checking gradation compliance for required stockpile gradation tests at the mix plant.

C. Aggregate Source Gradation Bands

The Contractor shall obtain certified aggregate gradation bands (including master band, if required) from the aggregate source for all certified aggregates prior to any shipment of material to the mix plant. Natural sand gradation bands shall be obtained from the appropriate District Materials Engineer.

D. General Procedure

The Contractor may modify the aggregate source gradation bands according to the following procedures, if necessary, to check incoming aggregate for gradation compliance at the mix plant. If not modified, the aggregate source gradation bands shall be considered the mix plant gradation bands when checking incoming aggregate.

1. Coarse Aggregate—The Contractor may shift the aggregate source master band a maximum of three percent (3%) upwards to establish a Mix Plant Master Band for each coarse aggregate used. All other aggregate source gradation bands, except for the top sieve and bottom sieve bands in the gradation specification, may also be shifted upward a maximum of three percent (3%). The top sieve and bottom sieve bands shall not be changed, except as follows:

At portland cement concrete plants, the Contractor may increase the specification limit for the minus 75- μ m (No. 200) Illinois Test Procedure 11 sieve material upwards one half percent (0.5%) if the 75- μ m (No. 200) material consists of dust from fracture, or degradation from abrasion and attrition, during stockpiling and handling (reference Article 1004.01[b] of the Department's *Standard Specifications for Road and Bridge Construction*).

2. **Manufactured Sand**—All aggregate source gradation bands, except the top sieve and bottom sieve bands in the gradation specification, for each certified manufactured sand may be shifted upwards a maximum of three percent (3%). The top sieve and bottom sieve bands shall not be changed.
3. **Natural Sand**—The gradation bands obtained from the Department for each natural sand shall not be changed.

E. Department Approval

All aggregate source gradation bands and mix plant gradation bands must be sent to the District Materials Engineer for approval prior to any shipment of aggregate to the mix plant. Once approved, the mix plant gradation bands shall not be changed without approval of the District Materials Engineer.

Appendix F

Illinois Department of Transportation

Required Sampling and Testing Equipment for Concrete

Effective: December 1, 1993

Revised: June 1, 2012

This document applies to cast-in-place, precast, and precast prestressed operations. This document summarizes the minimum requirements for sampling and testing Portland Cement Concrete (PCC) mixtures, Cement Aggregate Mixture II (CAM II), and Controlled Low-Strength Material (CLSM). Refer to the *Manual of Test Procedures for Materials* for detailed equipment information.

AT THE PLANT OR LOCATION APPROVED BY THE ENGINEER:

Proportioning PCC, CAM II, CLSM

Aggregate Moisture Test Equipment, and Balance¹ or Scale¹
(¹ The weighing equipment does not have to be electronic. Check weights are recommended.)

Sampling Plastic PCC, CAM II, CLSM

Wheelbarrow or Similar Equipment

Shovel

Testing Plastic PCC, CAM II, CLSM

Slump Kit (PCC or CAM II)

Plastic Cylinder for Flow Test (CLSM)

Air Meter Kit and Calibration Equipment

Unit Weight Kit, Calibration Equipment, and Balance¹ or Scale¹
(¹ The weighing equipment does not have to be electronic. Check weights are recommended.)

Thermometer

Ruler

Hand Scoop or Trowel

Vibrator (if required)

Slump Flow Kit (Required only for self-consolidating concrete.)

J-Ring or L-Box Kit (Required only for self-consolidating concrete.)

Aggregate Sampling Equipment for High/Low Volume Operation

Template and brush, or sampling device, or shovel.

Aggregate Testing Equipment for High Volume Operation

Definition of High Volume Aggregate Testing Operation – The high volume aggregate testing equipment may be used for multiple concrete plants, if approved by the Engineer. The decision will be based on specification requirements for providing test results.

Electronic Balance²

(² Check weights are recommended.)

Sieve Shaker, 305 mm (12 in.) sieve capacity and sufficient inside height to accept typical sieve stock

Sample Splitter, coarse aggregate, two pans³

(³ Three pans are required if the sample splitter does not have a hopper to hold aggregate.)

Sample Splitter, fine aggregate, two pans³

(³ Three pans are required if the sample splitter does not have a hopper to hold aggregate.)

(or)

Shovel, hand scoop, brush and dust pan,

Canvas blanket (optional), trowel (optional),

Sampling thief or small scoop or large spoon (optional)

Sieves, 305 mm (12 in.) brass with brass or stainless cloth

2 in. nominal height⁴— 25 mm (1 in.), 19 mm (3/4 in.),
16 mm (5/8 in.), 12.5 mm (1/2 in.)

1 5/8 in. nominal height⁴— 9.5 mm (3/8 in.), 6.25 mm (1/4 in.),
4.75 mm (No. 4), 1.18 mm (No. 16) two required,
0.3 mm (No. 50), 0.15 mm (No. 100),
0.075 mm (No. 200) two required

⁴ Distance from the top of the frame to the sieve cloth surface

Two Pans

Lid

Electric Drying Oven 110 ± 5 °C (230 ± 9 °F)

(or)

Two Double Electric Hot Plates or Gas Burners

Sink, Faucet, and Water Supply

Four Drying Pans 330 x 230 x 50 mm (13 x 9 x 2 in.), typical

Four Holding Pans 305 mm (12 in.), minimum diameter

Accessories: Large spoon, soft bristle brass brush, paint brush or stencil brush, and putty knife or pointed dowel rod.

Aggregate Testing Equipment for Low Volume Operation

Definition of Low Volume Aggregate Testing Operation – The low volume aggregate testing equipment may be used only for a single concrete plant. If a reduced testing time is desired, the high volume aggregate testing equipment is recommended, since the low volume 200 mm (8 in.) sieves will normally require the coarse aggregate sample to be sieved in parts to prevent overloading.

Electronic Balance²

(² Check weights are recommended.)

Sieve Shaker, 200 mm (8 in.) sieve capacity and sufficient inside height to accept typical sieve stock

Sample Splitter, coarse aggregate, two pans³

(³ Three pans are required if the sample splitter does not have a hopper to hold aggregate.)

Sample Splitter, fine aggregate, two pans³

(³ Three pans are required if the sample splitter does not have a hopper to hold aggregate.)

(or)

Shovel, hand scoop, brush and dust pan,

Canvas blanket (optional), trowel (optional),

Sampling thief or small scoop or large spoon (optional)

Sieves, 200 mm (8 in.) brass with brass or stainless cloth

2 in. nominal height ⁴ —	25 mm (1 in.), 19 mm (3/4 in.), 16 mm (5/8 in.), 12.5 mm (1/2 in.), 9.5 mm (3/8 in.), 6.25 mm (1/4 in.), 4.75 mm (No. 4)
-------------------------------------	---

1 in. nominal height ⁴ —	1.18 mm (No. 16) two required, 0.3 mm (No. 50) 0.15 mm (No. 100), 0.075 mm (No. 200) two required
-------------------------------------	---

⁴ Distance from the top of the frame to the sieve cloth surface

Two Pans

Lid

Two Double Electric Hot Plates or Gas Burners

Sink, Faucet, and Water Supply

Two Drying Pans 330 x 230 x 50 mm (13 x 9 x 2 in.), typical

Three Holding Pans 305 mm (12 in.), minimum diameter

Accessories: Large spoon, soft bristle brass brush, paint brush or stencil brush, and putty knife or pointed dowel rod.

AT THE JOBSITE:**Sampling Plastic PCC, CAM II, CLSM**

Wheelbarrow or Similar Equipment

Shovel

Testing Plastic PCC, CAM II, CLSM

Slump Kit (PCC or CAM II)

Plastic Cylinder for Flow Test (CLSM)

Air Meter Kit and Calibration Equipment

Thermometer

Ruler

Hand Scoop or Trowel

Vibrator (if required)

Slump Flow Kit (Required only for self-consolidating concrete.)

J-Ring or L-Box Kit (Required only for self-consolidating concrete.)

Making Strength Specimens (Cylinders or Beams)

Plastic Cylinder Molds, 152 x 305 mm (6 x 12 in.)

Plastic Cylinder Lids, 152 mm (6 in.), or other material per Illinois Modified AASHTO T 23

-----OR-----

Steel or Plastic Beam Molds (typical length)

152 x 152 x 457 mm (6 x 6 x 18 in.),

152 x 152 x 483 mm (6 x 6 x 19 in.),

152 x 152 x 508 mm (6 x 6 x 20 in.),

152 x 152 x 533 mm (6 x 6 x 21 in.), or

152 x 152 x 762 mm (6 x 6 x 30 in.)

Plastic Cover with Absorbent Pad, or other material per Illinois Modified AASHTO T 23

-----AND-----

Tamping Rod or Vibrator (as appropriate)

Mallet

Hand Scoop (optional)

Trowel or Wood Float

AT THE JOBSITE OR LOCATION APPROVED BY THE ENGINEER:**Curing Strength Specimens**

Moist Cabinet or Moist Room, with Air Temperature and
Relative Humidity Control Equipment

Recording Thermometer

Relative Humidity Measuring Device and Logbook, or
Relative Humidity Recording Device

-----OR-----

Water Storage Tank and Provisions for Water Temperature Control

Maximum/Minimum Thermometer and Logbook, or
Recording Thermometer

Testing Strength Specimens

Capping System for Compressive Strength

Mechanical Testing Machine for Compressive Strength

-----OR-----

Mechanical or Hand-Operated Testing Machine for
Flexural Strength (Using Simple Beam with Center-Point Loading)

Self-Consolidating Concrete

Saw to cut cylinders for hardened visual stability index.

PRECAST CONCRETE PLANTS (ADDITIONAL REQUIREMENTS):

For dry cast operations, the slump kit is optional and the air meter kit is not required.

Block/Brick Products – A compression test machine is required.

Pipe Products – A three-edge-bearing machine is required.

Applicable Products – When cores are used to determine compressive strength, the core drill shall have diamond impregnated bits attached to the core barrel.

Applicable Products – Absorption, permeability, hydrostatic, density, freeze/thaw, linear drying shrinkage, and abrasion resistance test equipment are required.

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Appendix H

ILLINOIS DEPARTMENT OF TRANSPORTATION

MODEL QUALITY CONTROL PLAN FOR CONCRETE PRODUCTION

Effective: December 1, 1993

Revised: June 1, 2012

INSTRUCTIONS: The Contractor shall respond to all items addressed in this model. This is applicable to work performed by the Contractor or subcontractor(s). Examples are provided to assist the Contractor, and any innovations to the quality control process may be presented.

Part 1 is completed by the Contractor.

Part 2 is completed by the Contractor or Commercial Concrete Producer. For the Contractor, Part 2 is submitted annually, for the period which begins April 1st, and which expires the following year on March 31st. For a Commercial Concrete Producer, Part 2 shall remain in effect until the Producer submits an updated document or the District requests the Producer to update Part 2. (Note: A District may require Part 2 to be updated annually or at a longer interval.)

If Part 2 is approved by the Department's District office for a one year period, the Contractor shall either attach the approved Part 2 to each Quality Control Plan submitted, or shall state "The approved Part 2, for the period from mo/day/yr to mo/day/yr, is on file at the District office; the contents are fully and thoroughly understood, and the contents are a part of this Contract." When Part 2 has been completed by the Commercial Concrete Producer, the Contractor shall not make any revisions. However, the Contractor and Commercial Concrete Producer have the option to amend Part 2 for a specific project, and submit it to the Department's District office for approval.

QUALITY CONTROL PLAN CONCRETE

County: _____

Section: _____

Route: _____

District: _____

Contract No.: _____

Job No.: _____

Project: _____

Contractor: _____

P.O. Box: _____

Street Address: _____

City/State/Zip Code: _____

Telephone No.: _____

Fax No.: _____

This Quality Control plan explains how _____ proposes to control the equipment, materials, and production methods to ensure the specified product is obtained.

PART 1 - QUALITY CONTROL PLAN AT THE JOBSITE

I. FIELD OFFICE

Location: _____

Contact Person: _____

Telephone Number: _____

In the event of field equipment failure, _____ will provide back up equipment.

II. FIELD QUALITY CONTROL PERSONNEL

Individual's Name: _____

Department Training: _____

Company Name: _____

Telephone Number: _____

_____ Primary or _____ Back Up

The Level II PCC Technician who will be responsible for plant mixture control and adjustments is indicated in Part 2.

_____ is the Level I PCC Technician who will be responsible for jobsite mixture control and adjustments.

_____ is the Quality Control Manager who will be responsible for overall project quality control.

III. FIELD SAMPLING AND TESTING

INSTRUCTIONS: Indicate whether beams and/or cylinders will be cast, as well as how the specimens will be initially cured.

Note: In some instances, such as Articles 503.05 and 503.06, only a flexural strength is specified. An equivalent compressive strength may be used if approved by the Engineer.

Example:

Plastic cylinder molds [6 by 12 in. (152 by 305 mm)] will be used to cast strength specimens. The plastic cylinder mold will be covered with a plastic cylinder lid. A curing box will be used to maintain the specimens within 60 to 80° F (16 to 27° C). The specimens will be transported after 24 hours for standard curing.

INSTRUCTIONS: Indicate the final location for standard curing and testing of the strength specimens, and the method of curing.

Example:

The strength specimens will be transported to the consultant's lab for standard curing in a water storage tank, and testing.

IV. FAILING TESTS AND DEFECTIVE WORK

INSTRUCTIONS: Indicate the communication procedures between the Commercial Concrete Producer, the Contractor, and Department personnel in the event of failing tests or observation of defective work. This may also be in flow chart form.

Example:

In the event of failing tests or observation of defective work at the jobsite, the Level I PCC Technician will be responsible for notifying the Superintendent and the Quality Control Manager. The Superintendent will be responsible for notifying the Resident Engineer.

In the event of failing tests at the plant, the Level II PCC Technician will be responsible for notifying the Superintendent and the Quality Control Manager. The Superintendent will be responsible for notifying the Resident Engineer.

V. COMMUNICATION

INSTRUCTIONS: For concurrent pours, indicate how each Concrete Tester will be able to contact the Level I PCC Technician.

Indicate how jobsite personnel will be able to contact the Level II PCC Technician.

Example:

For concurrent pours, each Concrete Tester will be able to contact the Level I PCC Technician by two-way radio. Jobsite personnel will use two-way radio to contact the Level II PCC Technician, when he/she is at the plant. When the Level II PCC Technician is not at the plant, jobsite personnel and the Level II PCC Technician will use a cellular phone.

VI. FIELD DOCUMENTATION

INSTRUCTIONS: Indicate the forms, the bound hardback field books, and bound hardback diaries that will be used to maintain documentation at the jobsite.

Example:

A bound hardback field book will be used for all documentation at the jobsite.

VII. PRE-POUR MEETING

INSTRUCTIONS: Indicate when a bridge deck pre-pour meeting will be scheduled. Meetings for other important pours are encouraged.

Examples:

A meeting will be scheduled the day before the bridge deck pour to discuss mix, concrete delivery, pumped concrete, finishing equipment and requirements, labor, deficiencies, curing, weather conditions (i.e. temperature, humidity, wind), and other pertinent issues.

Or

A meeting will be scheduled two months, two weeks, and two days before the bridge deck pour. The meetings will discuss mix, concrete delivery, pumped concrete, finishing equipment and requirements, labor, deficiencies, curing, weather conditions (i.e. temperature, humidity, wind), and other pertinent issues.

PART 2 - QUALITY CONTROL PLAN AT THE CONCRETE PLANT

If applicable:

Department Producer/Supplier Number: _____

Commercial Concrete Producer: _____

P.O. Box: _____

Street Address: _____

City/State/Zip Code: _____

Telephone Number: _____

I. MATERIALS

INSTRUCTIONS: The wording for "A) Aggregates" is provided for the Contractor. Indicate the material sources for "B) Coarse Aggregates" and "C) Fine Aggregates". If applicable, attach proposed mix plant gradation bands in accordance with the Department's "Development of Gradation Bands on Incoming Aggregate at Mix Plants."

A) Aggregates

Certified aggregate gradation bands (including master band, if required) will be obtained from the aggregate source for all certified aggregates, prior to any shipment of material to the plant.

B) Coarse Aggregates

Material: (Example: CA 11 - Crushed Stone)

ASTM C 1260 Expansion: _____ (This is not required for limestone or dolomite aggregate.)

Department Producer/Supplier Number: _____

Company Name: _____

Company Address: _____

Contact Person: _____

Telephone Number: _____

C) Fine Aggregates

Material: (Example: FA 01 - Natural Sand)

ASTM C 1260 Expansion: _____ (This is not required for limestone or dolomite aggregate.)

Department Producer/Supplier Number: _____

Company Name: _____

Company Address: _____

Contact Person: _____

Telephone Number: _____

D) Aggregate Stockpiling and Handling

INSTRUCTIONS: Aggregates shall be stockpiled and handled in a manner which minimizes segregation and degradation, prevents contamination, and produces a uniform gradation, before placement in the plant bins. This is according to Articles 106.06, 106.07, 1003.01 (e), 1004.01 (e), 1004.02 (d), and 1020.10, of the Standard Specifications for Road and Bridge Construction (January 1, 2012). Indicate the specific methods to be used.

Example:

Coarse aggregates are shipped by rail to the plant, in a uniform gradation condition. Upon delivery of the coarse aggregate, it will be transferred to a stockpile by a movable conveyor system. The stockpile will be built according to Article 1004.01 (e), of the Standard Specifications for Road and Bridge Construction (January 1, 2012).

Fine aggregates are shipped by truck to the plant, in a uniform gradation condition. The fine aggregate will be truck dumped into a stockpile. The truck stockpile will be built according to Article 1003.01 (e) of the Standard Specifications for Road and Bridge Construction (January 1, 2012).

All stockpiles will be separated with concrete block walls, sufficient in width, length, and height to prevent contamination. The maximum height of the walls will be ___ ft (___ m).

E) Uniform Aggregate Moisture

INSTRUCTIONS: According to Article 1020.10 of the Standard Specifications for Road and Bridge Construction (January 1, 2012), aggregates shall have a uniform moisture content before placement in the plant bins. Indicate the specific methods to be used.

Example:

Coarse and fine aggregates will be stockpiled and allowed to drain for 12 hours, before placement in the plant bins. However, during hot weather, the aggregate stockpiles will be periodically sprinkled with water.

F) Coarse Aggregate Moisture

INSTRUCTIONS: Indicate the frequency of coarse aggregate moisture testing to control production.

NOTE: Fine aggregate moisture testing is specified in the Special Provision for Quality Control/Quality Assurance of Concrete Mixtures.

G) Aggregate Gradation Samples

INSTRUCTIONS: Indicate how and where you will sample aggregates to assure they will meet current Department gradation specifications.

Example:

For aggregates arriving at the plant, truck-dump sampling will be performed for fine and coarse aggregate gradation tests.

For aggregates used during concrete production, on-belt sampling will be performed for fine and coarse aggregate gradation tests. The conveyor belt beneath the bin will be used.

H) Gradation Tests for Aggregates Arriving at the Plant

INSTRUCTIONS: Indicate the frequency of gradation testing for aggregates arriving at the plant, **to check the source**.

NOTE: The frequency of gradation testing **to check the production of concrete**, for aggregates stored at the plant in stockpiles or bins, is specified in the Special Provision for Quality Control/Quality Assurance of Concrete Mixtures.

II. PLANT AND DELIVERY TRUCKS

Plant Name: _____

Plant Location: _____

Producer No.: _____

NOTE: The plant and delivery trucks are to be approved according to the Bureau of Material and Physical Research's Policy Memorandum, "Approval of Concrete Plants and Delivery Trucks." Contact the Department's District office to obtain the required forms.

III. QUALITY CONTROL LABORATORY

Location: _____

Contact Person: _____

Telephone Number: _____

The quality control laboratory is _____ sq. ft. [The Department suggests 200 ft² (20 m²)].

The laboratory was approved on _____ by District _____.

In the event of lab equipment failure, _____ will provide back up equipment.

IV. PLANT QUALITY CONTROL PERSONNEL

Individual's Name: _____

Department Training: _____

Company Name: _____

Telephone Number: _____

_____ Primary or _____ Back Up

NOTE: Include personnel who have been trained by the Level II PCC Technician to sample and test aggregate for moisture.

_____ is the Level II PCC Technician who will be responsible for plant mixture control and adjustments.

The Level I PCC Technician who will be responsible for jobsite mixture control and adjustments is indicated in Part 1.

The Quality Control Manager who will be responsible for overall project quality control is indicated in Part 1.

V. MIX DESIGNS

INSTRUCTIONS: Provide mix design information as stated in 1.1 “Volumetric Mix Design and Mix Design Submittal” of the Portland Cement Concrete Level III Technician Course – Manual of Instructions for Design of Concrete Mixtures.

Otherwise state: “Only mix designs previously verified by the Department will be used”.

INSTRUCTIONS: Based on the ASTM C 1260 test information provided for the aggregates, indicate the mixture option selected for minimizing the risk of alkali-silica reaction. Refer to Article 1020.05(d).

VI. PLANT MIXTURE TESTING

INSTRUCTIONS: Indicate the plant start-up testing frequency, and the plant testing frequency thereafter, to control production. This is required for slump, air content, unit weight, yield, and temperature tests performed at the plant. Indicate any other tests that will be performed.

NOTE: Plant start-up situations are defined in the “Portland Cement Concrete Level II Technician Course” manual. Indicate if the manual’s plant start-up situations will be applicable, or if other start-up situations will apply.

VII. PLANT SUPERVISION

INSTRUCTIONS: If the Level II will supervise more than one plant, indicate his/her attendance at the various plants for large or critical pours.

VIII. COMMUNICATION

INSTRUCTIONS: Indicate how plant personnel will be able to contact the Level II PCC Technician, when he/she is not at the plant.

Example:

Plant personnel will use a land phone, to contact the Level II PCC Technician by cellular phone.

IX. PLANT DOCUMENTATION

INSTRUCTIONS: Indicate the forms, the bound hardback field books, and bound hardback diaries that will be used to maintain documentation at the plant, and at the laboratory.

Example:

A loose-leaf binder will be used to maintain any Department form which is required at the plant, or at the laboratory. A bound hardback field book will be used to record test results at the plant, and at the laboratory. A bound hardback diary will be used to document observations, inspections, adjustments to the mix design, and corrective actions at the plant.

INSTRUCTIONS:

To be completed by Contractor. Return with Quality Control Plan.

QUALITY CONTROL PLAN SIGNATURE SHEET

(IF AN INDIVIDUAL)

Firm Name _____

Print Name of Owner _____

Signature of Owner _____

Date: _____

(IF A CO-PARTNERSHIP)

Firm Name _____

Print Name of Partner _____

Signature of Partner _____

Date: _____

(IF A CORPORATION)

Corporate Name _____

Print Name of Authorized Representative _____

Signature of Authorized Representative _____

Date: _____

(ALL)

Business Address: _____

P.O. Box: _____

Street Address: _____

City/State/Zip Code: _____

INSTRUCTIONS: The Contractor shall complete this section for Addendums to a Quality Control Plan.

QUALITY CONTROL PLAN ADDENDUM
CONCRETE

County: _____
Section: _____
Route: _____
District: _____
Contract No.: _____
Job No.: _____
Project: _____
Contractor: _____
P.O. Box: _____
Street Address: _____
City/State/Zip Code: _____
Telephone No.: _____
Fax No.: _____

ADDENDUMS

INSTRUCTIONS: Indicate and/or attach addendums to Contractor Quality Control Plan.

INSTRUCTIONS:

To be completed by Contractor. Return with any amended Quality Control Plan.

QUALITY CONTROL PLAN ADDENDUM SIGNATURE SHEET

(IF AN INDIVIDUAL)

Firm Name _____

Print Name of Owner _____

Signature of Owner _____

Date: _____

(IF A CO-PARTNERSHIP)

Firm Name _____

Print Name of Partner _____

Signature of Partner _____

Date: _____

(IF A CORPORATION)

Corporate Name _____

Print Name of Authorized Representative _____

Signature of Authorized Representative _____

Date: _____

(ALL)

Business Address: _____

P.O. Box: _____

Street Address: _____

City/State/Zip Code: _____

Appendix I

ILLINOIS TEST PROCEDURE 255

TOTAL EVAPORABLE MOISTURE CONTENT OF AGGREGATE BY DRYING

Effective Date: June 1, 2012

1 SCOPE

- 1.1 This test procedure covers the determination of the percentage of evaporable moisture in a sample of aggregate by drying both surface moisture and moisture in the pores of the aggregate. Some aggregate may contain water that is chemically combined with the minerals in the aggregate. Such water is not evaporable and is not included in the percentage determined by this test method. Aggregate moisture content may be run on a gradation sample prior to gradation testing or on a separate test sample.
- 1.2 The values stated in SI units are to be regarded as the standard. The values in parentheses are provided for information only.
- 1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this procedure to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2 REFERENCED DOCUMENTS

2.1 Illinois Test Procedures (ITP):

- ITP 2, Sampling of Aggregates
- ITP 84, Specific Gravity and Absorption of Fine Aggregate
- ITP 85, Specific Gravity and Absorption of Coarse Aggregate
- ITP 248, Reducing Samples of Aggregate to Testing Size

2.2 Illinois Specifications:

- Illinois Specification 201, Aggregate Gradation Samples Size Table

2.3 AASHTO Standards:

- M 231, Weighing Devices Used in the Testing of Materials

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TOTAL EVAPORABLE MOISTURE CONTENT OF AGGREGATE BY DRYING

Effective Date: June 1, 2012

2.4 *ASTM Standards:*

- C 125, Standard Terminology Relating to Concrete and Concrete Aggregates
- E 29 (Illinois Modified), Using Significant Digits in Test Data to Determine Conformance with Specifications

3 **TERMINOLOGY**

3.1 *Definitions:*

3.2 For definitions of terms used in this test method, refer to ASTM C 125.

4 **SIGNIFICANCE AND USE**

4.1 This test method is sufficiently accurate for usual purposes such as adjusting batch quantities of ingredients for concrete. It will generally measure the moisture in the test sample more reliably than the sample can be made to represent the aggregate supply. In rare cases where aggregate itself is altered by heat, or where more refined measurement is required, the test should be conducted using a ventilated, controlled-temperature oven.

4.2 Large particles of coarse aggregate, especially those larger than 50mm (2 in.), will require greater time for the moisture to travel from the interior of the particle to the surface. The user of this test method should determine by trial if rapid drying methods provide sufficient accuracy for the intended use when drying large-size particles.

5 **APPARATUS**

5.1 *Balance* – The balance shall have sufficient capacity, be readable to 0.1 percent of the sample mass, or better, and conform to the requirements of AASHTO M 231.

5.2 *Source of Heat* – A ventilated oven capable of maintaining the temperature surrounding the sample at $110\pm 5^{\circ}\text{C}$ ($230\pm 9^{\circ}\text{F}$). The oven shall be specifically designed for drying.

5.2.1 Where close control of the temperature is not required (see Section 4.1), other suitable sources of heat may be used such as an electric or gas hot plate, electric

ILLINOIS TEST PROCEDURE 255

TOTAL EVAPORABLE MOISTURE CONTENT OF AGGREGATE BY DRYING

Effective Date: June 1, 2012

heat lamps, or a ventilated microwave oven. A microwave oven or an electric or gas hot plate may be used only when drying a non-gradation test sample.

- 5.3 *Sample Container* – A container not affected by the heat, and of sufficient volume to contain the sample without danger of spilling, and of such shape that the depth of sample will not exceed one-fifth of the least lateral dimension.

Note 1 – Except for testing large samples, an ordinary frying pan is suitable for use with a hot plate, or any shallow flat-bottomed metal pan.

- 5.4 *Stirrer* – A metal spoon or spatula of convenient size.

6 SAMPLE

- 6.1 Sampling shall generally be accomplished in accordance with ITP 2, except the sample size may be as stated in Table 1.

Table 1 – Sample Size for Aggregate

Nominal Maximum Size of Aggregate, mm (in.) ¹	Mass of Normal Weight Aggregate Sample, Min., kg ² (lb)
4.75 (0.187) (No. 4)	0.5 (1.1)
9.5 (3/8)	1.5 (3.3)
12.5 (1/2)	2 (4.4)
19.0 (3/4)	3 (6.6)
25.0 (1)	4 (8.8)
37.5 (1 1/2)	6 (13.2)
50 (2)	8 (17.6)
63 (2 1/2)	10 (22)
75 (3)	13 (28.7)
90 (3 1/2)	16 (35.3)
100 (4)	25 (55.1)
150 (6)	50 (110.2)

¹Based on sieves meeting M 92.

²Determine the minimum sample mass for lightweight aggregate by multiplying the value listed by the dry-loose unit mass of the aggregate in kg/m³ (determined using T 19M/T 19) and dividing by 1600.

- 6.2 Field samples of aggregate shall be reduced to test sample size before testing according to ITP 248.

ILLINOIS TEST PROCEDURE 255**TOTAL EVAPORABLE MOISTURE CONTENT
OF AGGREGATE BY DRYING**

Effective Date: June 1, 2012

Test sample size for non-gradation samples shall meet the minimum test sample size in Table 1.

Test samples having a gradation and moisture content test performed shall meet the minimum requirements of Illinois Specification 201.

Test samples shall be stored in sealable, non-absorbing bags or containers prior to determining mass to start the test.

7 PROCEDURE

7.1 The test sample shall have its mass determined to the nearest 1 gram for coarse aggregate and to the nearest 0.1 gram for fine aggregate. This procedure provides the "Original Sample Mass, g" (OSM).

7.2 The test sample shall be dried back to constant mass by the selected source of heat as specified herein.

7.2.1 **Caution** – When using a microwave oven, occasionally minerals are present in aggregates that may cause material to overheat and explode. If this occurs, it can damage the microwave oven. When a gas burner or electric hot plate is used for drying, the technician shall continually attend the sample. The gas burner or electric hot plate should be operated on a low-as-needed heat to prevent popping, crackling, and/or sizzling noise from the aggregate during drying. If these noises occur, the heat must be turned down and/or the sample must be constantly stirred during drying to prevent potential aggregate particle breakdown.

7.3 Constant mass is defined as the sample at which there has not been more than a 0.5-gram mass loss during a 1 hour of drying. This should be verified occasionally.

After the test sample has been dried to constant mass, the test sample shall have its mass determined as soon as the pan or container can safely be handled to prevent additional moisture from being pulled from the air into the aggregate structure.

7.4 Determine the mass of the test sample to the nearest 1 gram for coarse aggregate and to the nearest 0.1 gram for fine aggregate. .

This procedure provides the "Total Dry Mass, g" (TDM). The TDM will also be used for calculation of gradation samples.

ILLINOIS TEST PROCEDURE 255**TOTAL EVAPORABLE MOISTURE CONTENT
OF AGGREGATE BY DRYING**

Effective Date: June 1, 2012

8 CALCULATION

8.1 The "Aggregate Moisture Content" shall be determined by using the following formula:

$$P = 100(OSM - TDM) / TDM$$

where:

P = Aggregate Moisture Content (%)

OSM = Original Sample Mass, g.

and:

TDM = Dried Sample Mass g.

Results shall be reported as required and in the appropriate plant diary.

Test results shall be rounded to the nearest 0.1 percent. All rounding shall be according to ASTM E 29 (Illinois Modified)

8.2 Surface moisture content is equal to the difference between the total evaporable moisture content and the absorption, with all values based on the mass of a dry sample. Absorption may be determined in accordance with ITP 85, Test for Specific Gravity and Absorption of Coarse Aggregate, or ITP 84, Test for Specific Gravity and Absorption of Fine Aggregate.

9 PRECISION AND BIAS

9.1 *Precision:*

9.1.2 The within-laboratory single operator standard deviation for moisture content of aggregates has been found to be 0.28 percent. Therefore, results of two properly conducted tests by the same operator in the same laboratory on the same type of aggregate sample should not differ by more than 0.79 percent from each other.

9.1.2 The between-laboratory standard deviation for moisture content of aggregates has been found to be 0.28 percent. Therefore, results of properly conducted tests from

ILLINOIS TEST PROCEDURE 255**TOTAL EVAPORABLE MOISTURE CONTENT
OF AGGREGATE BY DRYING**

Effective Date: June 1, 2012

two laboratories on the same aggregate sample should not differ by more than 0.79 percent from each other.

- 9.1.3 Test data used to derive the above precision indices were obtained from samples dried to a constant mass in a drying oven maintained at $110\pm 5^{\circ}\text{C}$. When other drying procedures are used, the precision of the results may be significantly different than that indicated above.

Illinois Test Procedure 301
Effective Date: March 1, 2005

**Fine Aggregate Moisture Content
by the Flask Method**

Reference Test Procedure(s):

1. Illinois Specification 101, Minimum Requirements for Electronic Balances
2. AASHTO M 231, Weighing Devices Used in the Testing of Materials
3. AASHTO T 2 (Illinois Modified), Sampling of Aggregates
4. AASHTO T 84 (Illinois Modified), Specific Gravity and Absorption of Fine Aggregate
5. AASHTO T 248 (Illinois Modified), Reducing Field Samples of Aggregate to Testing Size
6. ASTM E 29 (Illinois Modified), Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

To maintain brevity in the text, the following will apply:

Example: AASHTO T 2 (Illinois Modified) will be designated as "T 2."
ASTM E 29 (Illinois Modified) will be designated as "ASTM E 29."

A. FINE AGGREGATE MOISTURE CONTENT

1. GENERAL

This Illinois Test procedure was developed to replace AASHTO T 142, "Surface Moisture in Fine Aggregate," which AASHTO discontinued. The equivalent ASTM designation is C 70. The test is a convenient procedure for field determination of **free moisture** (surface moisture) of fine aggregate, if specific gravity values are known.

The accuracy of the test procedure depends upon accurate information on the bulk specific gravity of the material in a saturated surface-dry condition.

All rounding shall be according to ASTM E 29.

2. EQUIPMENT

- a. Balance – The balance or scale shall conform to M 231 and Illinois Specification 101.
- b. Flask – A suitable container or flask, preferably of glass or non-corrosive metal. The container may be a pycnometer, volumetric flask, graduated volumetric flask, or other suitable measuring device. The volume of the container shall be from two to three times the loose volume of the test sample. The container shall be so designed that it can be filled to the mark, or the volume of its contents read, within 0.5 ml or less.

3. PROCEDURE

Select a representative sample of the fine aggregate to be tested for free moisture content. The sample shall be obtained according to T 2 and T 248. Protect the sample from moisture loss until weighing. The test sample shall have a minimum mass of 200 grams. However, larger test samples will yield more accurate results. If a Chapman Flask is used, as described in Section 5, then a 500 gram test sample shall be required.

The free moisture content may be determined either by mass or by volume. In each case, the test shall be performed at a temperature range of 18 to 29 °C (65 to 85 °F).

- a. Determination by Mass—Determine the mass of the container filled with water to the known volume mark. Before placing the test sample into the container, reduce the water level to prevent the water from going over the mark when the test sample is added. Introduce the test sample into the container, and remove entrapped air. Refill the container to the mark, and determine the mass of the container and test sample. Calculate the amount of water displaced by the test sample as follows:

$$V_S = W_C + W_S - W$$

Where: V_S = Mass of Water Displaced by the Test Sample, nearest 1 gram.

W_C = Mass of Container Filled to the Mark with Water, nearest 1 gram.

W_S = Mass of Aggregate Sample, nearest 1 gram.

W = Mass of Container, Aggregate Sample, and Water Filled to the Mark, nearest 1 gram.

- b. Determination by Volume—Measure a volume of water (ml) sufficient to cover the test sample, and place in the container. Introduce the test sample into the container, and remove entrapped air.

When a graduated flask is used, determine the combined volume of the test sample and the water by direct reading. When a pycnometer or volumetric flask of known volume is used, fill the container to the known volume mark with an additional measured volume of water. The flask or pycnometer volume is then equal to the combined volume of the test sample and water. Calculate the amount of water displaced by the test sample as follows:

$$V_S = V_2 - V_1$$

Where: V_S = Volume of Water Displaced by the Test Sample, nearest 1 ml.

V_2 = Combined Volume of the Test Sample and Water, nearest 1 ml.

V_1 = Total Volume of Water in the Container Required to Cover the Test Sample and Bring the Level up to the Known Volume Mark, nearest 1 ml.

Note: 1 ml of water has the mass of 1 gram.

4. CALCULATION

a. Percentage of Free Moisture in Terms of Saturated Surface-Dry Aggregate

$$P = [(V_S - V_D) - (W_S - V_S)] \times 100$$

Where:

P = Free Moisture in Terms of Saturated Surface-Dry Fine Aggregate, nearest 0.1 percent.

V_S = Mass of Water Displaced, nearest 1 gram.

V_D = Mass of Test Sample, nearest 1 gram, Divided by the Bulk Specific Gravity of the Fine Aggregate in a Saturated Surface-Dry Condition, nearest 0.01, Determined According to T 84.

W_S = Mass of Test Sample, nearest 1 gram.

b. Percentage of Free Moisture in Terms of Dry Aggregate with Known Absorption

$$P_D = P \times \left(1 + \frac{P_A}{100}\right)$$

Where:

P_D = Free Moisture in Terms of Dry Fine Aggregate, nearest 0.1 percent.

P = Free Moisture in Terms of Saturated Surface-Dry Fine Aggregate, nearest 0.1 percent.

P_A = Absorption of the Fine Aggregate, nearest 0.1 percent, Determined According to T 84.

Total moisture content, on a dry aggregate basis, is the sum of the free moisture, P_D , and the absorption, P_A .

5. FINE AGGREGATE MOISTURE CONTENT BY THE FLASK METHOD

The Chapman Flask is graduated as discussed in Section 3b. The Chapman Flask can be used to determine the percent of free moisture (surface moisture) of fine aggregate.

For example, assume a fine aggregate with a known saturated surface-dry specific gravity (G_S) of 2.62. The Chapman Flask is filled with water to the 200 ml line, which is located between the two bulbs of the flask. A 500 gram test sample of fine aggregate is then poured into the flask, and agitated to remove any entrapped air. The flask is then placed on a level surface, and the water level is read on the neck of the flask. For this example, assume a final reading (V) of 400 ml. The percent free moisture, P , is calculated to the nearest 0.1 percent as follows:

$$P = \left(\frac{V - 200 - \frac{500}{G_s}}{700 - V} \right) \times 100$$

$$P = \left(\frac{400 - 200 - \frac{500}{2.62}}{700 - 400} \right) \times 100$$

$$P = 3.1 \text{ percent}$$

The percent of free moisture can also be determined from the following tables using the above formula. Using the values from the previous example, enter the table at the final reading from the flask (e.g. $V = 400$ ml), read horizontally to the specific gravity column desired (e.g. $G_s = 2.62$), and read the percent moisture directly as 3.1 percent.

$$\text{FORMULA USED: PERCENT FREE MOISTURE, } P = \left(\frac{V - 200 - \frac{500}{G_s}}{700 - V} \right) \times 100$$

PERCENT FREE MOISTURE, P: CHAPMAN FLASK METHOD FOR 500 GRAM TEST SAMPLE

READING FROM FLASK	G _s												
	2.70	2.69	2.68	2.67	2.66	2.65	2.64	2.63	2.62	2.61	2.60	2.59	2.58
391	1.9	1.7	1.4	1.2	1.0	0.8	0.5	0.3	0.1	0.0	0.0	0.0	0.0
392	2.2	2.0	1.8	1.5	1.3	1.1	0.8	0.6	0.4	0.1	0.0	0.0	0.0
393	2.5	2.3	2.1	1.9	1.6	1.4	1.2	0.9	0.7	0.5	0.2	0.0	0.0
394	2.9	2.7	2.4	2.2	2.0	1.7	1.5	1.3	1.0	0.8	0.6	0.3	0.0
395	3.2	3.0	2.8	2.5	2.3	2.1	1.8	1.6	1.4	1.1	0.9	0.6	0.4
396	3.6	3.3	3.1	2.9	2.6	2.4	2.2	1.9	1.7	1.5	1.2	1.0	0.7
397	3.9	3.7	3.4	3.2	3.0	2.7	2.5	2.3	2.0	1.8	1.5	1.3	1.1
398	4.2	4.0	3.8	3.5	3.3	3.1	2.8	2.6	2.4	2.1	1.9	1.6	1.4
399	4.6	4.4	4.1	3.9	3.7	3.4	3.2	3.0	2.7	2.5	2.2	2.0	1.7
400	4.9	4.7	4.5	4.2	4.0	3.8	3.3	3.3	3.1	2.8	2.6	2.3	2.1
401	5.3	5.1	4.8	4.6	4.4	4.1	3.7	3.7	3.4	3.2	2.9	2.7	2.4
402	5.6	5.4	5.2	4.9	4.7	4.5	4.0	4.0	3.7	3.5	3.3	3.0	2.8

$$\text{FORMULA USED: PERCENT FREE MOISTURE, } P = \left(\frac{V - 200 - \frac{500}{G_s}}{700 - V} \right) \times 100$$

PERCENT FREE MOISTURE, P: CHAPMAN FLASK METHOD FOR 500 GRAM TEST SAMPLE

READING FROM FLASK	G _s												
	2.70	2.69	2.68	2.67	2.66	2.65	2.64	2.63	2.62	2.61	2.60	2.59	2.58
403	6.0	5.8	5.5	5.3	5.1	4.8	4.6	4.3	4.1	3.8	3.6	3.4	3.1
404	6.4	6.1	5.9	5.7	5.4	5.0	4.9	4.7	4.4	4.2	4.0	3.7	3.5
405	6.7	6.5	6.2	6.0	5.8	5.5	5.3	5.1	4.8	4.6	4.3	4.1	3.8
406	7.1	6.8	6.6	6.4	6.1	5.9	5.6	5.4	5.2	4.9	4.7	4.4	4.1
407	7.4	7.2	7.0	6.7	6.5	6.3	6.0	5.8	5.5	5.3	5.0	4.8	4.5
408	7.8	7.6	7.3	7.1	6.9	6.6	6.4	6.1	5.9	5.6	5.4	5.1	4.9
409	8.2	7.9	7.7	7.5	7.2	7.0	6.7	6.5	6.2	6.0	5.7	5.5	5.2
410	8.6	8.3	8.1	7.8	7.6	7.4	7.1	6.9	6.6	6.4	6.1	5.8	5.6
411	8.9	8.7	8.4	8.2	8.0	7.7	7.5	7.2	7.0	6.7	6.5	6.2	6.0
412	9.3	9.1	8.8	8.6	8.3	8.1	7.8	7.6	7.3	7.1	6.8	6.6	6.3
413	9.7	9.4	9.2	9.0	8.7	8.5	8.2	8.0	7.7	7.5	7.2	7.0	6.7
414										7.8	7.6	7.3	7.1

Illinois Test Procedure 302

Effective Date: April 1, 2008

**Aggregate Specific Gravity and
Moisture Content by the Dunagan Method**

Reference Test Procedure(s):

1. Illinois Specification 101, Minimum Requirements for Electronic Balances
2. AASHTO M 231, Weighing Devices Used in the Testing of Materials
3. AASHTO T 2 (Illinois Modified), Sampling of Aggregates
4. AASHTO T 84 (Illinois Modified), Specific Gravity and Absorption of Fine Aggregate
5. AASHTO T 85 (Illinois Modified), Specific Gravity and Absorption of Coarse Aggregate
6. AASHTO T 248 (Illinois Modified), Reducing Field Samples of Aggregate to Testing Size
7. ASTM E 29 (Illinois Modified), Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

To maintain brevity in the text, the following will apply:

Example: AASHTO T 2 (Illinois Modified) will be designated as "T 2."

ASTM E 29 (Illinois Modified) will be designated as "ASTM E 29."

A. SPECIFIC GRAVITY – DUNAGAN METHOD**1. GENERAL**

The specific gravity is determined, as specified by the Department, according to T 84 and T 85.

The Dunagan apparatus (specific gravity and moisture determinator) developed by Professor W.M. Dunagan is used as a convenient method for checking the specific gravity and moisture content of aggregate in the field.

All rounding shall be according to ASTM E 29.

2. EQUIPMENT

The Dunagan apparatus is a specially designed balance for determining an aggregate sample's mass in water and in air. As an alternative to acquiring a Dunagan apparatus kit, a homemade Dunagan apparatus can be assembled by acquiring the following equipment:

- a. Electronic Balance – The electronic balance shall conform to M 231 and Illinois Specification 101. The electronic balance shall have a weight below hook.
- b. Tank – The tank shall be made of non-corrosive material, and shall have an overflow spout. The tank shall be of sufficient size for the pail. The pail shall not touch the bottom or sides of the tank when submerged in the water held by the tank.

- c. Pail – The pail shall be made of non-corrosive material, and shall be of sufficient size to hold the aggregate sample.
- d. Stand – The stand shall be able to support the weighing operation. To allow for the balance's weigh below hook, a hole is required in the center of the stand. The stand shall have sufficient height to easily remove the submerged pail from the tank.

3. PROCEDURE FOR MASS OF AGGREGATE SAMPLE IN WATER

- Dunagan Apparatus Kit

The equipment is set up as illustrated in Figure 1. Fill tank "A" with water up to the overflow spout "B". The empty pail "C" is immersed in water and suspended from the balance. Place a clean, dry scoop "D" on the right hand scale pan and adjust the scales to balance. To perform the initial balance, it may be necessary to add washers on the left hanger "E" to act as counterweights. Thereafter, the final adjustment may be performed with the calibration screw on the balance.

Remove the pail from the tank. Partially fill the pail with water taken from the tank, and slowly pour the sample into the pail. Pouring the sample into the water will prevent the entrapping of air with the sample. The submerged sample shall be stirred to dislodge entrapped air. If material clings to the inside of the scoop, place the scoop in the mouth of the pail and rinse with the water. Then slowly immerse the pail obliquely into the tank, allowing water to flow slowly over one side of the pail. This immersion should be done carefully to prevent material from washing out of the pail. Suspend the pail from the end of the left hanger. If necessary, add water to the tank to bring the water level up to the overflow spout. Permit any excess water to overflow. Obtain the immersed mass, by placing weights in the scoop and adjusting the rider.

- Homemade Dunagan Apparatus

Fill the tank with water up to the overflow spout. The empty pail is immersed in water, and suspended from the end of the electronic balance weigh below hook. Tare the electronic balance.

Remove the pail from the tank. Partially fill the pail with water taken from the tank, and slowly pour the sample into the pail. Pouring the sample into the water will prevent the entrapping of air with the sample. The submerged sample shall be stirred to dislodge entrapped air. If material clings to the inside of the scoop, place the scoop in the mouth of the pail and rinse with the water. Then slowly immerse the pail obliquely into the tank, allowing water to flow slowly over one side of the pail. This immersion should be done carefully to prevent material from washing out of the pail. Suspend the pail from the end of the electronic balance weigh below hook. If necessary, add water to the tank to bring the water level up to the overflow spout. Permit any excess water to overflow. Obtain the immersed mass.

4. PROCEDURE FOR MASS OF AGGREGATE SAMPLE IN AIR

- Dunagan Apparatus Kit – Whole Number Kilograms

The Dunagan apparatus can be used to measure samples in whole number kilograms. This is convenient when the specified sample size is 1, 2, or 3 kilograms, as in Sections A.5., A.6., B.2., and B.3. The equipment is set up as illustrated in Figure 1. Adjust the scales to balance evenly as explained in the first paragraph of Section A.3 “Dunagan Apparatus Kit.” Place the slotted kilogram weights on the left hanger, and pour enough material into the scoop to balance the scales.

- Dunagan Apparatus Kit – Fractional Kilograms

The Dunagan apparatus can be converted to a balance which measures samples in fractional kilograms, such as 1.5 kilograms. This is convenient if an electronic balance is not required by specifications; or if the slotted kilogram weights discussed in “Dunagan Apparatus Kit – Whole Number Kilograms” are not available.

The equipment is set up as illustrated in Figure 2. Be advised that the pans are not interchangeable, and should be marked “L” and “S” respectively. “L” designates the pan for the long stirrup, and “S” is the pan which has been balanced for the short stirrup.

Place a clean, dry scoop “D” on the left hand scale pan and adjust the scales to balance evenly. To perform the initial balance, it may be necessary to use a counterweight constructed from a can and shot. Thereafter, the final adjustment may be performed with the calibration screw on the balance.

Place the sample in the scoop. Determine the sample mass by placing weights in the short stirrup pan, and adjusting the rider. The scale can measure to the nearest 0.1 gram.

- Homemade Dunagan Apparatus

Determine the sample mass by weighing on top of the electronic balance.

5. COARSE AGGREGATE SPECIFIC GRAVITY

The specific gravity of saturated surface-dry coarse aggregate is determined as follows:

- Select a representative sample of the coarse aggregate to be tested. The sample shall be obtained according to T 2 and T 248.
- Measure approximately 3,000 grams of coarse aggregate sample per Section A.4. Soak the sample in water for 24 hours. Surface-dry the sample to a saturated condition according to T 85.
- Measure a 2,000 gram test sample per Section A.4.
- Determine the mass of the immersed test sample to the nearest 1 gram per Section A.3. This mass will be designated “W” for the test sample.

- Calculate the saturated surface-dry specific gravity of the coarse aggregate as follows:

$$G_s = \frac{2000}{2000 - W}$$

Or per Figure 3, which is the simpler method to use. To determine G_s from Figure 3:

- Start at a point which corresponds to the immersed mass (submerged weight) “W” of the test sample.
- Project this point horizontally until it intersects the vertical line of zero free moisture, and determine the specific gravity, G_s , by interpolation, to the nearest 0.01.

As an example: Suppose “W” for a 2,000 gram test sample is 1,230 grams. Projecting this point horizontally to intersect the line of zero free moisture, it is found that G_s is approximately 2.60.

6. FINE AGGREGATE SPECIFIC GRAVITY

To determine the specific gravity of saturated surface-dry fine aggregate, the test is identical to coarse aggregate, except as follows:

- After soaking, spread a sample of 2,300 grams or more on a flat surface, and air dry until the surface moisture has evaporated. Do not heat the sample to speed the process. The saturated surface-dry condition is reached when the material will roll freely from a scoop or trowel without sticking.
- Measure a 1,000 gram test sample per Section A.4.
- Calculate the saturated surface-dry specific gravity of the fine aggregate as follows:

$$G_s = \frac{1000}{1000 - W}$$

Or per Figure 3, which is the simpler method to use.

B. MOISTURE CONTENT DETERMINATION – DUNAGAN METHOD

1. GENERAL

The test for free moisture or absorption is based upon a given sample of material (not in the saturated surface-dry condition) which will measure, when immersed in water, less or more than a sample of the same mass of material in the saturated surface-dry condition. This depends upon whether it contains free moisture or will absorb moisture.

For conducting this test, the equipment is set up as illustrated in Figure 1.

All rounding shall be according to ASTM E 29.

2. COARSE AGGEGATE MOISTURE CONTENT

To determine the free moisture or absorption of a sample of coarse aggregate, the test is conducted in the following manner:

- Select a representative sample of the coarse aggregate to be tested. The sample shall be obtained according to T 2 and T 248. Protect the sample from moisture loss until weighing.
- Measure a 2,000 gram test sample, as per Section A.4.
- Determine the mass of the immersed test sample to the nearest 1 gram. The immersed mass is obtained as per Section A.3., except the test sample shall remain in the pail for 10 minutes. This mass will be designated “W₁” for the test sample.
- If “W₁” is less than the “W” determined per Section A.5, the aggregate contains free moisture; if “W₁” is greater than “W,” the aggregate will absorb moisture. The percentage of free moisture or absorption is determined by one of the following formulae:

$$\text{Free Moisture (percent)} = \frac{0.05G_s \times (W - W_1)}{G_s - 1}$$

$$\text{Absorption (percent)} = \frac{0.05G_s \times (W - W_1)}{0.8G_s - 1}$$

NOTE: G_S is the saturated surface-dry specific gravity of the coarse aggregate.

The factor, 0.8, is based on the assumption that the sample will become 80% saturated in 10 minutes.

The simpler method is to use Figure 3 and the immersed mass (submerged weight) “W₁.” To determine the moisture content from Figure 3:

- Start at a point which corresponds to the immersed mass (submerged weight) “W₁” of the test sample.
- Project this point horizontally, until it intersects the line corresponding to the specific gravity of the aggregate, G_S.
- Project this point of intersection vertically and read the percentage of free moisture or absorption from the scale, at the bottom of the chart to the nearest 0.1. The value is interpolated.

As an example: Suppose G_S for the test sample is 2.56, and “W₁” is 1,170 grams. The vertical projection of the point of intersection of the line (representing these values) shows a free moisture content of approximately 4.0 percent.

3. FINE AGGREGATE MOISTURE CONTENT

To determine the free moisture or absorption of fine aggregate the test is identical to coarse aggregate. However, measure a 1,000 gram test sample and use one of the following formulae:

$$\text{Free Moisture (percent)} = \frac{0.1G_s \times (W - W_1)}{G_s - 1}$$

$$\text{Absorption (percent)} = \frac{0.1G_s \times (W - W_1)}{0.8G_s - 1}$$

NOTE: G_s is the saturated surface-dry specific gravity of the fine aggregate.

Again, the simpler method is to use Figure 3 for a 1,000 gram test sample.

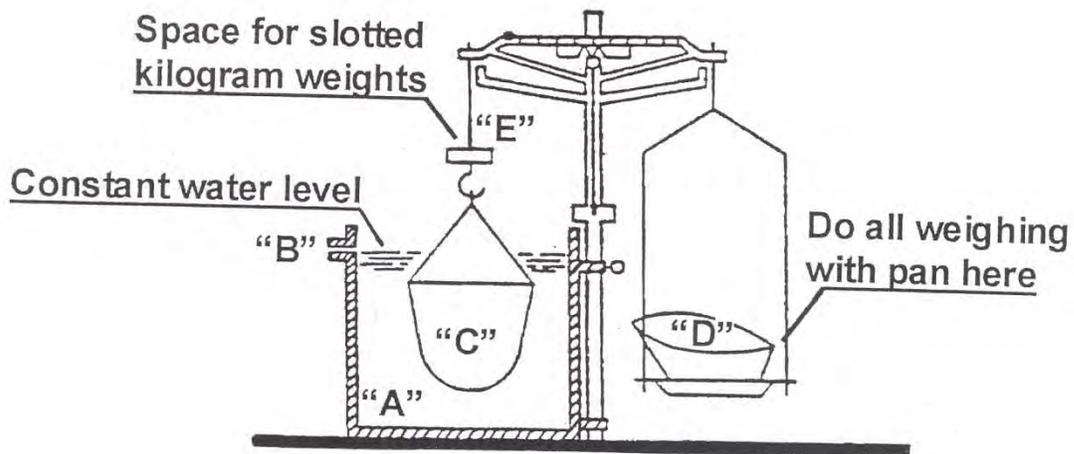


FIGURE 1

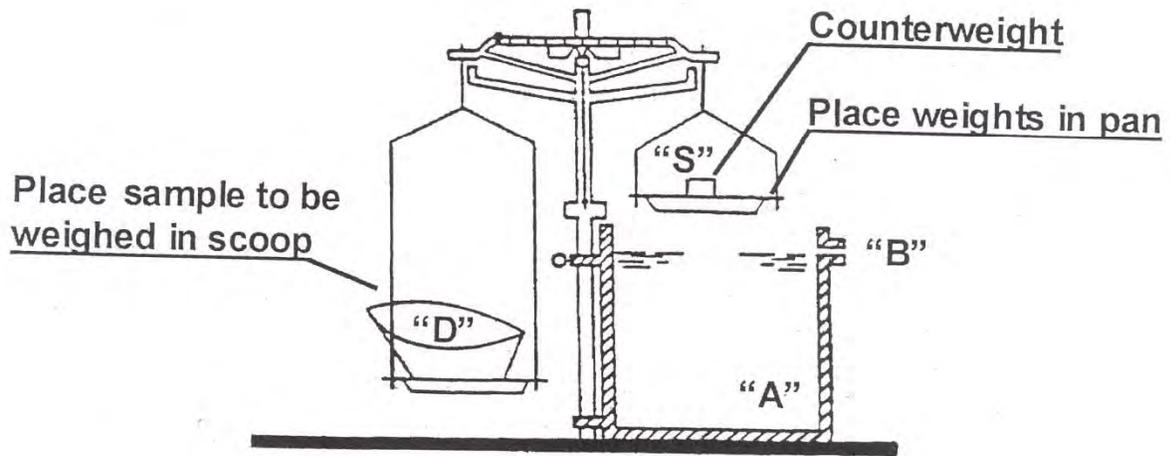
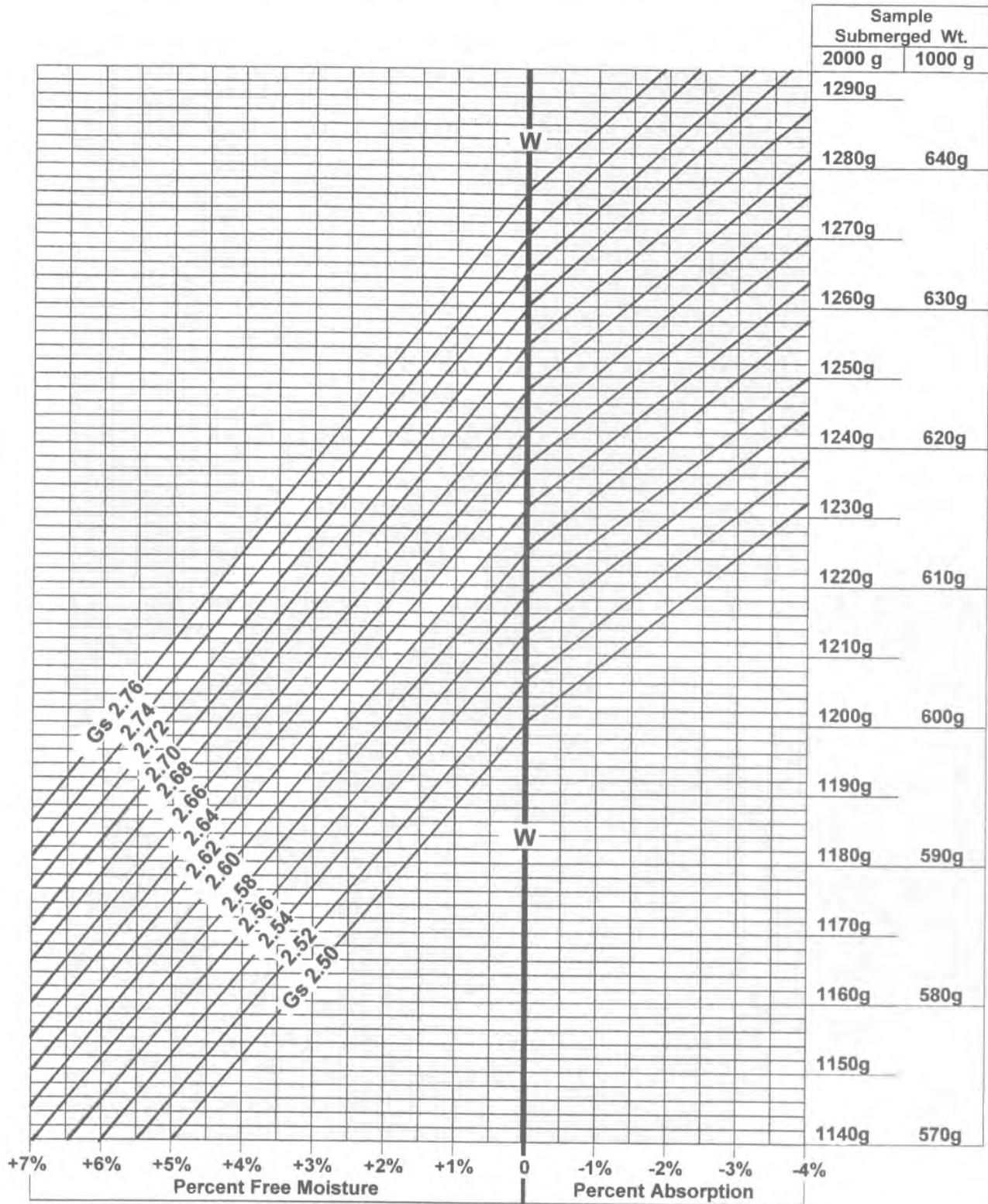


FIGURE 2

Figure 3
Chart for Determining Specific Gravity and Free Moisture or Absorption for either 1000 or 2000 Gram Samples Tested in the Specific Gravity and Moisture Determinator



Illinois Test Procedure 303
Effective Date: April 1, 2009

Fine or Coarse Aggregate Moisture Content by Pycnometer Jar Method

Reference Test Procedure(s):

1. Illinois Specification 101, Minimum Requirements for Electronic Balances
2. AASHTO M 231, Weighing Devices Used in the Testing of Materials
3. AASHTO T 2 (Illinois Modified), Sampling of Aggregates
4. AASHTO T 248 (Illinois Modified), Reducing Field Samples of Aggregate to Testing Size
5. ASTM E 29 (Illinois Modified), Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

To maintain brevity in the text, the following will apply:

Example: AASHTO T 2 (Illinois Modified) will be designated as "T 2."
ASTM E 29 (Illinois Modified) will be designated as "ASTM E 29."

A. FINE OR COARSE AGGREGATE MOISTURE CONTENT

1. GENERAL

This Illinois Test procedure has been used for many years by District 2 (Dixon), but the District is uncertain as to the origin of the test. However, this test is similar to a test procedure used by the Iowa Department of Transportation. The test is a convenient procedure for field determination of **free moisture** (surface moisture) of fine or coarse aggregate, if specific gravity values are known.

The accuracy of the test procedure depends upon accurate information on the bulk specific gravity of the material in a saturated surface-dry condition.

All rounding shall be according to ASTM E 29.

2. EQUIPMENT

- a. Balance – The balance or scale shall conform to AASHTO M 231 and Illinois Specification 101.
- b. Pycnometer – A glass jar, gasket, and conical pycnometer top. A 0.946 L (1 qt.) jar is used for fine aggregate, and a 1.892 L (2 qt.) jar is used for coarse aggregate. Typically, a canning jar is used.
- c. Funnel – A conical shape utensil which can be of any type of material. The funnel shall be of sufficient size for placement on top of the glass jar.

3. MATERIALS

- a. Potable Water
- b. Water Resistant Grease
- c. Aggregate Sample

4. PROCEDURE

Select a representative sample of the fine or coarse aggregate to be tested for free moisture content. The sample shall be obtained according to T 2 and T 248. Protect the sample from moisture loss until weighing.

a. Mass of Pycnometer Filled with Water

- Apply a light coat of grease to the side of the gasket which will be in contact with the glass jar.
- Screw the pycnometer top tightly on the glass jar.
- Place a mark on the pycnometer top and glass jar to indicate the position of the tightened top. Always tighten the pycnometer top to this position. If the pycnometer top is ever tightened beyond the mark on the glass jar, re-mark the top of the jar.
- Fill the glass jar nearly full of water and screw on the pycnometer top. Finish filling the pycnometer by pouring water until a bead of water appears above the top's opening.
- Wipe off all exterior water on the pycnometer, and then weigh to the nearest 1 gram. Record the value as M_1 .

b. Mass of Aggregate Sample

- When testing fine aggregate, measure a 1000 gram test sample.
- When testing coarse aggregate, measure a 2000 gram test sample.

c. Mass of Pycnometer Filled with Water and Aggregate

- Use the funnel to pour the aggregate sample into the glass jar. The jar shall contain approximately 50 mm (2 in.) of water.
- Fill the glass jar nearly full of water, and screw on the pycnometer top to the marked position. The water temperature shall be within ± 1.7 °C (3 °F) of the water used for calibrating the pycnometer. Finish filling the pycnometer.
- Place a finger over the pycnometer top opening, and gently roll and shake the pycnometer several times to remove entrapped air in the aggregate sample. When further rolling and shaking brings no more air bubbles to the top, finish filling the pycnometer. The pycnometer is filled when a bead of water appears above the top's opening.
- Wipe off all exterior water on the pycnometer, and then weigh to the nearest 1 gram. Record the value as M_2 .

5. CALCULATION

a. Mass of Water Displaced by the Aggregate Sample

$$V_S = M_1 + M_S - M_2$$

Where:

V_S = Mass of Water Displaced by the Aggregate Sample, nearest 1 gram.

M_1 = Mass of Pycnometer Filled with Water, nearest 1 gram.

M_S = Mass of Aggregate Sample (1000 grams for fine aggregate and 2000 grams for coarse aggregate).

M_2 = Mass of Pycnometer Filled with Water and Aggregate, nearest 1 gram.

b. Moisture Content

Calculate moisture content to the nearest 0.1 percent using the following equations:

$$\text{Fine Aggregate Free Moisture (percent)} = \frac{V_S - (1000 \div G_S)}{1000 - V_S} \times 100$$

$$\text{Coarse Aggregate Free Moisture (percent)} = \frac{V_S - (2000 \div G_S)}{2000 - V_S} \times 100$$

Where:

V_S = Mass of Water Displaced by the Aggregate Sample, nearest 1 gram.

G_S = Saturated Surface-Dry Specific Gravity of Aggregate, nearest 0.01.



**Aggregate Moisture Worksheet
Pycnometer Jar Method**

Date: (mm/dd/yyyy) _____
 Producer No.: _____
 Producer Name: _____
 Location: _____

	Coarse Aggregate	Fine Aggregate
1. Aggregate Specific Gravity at Saturated Surface-Dry (SSD).....	<input type="text"/>	<input type="text"/>
2. Sample Size, g.....	2000	1000
3. Sample Size ÷ Specific Gravity..... Line 2 ÷ Line 1	<input type="text"/>	<input type="text"/>
4. Mass of pycnometer full of water, g.....	<input type="text"/>	<input type="text"/>
5. Mass of pycnometer containing sample and water, g.....	<input type="text"/>	<input type="text"/>
6. Mass of water displaced by sample, g..... Line 2 + Line 4 - Line 5	<input type="text"/>	<input type="text"/>
7. Difference, g..... Line 6 - Line 3	<input type="text"/>	<input type="text"/>
8. Sample Size minus water displaced, g..... Line 2 - Line 6	<input type="text"/>	<input type="text"/>
9. Percent Surface Moisture, <i>P</i> , +/- % Line 7 ÷ Line 8 × 100	<input style="border: 2px solid black;" type="text"/>	<input style="border: 2px solid black;" type="text"/>

Coarse Aggregate Surface Moisture,
$$P = \left[\frac{V_s - (2000/G_s)}{2000 - V_s} \right] \times 100$$

Fine Aggregate Surface Moisture,
$$P = \left[\frac{V_s - (1000/G_s)}{1000 - V_s} \right] \times 100$$

Where: *P* is the surface moisture, to the nearest 0.1 %
V_s is the mass of water displaced by the aggregate sample, to the nearest 1 g
G_s is the aggregate specific gravity at saturated surface-dry, to the nearest 0.01

Effective Date: 03/10/09 BMPR PCCW02

Appendix J



**Illinois Department
of Transportation**

Water/Cement Ratio Worksheet

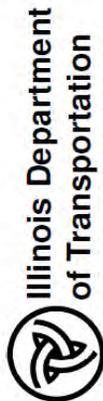
Date: (mm/dd/yyyy) _____	Ticket No.: _____
Producer No.: _____	Contract No.: _____
Producer Name: _____	Contractor Name: _____
Mix Design No.: _____	Resident Engineer: _____
PCC Level II: _____	Level II Employer: _____
Department Inspector at Plant: _____	Inspector Employer: _____

1. Total Cement plus Finely Divided Minerals*, lb/yd³ (kg/m³) lb/yd³ (kg/m³)
* Fly Ash, Ground Granulated Blast-Furnace Slag, Microsilica, High Reactivity Metakaolin
2. Maximum water/cement ratio
3. Maximum Allowable Water, gal/yd³ (L/m³) gal/yd³ (L/m³)
English: (Line 1 × Line 2) ÷ 8.33
 Metric: Line 1 × Line 2
4. Batch Size, yd³ (m³)..... yd³ (m³)
5. Water in Fine Aggregate per Batch, gal (L)..... gal (L)
English: {[(%FA Moisture ÷ 100) × FA lb/yd³] × Line 4} ÷ 8.33
 Metric: [(%FA Moisture ÷ 100) × FA kg/m³] × Line 4
 Moisture can be positive (+, excess water) or negative (-, short water)
6. Water in Coarse Aggregate per Batch, gal (L) gal (L)
English: {[(%CA Moisture ÷ 100) × CA lb/yd³] × Line 4} ÷ 8.33
 Metric: [(%CA Moisture ÷ 100) × CA kg/m³] × Line 4
 Moisture can be positive (+, excess water) or negative (-, short water)
7. Water in Admixtures per Batch, gal (L) gal (L)
English: {[0.7(d₁ + d₂ + d₃ + ...) × (Line 1 ÷ 100)] ÷ 128} × Line 4
 Metric: {[0.7(d₁ + d₂ + d₃ + ...) × (Line 1 ÷ 100)] ÷ 1000} × Line 4
 Where d₁, d₂, d₃, etc. is the dosage rate, oz/cwt (ml/100 kg), of each admixture.
 Note: 0.7 is the admixture water content factor. Use 0.5 for latex admixtures.
8. Plant Water per Batch, gal (L) gal (L)
(Design Water Requirement, gal (L) × Line 4) - (Line 5 + Line 6 + Line 7)
9. Wash Water in Truck per Batch, gal (L) 0.0 gal (L)
Truck mixer shall discharge all wash water.
10. Total Water in Batch, gal (L)..... gal (L)
Line 5 + Line 6 + Line 7 + Line 8 + Line 9
11. Maximum Water Allowed per Batch, gal (L)..... gal (L)
Line 3 × Line 4
12. Maximum Additional Water Allowed per Batch, gal (L)..... gal (L)
Line 11 - Line 10
13. Water Added to Batch at Jobsite, gal (L) gal (L)
14. Water in Admixture(s) Added to Batch at Jobsite, gal (L) gal (L)
Refer to Line 7 for calculation.
15. Total Water in Batch at Jobsite, gal (L) gal (L)
Line 10 + Line 13 + Line 14

Effective Date: 12/01/11 BMRP PCCW01

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APPENDIX K



Field / Lab Gradations

Inspector No.(2) _____ Inspector Name(3) _____ I.D. Number(1) _____
 Mix Plant No.(6) _____ Mix Plant Name(7) _____ Date Sampled(4) _____ Seq. No.(5) _____
 Responsible Loc.(10) _____ Lab(11) _____ Lab Name(12) _____ *Contract No.(8) _____ *Job No.(9) _____

Source Name(13) _____

Source(14)	Mat. Code # (15)	Type Test(16)	Insp. Qty(18)	Spec.(19)	Article(20)	Sampled From(21)	Wash/Dry(22)
CA 75 (3) or FA 6.3 (1/4)	50 (2) 25 (1)	45 (1.75) 9.5 (3/8)	37.5 (1.5) 4.75 (4)	25 (1) 2.36 (8)	19 (3/4) 2 (10)	16 (5/8) 1.18 (16)	12.5 (1/2) 0.6 (30)
						9.5 (3/8) 0.425 (40)	0.3 (50) 0.15 (100)
						2.36 (8)	0.6 (30)
						4.75 (4)	0.3 (50)
						1.18 (16)	0.15 (100)
						0.18 (80)	0.075 (200)

Wash - 0.075(24) PI Ratio(25) _____ Test Results(26) _____ Remarks(27) _____

Sieve	Indiv. Wt. Retained(28)	Cumul. Wt. Retained(29)	Cumul. % Retained(30)	Percent % Passing(31)	Spec. Range % Passing(32)
CA					
63 (2.5)					
50 (2)					
45 (1.75)					
37.5 (1.5)					
25 (1)					
19 (3/4)					
16 (5/8)					
12.5 (1/2)					
9.5 (3/8)					
6.3 (1/4)					
4.75 (#4)					
2.36 (#8)					
1.18 (#16)					
0.6 (#30)					
0.425 (#40)					
0.3 (#50)					
0.15 (#100)					
0.075 (#200)					
Pan					
Total Dry Wt.(33)					
Total Washed Wt.(34)					
Diff. -0.075(-200)(35)					
			% Washed - 0.075(36)		

Sampled From Codes	
BR Barge	RD Road
BE Belt Siream	SI Silo/Bin
CF Cold Feed	SP Stockpile
HB Hot Bin	TD Truck Dump
OB On Belt (Stopped)	TK Truck
PR Production	WB Weigh Belt
CR Rail Car	

0.075 (37) 0.425 (38)
 (Mix Plant Only)
 Lot(38) _____
 Bin(39) _____

Copies(40): _____
 Tester(41) _____
 Agency(42) _____

MISTIC INPUT
 Date Entered(43) _____
 Initials(44) _____

FIELD/LAB GRADATIONS

INSTRUCTIONS

BMPR MI504

1. **I.D. NUMBER:** MISTIC test identification number. Leave blank because the MISTIC system will generate the test identification number.
2. **INSPECTOR NO.:** Identify the individual who took the sample. For split samples, the same inspector number should be used for both halves of the sample.
 - a) IDOT personnel enter their MISTIC inspector number.
 - b) Contractor, Subcontractor and Producer personnel enter a "9", followed by the District number and seven zeroes (0's).
Example: 960000000 for District 6.
 - c) Consultant personnel enter their company's MISTIC inspector number.
 - d) Local agency personnel enter a "9"; followed by the District number, which is repeated until field is filled.
Example: 966666666 for District 6 local agency.
3. **INSPECTOR NAME:** Enter the name of the inspector who took the sample.
4. **DATE SAMPLED:** Enter the date the sample was taken as month, day, and year in mmddyy format. Example: 103112
5. **SEQ. NO.:** Sequence number. Enter any combination of letters and/or numbers up to 6 characters in length. It is used to differentiate multiple samples of the same gradation, taken on the same day. For a split sample, both halves of the split shall have "**SPLIT**" in this field.
6. **MIX PLANT NO.:** Enter the MISTIC code number for the Concrete or Hot Mix Asphalt Producer. Only one plant may be shown on one report.
7. **MIX PLANT NAME:** Enter the name of mix plant.
8. **CONTRACT NO.:** Leave blank unless the gradation has been sampled at a jobsite for a specific contract. Enter the 5 digit contract number. If it is a local agency contract without a 5 digit number, then enter the 16 or 17 character MFT (Motor Fuel Tax) contract number.
9. **JOB NO.:** Leave blank unless gradation sampled at the jobsite for a specific contract. Enter the 8 character number that corresponds with the 5 digit contract number. If the contract number is not 5 digits, leave this field blank.
10. **RESPONSIBLE LOC.:** Enter the District identification number as a "9" followed by the District number. Example: 96 for District 6
11. **LAB:** Enter the 2 letter MISTIC lab code.

Laboratory LocationsMISTIC Lab Codes

Producer Plant Site Laboratory	PP
Producer NonPlant Site Laboratory	PL
Producer Construction Site	PC
Producer Quarry Laboratory	PQ
Independent Plant Site Laboratory	IP
Independent NonPlant Site Laboratory	IL
Independent Construction Site	IC
Independent Quarry Laboratory	IQ
Independent Laboratory	IN
IDOT/Local Agency Plant Site Laboratory	FP
IDOT/Local Agency Construction Site	FC
IDOT/Local Agency Quarry Laboratory	FQ
District Laboratory	DI
District Satellite Laboratory	DS

NOTE: A Contractor, Subcontractor, and Producer are to use one of the “Producer” lab codes. An IDOT Consultant, Contractor Consultant, Subcontractor Consultant, and Producer Consultant are to use one of the “Independent” lab codes.

12. **LAB NAME:** Enter the name of the company which cannot exceed 20 characters.
13. **SOURCE NAME:** Enter the name of the aggregate producer.
14. **SOURCE:** Enter the MISTIC code number of the aggregate producer.
Example: 50912-02
15. **MAT. CODE # :** Material code for the aggregate product. Enter the 8 to 10 character code number of the material being tested.

The following information will help you determine if you have the correct material code number.

- The first space is a “0” to indicate the material is an aggregate.
- The second space indicates the QUALITY LEVEL of the aggregate. Concrete coarse and fine aggregates are always “A” quality. Cement aggregate mixture II coarse aggregate is “D” quality “stabilized,” and fine aggregate is “A” quality.

Controlled low-strength material fine aggregate is “A” quality, unless alternate fine aggregate materials are used. Hot mix asphalt surface coarse and fine aggregates are generally “B” quality. Hot mix asphalt binder coarse aggregates are generally “C” quality and fine aggregates are “B” quality. (see below).

- The third space indicates the Type of Material (see below).
- The fourth space indicates the Aggregate Type (see below).
- The fifth space indicates the Specification of the aggregate (see below).
- The sixth space may be a “M” to indicate **Metric**.
- The seventh and eighth spaces are the Gradation Number of the aggregate. See Articles 1003.01(c) and 1004.01(c) of the Standard Specifications.
- The ninth and tenth spaces indicate superstructure quality aggregate for concrete use. Always enter “01” if testing superstructure quality aggregate.

<u>QUALITY LEVEL</u>	<u>TYPE OF MATERIAL</u>	<u>AGGREGATE TYPE</u>
0 & 1 Have No Quality	0 = Gravel	C = Coarse Aggregate
2 = A Quality	1 = Crushed Gravel	F = Fine Aggregate
3 = B Quality	2 = Crushed Stone	
4 = C Quality	3 = ACBF Slag	
5 = D Quality	5 = Recycled	
6 = D Quality Stabilized	7 = Natural Sand	
	8 = Stone Sand	
	9 = Special Aggregate	

SPECIFICATION

A = Standard Specification
M = Modified or QC/QA Specification

16. **TYPE INSP:** Type of inspection (see below). For additional information see Attachment 4 in the Project Procedures Guide.

<u>AGENCY</u>	<u>QC/QA</u>	<u>NON QC/QA</u>
Contractor/Producer/ Consultant	PRO	-----
_____ IDOT/Consultant at Aggregate Source	IND (split), INV	PRO
_____ IDOT/Consultant at Mix Plant	IND (split), INV	IND (split-share), INV

17. **ORIG. I.D. #:** Original identification number. Use for resample tests only. Enter the original MISTIC test identification number of the failing test.
18. **INSP. QTY.:** Inspected Quantity. Leave blank. IDOT personnel may enter the quantity that is represented by the gradation test but it is not required.

19. **SPEC.:** Specification. Leave blank. IDOT aggregate personnel should enter the master band ranges under a “PRE” test at the beginning of each production season.
Example: MB2036
20. **ARTICLE:** Leave blank. IDOT aggregate personnel should enter the warning band ranges under a “PRE” test at the beginning of each production season.
Example: WB2234
21. **SAMPLED FROM:** Enter the 2 character designation in the first two spaces. Refer to “Sampled From Codes” box, which is on the form.
22. **WASH/DRY:** Enter a “W” for a washed gradation, or “D” for a dry gradation.
23. **GRADATION RESULTS INPUT TABLE:** Enter the percent passing test results, “percent % passing”, from the calculation table for all sieves. All test results shall be reported to the nearest 1%, except for the 0.075 mm (or 75µm) sieve, which shall be reported to the nearest 0.1%.
24. **WASH - 0.075:** Enter the washed minus .075 mm value from the calculation table to the nearest 0.1%.
25. **PI RATIO:** Plasticity index ratio. Leave blank. IDOT personnel, when appropriate, should enter the PI ratio value.
26. **TEST RESULTS:** Enter “APPR” for results meeting specifications or “FAIL” for failure to meet specifications. Show under “Remarks” action taken for samples not meeting specifications. For example, retest, checked equipment, test method incorrect, will monitor.
27. **REMARKS:** This space should be used to record any comments about the aggregates, or the stockpiling and handling methods used.

For “IND” inspection, a comparison remark is required, because the assurance test is from a split sample. For an acceptable comparison, enter the following:

- Enter “C” when tests compare within acceptable limits of precision.
- Enter date of comparison.
- Enter initials for “IND” inspector.
- If the sample was witnessed by the “IND” inspector, indicate as “ws.”
- Example: C - 100197 TCS ws.

For an unacceptable comparison, enter the following:

- Enter “X” when tests do not compare within acceptable limits of precision.
- Enter date of comparison.
- Enter initials for “IND” inspector.
- If the sample was witnessed by the “IND” inspector, indicate as “ws.”

- Explain reason for unacceptable comparison.
 - Examples are: Producer obtained sample incorrectly; IDOT equipment required repair; Producer performed test method incorrectly; problem was not identified, will investigate further if problem continues.
 - Example: X - 100297 TCS ws Producer performed test method incorrectly.
28. **INDIV. WT. RETAINED:** Enter the weight of aggregate on each sieve individually, starting with the largest sieve first. Weigh coarse aggregate to the nearest 1 gram, and fine aggregate to the nearest 0.1 gram. If the sieve was overloaded and split into two or more portions to hand sieve, then write a "S" outside the table on that row (right or left side).
29. **CUMUL. WT. RETAINED:** Cumulative Weight Retained. Add the weight on each sieve, to the weight on any larger sieve(s), and enter that value.
30. **CUMUL. % RETAINED:** Cumulative Percent Retained. Divide the cumulative weight retained by the total dry weight, and multiply by 100, for each sieve. Round to the nearest 0.1%, and enter that value.
31. **PERCENT % PASSING:** Subtract the cumulative percent retained, from 100, for each sieve. Record to nearest 0.1%, and enter that value.
32. **SPEC. RANGE % PASSING:** Enter the specification range for all appropriate sieves. These may be from a Standard Specification, a modified Standard Specification, or a master band limit.
33. **TOTAL DRY WT.:** Enter the weight of the sample after it has been dried to a constant weight. Weigh coarse aggregate to the nearest 1 gram, and fine aggregate to the nearest 0.1 gram.
34. **TOTAL WASHED WT.:** Enter the weight of the sample after it has been washed, and dried back to a constant weight. Weigh coarse aggregate to the nearest 1 gram, and fine aggregate to the nearest 0.1 gram.
35. **DIFF. -0.075 (-200):** Subtract total washed weight from the total dry weight, and enter that value.
36. **% WASHED -0.075:** Divide the "Diff. - 0.075" by the "Total Dry Wt." and multiply by 100. Round to the nearest 0.1%, and enter that value.
37. **0.075 / 0.425:** Leave blank. IDOT personnel , when appropriate, enter the ratio of the percent passing the .075 mm (#200) sieve and the .425 mm (#40) sieve.
38. **LOT:** Leave blank. IDOT mix plant personnel use if performing individual hot bin "IND" tests. Enter the lot corresponding to the Daily Plant Output (MI 305). Also, enter this in the remarks.
39. **BIN:** Leave blank. IDOT mix plant personnel use if performing individual hot bin "IND" tests. Enter the appropriate hot bin number. Also, enter this in remarks.

40. **COPIES:** Enter the distribution of this report. The normal distribution for mix plant results is the **original** goes to the District Materials Engineer, a copy goes to the Resident Engineer(s), and a copy goes to the QC Manager(s). The distribution for aggregate source tests is the original goes to the District Materials Engineer and a copy goes to the source's QC manager. Non-QC/QA - Same as above, except that the file copy stays with the tester or the individual who completed the report.
41. **TESTER:** Print the name of the individual who tested the aggregate. The individual's signature is also required. If the test is run by a Gradation Technician, then the supervisor should sign here also.
42. **AGENCY:** Enter the tester's employer.
43. **DATE ENTERED:** Leave blank. IDOT will enter the date the results are entered into MISTIC as month, day and year in mmddyy format.
44. **INITIALS:** Leave blank. IDOT will enter initials of the person entering the test results into MISTIC.

CONCRETE AIR, SLUMP AND QUANTITY INSTRUCTIONS BMPR MI654

1. **I.D. NUMBER:** MISTIC test identification number. Leave blank because MISTIC will generate the test identification number.
2. **PROJECT IDENTIFICATION:** Enter the project identification.
3. **INSPECTOR NO.:** Identify the individual who took the sample. For split samples, the same inspector number should be used for both halves of the sample.
 - a) IDOT personnel enter their MISTIC inspector number.
 - b) Contractor, Subcontractor and Producer personnel enter a "9", followed by the District number and seven zeros (0's).
Example: 960000000 for District 6.
 - c) Consultant personnel enter their company's MISTIC inspector number.
 - d) Local agency personnel enter a "9" followed by the District number, which is repeated until field is filled.
Example: 966666666 for District 6 local agency.
4. **DATE:** Enter the date the report is prepared as month, day, and year in mmddy format.
Example: 103112
5. **SEQUENCE NO.:** Enter any combination of letters and/or numbers up to 6 characters in length. It is used to differentiate multiple samples of the same materials taken on the same day.
6. **CONC. PROD. NO.:** Enter the MISTIC code number for the concrete producer. Only one plant may be shown on one report. Example: 5362-05
7. **CONCRETE CODE:** Enter the MISTIC material code for the concrete mixture. Only one code number is allowed per report. The "M" in the material code signifies a metric mixture. The unit of measure for metric mixtures is cubic meters. All metric contracts should be using metric mixtures.

Enter 21601 or 21601M for a portland cement concrete mixture.

Enter 21605 or 21605M for a portland cement and fly ash concrete mixture.

Enter 21606 or 21606M for a portland cement and latex concrete mixture.

Enter 21609 or 21609M for a portland cement and microsilica concrete mixture.

Enter 21611 or 21611M for a portland cement and ground granulated blast-furnace slag concrete mixture.

Enter 21613 or 21613M for a portland cement and high reactivity metakaolin concrete mixture.

Enter 21614 or 21614M for a portland cement, fly ash, and high reactivity metakaolin concrete mixture.

Enter 21620 or 21620M for a fabric formed concrete revetment mat mixture.

Enter 21621 or 21621M for a controlled low-strength mixture.

Enter 21622 or 21622M for a portland cement, fly ash, and microsilica concrete mixture.

Enter 21627 or 21627M for a portland cement, ground granulated blast-furnace slag, and microsilica concrete mixture.

- Enter 21628 or 21628M for portland cement, fly ash, ground granulated blast-furnace slag, and microsilica concrete mixture.
- Enter 21629 or 21629M for portland cement, ground granulated blast-furnace slag, and high reactivity metakaolin concrete mixture.
- Enter 21632 for a portland blast-furnace slag cement and fly ash concrete mixture.
- Enter 21633 for an insertion lining of pipe culverts grout mixture.
- Enter 21634 for a portland cement pervious concrete mixture.
- Enter 21635 for a portland cement and fly ash pervious concrete mixture.
- Enter 21636 for a portland cement and ground granulated blast-furnace slag pervious concrete mixture.
- Enter 21637 for a portland cement and Type K concrete mixture.
- Enter 21638 for a portland cement, fly ash, and Type K concrete mixture.
- Enter 21801 or 21801M for a cement aggregate mixture II.
- Enter 21803 or 21803M for a cement aggregate mixture II with fly ash.
- Enter 22106 or 22106M for a concrete mixture which uses a rapid hardening cement from the Department's Approved List of Packaged, Dry, Rapid Hardening Cementitious Materials for Concrete Repairs.
- Enter 22107 or 22107M for a concrete mixture which uses calcium aluminate cement.
8. **AEA:** Air-entraining admixture. Enter the 5 digit MISTIC material code number for the air-entraining agent used. Refer to the IDOT Approved List of Concrete Admixtures.
9. **PROD. NAME:** Enter the name of the ready mix or jobsite plant.
10. **PROD. LOCATION:** Enter the location of the ready mix or jobsite plant.
11. **CEMENT PROD.:** Enter the MISTIC code number for the plant that produced the portland cement. Refer to IDOT Approved List of Qualified Cement Plants.
Example: 4116-08
12. **CEMENT CODE:** Enter the 6 character MISTIC material code number for the type of cement used.
Only one code number is allowed per report.
- Enter 37601M for Type I cement.
Enter 37603M for Type II cement.
Enter 37605M for Type III cement.
Enter 37608M for Type V cement.
Enter 37609M for Type II (MH) cement.
Enter 37701M for Type IS cement.
Enter 37703M for Type IP cement.
Enter 37901M for rapid hardening cement.
Enter 37902M for calcium aluminate cement.
13. **ADMIXTURE:** Enter, left justified, the last 3 digits of the MISTIC material code number for the admixture(s) being used. Refer to the IDOT Approved List of Concrete Admixtures. A total of 3 different admixtures may be entered. For example, if a superplasticizer, a retarder, and a corrosion inhibitor are used, the entry may read:
Example: 738758725 for Melment, Recover, and DCI.
14. **RESPONSIBLE LOC.:** Enter the District identification number as a "9" followed by the District number. Example: 96 for District 6

15. **LAB:** Enter the 2 letter MISTIC lab code.

<u>Laboratory Locations</u>	<u>MISTIC Lab Codes</u>
Producer Plant Site Laboratory	PP
Producer NonPlant Site Laboratory	PL
Producer Construction Site	PC
Independent Plant Site Laboratory	IP
Independent NonPlant Site Laboratory	IL
Independent Construction Site	IC
Independent Laboratory	IN
IDOT/Local Agency Plant Site Laboratory	FP
IDOT/Local Agency Construction Site	FC

NOTE: A Contractor, Subcontractor, and Producer are to use one of the "Producer" lab codes.

An IDOT Consultant, Contractor Consultant, Subcontractor Consultant, and Producer Consultant are to use one of the "Independent" lab codes.

16. **LAB NAME:** Enter the name of the company which cannot exceed 20 characters.

17. **TYPE TEST:** See below for the correct 3 letter designation. For additional information see Attachment 4 in the Project Procedures Guide.

<u>AGENCY</u>	<u>QC/QA</u>	<u>NON QC/QA</u>
Contractor/Producer/ Consultant	PRO	----
IDOT/Consultant	IND (split), INV	ACC

ACC = Acceptance

IND = Independent Assurance

INV = Investigative

PRO = Process Control

18. **SFX:** Suffix. Leave blank because MISTIC will generate the MISTIC test identification number suffix.
19. **CONTRACT NUMBER:** Enter the 5 digit contract number. If it is a local agency contract without a 5 digit number, then enter the 16 or 17 character MFT (Motor Fuel Tax) contract number.
20. **JOB NUMBER:** Enter the 8 character job number that corresponds with the 5 digit contract number. If the contract number is not 5 digits, leave this field blank.

21. **DESIGN NUMBER:** Enter the 9 character mixture design number assigned by the District, for the concrete mixture being used. Example: 86PCC1234
22. **DATE CAST:** Enter the date of the pour as month, day, and year in mmddyy format.
23. **LOCATION:** Enter the location of the pour such as abutment, pier footing, sidewalk, etc. Station number may be shown. The field is 15 spaces long. For "IND" tests the sample comparison information should be entered in this field.

For "IND" inspection, a comparison remark is required for slump and air content, because the assurance test is from a split sample. For an acceptable comparison, enter the following:

- Enter "C" when tests compare within acceptable limits of precision.
- Enter date of comparison.
- Enter initials for "IND" inspector.
- If the sample was witnessed by the "IND" inspector, indicate as "ws".
Note: The sample should always be witnessed.
- Example: C - 100197 TCS ws.

For an unacceptable comparison, enter the following:

- Enter "X" when tests do not compare within acceptable limits of precision.
- Enter date of comparison.
- Enter initials for "IND" inspector.
- If the sample was witnessed by the "IND" inspector, indicate as "ws".
Note: The sample should always be witnessed.
- Explain reason for unacceptable comparison under "Remarks".
- Examples are: Contractor obtained sample incorrectly; IDOT equipment required repair; Contractor performed test method incorrectly; Problem was not identified, will investigate further if problem continues.
- Example: X - 100297 TCS ws Contractor performed test method incorrectly.

24. **WATER:** Enter the total liters of water per cubic meter (gallons per cubic yard) of concrete. This includes mixing water, free moisture in the aggregates and water added at the jobsite. The quantity must be between 0.0 and 999.9 liters (gallons). (Note: Water in admixtures and water used to rinse the discharge opening of a truck mixer should be included, if significant. Refer to Section 5.6 "Water-Cement Control" of the PCC Level II Technician Course manual for additional information.)
25. **CONC. TEMP.:** Enter the concrete temperature. It must be between 0.0 and 99.9 degrees Celsius (Fahrenheit).

26. **AIR TEMP.:** Enter the air temperature. It must be between 0.0 and 999.9 degrees Celsius (Fahrenheit).
27. **AIR %:** Enter all final results of air tests. It must be between 0.0 and 99.9 percent.
28. **SLUMP:** Enter all the final results of slump tests. It must be between 0.0 and 999.99 millimeters. Round to the nearest 5 mm (1/4 inch).
29. **TYPE CONST.:** Enter the 2 letter code for the type of construction.

<u>MISTIC Code</u>	<u>Construction Type</u>
01	PCC Base Course
02	PCC Base Course Widening
03	PCC Curb
04	PCC Gutter
05	PCC Combination Curb & Gutter
06	PCC Step Curb & Gutter
07	PCC Hub Guard & Gutter
08	PCC Paved Ditch
09	PCC Median
10	PCC Pavement
11	CRCP Pavement
12	PCC Railroad Crossing
13	PCC Sidewalk
14	PCC Slope Wall
15	Structures*
16	Bridge Deck
17	Pavement Patching
18	Bridge Deck Patching
19	Precast Deck Slab
20	Precast Prestressed Beams
21	Headwalls
22	Handrail
23	Seal Coat
24	Precast Piling
25	Precast Prestressed Piling
26	Pneumatic Concrete (Shotcrete)
27	Bridge Deck Concrete Overlay
28	Latex Concrete
29	PCC Shoulders
30	Sub-base
31	Incidental
32	CLSM for Backfill

* This item includes foundations such as drilled shafts, repairs such as formed concrete repair, bridge approach slab, and the "bridge approach footing" beneath the bridge approach slab.

30. **AEA:** Air-entraining admixture. Enter the dosage of the air-entraining admixture used. It must be between 0.0 and 9999.9 ml/100 kg (oz./cwt) of cement and finely divided minerals.

(Note: The completion of this field is a District option. Consultants need to verify with the District on the need to complete this field.)

31. **ADMIX:** Admixtures. Enter the dosage of any other admixture used. Must be between 0.0 and 9999.9 ml/100 kg (oz./cwt) of cement. If more than one admixture is used, the total combined dosage is entered in this field. The individual dosages can be written in the remarks.
(Note: The completion of this field is a District option. Consultants need to verify with the District on the need to complete this field.)
32. **QNTY.:** Enter the total quantity of the day's pour on the first test of the day. Round up to a whole cubic meter (cubic yard).
33. **SERIES:** Enter the 6 letter and/or number combination, assigned to the beam or cylinder series.
Example: 1P-A = Contractor 762 mm (30 in.) beam to be broken at 7 days.
1P-B = Contractor 762 mm (30 in.) beam to be broken at 14 days.
1P-C = IDOT 762 mm (30 in.) beam to be broken at 14 days.
Enter as "1P", and not as "1P-A", "1P-B", and "1P-C". If the A, B, C letter designation is included, MISTIC would interpret this as 3 series instead of 1 series with 3 beams. The beams are differentiated by age in MI 655.
(NOTE: Use same series designation for MI 655.)
34. **RESULT:** Enter "APPR" for approved tests, "FAIL" for failures and "INVL" for invalid tests. All failures must have remarks detailing the action taken to address the failure. For example, retest, checked equipment, test method incorrect, will monitor.
35. **LOAD NUMBER:** Enter the load number that applies to the tests.
36. **REPORTED BY:** Print the name of the individual who completed the report. The individual's signature is also required.
37. **REMARKS:** Enter any remark that pertains to the report.
38. **TESTER:** Enter the name of the individual(s) who performed the slump and air content tests.
39. **AGENCY:** Enter the tester's employer.
40. **COPIES TO:** Enter the distribution of this report. QC/QA - The original goes to the District Materials Engineer. A copy goes to the Resident Engineer and the file copy goes to the QC Manager. Non-QC/QA - Same as above except that the file copy stays with the tester or the individual who completed the report.
41. **C:** MISTIC convert flag for English data. If the data on the form is in English units, then mark "Y" and the MISTIC system will convert it to metric values (except for quantity). If the data on the form is in metric units, then leave blank. All test data that is stored in MISTIC must be metric.
42. **DATE ENTERED:** Leave blank. IDOT will enter the date the results are entered into MISTIC as month, day, and year in mmddyy format.
43. **INITIALS:** Leave blank. IDOT will enter the initials of the person entering the test results into MISTIC.



P.C. Concrete Strengths

Inspector No (3): _____ Date Reported (4): _____ Sequence No (5): _____

Type Insp (6): _____ Total Samples (7): 01

Prod. No (8): _____ **Prod. Name (9):** _____

Matl. Code (10): _____ **Name (11):** _____ Desc. _____ Copy (13): _____

Resp. Loc (14): _____ Lab (15): _____ Lab Name (16): _____ Compl. Date (17): _____ Test Results (18): _____

Remarks (19): _____

Assign (20): Y Contract (21): _____ Job No (22): _____

Trans: 655

I.D. Number (1):	_____
County (2):	_____
Section:	_____
Route:	_____
District:	_____
Contract No:	_____
Job No.	_____
Project:	_____
City:	_____

Design (23):	Type Const. (24):	Date Cast (25):	Series (26):	Type C or F (27):	Days or Hours (28):	Age (29):	Strength psi (30):	Strength psi (31):	Average psi (32):	Age (33):	Strength psi (34):	Strength psi (35):	Average psi (36):
Remarks (37):													
Remarks													
Remarks													
Remarks													
Remarks													
Remarks													
Remarks													
Remarks													
Remarks													
Remarks													

Reported By (38): _____ **Remarks (39):** _____ **Copies To (40):** _____
(Printed Name and signature are required)

Tester (41): _____ **Agency (42):** _____ **C (43):** _____
(Printed Name and signature are required)

/FOR DTY03000

BMPR MI655 (Rev. 11/01/12)
 (Formerly MI655)

MISTIC INPUT	
Date Entered (44):	_____
Initials (45):	_____

P. C. CONCRETE STRENGTHS INSTRUCTIONS BMPR MI655

1. **I.D. NUMBER:** MISTIC test identification number. Leave blank because MISTIC will generate the test identification number.
2. **PROJECT IDENTIFICATION:** Enter the project information.
3. **INSPECTOR NO.:** Identify the individual who took the sample. For split samples, the same inspector number should be used for both halves of the sample. If another individual made the beams or cylinders, enter this information in Item 19.
 - a) IDOT personnel enter the MISTIC inspector number.
 - b) Contractor, Subcontractor and Producer personnel enter a "9", followed by the District number and seven zeros (0's).
Example: 960000000 for District 6.
 - c) Consultant personnel enter their company's MISTIC inspector number.
 - d) Local agency personnel enter a "9" followed by the District number, which is repeated until field is filled.
Example: 966666666 for District 6 local agency.
4. **DATE REPORTED:** Enter the date the report was prepared as month, day, and year in mmddyy format. Example: 103112
5. **SEQUENCE NO.:** Enter any combination of letters and/or numbers up to 6 characters in length. It is used to differentiate multiple samples of the same materials taken on the same day.
6. **TYPE INSP.:** See below for the correct 3 letter designation. For additional information see Attachment 4 in the Project Procedures Guide

<u>AGENCY</u>	<u>QC/QA</u>	<u>NON QC/QA</u>
Contractor/Producer/ Consultant	PRO	-----
IDOT/Consultant	IND (split), INV	PRO, IND

IND = Independent Assurance
 INV = Investigative
 PRO = Process Control

7. **TOTAL SAMPLES:** Pre-printed on the form with a "01".

8. **PROD. NO.:** Enter the MISTIC code number for the concrete producer. Only one plant may be shown on one report. Example: 5362-05
9. **PROD. NAME:** Enter the name of ready mix or jobsite plant.
10. **MATL. CODE:** Enter the MISTIC material code for the concrete mixture. Only one code number is allowed per report. The "M" in the material code signifies a metric mixture. The unit of measure for metric mixtures is cubic meters. All metric contracts should use metric mixtures.

Enter 21601 or 21601M for a portland cement concrete mixture.

Enter 21605 or 21605M for a portland cement and fly ash concrete mixture.

Enter 21606 or 21606M for a portland cement and latex concrete mixture.

Enter 21609 or 21609M for a portland cement and microsilica concrete mixture.

Enter 21611 or 21611M for a portland cement and ground granulated blast-furnace slag concrete mixture.

Enter 21613 or 21613M for a portland cement and high reactivity metakaolin concrete mixture.

Enter 21614 or 21614M for a portland cement, fly ash, and high reactivity metakaolin concrete mixture.

Enter 21620 or 21620 M for a fabric formed concrete revetment mat mixture.

Enter 21621 or 21621M for a controlled low-strength mixture.

Enter 21622 or 21622M for a portland cement, fly ash and microsilica concrete mixture.

Enter 21627 or 21627M for a portland cement, ground granulated blast-furnace slag, and microsilica concrete mixture.

Enter 21629 or 21629M for portland cement, ground granulated blast-furnace slag, and high reactivity metakaolin concrete mixture.

Enter 21632 for a portland blast-furnace slag cement and fly ash concrete mixture.

Enter 21633 for an insertion lining of pipe culverts grout mixture.

Enter 21634 for a portland cement pervious concrete mixture.

Enter 21635 for a portland cement and fly ash pervious concrete mixture.

Enter 21636 for a portland cement and ground granulated blast-furnace slag pervious concrete mixture.

Enter 21637 for a portland cement and Type K concrete mixture.

Enter 21638 for a portland cement, fly ash, and Type K concrete mixture.

Enter 21801 or 21801M for a cement aggregate mixture II.

Enter 21803 or 21803M for a cement aggregate mixture II with fly ash.

Enter 22106 or 22106M for a concrete mixture which uses a rapid hardening cement from the Department's Approved List of Packaged, Dry, Rapid Hardening Cementitious Materials for Concrete Repairs.

Enter 22107 or 22107M for a concrete mixture which uses calcium aluminate cement.

11. **NAME:** Enter the name of the concrete mixture, which corresponds with the material code.
12. **DESC. 1:** Leave blank.
13. **COPY:** Leave blank.
14. **RESP. LOC.:** Enter the District identification number as a "9" followed by the District number. Example: 96 for District 6

15. **LAB:** Enter the 2 letter MISTIC lab code.

<u>Laboratory Locations</u>	<u>MISTIC Lab Codes</u>
Producer Plant Site Laboratory	PP
Producer NonPlant Site Laboratory	PL
Producer Construction Site	PC
Independent Plant Site Laboratory	IP
Independent NonPlant Site Laboratory	IL
Independent Construction Site	IC
Independent Laboratory	IN
IDOT/Local Agency Plant Site Laboratory	FP
IDOT/Local Agency Construction Site	FC

NOTE: A Contractor, Subcontractor, and Producer are to use one of the "Producer" lab codes.

An IDOT Consultant, Contractor Consultant, Subcontractor Consultant, and Producer Consultant are to use one of the "Independent" lab codes.

16. **LAB NAME:** Enter the name of the company which cannot exceed 20 characters.
17. **COMPL. DATE:** Complete date. Enter the most recent date the beams or cylinders were tested, from all tests on the report. Enter the date as month, day, and year in mmddyy format.
18. **TEST RESULTS:** Use "COMP" to indicate completed tests.
19. **REMARKS:** Enter any remark that pertains to the report.
20. **ASSIGN:** Pre-printed on form with a "Y".
21. **CONTRACT:** Enter the 5 digit contract number. If it is a local agency contract without a 5 digit number, then enter the 16 or 17 character MFT (Motor Fuel Tax) contract number.
22. **JOB NO.:** Enter the 8 character job number that corresponds with the 5 digit contract number. If the contract number is not 5 digits, leave this field blank.
23. **DESIGN:** Enter the 9 character mixture design number assigned by the District, for the concrete mixture being tested. Example: 86PCC1234

24. **TYPE CONST.:** Enter the 2 letter code for the type of construction.

<u>MISTIC Code</u>	<u>Construction Type</u>
01	PCC Base Course
02	PCC Base Course Widening
03	PCC Curb
04	PCC Gutter
05	PCC Combination Curb & Gutter
06	PCC Step Curb & Gutter
07	PCC Hub Guard & Gutter
08	PCC Paved Ditch
09	PCC Median
10	PCC Pavement
11	CRCP Pavement
12	PCC Railroad Crossing
13	PCC Sidewalk
14	PCC Slope Wall
15	Structures*
16	Bridge Deck
17	Pavement Patching
18	Bridge Deck Patching
19	Precast Deck Slab
20	Precast Prestressed Beams
21	Headwalls
22	Handrail
23	Seal Coat
24	Precast Piling
25	Precast Prestressed Piling
26	Pneumatic Concrete (Shotcrete)
27	Bridge Deck Concrete Overlay
28	Latex Concrete
29	PCC Shoulders
30	Sub-base
31	Incidental
32	CLSM for Backfill

* This item includes foundations such as drilled shafts, repairs such as formed concrete repair, bridge approach slab, and the "bridge approach footing" beneath the bridge approach slab.

25. **DATE CAST:** Enter the date the beams or cylinders were made as month, day, and year in mmddyy format.

26. **SERIES:** Enter the 6 letter and /or number combination, assigned to the beam or cylinder series.
Example: 1P-A = Contractor 762 mm (30 in.) beam to be broken at 7 days.
1P-B = Contractor 762 mm (30 in.) beam to be broken at 14 days.
1P-C = IDOT 762 mm (30 in.) beam to be broken at 14 days.
Enter as "1P" and not as "1P-A", "1P-B" and "1P-C". If the A, B and C letter designation is included, MISTIC would interpret this as 3 series instead of 1 series with 3 beams. The beams are differentiated by age in MI 655.
(NOTE: Use same series designation for MI 654.)
27. **TYPE C or F:** Enter "F" for flexural strength (Beam) or "C" for compressive strength (cylinder).
28. **DAYS OR HOURS:** Enter "D" if the beam/cylinder age to break is in days or "H" if the age is in hours. The age designation is applicable to Items 29 and 33.
29. **AGE:** At time of test, indicate the age of first 762 mm (30 in.) beam, or first set of cylinders/beams. The age must be between 0 and 99.
30. **STRENGTH:** Enter the compressive or flexural strength for the first cylinder or beam tested, or for the first break on a 762 mm (30 in.) beam; at the age indicated in Item 29. The strength must be between 0 and 999999 kPa (psi).
31. **STRENGTH:** Enter the compressive or flexural strength for the second cylinder or beam tested, or for the second break on a 762 mm (30 in.) beam; at the age indicated in Item 29. The strength must be between 0 and 999999 kPa (psi).
(NOTE: If the second break is not performed at that same age as Item 29, omit Items 31 and 32 and enter under Items 33 and 34, on the same line.)
32. **AVERAGE:** Enter the average strength of the two breaks (Item 30 and 31).
33. **AGE:** At time of test, indicate the age of second 762 mm (30 in.) beam, or second set of cylinders/beams. The age must be between 0 and 99. (NOTE: The beam or cylinder must correspond with Item 26.)
34. **STRENGTH:** Enter the compressive or flexural strength for the first cylinder or beam tested, or for the first break on a 762 mm (30 in.) beam; at the age indicated in Item 33. The strength must be between 0 and 999999 kPa (psi).
35. **STRENGTH:** Enter the compressive or flexural strength for the second cylinder or beam tested, or for the second break on a 762 mm (30 in.) beam; at the age indicated in Item 33. Must be between 0 to 999999 kPa (psi).
36. **AVERAGE:** Enter the average strength of the two breaks (Items 34 and 35).
37. **REMARKS:** Enter any remark that pertains to the set of beams/cylinders. For "IND" tests the sample comparison information is entered in this field.

For "IND" inspection, a comparison remark is required, because the assurance test is from a split sample. For an acceptable comparison, enter the following:

- Enter "C" when tests compare within acceptable limits of precision.
- Enter date of comparison.

- Enter initials for “IND” inspector.
- If the sample was witnessed by the “IND” inspector, indicate as “ws”.
NOTE: The sample should always be witnessed.
- Example: C - 100197 JLK ws.

For an unacceptable comparison, enter the following:

- Enter “X” when tests do not compare within acceptable limits of precision.
 - Enter date of comparison.
 - Enter initials for “IND” inspector.
 - If the sample was witnessed by the “IND” inspector, indicate as “ws”.
NOTE: The sample should always be witnessed.
 - Explain reason for unacceptable comparison.
 - Examples are: Contractor obtained sample incorrectly; IDOT equipment required repair; Contractor performed test method incorrectly; Problem was not identified, will investigate further if problem continues.
 - Example: X - 100297 JLK ws Contractor performed test method incorrectly.
38. **REPORTED BY:** Print the name of the individual who completed the report. The individual’s signature is also required.
39. **REMARKS:** Enter any remark that pertains to the report.
40. **COPIES TO:** Enter the distribution of this report. QC/QA - The original goes to the District Materials Engineer. A copy goes to Resident Engineer and the file copy goes to the QC Manager. Non-QC/QA - Same as above except that the file copy stays with the tester or the individual who completed the report.
41. **TESTER:** Print the name of the individual who tested the cylinders or beams. The individual’s signature is also required.
42. **AGENCY:** Enter the tester’s employer.
43. **C:** MISTIC convert flag for English data. If the data on the form is in English units, then mark “Y” and the MISTIC system will convert it to metric values (except for quantity). If the data on the form is in metric units, then leave blank. All test data that is stored in MISTIC must be metric.
44. **DATE ENTERED:** Leave blank. IDOT will enter the date the results are entered into MISTIC as month, day, and year in mmddyy format.
45. **INITIALS:** Leave blank. IDOT will enter the initials of the person entering the test results into MISTIC.

This Page Reserved

Appendix L

PLANT OR JOBSITE DOCUMENTATION EXAMPLE FORMAT

(NOTE: Record this information on inside cover of field book.)

Contractor Name: _____

Job Superintendent Name: _____

Contractor Address: _____

Contractor Phone Number: _____

Resident Name: _____

District Office Address: _____

District Office Phone Number: _____

County: _____

Section: _____

Route: _____

District: _____

Contract No.: _____

Job No.: _____

Project: _____

PLANT OR JOBSITE DOCUMENTATION EXAMPLE FORMAT

DATE: _____

WEATHER: _____

CONSTRUCTION TYPE: _____

CONSTRUCTION LOCATION: _____

CONCRETE PRODUCER AND LOCATION: _____

DEPARTMENT CONCRETE MIX DESIGN NUMBER: _____

TICKET NO.	TRUCK NO.	BATCH TIME	ARRIVAL TIME *	DISCHARGE TIME *	TRUCK MIXER REVOLUTIONS		BATCH SIZE
					INITIAL	FINAL**	
PLANT OR FIELD COMMENT:							
PLANT OR FIELD COMMENT:							
PLANT OR FIELD COMMENT:							
PLANT OR FIELD COMMENT:							
PLANT OR FIELD COMMENT:							
PLANT OR FIELD COMMENT:							
PLANT OR FIELD COMMENT:							

* This information is recorded at the jobsite.

** Per specification, this information is option

PLANT OR JOBSITE DOCUMENTATION EXAMPLE FORMAT

NOTE FOR ADJUSTMENTS AT JOBSITE: Tests for air content and slump shall be performed before adjusting a mix. Concrete which is modified at the jobsite, after initial testing, shall be retested. Documentation for air content and slump shall clearly indicate if these tests were performed before, or after, the addition of water or admixtures. Strength specimens shall not be molded until after the addition of all water and admixtures. Concrete shall not be placed until air content and slump tests are completed. When placing concrete by pump or conveyor, indicate which tests are performed before or after transport by pump or conveyor.

STATE INSPECTOR: _____

CONTRACTOR INSPECTOR: _____

PERCENT AIR		SLUMP		CONC. TEMP.		AIR TEMP.		WATER ADDED	ADMIX. ADDED	REV'S ADDED (Min. 40)	SERIES NUMBER/LETTER	
QC	QA	QC	QA	QC	QA	QC	QA				QC	QA
PLANT OR FIELD COMMENT:												
PLANT OR FIELD COMMENT:												
PLANT OR FIELD COMMENT:												
PLANT OR FIELD COMMENT:												
PLANT OR FIELD COMMENT:												
PLANT OR FIELD COMMENT:												

PLANT OR JOBSITE DOCUMENTATION EXAMPLE FORMAT

NOTE FOR ADJUSTMENTS AT JOBSITE: Tests for slump flow, VSI, J-ring, and L-box shall be performed before adjusting a self-consolidating concrete (SCC) mix. SCC which is modified at the jobsite, after initial testing, shall be retested. Documentation for slump flow, VSI, J-ring, and L-box shall clearly indicate if the tests were performed before, or after, the addition of water or admixtures. Specimens for Hardened Visual Stability Index (HVSI) test shall not be molded until after the addition of water and admixtures. Concrete shall not be placed until SCC tests are completed. When placing concrete by pump or conveyor, indicate which tests are performed before or after transport by pump or conveyor.

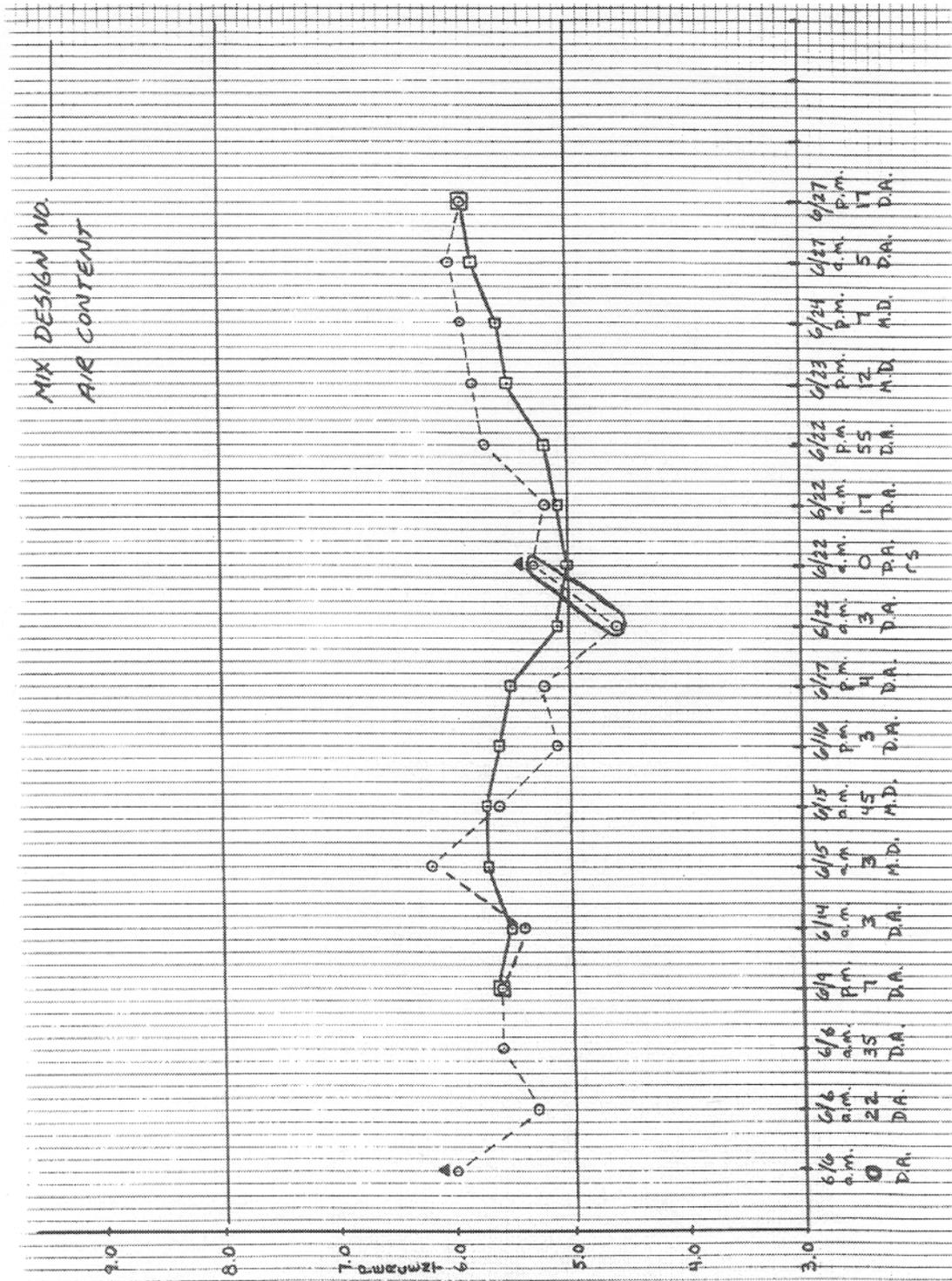
STATE INSPECTOR: _____

CONTRACTOR INSPECTOR: _____

SLUMP FLOW		VSI		J-RING		L-BOX		HVSI		DSI	
QC	QA	QC	QA	QC	QA	QC	QA	QC	QA	QC	QA
PLANT OR FIELD COMMENT:											
PLANT OR FIELD COMMENT:											
PLANT OR FIELD COMMENT:											
PLANT OR FIELD COMMENT:											
PLANT OR FIELD COMMENT:											
PLANT OR FIELD COMMENT:											
PLANT OR FIELD COMMENT:											

Appendix M

EXAMPLE CONTROL CHART



This Page Reserved

Appendix N

PCC MIX DESIGN COMPUTER PRINTOUT AND INSTRUCTIONS

```

PROGRAM: DTGMIRFD                PCC MIX DESIGN                MMTY3110.DOC
      TRANS: 110                  CREATE, UPDATE, DELETE SCREEN
      SCREEN: DTY03110            (NEW 7/09/96)
ACTIVATED: /FOR DTY03110
    
```

```

+-----+-----+-----+-----+-----+-----+-----+-----+
LN|COLS  ....1.....2.....3.....4.....5.....6.....7.....8
NO|1...5...0...5...0...5...0...5...0...5...0...5...0...5...0
+-----+-----+-----+-----+-----+-----+-----+-----+
1 |      DTT03110                PCC DESIGN MIX
2 |  CREATE: 1      UPDATE:      DELETE:      DATE
3 |  PCC MIX #: ---3----- MATERIAL: ---4-----5----- EFFECT: --6---
4 |  REF DESIGN #: ---7----- CLASS: 8- -- -- -- -- LAST YR USED: 9- TERM: -10---
5 |  RESP: 11- ***12***** LAB: 13 ----14----- REVIEWED BY: --15----- DFLAG:16-
6 |  MIX PROD: --17-----18----- CONTRACT: ----19-----
7 |  BATCH      H2O% FINE %      (Z)  MORTOR {TYPE} {H2O L/kg} {ABS. VOL}
8 |  CU m  ADX  RED  MOD  AIR  VOIDS  CEMENT FACTOR  ASH  FA  FA  CA  CA,B  FA,A
9 |  -20^- -21 22^- -^23 24^ ^25 -26- --^27 28 29 ^30- ^31- ^/32/ ^/33/
10|                                     %BLEND/ %MOIST/ {kg/CU m} LBS/
11| MATERIAL  PROD NO  PROD NAME      SP G  Z RATIO REPL  SSD  ADJ  CU YD
12| --34----- --35--- ****36***** -^37- 38-^ 39^-- /40/ /41/ /42/
13| -----
14| -----
15| -----
16| -----
17| -----
18| {CA + FA} {RATIOS} ADJ H2O(kg:LBS) /43/ /44/
19| MIX H2O: ^/45/ ASH/CMT WT: 46^/ TOTAL BATCH WT(kg:LBS) /47/ /48/
20| RED MIX H2O: ^/49/
21| TOTAL CEMENTITIOUS MATL: /50/ THEO. WATER(kg:LBS) /51/ /52/
22| REMARKS: ---53----- THEO H20(GAL) 54^/
23| REMARKS: -----55----- ADJ H20(GAL) 56^/
24| MESSAGES: PROCESS: _
+-----+-----+-----+-----+-----+-----+-----+-----+
|0.....1.....2.....3.....4.....5.....6.....7.....8
|1...5...0...5...0...5...0...5...0...5...0...5...0...5...0
+-----+-----+-----+-----+-----+-----+-----+-----+
    
```

NOTES: 1). Messages:

- ?? indicates required info is missing.
- \$\$ indicates illegal field contents.
- highlighted fields must be numeric.

LEGEND

- / - Represent Calculated fields; /'s would NOT display on Create\Update screen.
- ^ - Represent the decimal position within a field; ^'s would NOT display on screen.
- > - Represent new fields and or lables; >'s would not appear on the screen.
- _ - Represent INPUT fields and locations; would be displayed on Create screen.

1. **Create** : This field may be left blank or a “Y” may be entered. As soon as this screen is fully metricated, the cursor will start in the “Calc” field. Since this is a create transaction, update and delete are not available. Once a mix design has been used, it should never be deleted.
2. **Cal**: Calculation flag. Enter “Y” to have the screen calculate the design. Type “N” and press “Enter” in order to manually enter data into all fields. Once “Enter” has been pressed, the “Calc” field may not be changed in the create mode. This is a new field that is not currently displayed but will be after the screen conversion is complete.
3. *** PCC Mix #**: Mix design number Example: 82PCC1234. Any combination of letters and numbers may be used in the last four digits.
4. *** Material**: Material code for the concrete mix. This should always be **metric**. Example: 21601M or 21605M.
5. **Material code name**: Based on the input material code, MISTIC displays the associated material code name.
6. *** Effect**: Effective date of the mix design, “mmddyy.” This represents the date the mix design was available for use.
7. **Ref Design #**: Reference mix design number. If the mix design that is being created is similar to another one, then the similar design number can be entered here. When the “Enter” key is pressed all the design, component and remarks data will be automatically pulled from the referenced design into the new design. The data can be adjusted after entering a “N” in the process field. This will be working in the near future.
8. **Class**: Class of concrete. Example: BD for bridge deck (see spec book, pages 678-681). This field has five occurrences
9. **Last Yr Used**: This is the last year the mix design was used. **This is not an input field.** In the future, the year will be inserted/updated automatically each time the 654 screen creates a new record.
10. **Term**: Termination date of the mix design, “mmddyy.” If a 654 or 655 transaction uses a sample date greater than the termination date of a mix design, then a warning message will be displayed.
11. *** Resp**: Responsible location. Enter the digit “9” followed by the district number. Based on the number entered, MISTIC will generate the responsible location name.
12. **Resp Name**: Based on the input responsible location number, MISTIC will display the associated responsible location name.
13. **Lab**: Laboratory associated with the creation of the design. Based on the number entered, MISTIC will generate the laboratory name. Example: FP, for district paper designs; DI, for district laboratory; PP, for producer paper designs; PL, producer laboratory designs etc. This field is not required but it should be used.

14. **Lab Name:** Based on the input lab acronym, MISTIC displays the associated lab name.
15. **Reviewed by:** Name of the person that has reviewed the design.
16. **Dflag:** Delete flag. A "D" should be entered if the mix design is no longer valid or no longer being used.
17. **Mix Prod:** Concrete mix producer number, Example: 1945-01. Based on the number entered, MISTIC will display the concrete mix producer name when the screen is processed. Optional field.
18. **Mix Prod Name:** Based on the input mix producer number, MISTIC will display the associated mix producer name.
19. **Contract:** Contract number. This may be filled in for a contract specific mix design. Optional field.
20. *** Batch, CU m:** Batch size in cubic meters. This field should always be filled in with the number "1".
21. **Adx:** Admixture type. Enter as follows: "W" = water reducer, "S" = superplasticizer, "R" = Retarder
22. **H₂O% Red:** Percentage of water reducer used. Example: 2.5.
23. **Fine Mod:** Fineness modulus of the fine aggregate used in the mix design. Example: 2.36. Optional field.
24. *** % Air:** Percentage of air entraining. Example: 1.5.
25. *** Voids:** Percentage of voids in the coarse aggregate used in the mix design, entered as a decimal. Example: 0.42.
26. *** (Z) Cement:** Theoretical or original/target cement quantity in kilograms per cubic meter. This will not be the actual cement quantity if the mix contains any cement replacement products (fly ash, GGBF slag, microsilica, etc.) Conversion Example: $6.05 \text{ cwt/yd}^3 * 59.327583 = 359 \text{ kg/m}^3$, $605 \text{ lbs./yd}^3 * 0.593276 = 359 \text{ kg/m}^3$.
27. *** Mortar Factor:** Ratio of the volume of the mortar to the coarse aggregate volume. Example: .80
28. **Type, Ash:** Single letter designation for the type of fly ash used in the mix design. Use "C" or "F".
29. **Type, FA:** Single letter designation for the type of fine aggregate. Related to the relative angularity. Use "A", "B", or "C".

30. * **H₂O L/kg, FA:** Water requirement for fine aggregate in liters per kilogram of cement/cementitious materials. This value is based on what letter is used in the "Type, FA" field. "A" = .426 (5.1), "B" = .442 (5.3), "C" = .459 (5.5) Conversion: gallons/cwt * .0834541 = liters/kg
31. * **H₂O L/kg, CA:** Water requirement for coarse aggregate in liters per kilogram of cement/cementitious material. For gravel, "0" is commonly used; for crushed stone, "0.2" is commonly used. Use the same metric conversion as fine aggregate 0.2 gal/cwt * .0834541 = 0.017 liters/kg.
32. **Abs. Vol, CA,B:** Absolute volume of coarse aggregate per cubic meter of concrete. Calculated field.
33. **Abs. Vol, FA,A:** Absolute volume of fine aggregate per cubic meter of concrete. Calculated field.
34. * **Material:** Component material codes. There are six occurrences of this field. All material codes must be metric ("M" in the 6th position). All aggregate material codes should be "A" quality or superstructure quality. Fly ash, ground granulated blast furnace slag, or microsilica should be input in the 5th occurrence. The cement material code should always be in the 6th occurrence. MISTIC will check the component material for being an acceptable product under the producer
35. * **Prod No:** Component material producer number.. It is required for all aggregate and fly ash components but **it is not required for cement.**
36. **Prod Name:** Component material producer name. **This is not an input field.** Based on the producer number input, MISTIC will display the associated producer name.
37. * **Sp G:** Specific gravity of each component material. The specific gravity value should be entered to the nearest .001. Example: 2.675. The specific gravity to be used for cement is 3.150.
38. * **%Blend/Z Ratio:** This field has two uses: 1) %Blend for aggregate components - when using a blend of coarse aggregates or a blend of fine aggregates, the blend percentage must be entered for each component type that has a blend. Example: blending CA11 and CA16 @ 75%/25%--a 75 must be entered for the CA11 and a 25 for the CA16. The same would be true for fine aggregates. If there is not a blend, then the value should be "100". **Each component must have a value or the weights will not be calculated!** 2) Z Ratio for Fly ash and Cement components - when using fly ash the percentage of cement being replaced should be entered in this field for the fly ash material code. The remaining percentage should be entered for the cement. Example: 15 for fly ash and 85 for cement. If there is not any fly ash in the mix, then the value for cement should be "100".

39. * **%Moist/Repl:** This field has two uses: 1) %Moisture for aggregate components - the percentage moisture greater or less than saturated surface dry must be entered using a "+" or "-" sign. Example: +1.00. If the value is zero, it should be entered as "0" without a "+" or "-" sign. 2) Replacement for fly ash and cement - for fly ash enter the replacement ratio. Example: +1.5 or +1.25. A "+1", should always be entered for cement. The requirement for the "+" will be removed in the near future.
40. **kg/CU m, SSD:** The saturated surface dry weight in kilograms per cubic meter for each component. Conversion: lbs./yd³ * .593276 = kg/m³. Calculated field.
41. **kg/CU m, ADJ:** The moisture adjusted weight in kilograms per cubic meter for each component. Calculated field.
42. **lbs/CU YD:** The weight of each component in pounds per cubic yard. Calculated field.
43. **ADJ H₂O, kg:** Adjusted water content in kilograms per cubic meter. Conversion: lbs/yd³ * .593276 = kg/m³. Calculated field.
44. **ADJ H₂O, lbs:** Adjusted water content in pounds per cubic yard. Calculated field.
45. **Mix-H₂O:** Mix water in liters per kilogram of cement. This is the sum of the water requirements for fine (FA,A) and coarse (CA,B) aggregate. Calculated field.
46. **Ash/Cmt Wt:** Ratio of the weight of fly ash (kg) to the weight of cement (kg) per cubic meter. Calculated field.
47. **Total Batch Wt, kg:** Total weight of the components (including water) in kilograms per cubic meter. Calculated field.
48. **Total Batch Wt, lbs:** Total weight of the components (including water) in pounds per cubic yard. Calculated field.
49. **Red Mix H₂O:** Reduced mix water. This is the mix water reduced by the amount of water reducer that has been added to the mix. Calculated field.
50. **Total Cementitious Matl:** This is the weight of the cement and the fly ash per cubic meter. This value is the sum of the cement and fly ash from the adjusted weight column. If only cement is used, then this value will be the same as the "Z Factor". If both cement and fly ash are used, then this value will be larger than the "Z Factor". Calculated field.
51. **Theo. Water, kg:** Theoretical water in kilograms per cubic meter. Calculated field.
52. **Theo. Water, lbs:** Theoretical water in pounds per cubic yard. Calculated field.
53. **Remarks:** First remarks line. When required to mitigate against alkali-silica reaction (ASR), indicate the mixture option selected for reducing the risk of deleterious reaction.
54. **Theo H₂O (Gal):** Theoretical water in gallons per hundredweight of cement. Calculated field.

55. **Remarks:** Second remarks line.

56. **Adj H₂O (Gal):** Adjusted water in gallons per hundredweight of cement. Calculated field.

Footnotes:

* - Denotes a required input field

Additional Note:

Any fields labeled “calculated” are currently input fields but will become calculated fields after the enhancement of this screen is completed (in the very near future).

Appendix O



**Illinois Department
of Transportation**

Calibration of Concrete Test Equipment Slump

Owner of Equipment: _____ Manufactured By: _____
 Model No.: _____ Serial No.: _____ IDOT No.: _____
 Inspection References: (check one) Illinois Modified AASHTO T 119 ASTM C 143
 Frequency: a. Every 12 months, or
 b. When there is a question of calibration.

	Calibrations ^A					
	# 1	# 2	# 3	# 4	# 5	# 6
Record date of inspection. (mm/dd/yy)						
Indicate date of next inspection. (mm/dd/yy)						
Are interior and exterior clean? (Y/N)						
Record cone thickness. (0.060 in. (1.5 mm) minimum; 0.045 in. (1.15 mm) minimum if formed by the Spinning Process)						
Record top diameter of cone. (4 ± 1/8 in. (102 ± 3.2 mm))						
Record bottom diameter of cone. (8 ± 1/8 in. (203 ± 3.2 mm))						
Record height of cone. (12 ± 1/8 in. (305 ± 3.2 mm))						
Are sides smooth and free of dents? (Y/N)						
Are foot pieces and handles in good condition? (Y/N)						
Do base plate clamps and swing handle move freely? (Y/N)						
Is tamping rod tip hemispherical? (Y/N)						
Record diameter of tamping rod and hemispherical tip. 5/8 ± 1/16 in. (16 ± 2 mm)						
Record tamping rod length. (Refer to test method for acceptable length, but 16 in. (400 mm) to 24 in. (600 mm) is typically acceptable.)						

Name of Inspector/Comments: (For BMPR*: Supervisor shall initial each calibration following completion.)	
# 1	
# 2	
# 3	
# 4	
# 5	
# 6	

*BMPR: IDOT Bureau of Materials and Physical Research

^A A "No" answer or measured value outside of indicated tolerances requires the equipment to be repaired or replaced. For any discrepancy, the applicable inspection reference(s) checked above shall have precedence over this calibration form.

Revised Date: 09/17/12 BMPR PCCQ01



**Calibration of Concrete Test Equipment
Air Meter, Type "A"**

Owner of Equipment: _____ Manufactured By: _____

Model No.: _____ Serial No.: _____ IDOT No.: _____

Inspection References: (check one) Illinois Modified AASHTO T 152 ASTM C 231

- Frequency:
- a. Every 12 months according to Illinois Modified AASHTO T 152 (or every 3 months according to ASTM C 231, or
 - b. When there is an elevation change of more than 600ft (183 m) from the location at which the test equipment is calibrated, or
 - c. When there is a question of calibration.

Calibration Equipment: INTERNAL CALIBRATION CYLINDER

	Calibrations ^A					
	# 1	# 2	# 3	# 4	# 5	# 6
Record date of inspection. (mm/dd/yy)						
Indicate date of next inspection. (mm/dd/yy)						
Are interior and exterior clean? (Y/N)						
Clamps, funnel assembly, & petcocks work properly? (Y/N)						
Are gasket and gauge in good condition? (Y/N)						
Record bowl height.						
Record bowl diameter. (0.75 to 1.25 times the height?)						
Record the Expansion Factor. ^B						
Indicate volume (grams) of calibration cylinder. ^C						
Record Calibration Point Reading (%). ^D						
Is the air meter accurate? ^C (Y/N)						
Is tamping rod tip hemispherical? (Y/N)						
Record diameter of tamping rod and hemispherical tip. (5/8 ± 1/16 in. (16 ± 2 mm))						
Record tamping rod length. (Refer to test method for acceptable length, but 16 in. (400 mm) to 24 in. (600 mm) is typically acceptable.)						
Record mallet weight (mass). (1.25 ± 0.50 lb (0.57 ± 0.23 kg))						
Indicate rubber or rawhide mallet head.						

Name of Inspector/Comments ^B : (For BMPR*: Supervisor shall initial each calibration following completion.)	
# 1	
# 2	
# 3	
# 4	
# 5	
# 6	

*BMPR: IDOT Bureau of Materials and Physical Research

^A A "No" answer or measured value outside of indicated tolerances requires the equipment to be repaired or replaced. For any discrepancy, the applicable inspection reference(s) checked above shall have precedence over this calibration form.
^B Record calculation of expansion factor in the Comments section.
^C For Illinois Modified AASHTO T 152, refer to the Appendix of the Portland Cement Concrete Level I Technician Course manual for additional information on "Air Meter Adjustment Instructions."

Revised Date: 09/17/12 BMPR PCCQ02



Calibration of Concrete Test Equipment Air Meter, Type "B"

Owner of Equipment: _____ Manufactured By: _____

Model No.: _____ Serial No.: _____ IDOT No.: _____

Inspection References: (check one) Illinois Modified AASHTO T 152 ASTM C 231

Frequency: a. Every 3 months during use, or
b. When there is a question of calibration.

Calibration Equipment: A = TUBES AND CALIBRATION VESSEL
 B = INTERNAL CALIBRATION CYLINDER

	Calibrations ^A					
	# 1	# 2	# 3	# 4	# 5	# 6
Record date of inspection. (mm/dd/yy)						
Indicate date of next inspection. (mm/dd/yy)						
Indicate Type of Calibration Equipment. (A or B)						
Are interior and exterior clean? (Y/N)						
Clamps, funnel assembly, & petcocks work properly? (Y/N)						
Are gasket and gauge in good condition? (Y/N)						
Record bowl height.						
Record bowl diameter. (0.75 to 1.25 times the height?)						
A: Indicate volume (%) of calibration vessel. ^B						
A: Record Calibration Point Reading (%) at 0, 5, & 10. ^B	0					
	5					
	10					
B: Indicate volume (%) of calibration cylinder. ^B						
B: Record Calibration Point Reading (%) ^B						
Is the air meter accurate? ^B (Y/N)						
Is tamping rod tip hemispherical? (Y/N)						
Record diameter of tamping rod and hemispherical tip. (5/8 ± 1/16 in. (16 ± 2 mm))						
Record tamping rod length. (Refer to test method for acceptable length, but 16 in. (400 mm) to 24 in. (600 mm) is typically acceptable.)						
Record strike-off bar length. (≥ 12 in. (300 mm))						
Record strike-off bar width. (≥ 3/4 in. (20 mm))						
Record strike-off bar thickness. (≥ 1/8 in. (3 mm))						
Record mallet weight (mass). (1.25 ± 0.50 lb (0.57 ± 0.23 kg))						
Indicate rubber or rawhide mallet head.						
Name of Inspector/Comments: (For BMPR*: Supervisor shall initial each calibration following completion.)						
# 1						
# 2						
# 3						
# 4						
# 5						
# 6						

*BMPR: IDOT Bureau of Materials and Physical Research

^A A "No" answer or measured value outside of indicated tolerances requires the equipment to be repaired or replaced. For any discrepancy, the applicable inspection reference(s) checked above shall have precedence over this calibration form.
^B Refer to the Appendix of the Portland Cement Concrete Level I Technician Course manual for "Air Meter Adjustment Instructions," or ASTM C 231 if CCRL inspected.



Illinois Department of Transportation

**Calibration of Concrete Test Equipment
Air Meter, Volumetric**

Owner of Equipment: _____ Manufactured By: _____

Model No.: _____ Serial No.: _____ IDOT No.: _____

Inspection References: (check one) Illinois Modified AASHTO T 196 ASTM C 173

Frequency: a. Every 12 months, or
b. When there is a question of calibration.

	Calibrations ^A					
	# 1	# 2	# 3	# 4	# 5	# 6
Record date of inspection. (mm/dd/yy)						
Indicate date of next inspection. (mm/dd/yy)						
Are interior and exterior clean? (Y/N)						
Do clamps and screw cap work properly? (Y/N)						
Are gasket and transparent scale in good condition? (Y/N)						
Record bowl height.						
Record bowl diameter. (1.00 to 1.25 times the height?)						
Does funnel spout extend to a point just above the top section's bottom? (Y/N)						
Is calibrated cup total capacity or graduated increments equal to 1.00 ± 0.04% of the volume of the bowl? (Y/N)						
Is the rubber bulb syringe capacity at least 2 oz. (50 mL)? (Y/N)						
Is the alcohol 70 % by volume isopropyl alcohol? (Y/N)						
Is tamping rod tip hemispherical? (Y/N)						
Record diameter of tamping rod and hemispherical tip. (5/8 ± 1/16 in. (16 ± 2 mm))						
Record tamping rod length. (Refer to test method for acceptable length, but 16 in. (400 mm) to 24 in. (600 mm) is typically acceptable.)						
Record strike-off bar length. ^B (≥ 12 in. (300 mm))						
Record strike-off bar width. ^B (≥ 3/4 in. (20 mm))						
Record strike-off bar thickness. ^B (≥ 1/8 in. (3 mm))						
Record mallet weight (mass). (1.25 ± 0.50 lb (0.57 ± 0.23 kg))						
Indicate rubber or rawhide mallet head.						

Name of Inspector/Comments: (For BMPR*: Supervisor shall initial each calibration following completion.)	
# 1	
# 2	
# 3	
# 4	
# 5	
# 6	

*BMPR: IDOT Bureau of Materials and Physical Research

^A A "No" answer or measured value outside of indicated tolerances requires the equipment to be repaired or replaced. For any discrepancy, the applicable inspection reference(s) indicated above shall have precedence over this calibration form.
^B Refer to Illinois Modified AASHTO T 196 or ASTM C 173 to obtain required dimensions for high density polyethylene or other plastic strike-off bars.



Illinois Department of Transportation

**Calibration of Concrete Test Equipment
Unit Weight**

Owner of Equipment: _____ Manufactured By: _____

Model No.: _____ Serial No.: _____ IDOT No.: _____

Inspection References: (check one) Illinois Modified AASHTO T 121 and Illinois Test Procedure 19 ASTM C 138 and ASTM C 29

Frequency: a. Every 12 months, or
b. When there is a question of calibration.

	Calibrations ^A					
	# 1	# 2	# 3	# 4	# 5	# 6
Record date of inspection. (mm/dd/yy)						
Indicate date of next inspection. (mm/dd/yy)						
Are interior and exterior clean? (Y/N)						
Balance/scale conforms to Illinois Specification 101? (Y/N)						
Record the measure diameter.						
Record the measure height. (0.80 to 1.50 times the diameter? ^B)						
Record thickness of bottom, wall, and remainder. (Refer to Illinois Test Procedure 19 or ASTM C 29)						
	bottom					
	upper wall					
	wall remainder					
Is measure's top rim smooth and plane? (Y/N) (within 0.01 in. (0.25 mm))						
Record strike-off plate's thickness. (metal: ≥ 1/4 in. (6 mm); glass/acrylic: ≥ 1/2 in. (13 mm))						
Are strike-off plate edges straight/smooth? (Y/N) (within 1/16 in. (1.6 mm))						
Strike-off plate ≥ 2 in. (50 mm) larger than diameter of measure? (Y/N)						
Record calibration plate thickness. (1/4 in. (6 mm))						
Record calibration plate length/width. (≥ 1 in. (25 mm) larger than measure's diameter)						
Calculate and record calibration volume. (Refer to Illinois Test Procedure 19 or ASTM C 29)						
Record temperature of water used in calibration.						
Record diameter of tamping rod and hemispherical tip. (5/8 ± 1/16 in. (16 ± 2 mm))						
Record tamping rod length. (Refer to test method for acceptable length, but 16 in. (400 mm) to 24 in. (600 mm) is typically acceptable.)						
Record mallet weight (mass). (1.25 ± 0.50 lb (0.57 ± 0.23 kg) for measures ≤ 0.5 ft ³ (0.014 m ³); 2.25 ± 0.50 lb (1.020 ± 0.23 kg) for larger measures)						
Indicate rubber or rawhide mallet head.						

Name of Inspector/Comments: (For BMPR*: Supervisor shall initial each calibration following completion.)

# 1	
# 2	
# 3	
# 4	
# 5	
# 6	

*BMPR: IDOT Bureau of Materials and Physical Research

^A A "No" answer or measured value outside of indicated tolerances requires the equipment to be repaired or replaced. For any discrepancy, the applicable inspection reference(s) checked above shall have precedence over this calibration form.
^B The measure's height:diameter ratio requirement is not applicable for an air meter bowl used as a unit weight measure, which should have a diameter 0.75 to 1.25 times the height.



Illinois Department of Transportation

**Calibration of Concrete Test Equipment
Cylinder Molds, Plastic or Metal**

Note: Metal cylinder molds may be used for only precast concrete or precast prestressed concrete products when approved by the Engineer.

Owner of Equipment: _____ Manufactured By: _____

Model No.: _____ Serial No.: N/A IDOT No.: N/A

Inspection References: (check one) Illinois Modified AASHTO T 23 and IL Mod. M 205 ASTM C 31 and ASTM C 470^A

Frequency: a. Minimum 3 randomly chosen molds per shipment, or
b. When there is a question of calibration.

	Calibrations ^B					
	# 1	# 2	# 3	# 4	# 5	# 6
Record date of inspection. (mm/dd/yy)						
Indicate date of next inspection. (mm/dd/yy)						
Are interior and exterior clean? (Y/N)						
Record inside diameter. (6 ± 1/16 in. (152 ± 1.6 mm))						
Record height. (12 ± 1/4 in. (305 ± 6 mm))						
Record wall thickness.						
Is mold watertight? ^C (Y/N)						
Are top and bottom perpendicular to the vertical axis? ^C (within 1/8 in. in 12 in. (3 mm in 300 mm))						
Is bottom inside surface plane? ^C (within 1/16 in. in 6 in. (1.6 mm in 152 mm))						
Is bottom flush with sidewall bottom? ^C (within 1/16 in. (1.6 mm))						
Is sidewall bottom fillet within 1/8 in. (3 mm) vertical and 3/16 in. (5 mm) horizontal? ^C (Y/N)						
Is tamping rod tip hemispherical? (Y/N)						
Record diameter of tamping rod and hemispherical tip. (5/8 in. (16 mm) is specified)						
Record tamping rod length. (≥23 in. (584 mm); 20 ± 4 in. (500 ± 100 mm) ^A)						
Record mallet weight (mass). (1.25 ± 0.50 lb (0.57 ± 0.23 kg))						
Indicate rubber or rawhide mallet head.						
Is the cover for curing in good condition? (Y/N)						

Name of Inspector/Comments: (For BMPR*: Supervisor shall initial each calibration following completion.)	
# 1	
# 2	
# 3	
# 4	
# 5	
# 6	

*BMPR: IDOT Bureau of Materials and Physical Research

^A Only applies to laboratories inspected by the Cement and Concrete Reference Laboratory (CCRL).
^B A "No" answer or measured value outside of indicated tolerances requires the equipment to be repaired or replaced. For a shipment of molds, if one or more of the three random samples is unacceptable, return the shipment or check all molds. For any discrepancy, the applicable inspection reference(s) checked above shall have precedence over this calibration form.
^C Refer to Illinois Modified AASHTO M 205 or ASTM C 470 according to the reference checked above.

Effective Date: 06/03/09 BMPR PCCQ06



**Calibration of Concrete Test Equipment
Beam Molds, Steel**

Owner of Equipment: _____ Manufactured By: _____

Model No.: _____ Serial No.: _____ IDOT No.: _____

Inspection References: (check one) Illinois Modified AASHTO T 23 and IL Mod. M 205 ASTM C 31 and ASTM C 470^A

Frequency: a. Every 12 months, or
b. When there is a question of calibration.

	Calibrations ^B					
	# 1	# 2	# 3	# 4	# 5	# 6
Record date of inspection. (mm/dd/yy)						
Indicate date of next inspection. (mm/dd/yy)						
Are interior and exterior clean? (Y/N)						
Record width. (6 ± 1/4 in. (152 ± 6 mm))						
Record height. (6 ± 1/4 in. (152 ± 6 mm))						
Record length. (≥ 18 3/4 in. (476 mm) for one break; ≥ 29 3/4 in. (756 mm) for two breaks)						
Are inside mold surfaces smooth? (Y/N)						
Are mold sides, bottom, and ends perpendicular, straight and true, and free of warpage? (Y/N)						
Is the mold watertight? ^C (Y/N)						
Is tamping rod tip hemispherical? (Y/N)						
Record diameter of tamping rod and hemispherical tip. (5/8 in. (16 mm) is specified)						
Record tamping rod length. (≥23 in. (584 mm); 20 ± 4 in. (500 ± 100 mm) ^A)						
Record mallet weight (mass). (1.25 ± 0.50 lb (0.57 ± 0.23 kg))						
Indicate rubber or rawhide mallet head.						
Is the cover for curing in good condition? (Y/N)						

Name of Inspector/Comments: (For BMPR*: Supervisor shall initial each calibration following completion.)	
# 1	
# 2	
# 3	
# 4	
# 5	
# 6	

*BMPR: IDOT Bureau of Materials and Physical Research

^A Only applies to laboratories inspected by the Cement and Concrete Reference Laboratory (CCRL).
^B A "No" answer or measured value outside of indicated tolerances requires the equipment to be repaired or replaced. For any discrepancy, the applicable inspection reference(s) checked above shall have precedence over this calibration form.
^C Refer to Illinois Modified AASHTO M 205 or ASTM C 470 according to the reference checked above.

Effective Date: 06/03/09 BMPR PCCQ07



**Calibration of Concrete Test Equipment
Metal Retainers & Neoprene Pads**

Owner of Equipment: _____ Manufactured By: _____

Model No.: _____ Serial No.: _____ IDOT No.: _____

Inspection References: Illinois Modified AASHTO T 22 and ASTM C 1231

- Frequency: a. Every 3 months during use, or
b. When there is a question of calibration.

Note: A visual inspection shall be performed prior to first use each day, but does not need to be recorded.

	Calibrations ^A					
	# 1	# 2	# 3	# 4	# 5	# 6
Record date of inspection. (mm/dd/yy)						
METAL RETAINER						
Record inner wall height. (1.0 ± 0.1 in. (25 ± 3 mm))						
Record inside diameter. (102 – 107% of cylinder diameter)						
Are bearing surfaces plane? (Y/N) (within 0.002 in. (0.05 mm))						
Is bearing surface free of gouges, grooves, or indentations greater than 0.010 in. (0.25 mm) deep? (Y/N)						
Is bearing surface free of gouges, grooves, or indentations greater than 0.05 in. ² (32 mm ²) in surface area? (Y/N)						
Free of rust and other foreign material? (Y/N)						
NEOPRENE PADS						
Record Shore "A" Durometer hardness. (typically 70, tolerance ±5. See Table 1, ASTM C 1231)						
Record diameter. (not more than 1/16 in. (2 mm) smaller than inside diameter of retaining ring)						
Record thickness. (1/2 ± 1/16 in. (13 ± 2 mm))						
Free of excessive wear; damage (e.g., compression set); cracks or splits >3/8 in. (10 mm) in length regardless of depth? (Y/N)						
Is number of uses no more than 100? (Y/N)						

Name of Inspector/Comments: (For BMPR*: Supervisor shall initial each calibration following completion.)	
# 1	
# 2	
# 3	
# 4	
# 5	
# 6	

*BMPR: IDOT Bureau of Materials and Physical Research

^A A "No" answer or measured value outside of indicated tolerances requires the equipment to be repaired or replaced. For any discrepancy, the applicable inspection reference(s) indicated above shall have precedence over this calibration form.

Revised Date: 07/28/09 BMPR PCCQ08



**Calibration of Concrete Test Equipment
Capping Cylindrical Strength Specimens**

Owner of Equipment: _____ Manufactured By: _____

Model No.: _____ Serial No.: _____ IDOT No.: _____

Inspection References: (check one) Illinois Modified AASHTO T 231 ASTM C 617^A

Frequency: a. Every 3 months during use, or
b. When there is a question of calibration.

	Calibrations ^B					
	# 1	# 2	# 3	# 4	# 5	# 6
Record date of inspection. (mm/dd/yy)						
Indicate date of next inspection. (mm/dd/yy)						
Record capping plate thickness. (glass ≥ 1/4 in. (6 mm); metal ≥ 0.45 in. (11 mm); granite ≥ 3 in. (75 mm))						
Record capping plate side dimension. (≥ 1 in. (25 mm) larger than specimen's diameter)						
Is metal capping plate surface plane? (within 0.002 in. in 6 in. (0.05 mm in 150 mm))						
Is metal capping plate surface free of gouges, grooves, and indentations > 0.010 in. (25 mm) deep? (Y/N)						
Is metal capping plate surface free of gouges, grooves, and indentations > 0.05 in. ² (32 mm ²) in area? (Y/N)						
If recess, record metal plate thickness beneath recess. (≥ 1/2 in. (13 mm))						
If recess, record depth of metal plate recess. (≤ 1/2 in. (13 mm))						
Does alignment device ensure that no single cap will depart from perpendicularity of cylindrical specimen by more than 1/8 in. in 12 in. (3.2 mm in 305 mm)? (Y/N)						
Can the sulfur mortar be heated between 265° to 290°F (129° to 143° C)? (Y/N)						
Is capping material strength adequate for cylinder strength? ^C (Y/N)						

Name of Inspector/Comments: (For BMPR*: Supervisor shall initial each calibration following completion.)	
# 1	
# 2	
# 3	
# 4	
# 5	
# 6	

*BMPR: IDOT Bureau of Materials and Physical Research

^A Only applies to laboratories inspected by the Cement and Concrete Reference Laboratory (CCRL).
^B A "No" answer or measured value outside of indicated tolerances requires the equipment to be repaired or replaced. For any discrepancy, the applicable inspection reference(s) indicated above shall have precedence over this calibration form.
^C Refer to Illinois Modified AASHTO T 231 or ASTM C 617 according to the reference checked above.

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Appendix P

State of Illinois
Department of Transportation
Bureau of Materials and Physical Research
POLICY MEMORANDUM
Springfield

Revised: October 15, 2012

20-08.1

This Policy Memorandum supersedes number 20-08.0 dated January 1, 2008

TO: REGIONAL ENGINEERS AND HIGHWAY BUREAU CHIEFS

SUBJECT: FIELD TEST PROCEDURES FOR MIXER PERFORMANCE AND CONCRETE UNIFORMITY TESTS

I. SCOPE

These methods describe the procedures for obtaining and testing representative samples of fresh concrete in the field to determine the consistency and mixer efficiency of stationary mixers at different mixing time periods.

The concrete produced during the mixing time investigation and not used in the test program may be incorporated in the project provided it conforms with the Standard Specifications for Road and Bridge Construction.

As specified in Article 1020.11(c) a maximum of two mixing times will be considered by the Department. The Contractor shall provide all of the necessary equipment and personnel to perform the tests, and the Department will observe the testing.

II. EQUIPMENT

The following equipment shall be provided by the Contractor.

- a. Three (3) air meters according to Illinois Modified AASHTO T 152.
- b. Three (3) slump cone kits according to Illinois Modified AASHTO T 119.
- c. One (1) No. 4 sieve with a minimum screen area of 0.19 m² (2 sq. ft.) according to AASHTO M 92.
- d. One (1) unit weight weighing equipment according to Illinois Specification 101, "Minimum Requirements for Electronic Balances".
- e. Flexural strength molds according to Illinois Modified AASHTO T 23, or compressive strength molds according to Illinois Modified AASHTO T 23.
- f. Strength testing apparatus according to Illinois Modified AASHTO T 22 or T 177.
- g. Curing equipment according to Illinois Modified AASHTO T 23.
- h. Small tools such as shovels, scoops, buckets, etc., and water shall be furnished as required.

III. PROCEDURE

For an initial request, a minimum of ten (10) batches per drum shall be tested and evaluated for each original reduced mixing time . If the initial request is for a twin drum mixer, ten (10) batches shall be tested for the first drum and three (3) for the second drum.

Subsequent verification or a check test, consisting of three (3) batches, shall be required if the mixer is moved, major maintenance is performed (such as replacement of the mixer blades), the source/type/gradation of aggregate has changed, the batching sequence/procedure is altered, or twelve (12) months have elapsed between an initial or subsequent verification. For a twin drum mixer, a check test consisting of three (3) batches shall be performed on each drum. The Engineer reserves the right to request a check test if concrete build up or mixer blade wear is determined to be a concern because of use.

a. Mixing.

The mixing time and batch size to be evaluated shall be proposed by the Contractor. A tolerance of two (2) seconds will be permitted for the mixing time.

If approved by Engineer, minor adjustments in admixture dosage and water content will be allowed to account for weather conditions, provided that the maximum w/c ratio is not exceeded.

In the event of a plant malfunction, the Engineer will determine the need for a new batch.

b. Sampling.

At the conclusion of the mixing cycle, the mixer shall be discharged and appropriate samples obtained from the first, middle, and last third portions of the batch. Samples shall be obtained according to Illinois Modified AASHTO T 141.

As an alternate, the mixer may be stopped, and the samples removed by any suitable means at equally spaced points from the front to the back of the drum.

c. Testing.

1. Each third portion of the batch shall be tested simultaneously. The Contractor shall provide sufficient personnel to meet this requirement. The Contractor personnel performing the testing shall be Level I PCC Technicians or Concrete Testers. However, a Level I PCC Technician shall be provided to supervise the Concrete Tester.
2. From each third portion of the batch the mass (weight) of the concrete in one air meter measuring bowl shall be determined.
3. The air content of each third portion of the batch shall be determined according to Illinois Modified AASHTO T 152. The air content shall be the arithmetic average of two (2) tests from each third portion of the batch.

4. The target slump will be determined by the Engineer, but shall be a maximum 63 mm (2.5 in.). The slump of each third portion of the batch shall be determined according to Illinois Modified AASHTO T 119. The slump shall be the arithmetic average of two (2) tests from each third portion of the batch.
5. Flexural strength specimen(s) (two (2) breaks required) or two (2) compressive strength specimens shall be prepared from each third portion of the batch according to Illinois Modified AASHTO T 23. Flexural strength specimen(s) (two (2) breaks required) shall be tested according to Illinois Modified AASHTO T 177 at seven (7) days of age. Compressive strength specimens shall be tested according to Illinois Modified AASHTO T 22 at seven (7) days of age.
6. The contents from the weighed air meter measuring bowl (Step 2) shall be washed over a No. 4 sieve. Shake as much water as possible from the material retained on the sieve and then weigh the material. The coarse aggregate content (portion of mass (weight) of sample retained on a No. 4 sieve), expressed as a percent, shall be calculated.
7. After the required number of batches have been mixed and tested at the proposed mixing time, the mixing time shall revert back to the minimum time allowed without mixer performance testing, as specified in Article 1020.11(c).

IV. CONCRETE UNIFORMITY REQUIREMENTS

- a. Test results from each third portion of the batch shall be compared to one another according to TABLE 1. Each batch shall be evaluated individually.
- b. Mixer performance tests consisting of ten (10) batches: If more than seven (7) tests out of the total or more than three (3) in any one criteria are not in compliance with the uniformity requirements (air content, slump, coarse aggregate content, and strength), a reduced mixing time will not be granted.
- c. Mixer performance tests consisting of three (3) batches: If more than three (3) tests out of the total are not in compliance with the uniformity requirements, a full ten (10) batch investigation shall be required.

TABLE 1 - REQUIREMENTS FOR UNIFORMITY OF CONCRETE	
Test	Requirement (Note 1)
Air Content, percent by volume of concrete	1.0 (Note 2)
Slump, mm (inch)	25 (1.0) (Note 3)
Coarse aggregate content, portion by mass (weight) of each sample retained on the No. 4 sieve, percent	6.0
Average flexural or compressive strength at 7 days for each sample based on average strength of all comparative test specimens, percent	7.5 (Note 4)

Note 1. Expressed as maximum permissible difference in results of tests of samples taken from three locations in the concrete batch.

Note 2. The average air content sample shall be the arithmetic average of two (2) tests.

Note 3. The average slump sample shall be the arithmetic average of two (2) tests.

Note 4. The average flexural strength of each sample shall be the arithmetic average of two (2) beam breaks. The average compressive strength of each sample shall be the arithmetic average of two (2) cylinder breaks.

V. REPORT

Send copies of the report to the Bureau of Materials and Physical Research, District Materials office and the Resident Engineer/ Technician if applicable.



David L. Lippert, P.E.
Engineer of Materials
and Physical Research

Attachments

MSW/dkt

The following pages include a three batch example report and a blank ten batch report. A version of the spreadsheet with calculations following this Policy Memorandum is available to be downloaded from the IDOT web page.

MIXER PERFORMANCE TESTS

Plant Name W.S Babbitt
 Mixer Capacity 9 cy
 Mixer Make Erie
 Contractor Doland & Sons
 Mix Design Used 86PCC1234

Serial Number 123-456
 Capacity Checked 9 cy
 Mixing Time Checked 60 sec.
 Approved Mixing Time 75 sec.
 Date 09/30/2002
 Drum RPM 20

County Sangamon
 Section (14-3,3-1)RS-2
 Route I-55
 District 6
 Contract Number 94270
 Job Number C-97-062-94
 Project IM-57-3(133)94

Batch No.	Test No.	Slump (in)	Average	Total Var.(in)	Air (%)	Average	Total Var. (%)	Conc. Wt.	Plus #4 Wt.	CA %	Total Var. (%)	Strength (psi)	Avg. psi	Tot. Avg.	% of Average	Total Var. from Average	Maximum Var. from Average
1	1	2.50	2.38	0.25	4.9	4.70	0.60	30.62	16.56	54.08	3.33	3890	3899	3961	98.4	1.6	5.2
		2.25			4.5							3908					
	2	2.50	2.50		5.4	5.30		30.69	17.62	57.41		3749	3820		96.4	3.6	
		2.50			5.2												
	3	2.75	2.63		5.0	5.15		30.50	17.31	56.75		3908	4165		105.2	5.2	
		2.50			5.3							4421					
2	1	2.50	2.63	0.12	4.2	4.10	1.10	31.00	16.50	53.23	2.22	3378	3466	3578	96.9	3.1	4.3
		2.75			4.0							3554					
	2	2.75	2.63		5.0	4.85		30.87	16.87	54.65		3554	3731		104.3	4.3	
		2.50			4.7							3908					
	3	2.75	2.75		5.4	5.20		31.00	17.19	55.45		3537	3537		98.9	1.1	
		2.75			5.0							3537					
3	1	2.00	1.88	0.25	7.8	7.65	0.55	30.12	16.94	56.24	1.76	3908	3820	3840	99.5	0.5	1.3
		1.75			7.5							3731					
	2	1.75	1.75		6.9	7.15		30.50	17.69	58.00		3890	3890		101.3	1.3	
		1.75			7.4							3890					
	3	1.50	1.63		7.2	7.10		30.31	17.12	56.48		3890	3811		99.2	0.8	
		1.75			7.0							3731					
4	1																
	2																
	3																
5	1																
	2																
	3																

MIXER PERFORMANCE TESTS

Plant Name _____
 Mixer Capacity _____
 Mixer Make _____
 Contractor _____
 Mix Design Used _____

Serial Number _____
 Capacity Checked _____
 Mixing Time Checked _____
 Approved Mixing Time _____
 Date _____
 Drum RPM _____

County _____
 Section _____
 Route _____
 District _____
 Contract Number _____
 Job Number _____
 Project _____

Batch No.	Test No.	Slump (in)	Average	Total Var.(in)	Air (%)	Average	Total Var. (%)	Conc. Wt.	Plus #4 Wt.	CA %	Total Var. (%)	Strength (psi)	Avg. psi	Tot. Avg.	% of Average	Total Var. from Average	Maximum Var. from Average	
1	1																	
	2																	
	3																	
2	1																	
	2																	
	3																	
3	1																	
	2																	
	3																	
4	1																	
	2																	
	3																	
5	1																	
	2																	
	3																	

MIXER PERFORMANCE TESTS

Plant Name _____
 Mixer Capacity _____
 Mixer Make _____
 Contractor _____
 Mix Design Used _____

Serial Number _____
 Capacity Checked _____
 Mixing Time Checked _____
 Approved Mixing Time _____
 Date _____
 Drum RPM _____

County _____
 Section _____
 Route _____
 District _____
 Contract Number _____
 Job Number _____
 Project _____

Batch No.	Test No.	Slump (in)	Average	Total Var.(in)	Air (%)	Average	Total Var. (%)	Conc. Wt.	Plus #4 Wt.	CA %	Total Var. (%)	Strength (psi)	Avg. psi	Tot. Avg.	% of Average	Total Var. from Average	Maximum Var. from Average	
6	1																	
	2																	
	3																	
7	1																	
	2																	
	3																	
8	1																	
	2																	
	3																	
9	1																	
	2																	
	3																	
10	1																	
	2																	
	3																	

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